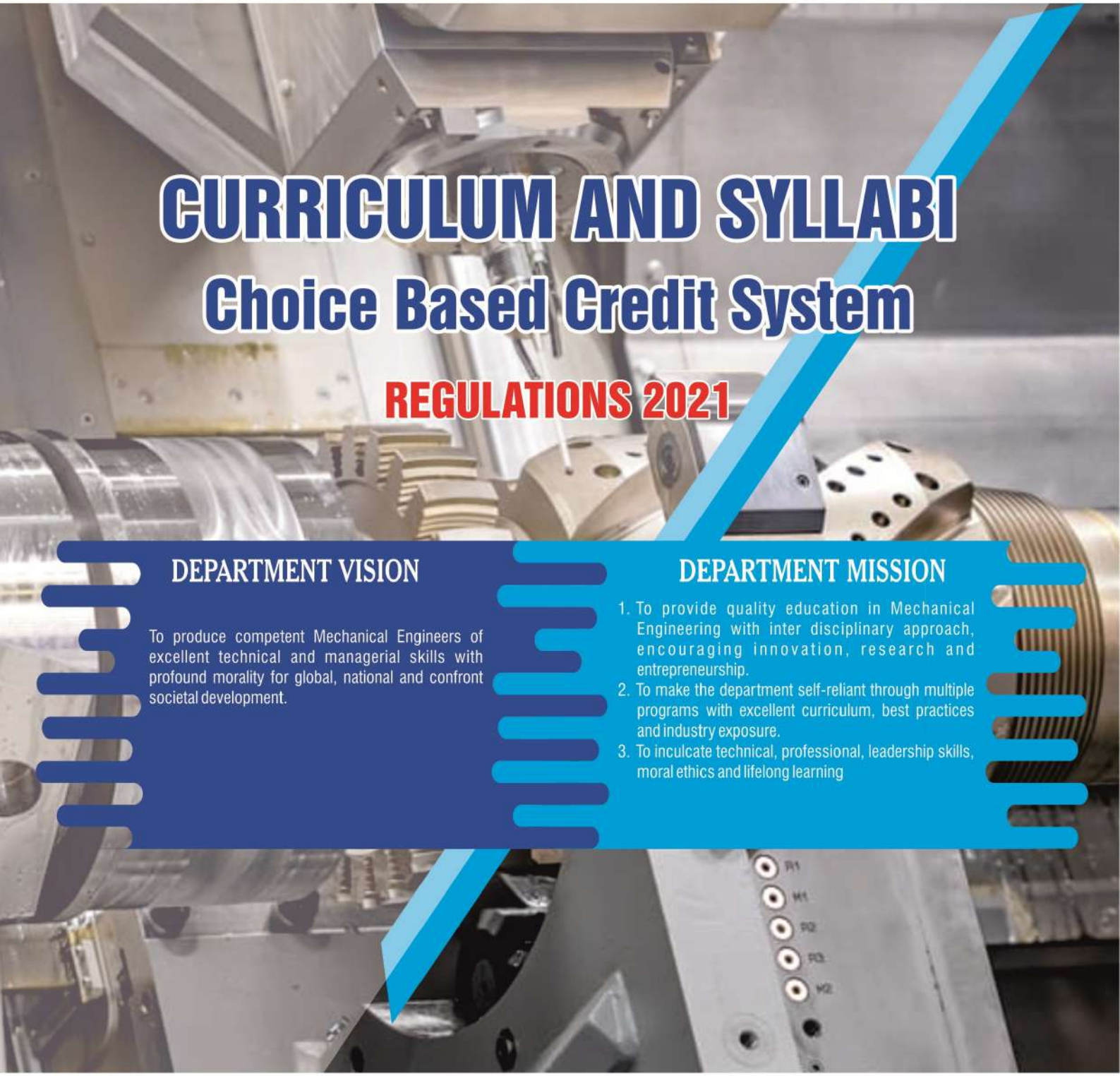
FRANCIS XAVIER®
ENGINEERING COLLEGE

Vannarpettai, Tirunelveli - 627 003.

B.E - Mechanical Engineering



CURRICULUM AND SYLLABI

Choice Based Credit System

REGULATIONS 2021

DEPARTMENT VISION

To produce competent Mechanical Engineers of excellent technical and managerial skills with profound morality for global, national and confront societal development.

DEPARTMENT MISSION

1. To provide quality education in Mechanical Engineering with inter disciplinary approach, encouraging innovation, research and entrepreneurship.
2. To make the department self-reliant through multiple programs with excellent curriculum, best practices and industry exposure.
3. To inculcate technical, professional, leadership skills, moral ethics and lifelong learning

DEPARTMENT OF MECHANICAL ENGINEERING

FRANCIS XAVIER ENGINEERING COLLEGE
AN AUTONOMOUS INSTITUTION

Department of Mechanical Engineering

Curriculum and Syllabi – R 2021-UG CHOICE BASED CREDIT SYSTEM(CBCS)OUTCOME BASED EDUCATION (OBE)

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Francis Xavier Engineering College

(An Autonomous Institution)
Tirunelveli 627 003
Tamil Nadu India

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Table of Content

Programme Educational Outcomes (PEOs)

Bachelor of Mechanical Engineering curriculum is designed to impart Knowledge, Skill and Attitude on the graduates to

PEO 1: Have a successful professional career in Mechanical Engineering and allied industries, either by employment or through entrepreneurship.

PEO 2: Establish competency in Design, Thermal, Materials and Manufacturing system with ethics and social responsibility.

PEO 3: Have a continual receptiveness for leadership and social challenges.

Programme Outcomes(POs)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-Long Learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

On successful completion of the Mechanical Engineering Degree programme, the Graduates shall exhibit the following

PSO 1: Apply the knowledge gained in Mechanical Engineering for **design,** development and **manufacture** of engineering systems.

PSO 2: Analyze, interpret and provide solutions to global needs of engineering industries, the **real life mechanical engineering problems** and **thermal systems** with regard to ethics, environment and society.

Mapping with PEOs with POs, PSOs

PO	PEO1	PEO2	PEO3	Average	Set Target for POs (80% of average)
1	3	3	1	2.3	1.9
2	3	3	1	2.3	1.9
3	3	3	1	2.3	1.9
4	3	3	1	2.3	1.9
5	3	2	2	2.3	1.9
6	2	3	2	2.3	1.9
7	2	3	2	2.3	1.9
8	2	3	2	2.3	1.9
9	2	2	3	2.3	1.9
10	2	2	3	2.3	1.9
11	2	2	2	2.0	1.6
12	2	2	2	2.0	1.6
PSO1	3	3	2	2.7	2.1
PSO2	2	2	3	2.3	1.9

FRANCIS XAVIER ENGINEERING COLLEGE

B.E. – MECHANICAL ENGINEERING REGULATIONS 2021

Choice Based Credit System and Outcome Based Education

SUMMARY OF CREDIT DISTRIBUTION

S. No	Category	Credits Per Semester								Total Credits	Credits in %
		I	II	III	IV	V	VI	VII	VIII		
1	HSSM	3	2	1	1		3	3		**13**	7.78
2	BS	12	4	4						**20**	11.98
3	ES	3	16	3						**22**	13.17
4	PC			16	23	17	8			**64**	38.32
5	PE					3	6	9		**18**	10.78
6	OE					3	3	6		**12**	7.19
7	EEC			1	1	1	3	6	6	**18**	10.78
TOTAL		18	22	25	25	24	23	24	6	**167**	

Minimum Number of Credits to be Acquired for UG Regular : 167

Minimum Number of Credits to be Acquired for UG Lateral : 125

HSS - Humanities and Social Sciences including Management

BS - Basic Science

ES - Engineering Sciences

PC - Professional Core

PE - Professional Elective

OE – Open Elective/Programme Specific Elective for Expandable Scope

EEC - Employability Enhancement Course

FRANCIS XAVIER ENGINEERING COLLEGE

B.E. – MECHANICAL ENGINEERING REGULATIONS 2021

Choice Based Credit System and Outcome Based Education

I-VIII Semester Curricula and Syllabi

SEMESTER I

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21MA1201	Matrices and Advanced Calculus	BS	4	3	1	0	4
2	21PH1302	Engineering Physics	BS	3	3	0	0	3
3	21CY1401	Engineering Chemistry	BS	3	3	0	0	3
Theory Cum Practical Courses								
1	21CS1514	C Programming	ES	4	2	0	2	3
2	21HS1101	English for Professional Communication	HSSM	4	2	0	2	3
Practical Courses								
1	21PY1311	Physics and Chemistry Lab	BS	4	0	0	4	2
			Total	**22**	**13**	**1**	**8**	**18**

SEMESTER II

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21HS2101	English for Technical Communication	HSSM	2	2	0	0	2
2	21MA2201	Partial Differential Equation and Application of Fourier Series	BS	4	3	1	0	4
3	21ME2501	Engineering Mechanics	ES	3	3	0	0	3
Theory cum Practical Courses								
1	21ME1513	Computer Aided Engineering Graphics	ES	5	3	0	2	4
2	21EE2501	Fundamentals of Electrical and Electronics Science	ES	4	2	0	2	3
3	21CS2512	Python Programming	ES	5	1	2	2	4
Practical Course								
1	21GE1512	Engineering Workshop	ES	4	0	0	4	2
			Total	**27**	**14**	**3**	**10**	**22**

SEMESTER III

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21MA3201	Probability and Statistical Analysis	BS	4	3	1	0	4
2	21ME3601	Engineering Thermodynamics	PC	4	3	1	0	4
3	21ME3602	Fluid Mechanics and Machinery	PC	3	2	1	0	3
4	21ME3501	Engineering Materials and Metallurgy	ES	3	3	0	0	3
5	21ME3603	Manufacturing Technology	PC	3	3	0	0	3
6	21PT3902	Verbal Ability	EEC	2	0	0	2	1
7	21HS1103	Tamil Heritage தமிழர் மரபு	HSSM	2	2	0	0	1
Practical Courses								
1	21ME3611	Computer Aided Machine Drawing Laboratory	PC	4	0	0	4	2
2	21ME3612	Manufacturing Technology Laboratory	PC	4	0	0	4	2
3	21ME3613	Fluid Mechanics and Machines Laboratory	PC	4	0	0	4	2
			Total	**33**	**16**	**3**	**14**	**25**

SEMESTER IV

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21ME4601	CNC Machines and Automation	PC	3	3	0	0	3
2	21ME4602	Strength of Materials	PC	3	2	1	0	3
3	21ME4603	Thermal Engineering	PC	3	2	1	0	3
4	21ME4604	Theory of Machines	PC	4	3	1	0	4
5	21GE2M02	Environmental and sustainable Engineering	MC	2	2	0	0	0
6	21PT3901	Aptitude – I	EEC	2	0	0	2	1
7	21HS2103	Technology in Tamil Culture தமிழரும் தொழில்நுட்பமும்	HSSM	2	2	0	0	1
Theory cum Practical Courses								
1	21ME4605	Metrology and Instrumentations	PC	5	3	0	2	4
Practical Courses								
1	21ME4611	Thermal Engineering Laboratory	PC	4	0	0	4	2
2	21ME4612	Strength of materials Laboratory	PC	4	0	0	4	2
3	21ME4613	Kinematics And Dynamics Laboratory	PC	4	0	0	4	2
			Total	**36**	**17**	**3**	**16**	**25**

SEMESTER V

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21ME5601	Heat and Mass Transfer	PC	3	2	1	0	**3**
2	21ME5602	Design of Machine Elements and Joints	PC	3	2	1	0	3
3	21ME5603	Automobile Engineering	PC	3	3	0	0	3
4	PE1	Professional Elective – I	PE	3	3	0	0	**3**
5	OE1	Open Elective – I	OE	3	3	0	0	3
6	21PT3904	Reasoning	EEC	2	0	0	2	1
Theory Cum Practical								
7	21ME5604	Mechatronics and Internet of Things	PC	5	3	0	2	4
Practical Courses								
1	21ME5611	Heat and Mass Transfer Laboratory	PC	4	0	0	4	2
2	21ME5612	CAD/CAM Laboratory	PC	4	0	0	4	2
3		Summer Internship / Industrial Training***	EEC	0	0	0	0	1
			Total	**30**	**16**	**2**	**12**	**24**

*** Optional

SEMESTER VI

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21ME6601	Design of Transmission Systems	PC	3	2	1	0	**3**
2	21ME6602	Finite Element Analysis	PC	3	2	1	0	**3**
3	21HS3101	Ethics And Values	HSSM	3	3	0	0	**3**
4	PE2	Professional Elective – II	PE	3	3	0	0	**3**
5	PE3	Professional Elective – III	PE	3	3	0	0	**3**
6	OE2	Open Elective – II	OE	3	3	0	0	**3**
7	21PT3903	Aptitude II	EEC	2	0	0	2	**1**
Practical Courses								
1	21ME6611	Finite Element Analysis Laboratory	PC	4	0	0	4	2
2	21ME6612	Design and Fabrication Project	EEC	4	0	0	4	2
			Total	**28**	**16**	**2**	**10**	**23**

SEMESTER VII

S. No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21HS7101	Total Quality Management	HSSM	3	3	0	0	3
2	PE4	Professional Elective – IV	PE	3	3	0	0	3
3	PE5	Professional Elective – V	PE	3	3	0	0	3
4	PE6	Professional Elective – VI	PE	3	3	0	0	3
5	OE3	Open Elective – III	OE	3	3	0	0	3
6	OE4	Open Elective – IV	OE	3	3	0	0	3
Practical Courses								
1	21ME7911	Technical Comprehension	EEC	4	0	0	4	2
			Total	**22**	**18**	**0**	**4**	**20**

SEMESTER VIII

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Practical Courses								
1	21ME8901	Project Work / Internship based Project	EEC	12	0	0	20	10
			Total	**12**	**0**	**0**	**20**	**10**

Minimum Number of Credits to be Acquired:167

List of Humanities and Social Sciences Including Management (HSSM)

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21HS1101	English for Professional Communication	HSSM	4	2	0	1	**3**
2	21HS1103	Tamil Heritage **தமிழர் மரபு**	HSSM	2	2	0	0	**1**
3	21HS2103	Technology in Tamil Culture தமிழரும் தொழில்நுட்பமும்	HSSM	2	2	0	0	**1**
4	21HS2101	English for Technical Communication	HSSM	2	2	0	0	**2**
5	21HS3101	Ethics And Values	HSSM	3	3	0	0	**3**
6	21HS7601	Total Quality Management	HSSM	3	3	0	0	**3**

List of Basic Science Courses

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21MA1201	Matrices and Advanced Calculus	BS	4	3	1	0	**4**
2	21PH1302	Engineering Physics	BS	3	3	0	0	**3**
3	21CY1401	Engineering Chemistry	BS	3	3	0	0	**3**
4	21MA2201	Partial Differential Equation And Application of Fourier Series	BS	4	3	1	0	**4**
5	21MA3201	Probability and Statistical Analysis	BS	4	3	1	0	**4**
Practical Courses								
1	21GE1311	Physics and Chemistry Lab	BS	4	0	0	2	**2**

List of Engineering Science Courses

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21ME2501	Engineering Mechanics	ES	3	3	0	0	**3**
2	21ME3501	Engineering Materials and Metallurgy	ES	3	3	0	0	**3**
Theory cum Practical Courses								
1	21EE2501	Fundamentals of Electrical and Electronics Science	ES	5	3	0	2	**4**
2	21ME1513	Computer Aided Engineering Graphics	ES	5	3	0	2	**4**
3	21CS1514	C Programming	ES	4	2	0	2	**3**
4	21CS2512	Python programming	ES	4	2	0	2	**3**
Practical Courses								
1	21GE1512	Engineering Workshop	ES	4	0	0	2	**2**

List of Employability Enhancement Course

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	21PT3902	Verbal Ability	EEC	2	0	0	2	1
2	21PT3901	Aptitude – I	EEC	2	0	0	2	1
3	21PT3904	Reasoning	EEC	2	0	0	2	1
4	21PT3903	Soft Skills Aptitude II	EEC	2	0	0	2	1
Practical Courses								
1	21ME6612	Design and Fabrication project	EEC	4	0	0	4	2
2	21ME7911	Technical Comprehension	EEC	4	0	0	4	2
3	21ME8602	Project Work / Internship based Project	EEC	12	0	0	20	10

LIST OF PROFESSIONAL ELECTIVE COURSES

S.No	Course Code	Course Name	Semester	L	T	P	C	Stream/ Domain
Professional Elective I								
1	21ME5701	Applied Hydraulics and Pneumatics	5	3	0	0	**3**	**Design**
2	21ME5702	Mechanical Behaviour of Materials	5	3	0	0	**3**	**Design**
3	21ME5703	Advanced IC Engines	5	3	0	0	**3**	**Thermal**
4	21ME5704	Alternate Fuels	5	3	0	0	**3**	**Thermal**
5	21ME5705	Maintenance Engineering	5	3	0	0	**3**	**I.A & M**
6	21ME5706	Principles of Management	5	3	0	0	**3**	**I.A & M**
7	21ME5707	Composite Materials	5	3	0	0	**3**	**Mat.Manufacturing**
8	21ME5708	Polymer Technology	5	3	0	0	**3**	**Mat.Manufacturing**
9	21ME5709	Professional Ethics in Engineering	5	3	0	0	**3**	**Diversified Group`**
10	21ME5710	Introduction to Aircraft System	5	3	0	0	**3**	**Diversified Group**
Professional Elective II								
1	21ME6701	Mechanical Vibration and Control	6	3	0	0	**3**	**Design**
2	21ME6702	Concepts of Engineering Design	6	3	0	0	**3**	**Design**
3	21ME6703	Fundamentals of Combustion	6	3	0	0	**3**	**Thermal**
4	21ME6704	Fuel Cell Technology	6	3	0	0	**3**	**Thermal**
5	21ME6705	Industrial Engineering and Management	6	3	0	0	**3**	**I.A & M**
6	21ME6706	Lean Six Sigma	6	3	0	0	**3**	**I.A & M**
7	21ME6707	Computer Integrated Manufacturing	6	3	0	0	**3**	**Mat.Manufacturing**
8	21ME6708	Flexible Manufacturing System	6	3	0	0	**3**	**Mat.Manufacturing**
9	21ME6709	Hybrid vehicle technology	6	3	0	0	**3**	**Diversified Group`**
10	21ME6710	Electric Vehicle	6	3	0	0	**3**	**Diversified Group`**
Professional Elective III								
1	21ME6711	Product Design for Sustainability	6	3	0	0	**3**	**Design**
2	21ME6712	Industrial Tribology	6	3	0	0	**3**	**Design**
3	21ME6713	Gas Dynamics and Jet Propulsion	6	3	0	0	**3**	**Thermal**
4	21ME6714	Refrigeration and Airconditioning	6	3	0	0	**3**	**Thermal**

5	21ME6715	Industry 4.0	6	3	0	0	**3**	**I.A & M**
6	21ME6716	Industrial Robotics	6	3	0	0	**3**	**I.A & M**
7	21ME6717	Modern Machining Process	6	3	0	0	**3**	**Mat.Manufacturing**
8	21ME6718	Solid State Joining Process	6	3	0	0	**3**	**Mat.Manufacturing**
9	21ME6719	Entrepreneurship Development	6	3	0	0	**3**	**Diversified Group**
10	21ME6720	Corrosion and Surface Engineering	6	3	0	0	**3**	**Diversified Group**
Professional Elective IV								
1	21ME7701	Design for Manufacturing and Assembly	7	3	0	0	**3**	**Design**
2	21ME7702	Industrial Ergonomics in Design	7	3	0	0	**3**	**Design**
3	21ME7703	Computational Fluid Dynamics	7	3	0	0	**3**	**Thermal**
4	21ME7704	HVAC systems	7	3	0	0	**3**	**Thermal**
5	21ME7705	Process Planning and Cost Estimation	7	3	0	0	**3**	**I.A & M**
6	21ME7706	Industrial Internet of Things	7	3	0	0	**3**	**I.A & M**
7	21ME7707	Manufacturing and Inspection of Gears	7	3	0	0	**3**	**Mat.Manufacturing**
8	21ME7708	Precision Manufacturing	7	3	0	0	**3**	**Mat.Manufacturing**
9	21ME7709	Traditional and Non-Traditional optimization tool	7	3	0	0	**3**	**Diversified Group`**
10	21ME7710	Vehicle styling and design	7	3	0	0	**3**	**Diversified Group`**
Professional Elective V								
1	21ME7711	Product Design and Development	7	3	0	0	**3**	**Design**
2	21ME7712	Product life Cycle Management	7	3	0	0	**3**	**Design**
3	21ME7713	Cryogenics Engineering	7	3	0	0	**3**	**Thermal**
4	21ME7714	Power Plant Engineering	7	3	0	0	**3**	**Thermal**
5	21ME7715	Production Planning and Control	7	3	0	0	**3**	**I.A & M**
6	21ME7716	Low Cost Automation	7	3	0	0	**3**	**I.A & M**
7	21ME7717	Sustainability through Green Manufacturing System	7	3	0	0	**3**	**Mat.Manufacturing**
8	21ME7718	Advanced Manufacturing Process for micro system fabrication	7	3	0	0	**3**	**Mat.Manufacturing**
9	21ME7719	Electro and Electroless Plating	7	3	0	0	**3**	**Diversified Group`**
10	21ME7720	Energy Conversion in Industries	7	3	0	0	**3**	**Diversified Group`**

Professional Elective VI								
1	21ME7721	Design of Jigs and Fixtures	7	3	0	0	**3**	**Design**
2	21ME7722	Failure analysis and NDT Techniques	7	3	0	0	**3**	**Design**
3	21ME7723	Energy Conservation and Waste Heat Recovery	7	3	0	0	**3**	**Thermal**
4	21ME7724	Simulation of IC Engines	7	3	0	0	**3**	**Thermal**
5	21ME7725	Supply chain Management and Logistics	7	3	0	0	**3**	**I.A & M**
6	21ME7726	Operations Research	7	3	0	0	**3**	**I.A & M**
7	21ME7727	Introduction to NANO Technology	7	3	0	0	**3**	**Mat.Manufacturing**
8	21ME7728	Smart and New Materials	7	3	0	0	**3**	**Mat.Manufacturing**
9	21ME7729	Drone Technologies	7	3	0	0	**3**	**Diversified Group`**
10	21ME7730	Industrial Safety Engineering	7	3	0	0	**3**	**Diversified Group`**

LIST OF OPEN ELECTIVES

S.No	Course Code	Course Name	Semester	L	T	P	C
OPEN ELECTIVE 1							
1	21ME5801	Nuclear Engineering	5	3	0	0	**3**
2	21ME5802	Renewable Energy Sources	5	3	0	0	**3**
3	21ME5803	Additive Manufacturing	5	3	0	0	**3**
4	21ME5804	Fundamental of Research	5	3	0	0	**3**
OPEN ELECTIVE 2							
1	21ME6801	Solar cells and Fundamentals	6	3	0	0	**3**
2	21ME6802	Energy Engineering and Management	6	3	0	0	**3**
3	21ME6803	Design of Experiments	6	3	0	0	**3**
4	21ME6804	Engineering Economics and Cost Analysis	6	3	0	0	**3**
OPEN ELECTIVE 3							
1	21ME7801	Industrial Economics and Foreign Trade	7	3	0	0	**3**
2	21ME7802	Fundamentals of Ergonomics	7	3	0	0	**3**
3	21ME7803	Pollution Control and its Equipments	7	3	0	0	**3**
4	21ME7804	Energy storage devices	7	3	0	0	**3**
OPEN ELECTIVE 4							
1	21ME7805	Digital Manufacturing	7	3	0	0	3
2	21ME7806	Marine Vehicles	7	3	0	0	3
3	21ME7807	Safety measures for Engineers	7	3	0	0	3
4	21ME7808	Introduction to Robotics	7	3	0	0	3

SEMESTER I

21MA1201	MATRICES AND ADVANCED CALCULUS	L	T	P	C
		3	1	0	4

Preamble:

The course consists of topics in Matrices, Differential calculus, Integral calculus, Differential Equations and Vector calculus with applications to various engineering problems. This course will cover the following main topics: Cayley Hamilton Theorem, Linear differential equations of second order with constant coefficients, Methods of Variation parameter, Taylor's expansion of two variables, Maxima and Minima for two variables, Area and Volume in a multiple integrals, Green's theorem and Gauss divergence theorem.

Prerequisites for the course:

Students should have basic knowledge about matrices, differentiation and integration

Objectives

1. To apply advanced matrix knowledge to Engineering problems
2. To familiarize with the applications of differential equations.
3. To familiarize with the functions of several variables
4. To have Knowledge in Multiple integrals
5. To improve their ability in Vector calculus.

UNIT I	MATRICES	9+3

Matrices - Characteristic equation – Eigen values and Eigen vectors of a symmetric and non symmetric matrix – Properties of Eigen values and Eigen vector – Cayley – Hamilton theorem and its applications

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Eigen values , Eigen Vectors and Cayley Hamilton Theorem and Add MATLAB and for application Add Power method to find Eigen value & Eigen vector

UNIT II	ORDINARY DIFFERENTIAL EQUATIONS	9+3

Differential Equations – Complementary Function – Particular Integral - Linear equations of second order with constant coefficients of types exponential, trigonometry, polynomial and its combination forms - Methods of Variation of parameter - Engineering Applications.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Linear differential equations of different types and Method of Variation parameters.

UNIT III	FUNCTIONS OF SEVERAL VARIABLES	9+3

Function of two variables – Partial derivatives – Taylor's expansion for two variables – Maxima and Minima for two variables – Jacobians of two and three variables – Euler's theorem for homogeneous function.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Taylor's series, Jacobians, Maxima and Minima for two variables

UNIT IV	MULTIPLE INTEGRALS	9+3

Definite Integrals – Properties of definite integrals - Double integration in Cartesian coordinates – Area as a double integral in Cartesian coordinates – Triple integration in Cartesian coordinates – Volume as a Triple Integral

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Area , Triple integration and Volume

UNIT V	VECTOR CALCULUS	9+3

Vector dot product and Vector cross product - Gradient, divergence, curl – Solenoidal and irrotational fields –Unit normal vector - Angle between two surfaces - Directional derivatives – Green's theorem, Gauss divergence theorem (without proof) – Engineering Applications.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Angle between two surfaces, Green's theorem, Gauss divergence theorem.

Total Periods	**45 + 15 = 60 Periods**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
1. Descriptive Questions	1.Assignment 2. Online Quizzes	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Find the eigen values, eigen vectors, inverse and the positive powers of a square matrix (Apply)

CO2: Identify the suitable method to solve second and higher order differential equations (Apply)

CO3: Find the maxima and minima for a given function with several variables, through by finding stationary points (Apply)

CO4: Compute area and volume using double and triple integration. (Apply)

CO5: Apply the concepts of Differentiation and Integration to Vectors. (Apply)

Text Books

1. B. S. Grewal, " Higher Engineering Mathematics", 43rd edition, 2017.
2. James Stewart, Calculus – Early Transcendals, 8th Edition, 2016.

Reference Books

1. A Textbook of Engineering Mathematics(Dr. A.P.J. Abdul Kalam Technical University, Lucknow) (For . Gautam Bhudh technical Universities ,Lucknow) January 2020
2. K. Ganesan, Sundarammal Kesavan, K. S. Ganapathy Subramanian & V. Srinivasan, "Calculus and Solid Geometry", Revised Edition, 2017

Web Resources

1. https://youtu.be/hbk01uhgsos
2. https://archive.nptel.ac.in/content/storage2/111/105/111105122/MP4/mod01lec01.mp4
3. Eigen values and eigen vectors - https://youtu.be/h5urBuE4Xh
   Cayley Hamilton theorem -https://youtu.be/WROFJ15hk00
4. ODE - https://youtu.be/Im242eBqaxw
5. Functions of several variables -https://youtu.be/PA82F91e1vs
6. Integration - https://youtu.be/bVui07yHjzE,
   Multiple integrals -https://youtu.be/3BbrC9JcjOU
   Volume as Triple integral - https://youtu.be/w_KiHgultbM
7. Vector calculus - https://youtu.be/v3ZC4Mo1fS0i
   Gauss divergence theorem https://youtu.be/U9LDcmKUGS0

CO Vs PO Mapping and CO Vs PSO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
1	3	2	1	1	1			1	1			1			
2	3	2	1	1				1	1			1			
3	3	2	1	1				1	1			1			
4	3	2	1	1				1	1			1			
5	3	2	1	1				1	1			1			

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 (CO 1) : (Apply)

1) Compute the eigen values and eigen vectors for the Symmetric matrix A = $\begin{bmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{bmatrix}$

2) Find A^{-1} and A^4 using Cayley Hamilton Theorem for the matrix A= $\begin{bmatrix} 1 & -1 & 4 \\ 3 & 2 & -1 \\ 2 & 1 & -1 \end{bmatrix}$.

COURSE OUTCOME 2 (CO 2) : (Apply)

1) Solve $(D^2 - D + 1)y = \sin sin\, 2x + e^{-4x}$

2) Solve $(D^2 +)^2 y = \tan tan\, ax$ by using method of variation of parameters.

COURSE OUTCOME 3(CO 3) : (Apply)

1. Find the extreme values of the function $(x, y)= x^3 + y^3 - 12x - 3y + 20$.

2. Calculate the maxima and minima of the function $(x, y) = x\ y^3\ ^2$ (1-x-y).

COURSE OUTCOME 4(CO 4) : (Apply)

1)Find the area of the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

2) Find $\int_0^a \int_0^b \int_0^c xyz\, dz\, dy\, dx$

COURSE OUTCOME 5(CO 5) : (Apply)

1. Find the directional derivative of $\emptyset = xy^2 + yz^3$ at the point (2,-1,1) in the direction of $\vec{i} + 2\vec{j} + 2\vec{k}$.

2. Using Green's theorem , find $\int_c (x^2 - y^2)dx + 2xydy$ where C is the boundary of the rectangle in the XOY-plane bounded by the lines $x = 0, x = a, y = 0, y = b$.

3. Verify Gauss divergence theorem for $\vec{F} = 4xz\vec{i} - y^2\vec{j} + yz\vec{k}$ over the cube bounded by $x = 0, x = 1, y = 0, y = 1, z = 0$ and $z = 1$.

Prepared by,
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Verified by,
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Asso.Prof/Maths

21PH1302	ENGINEERING PHYSICS (COMMON TO CIVIL & MECH)	L	T	P	C
		3	0	0	3

Preamble

This course aims in imparting the fundamental connection of physics and engineering with machines and materials by incorporating the basic concepts & principles of physics to encompass the application in engineering.

Prerequisites for the course

Students should have Basic theoretical concepts of Physics in XI and XII

Objectives

1. To enable the students to gain knowledge on properties of matter.
2. To inculcate knowledge on heat transfer.
3. To study the basics of acoustics and ultrasonics.
4. To understand the crystal parameters and to classify the type of the defect present in the crystal.
5. To explore the wide advancement in engineering materials by motivating the applications of quantum mechanics.

UNIT I	PROPERTIES OF MATTER	9

Elasticity - Poisson's ratio and relationship between moduli (qualitative) - Stress-strain diagram - Factors affecting elasticity - Torsion pendulum -Determination of rigidity modulus- Moment of inertia of a body (regular)- Bending of beams - Bending moment - Cantilever - Theory and experiment of Young's modulus determination - Uniform and non-uniform bending - I shaped girders.

UNIT II	THERMAL PHYSICS	9

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints – bimetallic strips – thermal conduction, convection and radiation – heat conductions in solids – thermal conductivity – Lee's disc method: theory and experiment – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

UNIT III	ACOUSTICS AND ULTRASONICS	9

Classification of Sound- decibel- Weber–Fechner law –Absorption Coefficient and its determination-Sound absorbing materials –factors affecting acoustics of buildings and their remedies. Production of ultrasonics by magnetostriction and piezoelectric methods - Engineering applications of Ultrasonics -Non-destructive testing- Pulse echo technique.

UNIT IV	SOLID STATE PHYSICS	9

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, coordination number and packing factor for SC, BCC, FCC, HCP – Crystal imperfections: point defects, line defects – Burger vectors. Applications: Powder X-ray diffraction

UNIT V	ADVANCED ENGINEERING MATERIALS	9

Metallic glasses: Types, Glass forming ability of alloys, melt spinning process and applications.

Shape memory alloys (SMA): Phase, shape memory effect, pseudo elastic effect NiTi alloy, application, Nanomaterials: Preparation (bottom up and top down approaches) -Pulsed Laser Method- Ball Milling Method – properties and applications.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 Marks CAT 2 – 10 Marks Descriptive Questions	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	Descriptive

Outcomes	
Upon completion of the course, the students will be able to:	
CO1	Recognize the concept of elasticity, stress, strain and bending moments as well as Uniform and non-uniform bending in beams. (Understand)
CO2	Apply the thermal applications to various home appliances. (Apply)
CO3	Understand the characteristics of Music and Noise, Noise pollution and its control using the basic concepts of acoustics and know the principle and properties of ultrasonics using different testing methods. (Understand)
CO 4	Demonstrate an understanding of several key areas of Crystal Physics. (Understand)
CO 5	Identify different types of material processing techniques for advanced materials. (Understand)

Text Books

1. Bhattacharya, D.K. & Poonam, T. "Engineering Physics". Oxford University Press, 2015.
2. Rajendran V, "Engineering Physics". Tata Mc-Graw Hill publishing company limited, New Delhi, Revised Edition 2018

Reference Books

1. Pandey, B.K. & Chaturvedi, S. —Engineering Physics.Cengage Learning India2018.
2. Raghavan, V. "Materials Science and Engineering: A First course". PHI Learning, 2015.
3. Sankar, B.N., Pillai.S.O., Engineering Physics I, New Age International (P) Ltd., 2015
4. D. Halliday, R. Resnick and J. Walker. Principles of Physics, Wiley (Indian Edition), 2015.
5. Guozhong Cao, Nanostructures and Nanomaterials, Imperial College Press, 2004.
6. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, McGraw-Hill (Indian Edition), 2017.

Web Resources

1. https://archive.nptel.ac.in/courses/122/107/122107035/
2. https://archive.nptel.ac.in/courses/115/105/115105099/
3. Unit I,II,IV -https://www.brainkart.com/subject/Engineering-Physics_263/
4. Unit III- https://www.tce.edu/sites/default/files/PDF/RV3-ACOUSTICS-ULTRASONICS.pdf
5. UnitV-https://www.brainkart.com/article/Advanced-Engineering-Materials-Metallic-Glasses_6815/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	3	2	1				1	1				1		
2	3	2	1				1	1				1		
3	3	2	1				1	1				1		
4	3	2					1	1				1		
5	3	2					1	1				1		

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Recognize the concept of elasticity, stress, strain and bending moments as well as Uniform and non-uniform bending in beams. (Understand)

1.A Scale is under depression at the free end of a cantilever due to load. Describe an experiment to determine the young's modulus of the cantilever using this expression.

2.Give the theory of torsion pendulum and describe a method to find the moment of inertia of an irregular body.

3.How will you determine the young's modulus of material of a bar by non-uniform Bending method? Explain briefly the theory behind the determination of young's modulus.

COURSE OUTCOME 2: Apply the thermal applications to various home appliances. (Apply)

1. Can heat exchange through a medium, explain their detailed overview depending on the medium. .
2. Imagine a quantity of heat flowing through a metal slab whose faces are kept at two different temperatures. Determine the thermal conductivity of a bad conductor.
3. The total area of a glass window pane is 0.8 m^2. Calculate how much heat is conducted per hour through the glass window pane if the thickness of glass is 3 mm. The temperature of the inside surface is 25 °C and outside surface is 4 °C. The thermal conductivity of glass is 1.1 Wm-1K-1

COURSE OUTCOME 3: Understand the characteristics of Music and Noise, Noise pollution and its control using the basic concepts of acoustics and know the principle and properties of ultrasonics using different testing methods. (Understand)

1. With the help of a neat sketch the construction and production of ultrasonic waves using piezoelectric oscillator.
2. Explain the process of non–destructive testing of materials using ultrasonic waves by pulse echo overlap method.
3. Exemplify the increase in the acoustic intensity level when the sound intensity is doubled

COURSE OUTCOME 4: Demonstrate an understanding of several key areas of crystal physics (Understand)

1. Estimate the atomic packing factor for SC, BCC & FCC structures.
2. Classify the types of the defects present in the crystal.

COURSE OUTCOME 5: Identify different types of material processing techniques for advanced materials. **(Understand)**

1. Explain the preparation, types, properties and application of metallic glasses.
2. Describe the properties and applications of shape memory alloys.
3. Discuss briefly about the working of pulsed laser method used for nanoparticle deposition

21CY1401	ENGINEERING CHEMISTRY	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Basic theoretical concepts of Chemistry in higher secondary level.

Preamble

To enable the students to acquire knowledge in the concepts of chemistry for engineering applications and to familiarize the students with different application-oriented topics like electrochemistry, corrosion prevention methods, significance of alloys, benefits of renewable energy sources, engineering materials, desalination etc., which enable them to develop abilities and skills that are relevant to the study and practice of engineering chemistry.

Objectives

1. To equip the students in conversant with boiler feed water requirements, related problems and water treatment techniques.
2. To make the students familiar with the principles of electrochemistry and corrosion.
3. To develop an understanding of the basic concepts of phase rule and its applications to single and two component systems and appreciate the purpose and significance of alloys.
4. To have a thorough understanding on the principles and generation of energy in batteries, nuclear reactors, solar cells, wind mills and fuel cells.
5. To make the students learn the basics of polymer chemistry and mechanism of lubrication.

UNIT I	WATER AND ITS TREATMENT	9

Hardness of water – types – expression of hardness – units – estimation of hardness of water by EDTA – numerical problems – boiler troubles (scale and sludge) – treatment of boiler feed water – Internal treatment (phosphate and calgon conditioning) external treatment – Ion exchange process- desalination of brackish water - Reverse Osmosis.

UNIT II	ELECTROCHEMISTRY AND CORROSION	9

Electrodes- types, Cells- types, Construction (Daniel cell) - Electrode potential- Photo electrochemical cell-working and applications – Nernst equation and its applications- Emf series & its applications.

Corrosion- Causes- Types- Chemical, Electrochemical corrosion (galvanic, differential aeration), Corrosion control – Material selection and design aspects – Electrochemical protection – Sacrificial Anode cathodic Protection method.

UNIT III	PHASE RULE AND ALLOYS	9

Phase rule: Introduction, definition of terms with examples, one component system -water system - reduced phase rule - thermal analysis and cooling curves - two component systems - lead-silver system – Pattinson's process.

Alloys: Introduction- Definition- properties of alloys- significance of alloying, functions and effect of alloying elements- Nichrome and stainless steel (18/8) – heat treatment of steel.

UNIT IV	ENERGY SOURCES AND STORAGE DEVICES	9

Nuclear fission - Nuclear fusion - Differences between nuclear fission and fusion - Nuclear chain reactions - Nuclear energy - Light Water Nuclear Power Plant - Solar energy conversion - Solar cells - Wind energy.

Batteries & Fuel cells: Types of batteries – Primary battery (dry cell) Secondary battery (lead acid battery) Lithium ion battery – Electric Vehicles – working principles, Fuel cells – H_2-O_2 fuel cell and microbial fuel cell; Supercapacitors: Storage principle, types and examples.

UNIT V	ENGINEERING MATERIALS	9

Polymers: Classification of Polymers – Preparation, properties and uses of Teflon and Nylon 6,6- Benefits and Applications. Composites: Introduction: Definition & Need for composites; Properties and applications of Polymer matrix composites and hybrid composites.

Nanomaterials: Types of nanomaterials; properties and uses of nanoparticle, nanocluster, nano rod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, chemical vapour deposition and electrochemical deposition methods. Applications of nanomaterials in medicine, agriculture, energy and electronics.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
Descriptive Type CAT 1 10 Marks CAT 2 10 Marks	1. Assignment 2. MCQs	1.Descriptive Type Questions

Outcomes

Upon completion of the course, the students will be able to:

CO.1: Infer the quality of water parameters from quality parameter data and propose suitable methodologies to treat water. (Remember).

CO2: Identify and apply the basic principles of electrochemistry and corrosionC103.3:

CO3: Identify suitable alloys for material analysis.

CO4: Identify different forms of energy resources and apply them in suitable energy sectors.C103.5:

CO5: Recognize and apply basic knowledge on polymers and nanomaterials to futuristic materials fabrication needs

Text Books

1. P. C. Jain and Monika Jain, "Engineering Chemistry" DhanpatRai Publishing Company (P) LTD, New Delhi, 2018

Reference Books

1. Friedrich Emich, "Engineering Chemistry", Scientific International PVT, LTD, New Delhi, 2014.
2. PrasantaRath, "Engineering Chemistry", Cengage Learning India PVT, LTD, Delhi, 2015.
3. B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday, "Text book of nanoscience and nanotechnology", Universities Press-IIM Series in Metallurgy and Materials Science, 2018.
4. ShikhaAgarwal, "Engineering Chemistry-Fundamentals and Applications", Cambridge University Press, Delhi, Second Edition, 2019.
5. O.V. Roussak and H.D. Gesser, Applied Chemistry-A Text Book for Engineers and Technologists, Springer Science Business Media, New York, 2nd Edition, 2013.
6. S. S. Dara and S. S. Umare, "A Textbook of Engineering Chemistry", S. Chand & Company LTD, New Delhi, 2018.

Web Resources

1. NPTEL Course https://www.digimat.in/nptel/courses/video/121106014/L01.html
2. Mod-06 Lec-36 Fundamentals of Electrochemical Techniques https://www.youtube.com/watch?v=l2ENx_Y0dNU
3. Heat treatment of steel https://www.youtube.com/watch?v=3IQz9LAPuIA
4. Renewable energy resources https://youtu.be/mh51mAUexK4
5. Nanomaterials https://youtu.be/qUEbxTkPIWI

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1		1	1					1		
CO2	3	2	2	1		1	1					1		
CO3	3	1	1	1		1	1					1		
CO4	3	2	2	1		1	1					1		
CO5	3	2	2	1		1	1					1		

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to infer the quality of water parameters from quality parameter data and propose suitable methodologies to treat water. **(Understand)**

1. How is the exhausted resin regenerated in an ion exchanger?
2. Suggest your valuable ideas to protect the boiler from corrosion.

COURSE OUTCOME 2: Students will be able to identify and apply the basic principles of electrochemistry, corrosion and corrosion control. **(Apply)**

1. Compare the mechanisms involved in electrochemical cells and electrolytic cells.
2. How corrosion is prevented by sacrificial anode cathodic protection methods.

COURSE OUTCOME 3: Students will be able to apply the knowledge of phase rule and alloys for material analysis. (Apply)

1. Illustrate phase, component and degree of freedom with example
2. Will stainless steel rust? Justify.

COURSE OUTCOME 4: Students will be able to recognise different forms of energy resources and apply them in suitable energy sectors. . **(Apply)**

1. Is it safe to utilize wind energy for domestic purposes? How are commercial wind farms developed and how can I get a wind farm on my property?
2. Critically analyze nuclear power technology in terms of environmental and health safety. Draw a general layout of the Light water nuclear reactor and explain its components.

COURSE OUTCOME 5: Students will be able to identify and apply basic concepts of polymer science, composites and nanotechnology in designing the synthesis of materials for engineering and technology applications. (Apply)

1. What do you feel the repercussions are for extended life through utilization of nanotechnology?
2. Give an account of the preparation properties and uses of Teflon and nylon 6,6.
   d nylon 6,6.

21CS1514	C Programming (Common for MECH & CIVIL)	L	T	P	C
		2	0	2	3

Preamble

This course is intended for the students to learn the basic concepts of C programming to enhance the programming knowledge of students. C programming provides the basis for many new programming languages. The lab experiments will provide practical exposure because C programming is the basic language of choice for hardware interfaces, real time robotic control and to develop and test prototypes in the field of engineering.

Prerequisites for the course

- NIL

Objectives

1. To develop a basic programs using conditional statements.
2. To develop the problem solving ability in using iterations and arrays
3. To solve the complex problems using strings, functions and pointers.
4. To develop programs for storing different data using structures and union
5. To learn the concept of files and to perform read and write operations

UNIT I	BASICS OF C & CONDITIONAL STATEMENTS	6

Structure of a C program – Compiling and executing C programs - Character Sets in C- Keywords- Identifiers- **Tokens:** Constants, Variables – Data types**-** Operators and Expressions – Managing Input and Output Operations – **Branching statements:** if – if else – nested if - else if ladder – switch case- break, continue, go-to statement.

SUGGESTED ACTIVITIES

- Demonstrate the use of data types and operators

SUGGESTED EVALUATION METHODS

- Quiz on the basics of C programming
- Write programs using types of branching statements

UNIT II	LOOPS AND ARRAYS	6

Looping statements: Entry controlled loops – for loop - while loop– exit controlled loops – do while loop-Nested loops - **Arrays:** Declaration- Initialization- One Dimensional Array- Two DimensionalArray and Multidimensional Arrays.

SUGGESTED ACTIVITIES

- Demonstrate the types of looping statements
- Demonstrate the types of arrays

SUGGESTED EVALUATION METHODS		
• Quiz on the basics of loops and arrays • Write programs using loops in one, two and multidimensional arrays		
UNIT III	**STRINGS, FUNCTIONS AND POINTERS**	**6**
Strings: Declaration, Initialization - String Operations – **Functions:** Declaration, Definition, Function Call – Call by Value, Call by Reference - Parameter passing methods, Recursion **Pointers:** Declaration- Definition- Pointers and Functions – Dynamic Memory Allocation.		
SUGGESTED ACTIVITIES		
• Discussion on functions about Call by Value, Call by Reference and recursion examples • Demonstrate the use of strings and dynamic memory allocation using pointers		
SUGGESTED EVALUATION METHODS		
• Quiz on the basics of strings, functions and pointers • Write programs using functions by incorporating strings and pointers in functions		
UNIT IV	**STRUCTURES AND UNION**	**6**
Structure: Definition – need – general form - Nested structures – Pointer and Structures – Array of structures– Self-referential Structures - **Unions**: Definition – need – general form –Programs using structures and unions.		
SUGGESTED ACTIVITIES		
• Discussion on nested structures and self-referential structures using examples • Demonstrate the difference between structures and unions		
SUGGESTED EVALUATION METHODS		
• Quiz on the basics of structures and unions • Write programs using pointers in structures and unions		
UNIT V	**FILE PROCESSING**	**6**
Introduction to files – **Types of files:** Text, Binary – File Operations – Functions – **Types of File Processing:** Sequential access, Random access – Sequential access files – Random access files.		
SUGGESTED ACTIVITIES		
• Discussion on the need for file processing and access • Demonstrate the difference between sequential access files and random access files		
SUGGESTED EVALUATION METHODS		
• Quiz on the basics of files • Write programs using modes of file operations		
	Total Periods	**30 Theory +30 Lab**

Laboratory Requirements

- 60 Systems with windows / LINUX operating system with C Software or equivalent.

Suggestive Assessment

Continuous Assessment Test (30 Marks)	Lab Components Assessments (20 Marks)	End Semester Exams (50 Marks)
1. DESCRIPTIVE QUESTIONS 2. PROGRAMMING QUESTIONS	1. LAB EXPERIMENTS 2. MODEL EXAMINATION	

Outcomes

Upon completion of the course, the students will be able to:

CO1: To develop the basic problem solving logics using conditional statements.
CO2: To demonstrate the use of iterations and to apply the basic concepts of arrays.
CO3: To make use of the strings, functions and pointers to solve the complex problems.
CO4: To implement the structure and union concepts with pointers.
CO5: To handle the files and to access the data from the files to implement real time projects.

Text Books

1. ReemaThareja, "Programming in C", Oxford University Press, Second edition, 2016

Reference Books

1. Byron Gottfried "Programming With C" Fourth Edition, McGrawHill, 2018.

Web Resources

1. C Programming Fundamentals - https://nptel.ac.in/courses/106105171/
2. https://w
3. https://w
4. https://w
5. https://w
6. https://w
7. https://w

List of experiments

S.NO	NAME OF EXPERIMENTS	CO
1	Programs using simple statements a) Write a program to calculate the slope of a line. b) Write a program to convert polar coordinates to Cartesian coordinates	CO1

2	Programs using decision making statements a) Design a calculator to perform the arithmetic operations. b) A weather forecasting agency would like to intimate the people about the current temperature with the properclimatic message. Develop a C program to read temperature in centigrade and display a suitable message according to temperature state below : Temp < 0 then Freezing weather Temp 0-10 then Very Cold weather Temp 10-20 then Cold weather Temp 20-30 then Normal in Temp Temp 30-40 then Its Hot Temp >=40 then Its Very Hot	CO1
3	Programs using looping statements a) A supermarket manager wishes to keep some toys and puzzle games to enable the customers to manage theirkids during the purchase time. He kept a machine called "Fortune Teller machine", it replies the kid with some fortune message if he enters the palindrome number. It replies with "try again later" if the kid failed to input a valid palindrome number. Write a C program to help the manager to run the "Fortune Teller Machine" perfectly. b) Write a C program to find the factorial of a number using all types of loops	CO2
4	Programs using one dimensional and two dimensional arrays a) Given below is the list of marks obtained by a class of 20students in an annual examination. 43 65 7 24 87 90 19 39 58 75 67 87 90 92 14 78 82 99 56 89 Write a program to count the number of students belonging to each of following groups of marks: 0- 9,10-19,upto… ,100. b) Write a C program to input a set of integer numbers, count and sum the positive numbers and the negative numbers then print the count and sum of all positive numbers and negative numbers.	CO2
5	Programs using string operations a) Write a C program to find if the given string is palindrome or not b) Write a C program to reverse the given string	CO3
6	Programs using user defined functions and recursive functions a) From a given paragraph perform the following using built-infunctions: 1. Find the total number of words. 2. Capitalize the first word of each sentence. 3. Replace a given word with another word. b) Sort the list of numbers using pass by reference.	CO3
7	Programs using functions and pointers a) Write a program in C to store n elements in an array and print the elements using pointer. b) Write a program in C to find the factorial of a given number using pointers	CO3
8	Programs using structures and pointers a) Write a C program to calculate the salary of employees in an organization using the concept of structures with and without the usage of pointers	CO4

9	Programs using structures and unions a) Write a C program to display the memory allocation of multiple data types using structure and union	CO4
10	Programs using file concepts a) Write a program to create a file and store 20 names in it. Write a program to read the names in the file. b) Write a program to add five new names in the existing list by appending the names in the existing file.	CO5

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
1	3	3	3										3		
2	3	3	3										3		
3	3	3	3										3		
4	3	3	3										3		
5	3	3	3										3		

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	Lab Components	Model Exam	END SEM EXAM
REMEMBER	15	15			20
UNDERSTAND	15	15			30
APPLY	60	60	100	100	50
ANALYZE					
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1:

1. Write a program to round off an integer 'i' to the next largest multiple of another integer 'j'. Example: 256 days when rounded off next largest multiple divisible by a week resulted into 259.
2. Suppose a, b and c are integer variables that have been assigned the values a=8, b=3, and c=-5. Determine the value of each of the following arithmetic expressions in C program.

   (i) a+b+c
   (ii) 2*b+3*(a-c)

   (iii) a/b

   (iv) a%b

   (v) a*(b/c)

COURSE OUTCOME 2:

1. Write a C program to reverse a number using while, do while and for loop
2. Write a C program to get the two matrices as a run time input and perform addition operation and display the resultant matrix as the output. Let the Matrix A = $\begin{bmatrix} 2 & 4 \\ 3 & 1 \end{bmatrix}$ and

   Matrix B = $\begin{bmatrix} 3 & 2 \\ 1 & 4 \end{bmatrix}$

COURSE OUTCOME 3:

1. Write a C program to sort an array of numbers using function pointers.

2. Write a C program to find factorial of a number using call by value and call by reference methods

COURSE OUTCOME 4:

1. Write a C program to store employee information and search a particular employee using employee number.
2. Write a C program to get a student data with name, id and percentage and display it using pointers.

COURSE OUTCOME 5:

1. Write a C program to read from the num.dat file and find the average of the numbers using random access.
2. Write a C program to simulate and maintain the bank's account information such as authentication and authorization of inserted card, and performing the functions of cash withdrawal, cash deposit, and account's balance enquiry. Implement the scenario using random access file.

21HS1101	ENGLISH FOR PROFESSIONAL COMMUNICATION	L	T	P	C
		2	0	2	3

Preamble

This course is offered to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

Prerequisites for the course

The prerequisite knowledge required to study this Course is the basic knowledge in English Language.

Objectives

1. To develop listening skills, and enhance the ability of comprehending.
2. To communicate confidently in varied real life situations.
3. To widen the basic reading skills of the first year Engineering and Technology students.
4. To master vocabulary, sentence structure and to write articles.
5. To create emotional awareness.

Module I	SHARING BASIC INFORMATION	12

Listening - Listening to basic technical concepts, short formal and informal conversations; Speaking- Formal Self-Introduction – Etiquette – Phrases to be used highlighting the characteristics, strengths and weaknesses - Conversation Practice; Reading - short comprehension passages on fundamental concepts, principles, and ideas that helps to understand the need of Technology in a rapidly changing global environment; Writing - restructuring sentences from the jumbled words – creating coherence; Language development - Framing Yes/No questions, Question tag, Vocabulary development - formation of words– verb – Noun – Adjectives, Standard Abbreviations related to Engineering.

Suggested Activities	Evaluation Method
i) Listening to Conversations/ technical concepts from suggested app/prescribed modules - Submission of 5 Recorded Conversations.	i) Listening & Speaking: Submitted Conversation will be assessed for a) Language style as that of the sample audio. b) Pronunciation c) Intonation
ii) Introducing oneself to the audience in a professional way - Video Recording to be submitted.	ii) Introduction: Submitted Video Recording will be assessed for a) Communication Etiquette b) Language Style c) Sentence Construction
iii) Reading 3 Passages on Technology and answering questions through Google forms.	
iv) Rearranging Jumbled words - Exercises	
v) Teaching of Grammar Contents	Activities iii to v will be assessed through Google form tests/ written tests.

Module II	SHARING TECHNICAL INFORMATION	12

Listening - Listening to technical lectures by native speakers; Speaking - introducing a device/gadget to the audience – giving importance to its specifications, descriptions, merits and demerits; Reading - extensive reading – short narratives and news items from newspapers related to technology; Writing - sentence structure – short passages / reviews on any gadget – describing an electronic/ mechanical gadget, importance of punctuation, organizing paragraphs; Language development - framing 'Wh' Questions, writing a complete sentence using the fragments given; Vocabulary development- prefix and suffix.

Suggested Activities	Evaluation Method
i) Listening to Technical Lectures - Suggested Youtube channels a) Learn Engineering b) Jared Owen c) Interesting Engineering d) Practical Engineering	i) Listening skills will be tested through a) MCQs - Google Forms - 3 Sets b) Quiz - Polling - 2 set
ii) Speaking / Submitting video recording / classroom presentation about an electronic/electrical/ a mechanical gadget giving importance to its specifications, descriptions, merits and demerits.	ii)Speaking: Submitted Video Recording/Presentation during class hours will be assessed for a) Language Style & Fluency b) Creation of Google Slides / Canva Slides c) Content delivery
iii) Reading articles from Newspaper/ Google News / Times Now / and other Tech News Sites iv) Writing reviews of a product v) Teaching of Grammar Contents	Activities iii to v will be assessed through Google form tests/ written tests.

Module III	**UNDERSTANDING TECHNOLOGY**	**12**

Listening - listening to technical talks on emerging trends and filling in the blanks – cloze test; Speaking - asking for opinions about technical gadgets – presentation of reviews on electronic/electrical/mechanical/software products; Reading - Reading Comprehension – technical passages – Articles from journals; Writing - rearranging jumbled sentences, writing short essays; Language development - Direct Speech and Indirect Speech – Framing Indirect – Questions - Prepositions – Articles; Vocabulary development – Select Single Word Substitutes used in Engineering.

Suggested Activities	Evaluation Method
i) Listening to Technical talks on emerging trends - Suggested YouTube channels a) Bernard Marr b) Concerning Reality c) Ideas and Inspiration	i) Listening skills will be tested through a) Cloze Test - 2 Sets
ii) Speaking / Submitting video recording / classroom presentation on giving reviews about a product.	ii)Speaking: Submitted Video Recording/Classroom presentation will be

iii) Reading articles -Extracts from reputed journals. iv) Writing essays and rearranging Jumbled Sentences. v) Teaching of Grammar Contents	assessed for a) Inquisitiveness b) Analytical skills c) Presentation Skills Activities iii to v will be assessed through Google form tests/ written tests.

Module IV	**STATING PROBLEMS AND EXPRESSING SOLUTIONS**	**12**

Listening- listening to talks relating to technology and noting down the merits and demerits; Speaking - stating a problem and expressing solutions giving more focus on pronunciation of words and sentence structure; Reading - comprehending Articles from Magazines – Identify the problem statement and note down solution statements; Writing - Identifying problems – Writing problem statement, Analyzing the situation – Gathering information related to the problem stated – Identifying solution criteria – Choosing the best solution – Implementing a solution – writing solution content - Measuring solution success – Report preparation – White paper writing – Release/launch notes; Language development- Tenses; Vocabulary development- Synonyms, Antonyms, Phrasal Verbs.

Suggested Activities	Evaluation Method
i) Listening to talks related to Technology - Suggested YouTube channels a) Auto Car India b) Lesics c) Student Energy ii) Speaking / Submitting video recording / Classroom presentation on Technical issues faced in a gadget and expressing suitable solutions. iii) Reading articles -Extracts from reputed journals and identify problem statements and solution statements. iv) Writing - Identifying problems – Writing problem statement, Analyzing the situation – Gathering information related to the problem stated – Identifying solution criteria – Choosing the best solution – Implementing a solution – writing solution content - Measuring solution success – Report preparation – White paper writing – Release/launch notes v) Teaching of Grammar Contents	i) Listening skills will be tested through a) Note making - 2 Sets ii)Speaking: Submitted Video Recording / Classroom Presentation will be assessed for a) Expression of Innovative Ideas and Solution b) Sentence Structure Activities iii to v will be assessed through Google form tests/ written tests/ written exercises.

Module V	**EMOTIONAL AWARENESS AND MANAGEMENT**	**12**
Listening - Listening Types - Appreciative listening – Critical Listening – Relationship Listening; Speaking - presentation on the importance of Emotional Intelligence; Reading- Reading Articles on High Level Cognition - Cognitive Control – Decision Making – Social Behaviour – Emotion – Language and Consciousness; Writing - Articulate emotions using the right language - Balance optimism and pessimism to effectively impact others; Language development - modal verbs; Vocabulary Development - Fixed and Semi-Fixed Expressions.		

Suggested Activities	Evaluation Method
i) Watching videos on types of Listening	i) Listening skills will be tested through a) Google form test- 2 Sets
ii) Presentation on Emotional Intelligence	ii) Speaking: Submitted Video Recording / Classroom Presentation will be assessed for a) Emotional awareness b) Communication Skills
iii) Reading Articles on High Level Cognition	
iv) Writing - Articulate emotions using the right language - Balance optimism and pessimism to effectively impact others	Activities iii to v will be assessed through Google form tests/ written tests/ written exercises.
v) Teaching of Grammar Contents	

S.No	**List of Exercises**	**CO**
1.	Conversation Recording using the suggested app	CO 1
2.	Self Introduction Video	CO 1
3.	Listening Test - Google Form	CO 2
4.	Presentation on the working principle of a gadget	CO 2
5.	Listening - Cloze Test	CO 3
6.	Reviewing a Product - Video Submission	CO 3
7.	Listening and Note Making	CO 4
8.	Talk on technical issues in a gadget and express suitable solutions.	CO 4
9.	Types of Listening - Google Form	CO 5
10.	Presentation on Emotional Intelligence	CO 5
Total Periods		30 Theory +30 Lab

Laboratory Requirements for a batch of 60 Students

Software: Globarena

1. Teacher console and 30 systems for students.
2. English Language Lab Software
3. Career Lab Software

Suggestive Assessment Methods:

1) Listening and answering questions - MCQ - Cloze Test - Note Making
2) Speaking - App/Software based testing
3) Reading - analyze the passage given - understand the concept and answer Questions - On-line Based
4) Written Tests

Continuous Assessment Test (20 Marks)	**Lab Components Assessments (30 Marks)**	**End Semester Exams (50 Marks)**
Written Examination	Completion of Suggested Exercises	Written Examination

Outcomes

Upon completion of the course, the students will be able to:

CO 1	Enumerate basic information using communication etiquette on par with international communication standards. (Apply)
CO 2	Interpret fundamental technical concepts in English language giving importance to syntax. (Apply)
CO 3	Evaluate advanced varied technical concepts in the current scenario and emerging trends to invent new concepts. (Apply)
CO 4	Write solutions for problems identified using the exact vocabulary and structure without grammatical errors as expected by the corporate world. (Apply)
CO 5	Manage and respond to self, others' emotions using skills of Self Awareness, Self Management, Self- Motivation, Empathy & Social Relations to be an Emotionally Intelligent Human Being. (Apply)

Text Books

1. Butterfield, Jeff. Soft Skills for Every one. Cengage Learning: New Delhi,2017.
2. Sudharshana.N.P and Saveetha. C. English for Technical Communication. Cambridge University Press: New Delhi, 2016.

Reference Books

1. Kumar, Suresh. E. Engineering English. Orient Blackswan: Hyderabad,2015
2. Means, L. Thomas and Elaine Langlois, English & Communication For Colleges.

Web Resources

1. Self Introduction: https://youtu.be/Osa53-RYBk4
2. Working Principle of a Gadget: https://www.youtube.com/channel/UC6qf8AGvAGixZXWdxapvCqw
3. Product Review: https://youtu.be/ByhA05x7CWI
4. Times of India: https://timesofindia.indiatimes.com/home/headlines
5. Listening to Technical talks:
   Auto Car India https://m.youtube.com/user/autocarindia1
   Lesics :https://www.youtube.com/channel/UCqZQJ4600a9wIfMPbYc60OQ Student Energy https://www.youtube.com/user/studentenergy?app=desktop
6. Types of Listening https://www.youtube.com/watch?v=22gzvSindTU&t=1s

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1				2				2	1	3	2	2			
2	1	1		1				1	2	3	2	2			
3	1	1		1			2	1		2	2	2			
4	1	1		1				2		2	2	2			
5						1	1	2	2	3		2			

SUGGESTED COURSE LEVEL ASSESSMENT QUESTIONS:

COURSE OUTCOME 1 (CO 1) : Enumerate basic information using communication etiquette on par with international communication standards.

1) Listen to the talk on basic technical topics and answer the questions provided.
2) Introduce yourself in a professional way highlighting Characteristics, Strengths & Weaknesses.
3) Read the given technical passage and answer the questions provided.
4) Frame Yes/No Questions for the statements given.
5) Frame Question tags for the statements given.
6) Rearrange the jumbled words into a meaningful sentence.
7) Complete the sentence with the Noun form/ Verb Form/ Adjective form (as Directed) of the word given.
8) Give the expansion of the Abbreviations given.

COURSE OUTCOME 2 (CO 2) : Interpret fundamental technical concepts in English language giving importance to syntax.

1) Listen to the technical lecture and answer the questions provided.
2) Introduce a device or a gadget to the class giving importance to its specifications, description, merits and demerits.
3) Read the given passage / short narrative / article from a journal or newspaper to the class.

4) Write your review on any one of the gadgets you are using.
5) Frame "Wh" Questions for the statements given.
6) Punctuate the following statement given.
7) Complete the sentence using the fragments given.
8) Write a short passage on the given topic.
9) Fill in the blanks with the suitable prefix or suffix as directed.

COURSE OUTCOME 3 (CO 3) :Evaluate advanced varied technical concepts in the current scenario and emerging trends to invent new concepts.

1) Listen to the technical talk on the emerging trends and complete the statements given. (Cloze Test)
2) Ask questions to get an opinion about technical gadgets / software / devices
3) Read the given article from a journal and provide your ideas for further developments.
4) Rearrange the following sentences in the proper chronological order.
5) Write a short essay on any one of the given technical topics highlighting the future scope of the product.
6) Rewrite the following into Indirect Speech.
7) Frame indirect questions for the questions given.
8) Fill in the blanks with the suitable articles.
9) Give the one word substitutes for the given statement.

COURSE OUTCOME 4 (CO 4) : Write solutions for problems identified using the exact vocabulary and structure without grammatical errors as expected by the corporate world.

1) Listen to the technical talks and write down the merits and demerits of the product discussed.
2) Watch the video, evaluate the concept and express your solutions to the problem.
3) Read the given article and note down the problems stated.
4) Write down solutions for the problems faced while using a product.
5) Draft a white paper writing for the given situation..
6) Write launch notes for a product.
7) Convert the given statement to another form of the tenses as directed.
8) Pick out the suitable synonym for the underlined word in order to minimize plagiarism.
9) Fill in the blank with the suitable phrasal verb.

COURSE OUTCOME 5 (CO 5) : Manage and respond to self, others' emotions using skills of Self Awareness, Self Management, Self Motivation, Empathy & Social Relations to be an Emotionally Intelligent Human Being.

1) Watch the video on Types of listening and answer the questions.
2) Make a presentation on the importance of Emotional Intelligence.
3) Read the given article on High level cognition and answer the questions.
4) Read the article on social behaviour and redraft it in your own style.
5) Comprehend the passage and give your inputs for decision making.
6) Watch the video and articulate your emotions using appropriate words.
7) Write a note on optimism and pessimism.
8) Fill in the blank with the suitable modal verb.
9) Pick out the suitable fixed/ semi-fixed expression to complete the given statement.

21PY1311	PHYSICS AND CHEMISTRY LABORATORY	L	T	P	C
		0	0	4	2

Preamble

The aim of this course is to make the students gain practical knowledge to co-relate with the theoretical studies and develop their practical applications in engineering materials by usingthe principles in the right way to implement in modern technology.

Prerequisites

Basic practical concepts of Physics and Chemistry in higher secondary level.

Objectives

- To analyze the instrumental techniques used in measuring data.
- To interrogate the competency and understanding of the basic concepts found in experimental Physics.
- To learn about the electronic mechanisms and their usage in a practical manner.
- To learn the interpretation of experimental data using the equipment in the physics laboratory.
- To investigate the errors in experimental measurements and techniques.

Objectives (Chemistry)

- To make the students acquire practical skills in the determination of water quality parameters through volumetric and instrumental analysis.
- To develop an understanding about the range and uses of analytical methods in chemistry.
- To explain the concept of corrosion, its causes, and its environmental consequences.
- To acquaint students with knowledge of molecular weight determination and polymer solubility.

To interpret chemical and physical phenomena through experimental investigations.

PHYSICS

S. No	List of Experiments	CO
1	Determination of specific resistance of a given coil of wire – Carey Foster's Bridge.	**3**
2	Determination of band gap of a Semiconductor (Forbidden energy band gap kit).	**1**
3	Determination of planck's constant and work function using the principle of photoelectric effect	**5**
4	Determination of Young's modulus of the material-Non Uniform bending method.	**1**
5	Determination of thermal conductivity of a bad conductor – Lee's Disc method.	**4**
6	Determination of velocity of sound and compressibility of liquid – Ultrasonic Interferometer.	**1**
7	Determination of wavelength of spectral lines using grating – Spectrometer.	**2**

CHEMISTRY

1	Determination of total, temporary & permanent hardness of water by EDTA method.	**1,5**
2	Corrosion experiments – weight loss method.	**3,5**
3	Estimation of iron content of the given solution using potentiometer.	**2**
4	Conductometric titration of strong acid vs strong base.	**2**
5	Determination of molecular weight of polyvinyl alcohol using Ostwald viscometer.	**4**
6	Estimation of HCl using Na_2CO_3 as primary standard and determination of alkalinity in water sample.	**1,5**

7	Determination of strength of given hydrochloric acid using pH meter.	**2**

List of Projects (PHYSICS)			
S. No.	**List of Projects**	**Related Experiment**	**CO**
1	To study Infrared radiation emitted by different sources using phototransistors.	3	5
2	To study the variations, in current flowing in a circuit containing a LDR, because of a variation: (a) In the power of the incandescent lamp, used to 'illuminate' the LDR. (Keeping all the lamps at a fixed distance). (b) In the distance of an incandescent lamp, (of fixed power), used to 'illuminate' the LDR.	2	1
3	Design a circuit for cool automatic timer controlled Light which controls vehicle traffic passing through the intersection of two or more roadways by giving a visual indication to drivers when to proceed, when to slow , and when to stop using LED and 4017 counter IC along with the 555 timer.	2	1
4	Design and implement a circuit which anyone can make at home to save their home from thefts using the light has high intensity, monochromatic, directional and coherent in nature.	7	2
5	Construct a household circuit consisting of three bulbs using a dual switching method.	1	3
6	Using ultrasonic sensor, design a ultrasonic distance finder using 8051	6	1
7	Design a water level indicator by connecting a Buzzer, resistor and transistor in series and connect this in parallel to LED.	2	1
List of Projects (CHEMISTRY)			
1	Water Analysis : Analysis of perennial Thamirabarani River water samples collected from various locations (before and after blending of industrial waste water). i) Determination of various physical and chemical parameters (Hardness, pH,TDS, Alkalinity) of different water samples. ii) From the result, give a detailed report about the water sample whether it is fit/unfit for domestic and industrial purposes.	1, 6,7	1,5
2.	Water Quality Monitoring : Analysis of ground water samples collected from various districts (Tirunelveli, Madurai, Tuticorin, Kanyakumari, Tenkasi etc.,). i) Determination of various physical and chemical parameters (Hardness, pH, TDS, Alkalinity) of different water samples. ii) From the result, give a detailed report about the water sample whether it is fit/unfit for domestic and industrial purposes.	1,6,7	1,5
3.	Household Plumbing Deterioration Monitoring : Study		

	of Conductivity of domestic water (Home) by Arduino method to track the deterioration of household plumbing. i) From the observations give a detailed report about the existence of various ions in water. ii) Give an explanatory report on tracking the deterioration in household plumbing.	2	3,5
4	Air quality monitoring : Study of air pollution in Nellai smart city in the early morning, noon and evening due to CO/CO2 emissions by Arduino method. i) From the observations give a detailed report about the impact of air pollution on human health. ii) Deduce an explanatory report on environmental impact due to CO/CO2 emissions.	4	5
5.	Food adulteration : Investigation of adulterants in various food stuffs (milk, chilli powder, turmeric powder, wheat flour, honey and ghee) by Chemical methods. i) Give a report on the presence of adulterants in the given food samples. ii) From the observations give a brief report about the impact of food adulteration on human health.	1	5

Lab Assessment	
Lab Components Assessments (50 Marks)	**End Semester Exams (50 Marks)**

Outcomes(Physics)	
Upon completion of the course, the students will be able to:	
CO1	Analyzation of new instruments and real time application in engineering materials. (Analyse)
CO2	Applying the basic concepts of physics in the experiments by interrogating the data.(Apply)
CO3	Applying basic knowledge to design circuits using basic components. (Apply)
CO4	Acquire the basic enlightenment of the experimental data for interpretation (Apply)
CO5	Solve problems individually using critical thinking collaboratively. (Analyse)
Outcomes(Chemistry)	
CO1	Analyze the water quality related parameters quantitatively. (Analyse)
CO2	Explain the use of equipment for the measurement of conductance, electrode potential, pH of solutions, and viscosity. (Apply)
CO3	Analyze the probable corrosion, corrosion rate, and corrosion mechanism of the metallic material in the given environment (Analyze)
CO4	Analyze polymerization data and predict the conversion and molecular weight, which will lead to critical thinking about how to improve the setup for better polymerization.(Analyze)
CO5	Apply the knowledge of practical to enhance the quality of the environment .(Apply)

Reference Books (Physics)

- Physics Laboratory Manual, Department of Physics, Francis Xavier Engineering College, Tirunelveli.
- A Textbook of Engineering Physics Practical ,UNIVERSITY SCIENCE PRESS (An Imprint of Laxmi Publications Pvt. Ltd.)2nd edition.

Reference Books (Chemistry)

J.Mendham, R.C. Denney, J.D.Barnes, M.Thomas and B.Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis (5th edition 2009).

Web Resources

1. **Virtual Lab -** https://bop-iitk.vlabs.ac.in/basics-of-physics/List%20of%20experiments.html

Young's Modulus- https://vlab.amrita.edu/?sub=1&brch=280&sim=550&cnt=1

Virtual Lab - https://www.vlab.co.in/ba-nptel-labs-physical-sciences

Numerical Aperture - https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=343&cnt=1

Web Resources (Chemistry)

1. **Water Quality standards - https://www.youtube.com/watch?v=OlGllOZlIyI**

2.Corrosion experiments – weight loss method

https://www.youtube.com/watch?v=SMlgTWfdHb8

PHYSICS MAPPING

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	3	2	1	1	1		1	1	1		1	1		
2	3	2	1	1	1		1	1	1		1	1		
3	3	2	1	1	1		1	1	1		1	1		
4	3	2	1	1	1		1	1	1		1	1		
5	3	2	1	1	1		1	1	1		1	1		

CHEMISTRY MAPPING

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
1	3		1			2	2					2		
2	3	1	2			1	2					1		
3	3	2	1	1			1					1		
4	2	1	2			2	2					1		
5	2	1	2		1	2	2					1		

COURSE LEVEL ASSESSMENT QUESTIONS - PHYSICS

COURSE OUTCOME 1: The students will be able to analyzation of new instruments and real time application in engineering materials. (Analyse)

1. Determination of band gap of a Semiconductor (Forbidden energy band gap kit).
2. Determination of velocity of sound and compressibility of liquid – Ultrasonic Interferometer.

COURSE OUTCOME 2: The students will be able to apply the basic concepts of physics in the experiments by interrogating the data.(Apply)

1. Determination of wavelength of spectral lines using grating – Spectrometer.

COURSE OUTCOME 3: The students will be able to apply basic knowledge to design circuits using basic components. (Apply)

1. Design a circuit for finding unknown resistance and specific resistance of a given coil of wire.

COURSE OUTCOME 4: The students will be able to acquire the basic enlightenment of the experimental data for interpretation (Apply)

1. Determine the thermal conductivity of a given bad conductor (Glass) using Lee's disc method. (Given: M= 800 $X10^{-3}$ Kg, S = 370 $JKg^{-1}K^{-1}$).

COURSE OUTCOME 5: The students will be able to solve problems individually using critical thinking collaboratively. (Analyse)

1. Determination of planck's constant and work function using the principle of photoelectric effect
2. Find the Young's modulus of the material of a beam using Non-Uniform bending method. (Given : Thickness of the beam d = 6.35 mm)

SEMESTER II

21HS2101	ENGLISH FOR TECHNICAL COMMUNICATION	L	T	P	C
		2	0	0	2

Preamble

This course is offered to develop strategies and skills to enhance professional students' ability to read and comprehend engineering and technology texts. Foster their ability to write convincing job applications and effective reports. Develop their speaking skills to make technical presentations, participate in group discussions. The outcome of the course is to help students acquire the language skills of listening, speaking, reading and writing competency in English language thereby making them meet the global expectations.

Prerequisites for the course

- The prerequisite knowledge required to study this Course is the basic knowledge in English Language.

Objectives

1. To widen strategies and skills to augment ability to read and comprehend engineering and technology texts.
2. To draft convincing job applications and effective reports.
3. To develop speaking skills to make technical presentations, participate in group discussions.
4. To strengthen listening skills to comprehend technical lectures and talks in their areas of specialization.
5. To cultivate writing skills both technical and general.

MODULE 1	READING AND STUDY SKILLS	6

Reading - Reading longer technical texts / technical blogs and taking down notes; Writing - interpreting charts (all the types), graphs – comparing and contrasting statements/paragraphs – analyzing technical details - writing technical blogs; Vocabulary Development - Select Technical Vocabulary; Language Development - Active Voice and Passive Voice

Suggested Activities	
i) Visit to the Library - Reading articles on emerging trends and taking down notes in the prescribed format - Submission through FAST FORMS - Minimum 2	Evaluation Method i) Content & Structure
ii) Writing compare and contrast statements. (Eg. Windows 10 Vs Windows 1, RPA Developer Vs RPA Analyst, Edge Computing Vs Quantum Computing) related to the programme.	ii) Submission: Fast form Document Submitted document will be assessed for a) Communication Etiquette b) Language Style c) Sentence Construction
iii) Teaching of Grammar Contents	Activity iii will be assessed through Google form tests/ written tests.

MODULE 2	**INTRODUCTION TO PROFESSIONAL WRITING**	**6**
Reading - Technical related topics; Writing - statement of purpose - press release – extended definitions - writing instructions – checklists – recommendations – Minutes of the Meeting ; Language Development - Subject Verb Agreement, Compound Words.		
Suggested Activities i) Visit to the Library - Reading articles on emerging trends and writing down purpose statements and extended definitions. Submission through FAST FORMS - Minimum 2 ii) Writing a set of 8 Instructions, Recommendations and Checklists for the suggested topics. (each 2 sets) iii) Teaching of Grammar Contents	Evaluation Method i) Content & Structure ii) Submission: Fast form Document Submitted document will be assessed for a) Format b) Language Style c) Sentence Construction Activity iii will be assessed through Google form tests/ written tests.	
MODULE 3	**INTERVIEW SKILLS**	**6**
Listening - Listening to mock Interviews ; Speaking - answering Interview questions – GD Strategies; Reading- newspaper article - read company profile - practice in speed reading ; Writing - Job Application - Resume- Internship application - letter to the editor - email etiquette - positive, negative and neutral responses - sending professional emails; Writing opinion paragraph - Writing paragraphs with reasons; Vocabulary Development - select Technical Vocabulary Language Development - If – Conditionals		
Suggested Activities i) Listening to UPSC Toppers Mock Interviews. ii) Drafting Job application and Resume building. iii) Teaching of Grammar Contents	Evaluation Method i) Answering questions for Interview questions(Android app based) Responses will be assessed for a) Fluency b) Communication etiquette c) Language style ii) Submission: Fast form Document Submitted document will be assessed for a) Language Style b) Design Activity iii will be assessed through Google form tests/ written tests.	
MODULE 4	**REPORT WRITING I**	**6**
Writing - Fire accident Report, Industrial Visit Report, Project Report; Vocabulary Development- finding suitable synonyms - paraphrasing ; Language Development - Clauses.		

Suggested Activities i) Drafting reviews and reports on Industries - a) Profile & Products b) Trending technology adopted	Evaluation Method i) Content & Structure
c) Careers d) Latest news Min - 2 Industries ii) Teaching of Grammar Contents	Activity ii will be assessed through Google form tests/ written tests.

MODULE 5	REPORT WRITING II	**6**

Writing - Writing Feasibility Reports, Survey Reports, Business Report; Vocabulary Development - verbal analogies ; Language Development - advanced use of Articles, Prepositional Phrases.

Suggested Activities i) Drafting feasibility report on- a) Launching a new product / Technology Min - 2 ii) Teaching of Grammar Contents	Evaluation Method i) Content & Structure Activity ii will be assessed through Google form tests/ written tests.

Total Periods	**30**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
(i) Google Form based - on-line Test (i) (ii) Written Test	(i) Google Form based - on-line Test incorporating Listening, Speaking and Reading	Written Test

Outcomes

Upon completion of the course, the students will be able to:

CO1	Understand advanced technical texts from varied technical genres to understand engineering concepts and explore more. (Apply)
CO2	Review technical contents written on par with international standards and rewrite contents using the right vocabulary without grammatical errors to make their articles published in reputed journals. (Apply)
CO3	Articulate appropriately in interviews and Group Discussions effortlessly following the strategies expected by the corporate world. (Apply)
CO4	Write reports utilizing the required format prescribed on par with international standards using the exact vocabulary to make their reports worthy to be read. (Apply)
CO5	Appraise the need for new products and write feasibility and survey reports following the format prescribed in a way to create awareness. (Apply)

Text Books

1. Mike Markrl. Technical Communication,Palgrave Macmillan: London, 2012.
2. Sumant,S and Joyce Pereira. Technical English II. Chennai: Vijay Nicole Imprints Private Limited, 2014.
3. Kumar, Sanjay and Pushp Lata. Communication Skills: A Workbook. New Delhi: OUP, 2018.

Reference Books

1. Raman, Meenakshi & Sangeetha Sharma. Communication Skills. New Delhi: OUP, 2018
2. Rizvi M, Ashraf. Effective Technical Communication. New Delhi: Tata McGraw-Hill Publishing Company Limited, 2007

Web Resources

1. Interpretation of Charts : https://youtu.be/4lxA7lo9GLU : https://www.englishhints.com/charts-and-graphs.html
2. Instructions https://www.wikihow.com/Write-Clear-Instructions
3. Resume building https://novoresume.com/career-blog/how-to-write-a-resume-guide
4. Report writing - https://www.youtube.com/watch?v=FXIuHOFAxos ; https://www.deakin.edu.au/students/studying/study-support/academic-skills/report-writing
5. UPSC Interview: https://www.youtube.com/watch?v=OhJWg-0qdI0

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O 2	PS O 3
1	1		1	2		2	1	1		2	1	1			
2	1			2		1		1		3	2	1			
3						3	2	1	2	3		2			
4		1	1	1		1	1	1	2	3	2	2			
5		1		1		1	1	1	1	3	2	2			

SUGGESTED COURSE LEVEL ASSESSMENT QUESTIONS:

COURSE OUTCOME 1 (CO 1) : Understand advanced technical texts from varied technical genres to understand engineering concepts and explore more.

1) Read the given passage and take notes.
2) Analyse the given type of chart or graph and answer the questions given.
3) Analyse the given chart or graph and write paragraphs comparing and contrasting the data.
4) Analyse the given chart or graph and write paragraphs giving importance to technical details.
5) Fill in the blank with appropriate technical vocabulary.
6) Convert the given active voice sentence into passive voice or impersonal passive voice.

COURSE OUTCOME 2 (CO 2) : Review technical contents written on par with international standards and rewrite contents using the right vocabulary without grammatical errors to make their articles published in reputed journals.

1) Write a purpose statement for the tool or gadget given.
2) Write an extended definition for the given word.
3) Write 8 instructions / recommendations on the given topic.
4) Write the Minutes of the meeting for the given meeting.
5) Fill in the blank with appropriate Subject Verb agreement.
6) Fill in the blank with suitable compound words.

COURSE OUTCOME 3 (CO 3) : Articulate appropriately in Interviews and Group Discussions effortlessly following the strategies expected by the corporate world.

1) Listening to mock interviews and answering the questions.
2) Listen to the strategies of GD and answer the given questions.
3) Read and submit a recording of technical content following the strategies of speed reading.
4) Write Job application with a cover letter for the given job description.
5) Write paragraphs expressing opinion on the given topic.
6) Fill in the blank / complete the sentence with appropriate If-Conditionals.

COURSE OUTCOME 4 (CO 4) : Write reports utilizing the required format prescribed on par with international standards using the exact vocabulary to make their reports worthy to be read.

1) Write a fire accident report for the provided incident.
2) Write an Industrial visit report.
3) Write a report on the Project work undertaken by the candidate giving importance to the current status report and the time needed for the completion of the project.
4) Find the appropriate synonym for the given word.
5) Paraphrase the given passage.
6) Fill in the blank with appropriate clauses.

COURSE OUTCOME 5 (CO 5) : Appraise the need for new products and write feasibility and survey reports following the format prescribed in a way to create awareness.

1) Write a Feasibility report for a business / project proposal given.
2) Write a survey report for the given scenario.
3) Pick out the appropriate Verbal Analogy.
4) Fill in the blank with appropriate articles.
5) Complete the sentence with appropriate Prepositional Phrases.
6) Choose the appropriate word to complete the sentence.

21MA2201	PARTIAL DIFFERENTIAL EQUATION AND APPLICATIONS OF FOURIER SERIES	L	T	P	C
		3	1	0	4

Preamble:

The course consists of topics in Complex Integration, Partial Differential Equations and Laplace Transforms with applications to various engineering problems. This course will cover the following main topics: Construction of analytic function, Taylors and Laurent's series, Poles and Residues, Half range sine series, Harmonic analysis, Fourier Series Solutions of one dimensional wave and heat flow equation and Applications of Laplace transforms for solving linear ordinary differential equations up to second order with constant coefficients.

Prerequisites for the course

Basic knowledge of Partial differentiation and Integration.

Objectives

1. To introduce to the concept of Analytical function
2. To familiarize with Complex integration
3. To introduce Fourier series analysis which is central to many applications in engineering field and its use in solving boundary value problems
4. To acquaint the student with PDE and Fourier series techniques in solving wave and heat flow problems used in various situations.
5. To improve the knowledge of Laplace transform.

UNIT I	ANALYTIC FUNCTIONS	9+3

Definition of Analytic Function – Cauchy Riemann equations – Properties of analytic functions – Harmonic function – Harmonic Conjugate - Construction of analytic function by Milne Thomson's method and bilinear transformation.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Construction of analytic function by Milne Thomson's method and bilinear transformation.

UNIT II	COMPLEX INTEGRATION	9+3

Complex numbers and its conjugate - Cauchy's integral theorem (without proof) – Cauchy's integral formulae and its higher order derivatives (without proof) and its applications – Taylors and Laurent's series – Types of Singularities – Poles and Residues – Cauchy's residue theorem (without proof).

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Taylors series, Laurent's series and Cauchy's residue theorem.

UNIT III	FOURIER SERIES	9+3

Dirichlet's conditions – General Fourier series – Change of Intervals - Odd and even functions – Half range sine series – Half range cosine series - Root mean square value – Harmonic analysis for Fourier series - Engineering Applications.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Fouries series of Odd and even functions, Half range sine and cosine series, Harmonic analysis.

UNIT IV	PDE AND APPLICATIONS OF FOURIER SERIES	9+3

Classification of PDE – Method of separation of variables - Fourier Series Solutions of one dimensional wave equation – Fourier Series Solutions of one dimensional equation of heat conduction - Engineering Applications.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Fourier Series Solutions of one-dimensional wave equation and heat conduction equation.

UNIT V	LAPLACE TRANSFORMS	9+3

Properties of Laplace Transform – Inverse transforms – Convolution theorem (Without Proof) – Partial fraction - Applications of Laplace transforms for solving linear ordinary differential equations up to second order with constant coefficients only - Engineering Applications.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Laplace transform using partial fraction, Convolution theorem and solving ODE.

Total Periods	**45 + 15 = 60 Periods**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
1. Descriptive Questions CAT 1 – 10 Marks CAT 2 – 10 Marks	1. Assignment 2. Online Quizzes	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

C108.1. : Apply Cauchy-Riemann equations to problems of fluid mechanics, thermodynamics and electro-magnetic fields. (Apply)
C108.2: Solve complex valued integral functions using residues. (Apply)
C108.3: Construct the Fourier series expansion of the periodic function. (Apply)
C108.4: Solve the problems of one dimensional wave and heat equation. (Apply)
C108.5: Apply Laplace Transform technique to solve the given ordinary differential equation. (Apply)

Text Books

1. B. S. Grewal, " Higher Engineering Mathematics", 45rd edition, 2017.
2. Kreyszig.E, "*Advanced Engineering Mathematics*", John Wiley & Sons. Singapore, 15th edition, 2017.

Reference Books

1. A Textbook of Engineering Mathematics(Dr. A.P.J. Abdul Kalam Technical University, Lucknow) (For . Gautam Bhudh technical Universities ,Lucknow) January 2020
2. Advanced Engineering Mathematics , H. K. DASS, S. CHAND and Company Limited, New Delhi, 22nd revised edition, 2018.

Web Resources

1. Analytic functions - https://youtu.be/8jPr6rGstYk
2. Complex Integration - https://youtu.be/4yC4IXcMKJg
3. Fourier series - https://youtu.be/LGxE_yZYigI
4. Applications of fourier series - https://youtu.be/YfGHNdVeyB4
5. Laplace Transform - https://youtu.be/c9NibpoQjDk

CO Vs PO Mapping and CO Vs PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2												
2	3	2												
3	3	2										2		
4	3	2										2		
5	3	2												

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 (CO 1) : (Apply)

1. Construct an analytic function whose imaginary part is $v = e^x(x\cos y - y\sin y)$
2. Find the bilinear transformation that maps the points Z =0, -1 ,$\vec{i}$ on to the points $\vec{i}$, 0, ∞.

COURSE OUTCOME 2 (CO 2) : (Apply)

1) Solve $\int \frac{e^{2z}}{(z+1)^4} dz$ using Cauchy's Integral formula where C is $|z| = 2$.
2) Compute $\int \frac{2z-1}{z(z+1)(z-3)} dz$ using Cauchy's Residue theorem where C is $|z| = 2$.

COURSE OUTCOME 3 (CO 3) : (Apply)

1) Construct Fourier series for $f(x) = x$ in $(-\pi, \pi)$.
2) Construct Fourier series for $f(x) = x^2$ in $(-l, l)$.

COURSE OUTCOME 4 (CO 4) : (Apply)

1) Identify the PDE $u_{xx} = a^2 u_{tt}$
2) A tightly stretched string with fixed end points $x = 0$, $x = l$ is initially at rest in its equilibrium position. If it is vibrating, giving each point a velocity $\lambda x(l - x)$. Find the displacement of the string at any time 't'.

COURSE OUTCOME 5 (CO 5) : (Apply)

1) Solve $\frac{d^2x}{dt^2} - 3\frac{dx}{dt} + 2x = 2$, given $x = 0$ and $\frac{dx}{dt} = 5$ for $t = 0$ using Laplace transform method.
2) Find the Laplace transform for $\frac{\cos at - \cos bt}{t}$

21ME2501	ENGINEERING MECHANICS	L	T	P	C
		2	1	0	3

Prerequisites for the course

Engineering Physics

Objectives

To develop the capacity to predict the effects of force and motion while carrying out the creative design functions of engineering

UNIT I	STATICS OF PARTICLES	7+2

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility

UNIT II	EQUILIBRIUM OF RIGID BODIES	7+2

Free body diagram – Types of supports – Action and reaction forces – stable equilibrium –Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Single equivalent force – equilibrium of Rigid bodies in two dimensions

UNIT III	PROPERTIES OF SURFACES AND SOLIDS	8+2

Centroids and centre of mass – Centroids of lines and areas – Rectangular, circular, triangular areas by integration – T section, I section, – Angle section, Hollow section by using standard formula – Theorems of Pappus – Area moments of inertia of plane areas – Rectangular, circular, triangular areas by integration – T section, I section, Angle section, Hollow section by using standard formula – Parallel axis theorem and perpendicular axis theorem – Principal moments of inertia of plane areas – Principal axes of inertia-Mass moment of inertia

UNIT IV	DYNAMICS OF PARTICLES	8+2

Displacements, Velocity and acceleration, their relationship – Relative motion – Curvilinear motion – Newton's laws of motion – Work Energy Equation – Impulse and Momentum – Impact of elastic bodies

UNIT V	FRICTION	5+2

Friction force – Laws of sliding friction – equilibrium analysis of simple systems with sliding friction – wedge friction – belt friction – ladder friction

	Total Periods	35+10=45 hours

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT – I (10 Marks) CAT – II (10 Marks)	Assignment, Multiple Choice Questions	Multiple Choice Questions

Outcomes

Upon completion of the course, the students will be able to:

C109.1: Enumerate the basic laws of mechanics and practice the vector manipulation, equilibrium conditions on the systems of forces acting on particles.

C109.2: Compute reaction force and moment on the rigid bodies using both vector and scalar methods

C109.3: Determine the center of gravity and moment of inertia of the standard and composite section

C109.4: Apply equation of motion, principles of D'Alembertz work energy and impulse momentum to the problems on dynamics of particles.

C109.5: Describe frictional laws to compute the frictional forces for bodies in contact.

Text Books

1. Beer, Johnston, Mazurek, Cornwells and Sanghi, "Vector Mechanics for Engineers: Statics, Dynamics", 10th Edition, Tata McGraw Hill Noida, Uttar Pradesh, (2019)
2. N.H. Dubey, "Engineering Mechanics Statics and Dynamics", 1st Edition, McGraw-Hill Education India Private Ltd., New Delhi, (2017)

Reference Books

1. J.L. Meriam and L.G. Kraige, "Engineering Mechanics: Dynamics", 7th Edition, Wiley India Private Limited, (2016)
2. Irving H. Shames, "Engineering Mechanics Statics and Dynamics", 4th Edition, Pearson India, (2011)
3. R.K Bansal," Textbook of Engineering Mechanics", 7th Edition, LP publications.

Web Resources

1. https://nptel.ac.in/courses/122/104/122104015/
2. https://nptel.ac.in/courses/112/103/112103109/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
109.1	2	2	2	2								1	3	2
109.2	2	2	2	2								1	3	2
109.3	1	1	1	2								1	3	2
109.4	1	1	1	2								1	3	2
109.5	1	2	2	1								1	3	2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	15	5		10
UNDERSTAND	30	20	10	10	30
APPLY	30	30	10	10	30
ANALYZE	20	20		5	15
EVALUATE		15			15
CREATE					

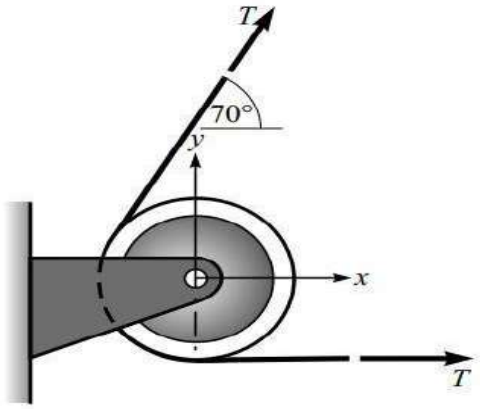
COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Enumerate the basic laws of mechanics and practice the vector manipulation, equilibrium conditions on the systems of forces acting on particles. (Remember, Understand, Apply, Analyse)

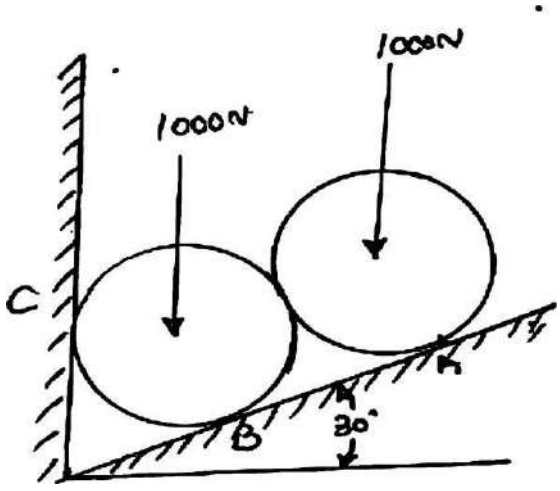
1. Define coplanar and non-coplanar forces (Remember)

2. Determine the magnitude and direction of the resultant of two forces 100 N and 150 N acting at angle of 45◦ (Understand)

3. If the two tensions in the pulley cable shown in Fig. are 400 N, determine the resultant R exerted on the pulley by the two tensions. (Apply)



4. Two identical rollers each of weight 1000N are supported by an inclined plane and a vertical wall asshown in fig below. Find the support reactions at points A, B & C. assume all surfaces to be smooth (Analyse)

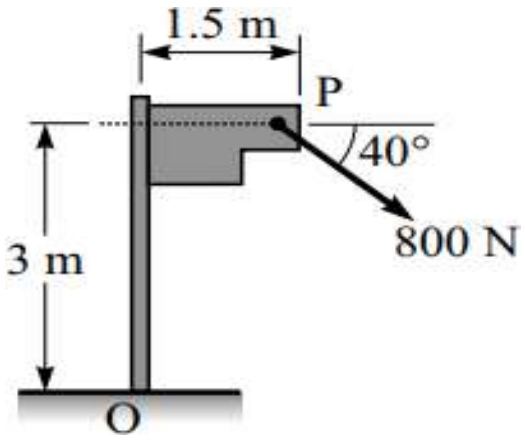


COURSE OUTCOME 2: Compute reaction force and moment on the rigid bodies using both vector and scalar methods (Remember, Understand, Apply, Analyse)

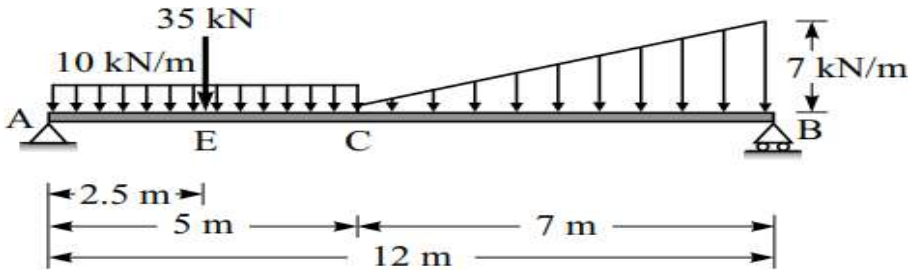
1. List some types of beams based on supports (Remember)

2. State Varignon's theorem (Understand)

3. An 800-N force is applied to a 3-m high pole at the point P, as shown in Fig. Calculate the magnitude of moment of this force about the base point O by four different methods. (Apply)

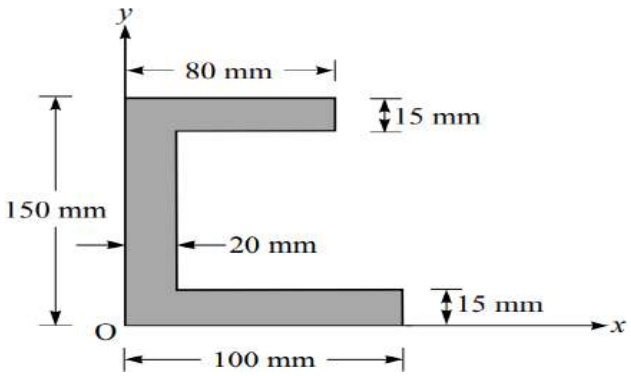


4. Calculate the support reactions for a simply supported beam with hinged support at the end A and roller support at the end B, subjected to inclined loading as shown in Fig. (Analyse)

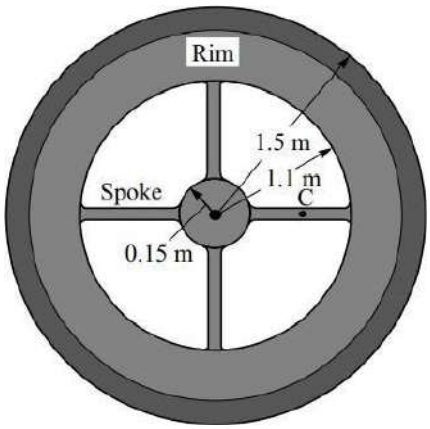


COURSE OUTCOME 3: Determine the center of gravity and moment of inertia of the standard and composite section (Remember, Understand, Apply)

1. Write the formula for finding moment of inertia about X and Y axis (Remember)
2. Find the centroid of the plane lamina shown in Fig. (Understand)

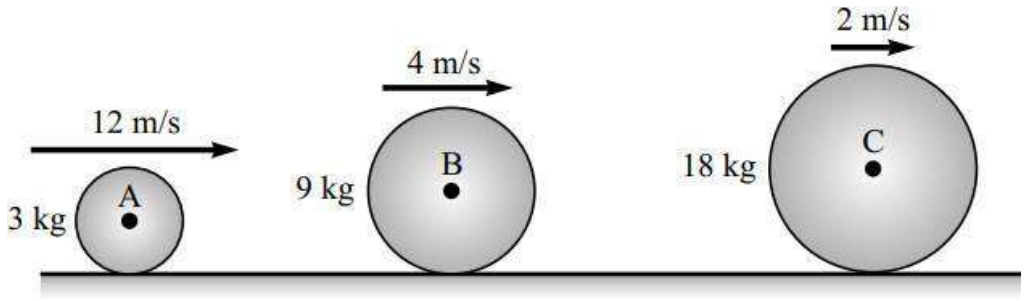


3. A flywheel (Fig.) consists of a rim of 2500-kg mass and four spokes each of 60-kg mass. The rim has inner and outer radii of 1.1 m and 1.5 m, respectively. The shaft at the center of the wheel has a diameter of 0.25 m and a mass of 1200 kg. Determine (a) the moment of inertia of flywheel about its axis of rotation, and (b) its radius of gyration. (Apply)



COURSE OUTCOME 4: Adapt equation of motion, principles of D'Alembertz, work energy and impulsemomentum to the problems on dynamics of particles. (Understand, Remember, Apply, Analyse, Evaluate)

1. State Newton's second law of motion (Remember)
2. State law of conservation of momentum (Understand)
3. In Asian games, for 100 m event an athlete accelerates uniformly from the start to this maximum velocity in a distance of 4 m and runs the remaining distance with that velocity. If the athlete finishes the race in 10.4 seconds, determine (i) his initial acceleration (ii) his maximum velocity (Apply)
4. Three spherical balls A, B and C of 3kg, 9kg and 18 kg masses are moving in the same direction with velocities of 12 m/s, 4 m/s and 2 m/s, respectively, as shown in Fig. If the ball A Collides with the ball B which in turn collides with the ball C, proves that the balls A and B come to rest after the impacts. Assume that all the impacts are perfectly elastic. (Analyse)



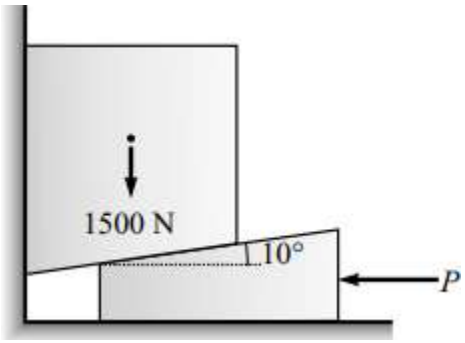
5. Direct central impact occurs between 300 N body moving to the right with the velocity of 6 m/s and 150 N body moving to the left with the velocity of 10 m/s. Find the velocity of each body after impact if the coefficient of restitution is 0.8 (Evaluate).

COURSE OUTCOME 5: Describe frictional laws to compute the frictional forces for bodies in contact. (Understand, Remember, Apply, Analyse)

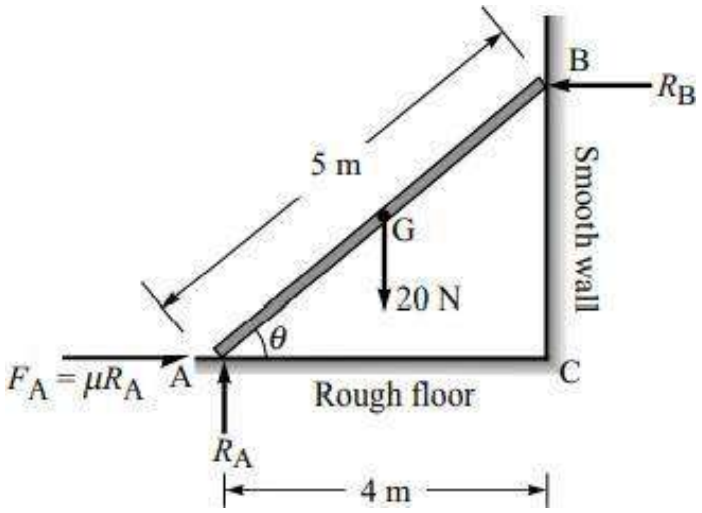
1. State the laws of dry (coulomb) friction (Remember)

2. Define angle of repose (Understand)

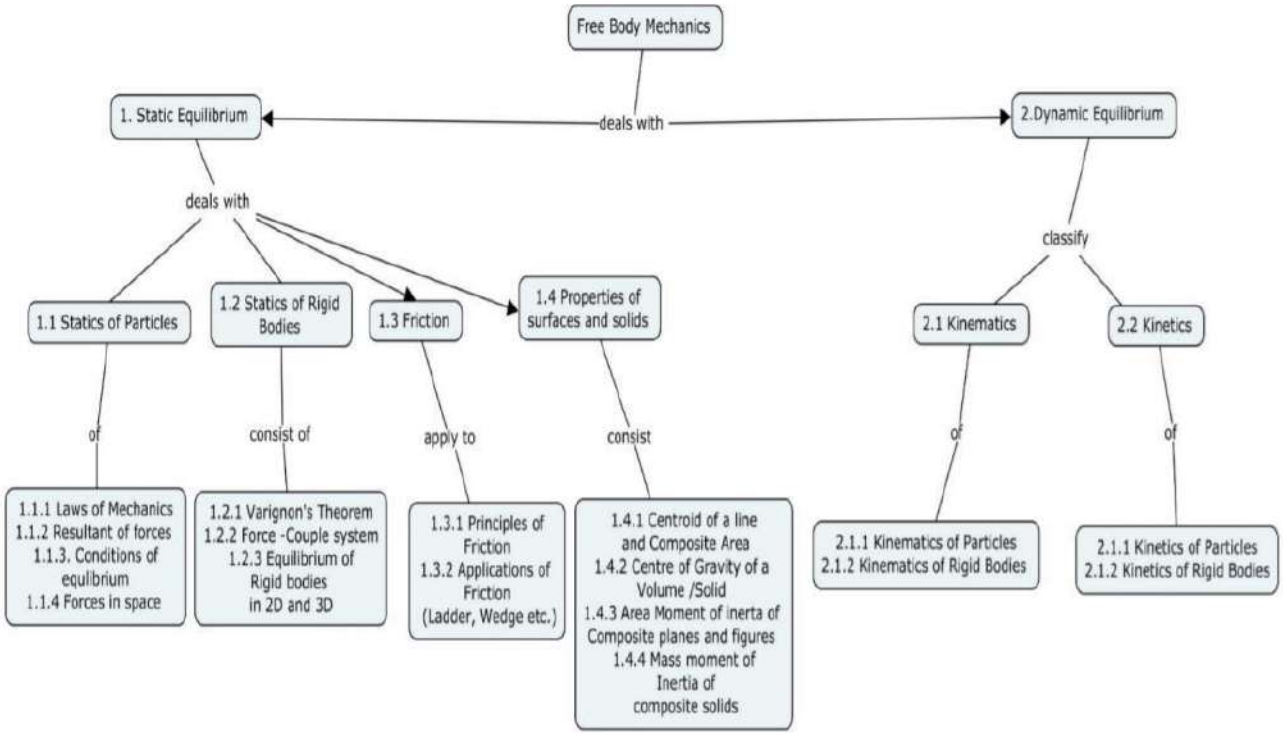
3. A 1500-N block overlaying a 10-degree wedge on a horizontal floor and leaning against a vertical wall, is to be raised by applying a horizontal force P as shown in Fig. Determine the force P necessary to just start the motion, if the coefficient of friction is 0.3 (Analyse)



4. A uniform ladder of 5-m length and 20-N weight is placed against a smooth vertical wall with its lower end 4 m away from the wall. If the ladder is just to slip, determine the coefficient of friction between the ladder and floor, and the frictional force acting on the ladder at the point of contact with the floor. (Apply)



CONCEPT MAP



COURSE DESIGNERS:

1. M.SARAVANA KUMAR saravanakumar@francisxavier.ac.in
2. M. AYYANAR RAJA ayyanarraja@francisxavier.ac.in
3. S. M. RAJ KUMAR rajkumarsm@ francisxavier.ac.in

HoD/Mech

21ME1513	COMPUTER AIDED ENGINEERING GRAPHICS	L	T	P	C
		1	2	2	4

Prerequisites for the course

NIL

Preamble

Engineering drawing is an important tool for all Engineers and for many others professionals. It is the language of Engineers. Engineering Drawing communicates all needed information from the engineer who designed a part to the workers who will manufacture it.

Objectives

1. To understand the importance of the drawing in engineering applications
2. To improve their visualization skills so that they can apply this skill in developing newproducts.
3. To expose them to existing standards related to technical drawings.
4. To develop graphic skills for communication of concepts, ideas, and design of engineering products
5. Train to practice engineering graphics through drafting software.

CONCEPTS AND CONVENTION

Importance of graphics in engineering applications – Use of drafting instruments – BIS conventionsand specifications – Size, layout of drawing sheets – Lettering and Dimensioning

UNIT I	PROJECTION OF POINTS, LINES AND PLANES	9

General Principles of orthographic projection – First Angle Projection, projection of points in four quadrants – Projection of straight lines located in the first quadrant – inclined to both planes – Projection of planes (Change of position method only)

UNIT II	PROJECTION OF SOLIDS	10

Projection of simple solids like prisms, pyramids, cylinder, and cone when the axis is inclined to onereference plane by change of position method.

UNIT III	SECTIONS OF SOLIDS AND DEVELOPMENT OF SURFACES	10

Sections of regular solids as per BIS conventions - Constructing sectional views of simple objects and components - Development of lateral surfaces of regular solids-Projection of truncated solids- Combinations of solids

UNIT IV	ISOMETRIC PROJECTIONS	8

Principles of isometric projection – isometric scale – isometric projections of simple solids, truncatedprisms, pyramids, cylinders, and cones.

UNIT V	PERSPECTIVE PROJECTIONS	8

Perspective projection of prisms, pyramids, and cylinders by visual ray method.

S.No	List of Experiments	CO
1.	Introduction to drafting commands in AutoCAD. Creation of simple geometry and editing practice.	C112.1
2.	Projection of simple Geometric objects and engineering components using AutoCAD	C112.2
3.	Construction of simple objects and components sectional views using AutoCAD	C112.3
4	Construction of development of surfaces of simple solids	C112.3
5.	Isometric projection of simple components-flange, cylinder, chimney, lamp shades, valve, Brackets using AutoCAD	C112.4
6.	Creating a Perspective Projection of solids using AutoCAD	C112.5
7.	Conversion of isometric projections into orthographic projection	C112.4
	Total Periods	**15 Lecture +30 Tutorial+ 30 Lab Hours**

Laboratory Requirements

SYSTEM REQUIREMENTS

(For a batch of 30 Students)

Hardware:

1. Intel i3 core due processor with 4GB ram with 500GB hard disk – 30 Nos.
2. Laser Printer – 1 No.

Software:

Drafting package – AutoCAD – Adequate license (Open source)

Suggestive Assessment Methods

CAT 1 (20Marks)	LAB COMPONENTS (30 Marks)	End Semester Exams (50 Marks)
CAT 1 10 MARKS CAT 2 10 MARKS	Model Lab with project (10 Marks) Lab Experiment (20 Marks)	50

Outcomes

Upon completion of the course, the students will be able to:

C112.1: Apply the principles of first angle projection in construction of points, lines and planes
C112.2: Apply the principles of change of position method in projection of simple solids.
C112.3:Develop projections of sectioned solids and their developmental surface.
C112.4:Develop isometric views from orthographic projections
C112.5: Construct the perspective projections of simple solids

Text Books

1. Venugopal K. and Prabhu Raja V., "Engineering drawing + AutoCAD", New Age International (P) Limited (2022)
2. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai (2015)
3. Patil, Rajashekar, "Computer Aided Engineering Graphics", New Age International Ltd,2018

Reference Books

1. Kumar M.S., "Engineering Graphics", D.D. Publications, (2015)
2. Parthasarathy N.S. and Vela Murali, "Engineering Graphics", Oxford University, Press, New Delhi, (2015)
3. Shah M.B. and Rana B.C., "Engineering Drawing", Pearson Education (2009)
4. N.D.Bhatt, "Engineering Graphics", Charotor Publishing House, 53RD Edition 2019

Publication of Bureau of Indian Standards:

1. IS 10711 – 2001: Technical products Documentation – Size and lay out of drawing sheets
2. IS 9609 (Parts 0 and 1) – 2001: Technical products Documentation – Lettering
3. IS 10714 (Part 20) – 2001 and SP 46 – 2003: Lines for technical drawings
4. IS 11669 – 1986 and SP 46 – 2003: Dimensioning of Technical Drawings
5. IS 15021 (Parts 1 to 4) – 2001: Technical drawings – Projection Methods

Web Resources

1. http://nptel.ac.in/courses/112103019
2. https://archive.nptel.ac.in/courses/112/105/112105294/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
112.1	3	1	1	2									3	2
112..2	3	1	1	1	1								3	2
112.3	3	1	1	1	1								3	2
112.4	2	2	1	1	1								3	1
112.5	2	2	1	1	1								3	2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	MODEL	END SEM EXAM
REMEMBER				
UNDERSTAND				
APPLY	10	10	30	50
ANALYZE				
EVALUATE				
CREATE				

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Apply the principles of first angle projection in construction of points and lines. (Apply)

1. Draw the projections of the following points on a common reference line. (Apply)
   A,35 mm above HP and 25 mm in front of VP
   B,40 mm below HP and 15mm behind VP
   C,50 mm above HP and 25 mm behind VP
   D,45 mm below HP and 25 mm behind VP
   E, 30 mm behind VP and on HP

2. A line CD measuring 80 mm is inclined at an angle of 30° to HP and 45° to VP. The point C is 20 mm above HP and 30 mm in front of VP. Draw the projections of the straight line.(Apply)

COURSE OUTCOME 2: Apply the principles of change of position method in projections of solid problems and draw graphically

1. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30o to VP. Draw the projections of the solid. (A)

2. A hexagonal prism has side 25mm and height 50mm has a corner of its base on the ground and the long edge containing that corner inclined at 30o to HP and 45o to VP. Draw the projections of the solid. (A)

COURSE OUTCOME 3: Develop projections of sectioned solids and their developmental surface.

1. A cylinder of base diameter 50mm and height 60mm rest on its base on HP. It is cut by a plane perpendicular to VP and inclined at 45^0 to HP. The cutting plane meets the axis at a distance 15mm from its top base. Draw the sectional plan and true shape of the section. (A)
2. A regular hexagonal pyramid side of base 30 mm and height 60 mm is vertically on its base on HP, such that two of its sides of the base are perpendicular to VP. It is cut by a plane inclined at 30° to HP and perpendicular to VP. The cutting plane bisects the axis of the pyramid. Obtain the development of the lateral surface of the truncated pyramid. (A)

COURSE OUTCOME 4: Develop isometric views from orthographic projections

1. A cone of diameter 50 mm and axis 70 mm rests on its base on HP. A section plane perpendicular to VP and inclined at 30° to HP cuts the solid and passes through a point on axis which is 40 mm above HP. Draw the isometric view of a truncated cone. (A)

2. A pentagonal pyramid of base edge 25 mm and height 65 mm rests vertically on its base on the HP such that one of its base edge parallel to VP. It is cut by a plane, parallel to HP and perpendicular to VP and passes through a point 25 mm from the apex. Draw the isometric view of the frustum of pyramid. (A)

COURSE OUTCOME 5: Construct the perspective projections of simple solids

1. Draw the perspective view of a square prism of base side 40mm and height 50mm. one vertical lateral face is parallel to PP and 30mm away from it. The station point is 80mm from PP, 80mm above the base and 60mm to the right of the axis of the prism. (APPLY)

2.A hexagonal pyramid of base side 25mm and axis length 50mm is resting on GP on its base with a side of base is parallel to and 20mm behind PP. The station point is 60mm above GP and 80mm in front of PP and lies in a central plane which is 50mm to the left of the axis of the pyramid. Draw the perspective view of a pyramid. (APPLY)

21EE2501	FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS SCIENCE	L	T	P	C
		3	0	2	4

Prerequisites for the course

Basic Science

Objectives

To impart knowledge on

1. DC and AC circuits using basic laws.
2. Construction, working principle, EMF equation of DC machines, single phase transformer, alternator, synchronous motor and induction motor.
3. Electrical Drives and Characteristics
4. Construction, operation, characteristics and applications of semiconductor devices.
5. Concepts of logic gates and their applications.

UNIT I	ELECTRIC CIRCUITS	9

Ohms law, Kirchhoff‟s Laws, Reduction of series and parallel circuits solving simple DC Circuits-single phase AC circuit fundamentals-Power, Power factor-solving simple AC circuits- Introduction to three phase AC circuits

UNIT II	ELECTRICAL MACHINES	9

DC MACHINE: Principle of Operation DC Motor-types-torque equation - speed-torque characteristics-losses and efficiency- speed control of DC motors-Electric Braking

AC MACHINES: Single phase Transformers - Construction and working principle, 3 phase Induction Motor-construction–Principle of operation- types-torque equation-speed -torque characteristics-1 phase Induction Motor-Principle of operation-types – Industrial Applications.

UNIT III	ELECTRICAL DRIVES AND CHARACTERISTICS	9

Basic Elements – Types of Electric Drives – Factors are influencing the choice of Electrical Drive – Heating and Cooling curves – Loading Conditions and Classes of Duty – Speed – Torque – Characteristics curves of various electrical drives. – Speed Control of DC and AC drives

UNIT IV	ELECTRONIC DEVICES	9

Operation of PN junction diodes, VI characteristics, zener diode, BJT, types-CB, CE, CC configurations, input and output characteristics, JFET - working principle and characteristics - Comparison of BJT and FET. MOSFET-types, principle of operation and characteristics, Opto Electronic Devices - Principles and Applications.

UNIT V	DIGITAL ELECTRONICS	9

Number systems-representation of signed numbers: 1‟s complement and 2‟s complement, logic gates, Combination logic circuits, Half adder, full adder, Flip flops, RS,JK,JK Master slave, D and T type, counters and shift registers.

Total Periods	45 Theory + 30Practical

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Model Exam (30 Marks)**	**End Semester Exams (50 Marks)**
CAT – 1 10 Marks CAT – II 10 Marks	Lab Experiments – 10 Marks Model lab with project – 20 Marks	Descriptive Types

Outcomes

Upon completion of the course, the students will be able to:

C110.1**:** Analyze DC and AC circuits using basic laws.
C110.2: Explain about DC &AC machines and identify their applications.
C110.3: Explain the concepts of drives and characteristics of motor es.
C110.4: Analyze and compare the construction, theory and characteristics of the semiconductor device
C110.5: Design basic combinational and sequential logic circuits

Text Books

1. Muthu Subramanian R, Salivahanan S, "Basic Electrical and Electronics Engineering", McGraw Hill, New Delhi, 2009.
2. Juha Pyrohonen, Valeria Hrabovcova, " Electrical Machine Drives Control – An introduction", Wiley 2016

Reference Books

1. Nagsarkar T K and Sukhija M S, "Basics of Electrical Engineering", Oxford University press, 2012.
2. V K Mehta, Rohit mehta "Principles of Electronics", S.Chand& Company Ltd, 2015.
3. Mahmood Nahvi & Joseph A. Edminister, "Electric Circuits", Schaum' Outline Series, Mc Graw Hill, 5th Edition,2009.

Web Resources: Nil

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
110.1	3	3	3	3								2	2	
110.2	3	3	3	3								2	3	
110.3	3	3	3	3								2	3	1
110.4	3	3	3	3	2	1						2	3	1
110.5	3	3	3	3	2	1						2	3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	Lab Experiment	Model Exam	END SEM EXAM
REMEMBER	20	20			20
UNDERSTAND	30	30			30
APPLY	20	20	10	10	20
ANALYZE	15	15			15
EVALUATE	15	15			15
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1:

1. The resistivity of the conductor depends on_____(u)
2. The resistance of a conductor of diameter d and length l is R Ω. If the diameter of the conductor is halved and its length is doubled, the resistance will be_____(U)

COURSE OUTCOME 2:

1. If field current is decreased in shunt dc motor, the speed of the motor_____(U)
2. What is the shunt resistance component equivalent circuit obtained by no load test of an induction motor representative of ? (U)

COURSE OUTCOME 3:

1. Explain different types of electric drives and the factors affecting the selection of drives (U)
2. Explain the thermal model of an electric motor for
   (a). Heating the electric motor when starting form cold
   (b). Cooling the electric motor when it is switched off from the mains. (U)

COURSE OUTCOME 4:

1.A CE amplifier when bypassed with a capacitor at the emitter resistance has _____
2. A transistor has h_{ie} =1KΩ and h_{fe}=60 with an bypassed emitter resistor R_e=1kΩ. What will be the input resistance and output resistance?

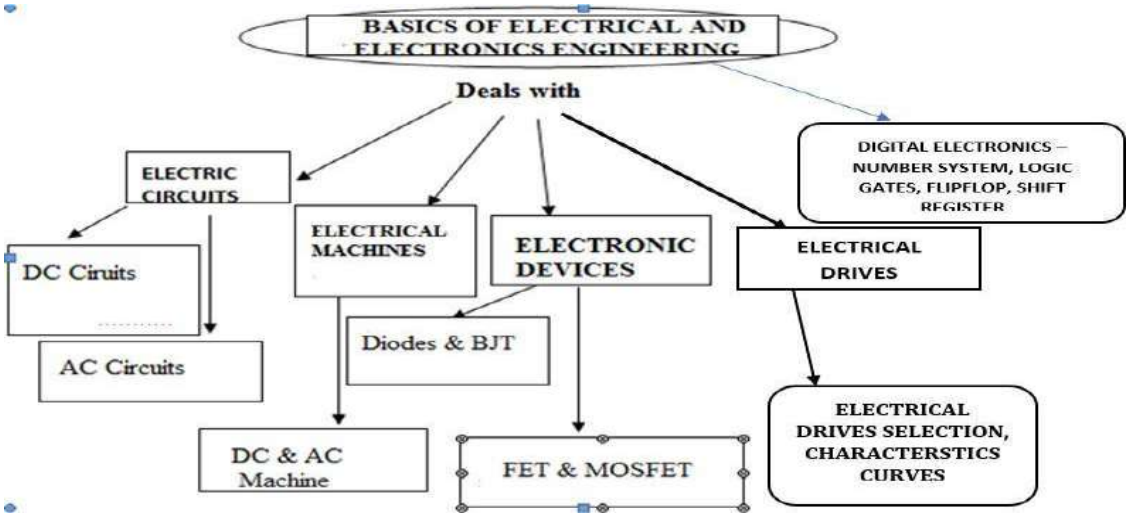
3. Describe the working of a PN junction diode with neat diagrams. Also explain its V-I Characteristics.
4.Explain the working of the CB configuration of BJT

COURSE OUTCOME 5:

1. The following hexadecimal number $(1E.43)_{16}$ is equivalent to _____ (U)
2. In an SR latch built from NOR gates, which condition is not allowed _____ (U)
3. Explain the working of JK flip flop with its logic Diagram.(U)
4. Design a full adder, construct the truth table, simply the output equations and draw the logic diagram. (U)

S.No	List of Experiments	CO
1	Verification of Ohm‟s and Kirchhoff‟s Laws	**C110.1**
2	Measurement of Power and Power Factor in Single Phase RLC Circuit	**C110.1**
3	Mechanical Characteristics of DC Shunt and Compound Motor	**C110.2**
4	Load Test on 3 Phase Induction Motor and Electric Braking	**C110.2**
5	Different Configuration of Bipolar Junction transistor & Field Effect Transistor	**C110.3**
6	Study of characteristics of Zener diode.	**C110.3**
7	Speed Control of DC Shunt Motor	**C110.4**
8	Speed Control of Single phase slip ring induction Motor	**C110.4**
9	Study of Logic Gates and Implementation of Binary Adder / Subtractor	**C110.5**
10	Implementation of Shift registers & Modulo – 16 Counter	**C110.5**

CONCEPT MAP



COURSE DESIGNERS:

1. Kannan P Assistant Professor/ECE kannanece@francisxavier.ac.in

21CS2512	Python Programming (Common for Mechanical and Civil)	L	T	P	C
		2	0	2	3

Preamble

This course is an introduction to the Python programming language for students without prior programming experience. Students are introduced to core programming concepts like data structures, conditionals, loops, variables, and functions. This course includes an overview of thevarious tools available for writing and running Python, and gets students coding quickly. It is easy for beginners to learn, it is widely used in many scientific areas for data exploration.

Prerequisites for the course

- Problem Solving Techniques, Logical Thinking

Objectives

1. To know the features of Python.
2. To develop Python programs with conditionals and loops.
3. To define Python functions and use function calls.
4. To make students to apply Python data structures – strings, lists, tuples, dictionaries.
5. To work with files in Python.
6. To handle exceptions.
7. To analyse and explore data using python libraries.

UNIT I	INTRODUCTION TO PYTHON	5

Features of Python - Modes of Python - values and data types: Variables - expressions -statements – Operators - Input and Output – comments.

UNIT II	CONTROL FLOW, FUNCTIONS	5

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Functions: function definition and use, parameters and arguments, recursion.

UNIT III	STRING, LIST, TUPLES	8

Strings: string slices, string functions and methods. Compound data - Lists: list operations - listslices - list methods - list loop. Tuples: tuple assignment - tuple as return value

UNIT IV	DICTIONARY, FILES AND EXCEPTION HANDLING	7

Dictionaries: operations and methods

Files and exception: text files, reading and writing files, Command line argument, Errors: Syntax Errors, Runtime errors, Logical Errors – Exceptions – handling exceptions		
UNIT V	**MODULES AND PACKAGES**	**5**
Modules, packages, Numpy, Seaborn, Pandas		
	Total Periods	**30 Theory +60 Lab**

S.No	**List of Experiments**	**CO**
1	Python Program using conditional statements a) Write a program for checking the given number is even orodd. b) Write a program for finding biggest number among 3 numbers c) Implement python script to read person's age from keyboard and display whether he is eligible for voting or not. d) Implement python script to check the given year is leap year or not.	CO1
2	Python Program using looping statements a) Write a Python Program to generate first N natural numbers. b) Write a python program to read a integer and for all non-negative integers i<n , print i^2. c) Write a Python Program to print factorial of a number. d) Write a Python Program to print sum of digits of anumber e) Python Program to Print All Numbers in a Range Divisible by a Given Number f) Python Program to Find Numbers which are Divisible by 7 and Multiple of 5 in a Given Range	CO2
3	Python Programs using functions a) Write a Python Program to Find Fibonacci Numbersusing Recursion b) Write a Python Program to generate Electricity Bill.	CO2
4	Python Programs using string	CO3

	a) Write a Python Program to calculate the number of digits and letters in a string. b) Write a Python Program to Count Number of Lowercase Characters in a String c) Write a Python Program to Check if the Substring is Present in the Given String	
5	Python Programs using list a) Python Program to Print Largest Even and Largest Odd Number in a List b) Python Program to Remove Duplicates from a List.	CO3
6	Python Programs using tuples a) Write a Python Program to Create a List of Tuples with the First Element as the Number and Second Element as the Square of the Number	CO3
	Python Programs using dictionaries a) Write a Python Program to Find the Sum of All the Items in a Dictionary b) Write a Python Program to Multiply All the Items in a Dictionary	CO4
5	Python Programs using files a) Write a Python Program to Count the Number of Lines, words, characters a in Text File b) Python Program to Copy One File to Another File.	CO4
7	Implementing real-time/technical applications using Exception handling. (divide by zero error, voter's age validity)	CO4
8	Programs using Python library – NumPy, Pandas, Seaborn a) Write a NumPy program to create an element-wise comparison (greater, greater_equal, less and less_equal) of two given arrays. b) Write a NumPy program to multiply the values of two given vectors. c) Write a Pandas program to get the powers of an array values element-wise. d) Write a Pandas program to create and display a DataFrame from a specified dictionary data which has the index labels.	CO5

	e) Write a Python program to find the correlation between variables of iris data. Also create a hitmap using Seaborn to present their relations.	

Laboratory Requirements

- 60 Systems with windows / LINUX operating system with python IDLE or equivalent.

Continuous Assessment Test (20 Marks)	Lab Components Assessments (30 Marks)	End Semester Practical Exams (50 Marks)
1. Descriptive questions CAT 1 – 10 Marks CAT 2 - 10 Marks	1. Lab experiments 10 Marks. 2. Model examination with project 20 Marks	1. Descriptive questions

Outcomes

Upon completion of the course, the students will be able to:

C111.1: Write Python programs for solving problems using conditional statements.

C111.2: Write Python programs for solving problems using looping statement and list and decompose a Python program into functions.

C111.3: Represent data using Python strings, lists, and tuples, and solve computational problems using them.

C111.4: Solve computational problems using data represented in dictionaries and files handle exceptions while dealing with data.

C111.5: Write modules and packages and Use Numpy, Seaborn and Pandas libraries in real time to solve scientific problems.

Text Books

1. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", Second Edition, Shroff/O'Reilly Publishers, 2016.

Reference Books

1. Charles Dierbach, "Introduction to Computer Science using Python", Wiley India Edition, 2016.

Web Resources

1. Python for Data science - https://onlinecourses.nptel.ac.in/noc20_cs36/course (Unit V – Numpy, Pandas, Seaborn)

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	2	1	1									
2	1	1	1	2	1									
3	2	2	1	1	1									
4	2	1	1	2	1									
5	1	1	1	2	1									

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	Lab Experiments	Model Lab	END SEM PRACTICAL EXAM
Remember	10	10			10
Understand	10	10			10
Apply	80	80	100	100	80
Analyze					
Evaluate					
Create					

COURSE LEVEL ASSESSMENT

QUESTIONSCOURSE OUTCOME 1:

1. Write a Python Program to read the unit of electricity consumed in a house and calculate the amount to be paid for the electricity consumed. The bill amount should be calculated as per the given specification:
    a. For 0 to 100 units the per unit is ₹ 0/-

b. For 0 to 200 units, for the first 100 unit the per unit cost is zero and the next 100 units, the consumer shall pay ₹ 1.5 per unit.
c. For 0 to 500 units, the consumer shall pay ₹ 0 for the first 100 units, for the next 100 units the consumer shall pay ₹ 2 per unit, for the next 300 units the unit cost is ₹3.00/- (Apply)

2. Explain in detail about the various conditional statements that are supported by Python. (Understand)
3. Differentiate variables and constants. (Analyse)

COURSE OUTCOME 2:

1. Write a Python Program to Read a Number n and Compute n+nn+nnn. (Apply)
2. Differentiate break and continue. (Analyse)
3. Write a Python Program to read the unit of electricity consumed in a house and calculate the amount to be paid for the electricity consumed. The bill amount shouldbe calculated as per the given specification:
   a. For 0 to 100 units the per unit is ₹ 0/-
   b. For 0 to 200 units, for the first 100 unit the per unit cost is zero and the next 100 units, the consumer shall pay ₹ 1.5 per unit.
   c. For 0 to 500 units, the consumer shall pay ₹ 0 for the first 100 units, for the next 100 units the consumer shall pay ₹ 2 per unit, for the next 300 units the unit cost is ₹3.00/- (Apply)

COURSE OUTCOME 3:

1. What is printed by the following statements? (Appy)

```
s = "engineering"

r = ""

for item in s:

    r = item.upper() + rprint(r)
```

2. Is string mutable. Justify your answer. (Understand)
3. List out some compound data type that are supported by python.(Remember)

COURSE OUTCOME 4:

1. What happens if the file is not found in the following Python code? (Apply)

```
a=False

while not a:

try:
```

```
        f_n = input("Enter

        file name")i_f =

        open(f_n, 'r')

    except:

        print("Input file not found")
```

2. Write a Python Program that Reads a Text File and Counts the Number of Times a Certain Letter Appears in the Text File. (Apply)
3. How will you handle exception when it is raised? Explain. (Understand)

COURSE OUTCOME 5:

1. Write a Pandas program to create and display a one-dimensional array-like object containing an array of data using Pandas module. (Apply)
2. Explain in detail about modules and packages in Python. (Understand)

21GE1512	Engineering Workshop	L	T	P	C
		0	0	4	2

Prerequisites for the course

Basic Science

Objectives

To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical, Electrical and Electronics Engineering.

S.No	List of Experiments	CO
1	Study of joints in roofs	C112.1
2	Hands-on-practice: T joint	C112.1
3	Preparation of Butt joints, lap joints and T joints by shielded metal arc welding	C112.2
4	Forming and Bending - Model Making-Tray, Funnel, dust pan	C112.2
5	Study of pipeline joints, its locations and functions; valves, taps, couplings, unions, reducers, elbows in household fittings	C112.3
6	Hands-on-exercise: Basic pipe connections, mixed pipe material connections, pipe connections with different joining components	C112.3
7	Study of basic construction materials, masonry and concretes	C112.3
8	Residential house wiring using switches, fuse, indicator, lamp and energy meter	C112.4
9	Fluorescent lamp wiring	C112.4
10	Earthing Techniques	C112.4
11	Stair case wiring	C112.4
12	Go down Wiring	C112.4
13	Study of Electronic components and equipment's- Resistor Color Coding and CRO	C112.5
14	Study of logic gates AND, OR, EX-OR and NOT	C112.5
15	Soldering practice – Components Devices and Circuits – Using general purpose PCB	C112.6

S.No.	List of Projects	Related Experiment	CO
1.	Making a Switch Board		C112.1

2.	Making a Tool Stand	Carpentry	C112.1
3.	Making a Table Drawer		C112.1
4.	Fabrication of Footstep Pedastal		C112.1
5.	Making a Welding Fixtures	Welding	C112.2
6.	Making a Sheet Metal Bending Machine		C112.2
7.	Fabrication of Metal Box		C112.2
8.	Fabrication of Welding Chute	Sheet Metal	C112.2
9.	Fabrication of Tool Box		C112.2
10.	Fitting water pipeline to wash basin	Plumbing	C112.3
11.	Construct of partition wall using Flemish bond	Masonry & Concrete	C112.3
12.	Grade of Concrete		C112.3
13.	House Wiring	1. Fluorescent Wiring 2. Staircase Wiring 3. Go down Wiring 4. Residential House Wiring	C112.4
14.	GSM based House Monitoring Control System	Soldering Practice – Component Devices & Circuits	C112.6
15.	Android based electrical appliance control	Soldering Practice – Component Devices & Circuits	C112.6

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	**End Semester Exams (40 Marks)**
LAB EXPERIMENTS 40 MARKS **MODEL LAB WITH PROJECT 20 MARKS**	**40**

Outcomes

Upon completion of the course, the students will be able to:

C113.1	Fabricate carpentry components
C113.2	Use welding equipment's to join the structures and sheet metal works
C113.3	Perform basic plumbing operations and concrete study

C113.4	Carry out basic home electrical works and appliances
C113.5	Measure the electrical and electronic Parameters and quantities
C113.6	Elaborate on the components, gates, soldering practices

Laboratory Requirements

	CIVIL	
1	Assorted components for plumbing consisting of metallic pipes, Plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings	15 Sets
2	Carpentry vice (fitted to work bench)	15 Nos
3	Standard woodworking tools	15 Sets
4	Models of industrial trusses, door joints, furniture joints	5 Nos
5	Power Tools: Demolition Hammer Hand Drilling Machine Wooden Cutter	2 Nos. 2 Nos. 2 Nos.
	MECHANICAL	
1	Arc welding transformer with cables and holders	5 Nos.
2	Welding booth with exhaust facility	5 Nos.
3	Welding accessories like welding shield, chipping hammer, Wire brush, etc.,	5 Sets
4	Power Tool: Angle Grinder	2 Nos.
5	Sheet metal working tools	15 Sets.
6	Standard working tools	15 sets
	ELECTRICAL	
1	Assorted electrical components for house wiring	15 Sets
2	Electrical Measuring Instruments	10 Sets
3	Study purpose items: Iron box, fan and regulator, emergency lamp	1 Each
4	Megger (250V/500V)	1No.
5	Power Tools: (a) Range Finder (b) Digital Live-wire detector	2 Nos
	ELECTRONICS	
1	Soldering guns	10 Nos.
2	Assorted electronic components for making circuits	50Nos.
3	Small PCBs	10 Nos.
4	Multimeters	10Nos.

Reference Books

1. K.Jeyachandran, S.Natarajan& S, Balasubramanian, "A Primer on Engineering Practices Laboratory", Anuradha Publications, (2007)
2. T.Jeyapoovan, M.Saravanapandian&S.Pranitha, "Engineering Practices Lab Manual", Vikas Publishing House Pvt. Ltd, (2006)
3. H.S. Bawa, "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, (2007)
4. A.Rajendra Prasad & P.M.M.S. Sarma, "Workshop Practice", Sree Sai Publication, (2002).

Web Resources

https://mechanicalenotes.com/engineering-workshop/

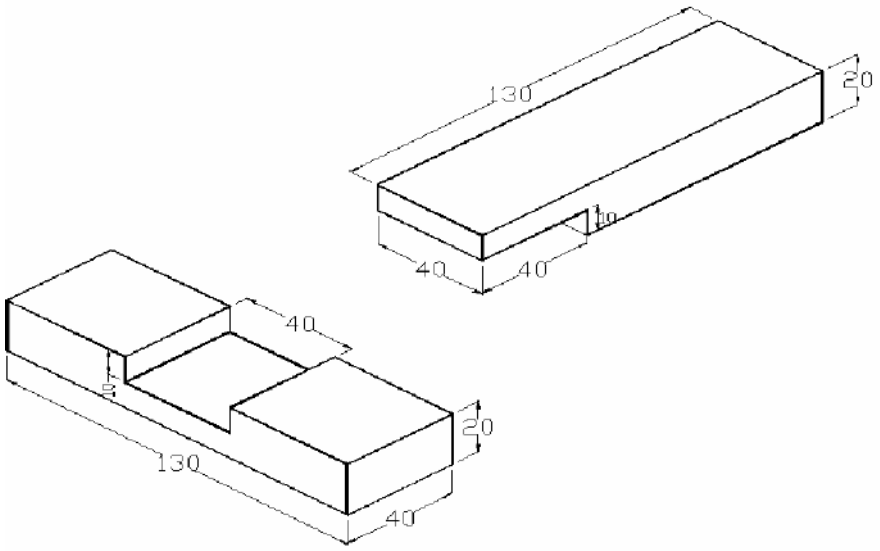
CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	**3**	**2**	**2**						**1**			**1**	**3**	
2	**2**	**3**	**2**						**1**			**1**	**3**	
3	**3**	**3**	**1**						**1**			**1**	**3**	
4	**3**	**2**	**2**						**1**			**1**	**3**	
5	**2**								**1**				**1**	
6	**3**	**2**							**1**				**2**	

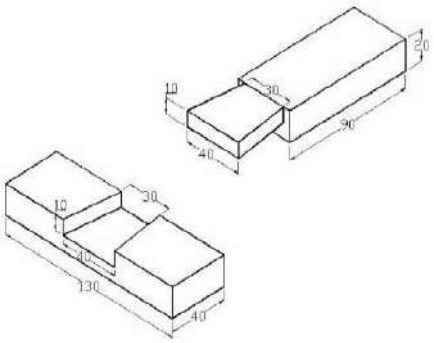
COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to fabricate carpentry components (Apply)

1) Make a T-lap joint from the given wood pieces as shown in the drawing**.**

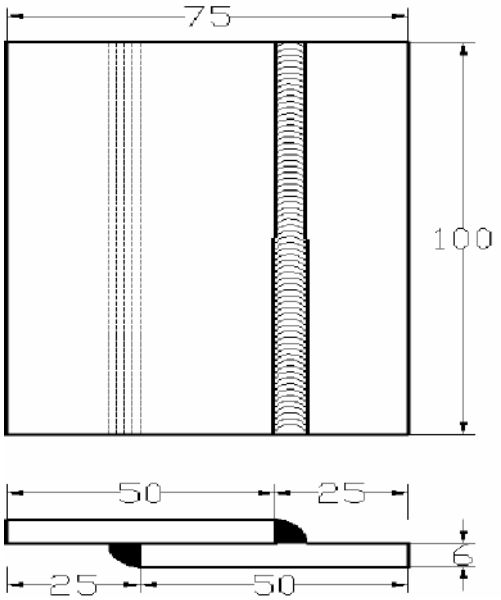


2) Make a dovetail joint from the given wooden work piece as per the drawing given below.

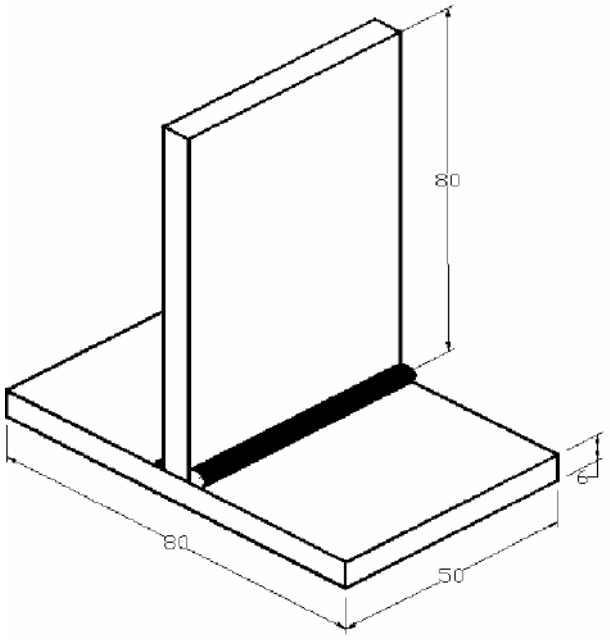


COURSE OUTCOME 2: Students will be able to Use welding equipment's to join the structures and sheet metal works (Apply)

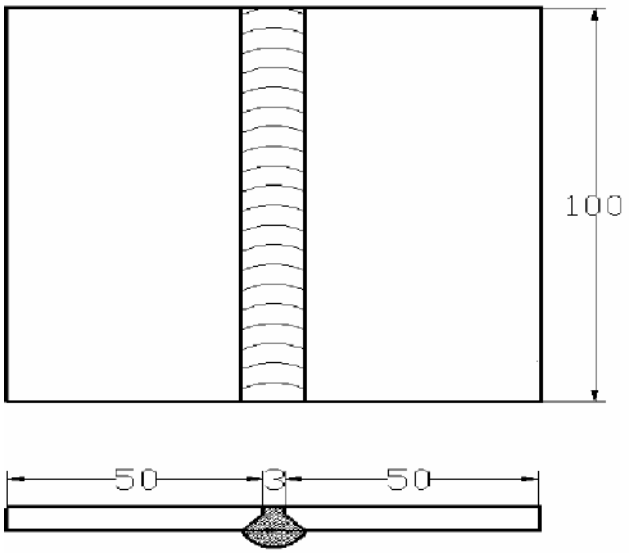
1. Make a Lap joint from the given pieces using arc welding as shown in the drawing.



1. Prepare a 'T' joint from the given M.S. plates using arc welding as shown in the diagram

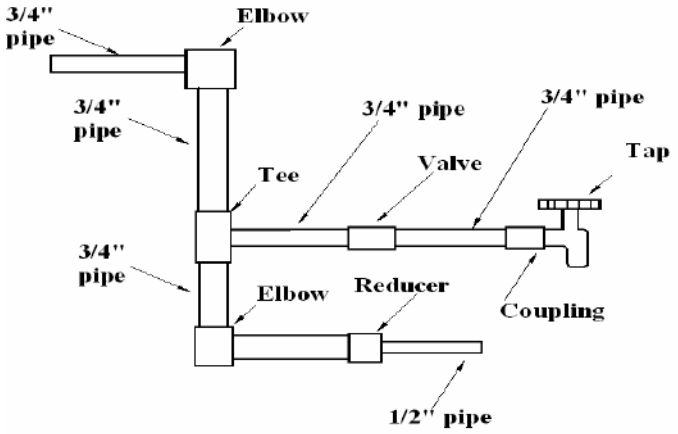


2. Prepare a 'Butt' joint from the given M.S. plates using arc welding as shown in the diagram

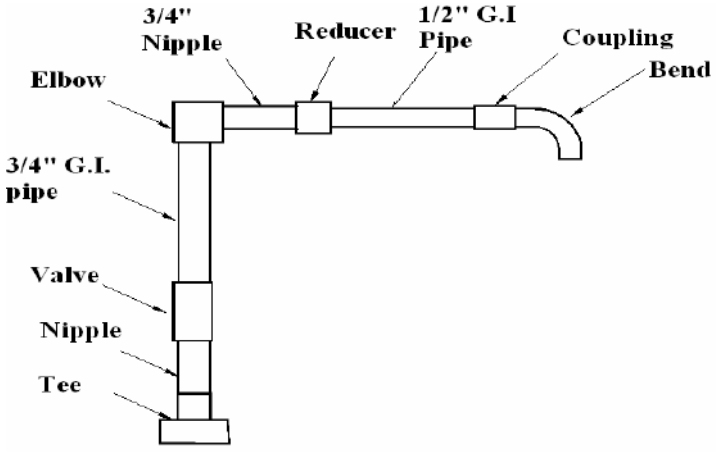


COURSE OUTCOME 3: Students will be able to perform basic plumbing operations

1. Make a pipe fitting connections from the given GI / PVC pipes and fittings as shown in the drawing.



2. Prepare the GI / PVC Pipe joint by using the given pipes and fittings as per the diagram given below.



3. Study of basic construction materials, masonry and concretes

COURSE OUTCOME 4: Students will be able to carry out basic home electrical works and appliances.

1. Make an industrial illumination circuit wiring using switches, fuse, indicator, lamp and energy meter.

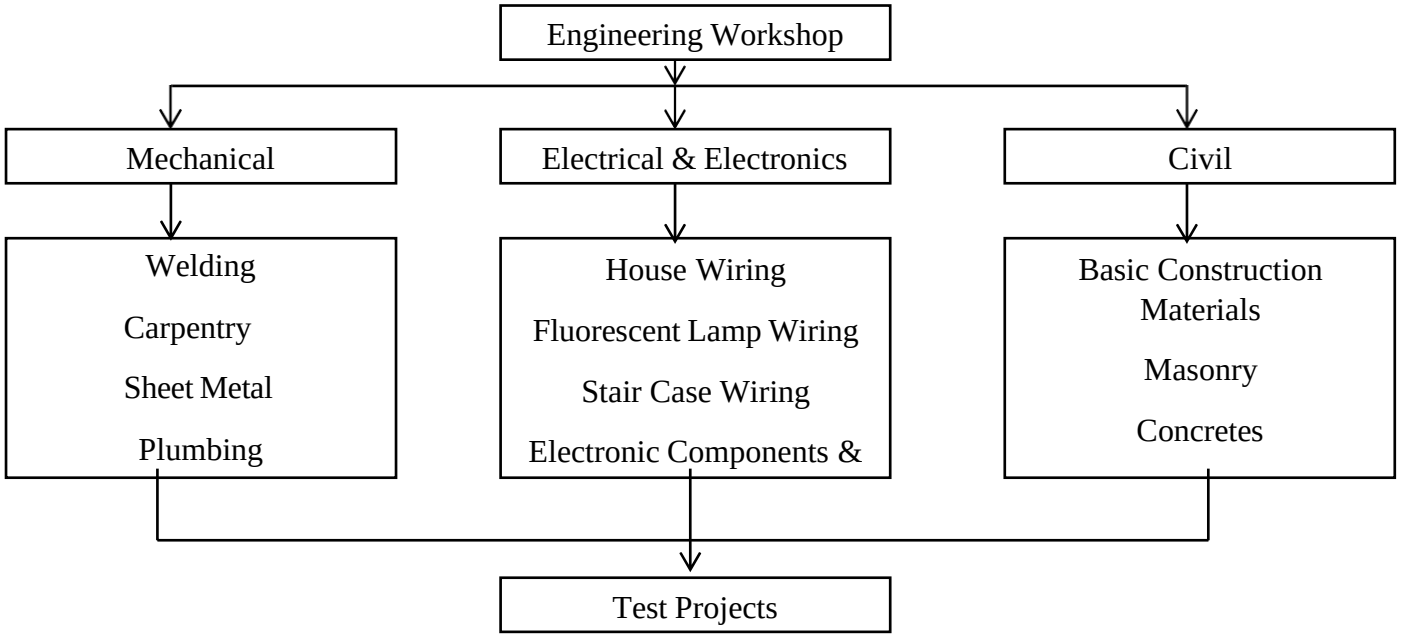
COURSE OUTCOME 5: Students will be able to measure the electrical and electronic parameters and quantities

1. Conduct an experiment using a starter to show the lamp will continue to glow even when starter is removed.

COURSE OUTCOME 6: Students will be able to elaborate on the components, gates, soldering practices

1. To perform soldering and Desoldering of electronic components on PCB

Concept Mapping



COURSE DESIGNERS

1. Dr.RKA Bhalji, Assistant Professor /Mech **HoD/Mech**

SEMESTER III

21MA3201	Probability and Statistical Analysis	L	T	P	C
		3	1	0	4

Preamble:

This course provides an introduction to numerical methods and engineering statistics for engineering students. The focus of numerical methods is translating engineering problems into algorithms and implementing them in a spreadsheet or programming language. Topics covered include numerical interpolation, integration and differential equations. The statistics portion teaches students basic probability theory, standard distribution, the central limit theorem, hypothesis testing, confidence intervals and design of experiments.

Prerequisites for the course

Basic knowledge in probability theory.

Objectives

The Course will enable learners:

1. To improve their ability in solving partial and ordinary differential equations with initial and boundary conditions.
2. To have knowledge in simple integrals.
3. To introduce the basic concepts of probability.
4. To familiarize with ANOVA
5. To apply the concept of testing of hypothesis to Engineering problems

UNIT I	Interpolation and Numerical Integration	9+3

Lagrange's interpolation formula for unequal intervals – Newton's forward and backward difference interpolation for Equal intervals – Numerical single integrations using Trapezoidal, Simpson's 1/3 rule and Simpson's 3/8 rule

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Newton's forward and backward interpolation, Numerical integration.

UNIT II	Numerical Solution of Ordinary Differential Equations	9+3

Solution of ODE by Single step methods: Taylor's series method - Euler's method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods : Milne's method for solving first order equations.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Taylor's series, Euler's method, Fourth order Runge-Kutta method and Adam's method

UNIT III	Probability and Distributions	9+3

Definitions of probability, sampling theorems, conditional probability; mean, median, mode and Standard deviation; Random variables, Binomial, Poisson and Normal distribution.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Probability, Random variables and distributions.

UNIT IV	Testing of Hypothesis	9+3

Sampling distributions and Standard Error - Small samples and large samples - Test of hypothesis - Type I, Type II Errors - Large sample tests for mean –Small sample tests for mean – t and f test - Chi-Square distribution -Test of independence of attributes.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on Small sample tests for mean – t ,f test, Chi- Square distribution.

UNIT V	Design of Experiments	9+3

Basic principles of experimentation - Analysis of variance – One-way classification – Completely Randomized Design –Two-way classification - Randomized Block Design – Comparison of CRD and RBD.

SUGGESTED EVALUATION METHODS:

- Tutorial Problems on ANOVA, Completely Randomized Design

Total Periods	**45 + 15 = 60 Periods**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
1. Descriptive Questions CAT 1 – 10 Marks CAT 2 – 10 Marks	1. Assignment 2. Online Quizzes	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO 1: Apply numerical techniques in interpolations and Integration (Apply)
CO 2: Apply the concepts of probability which can describe real life phenomenon. (Apply)
CO 3: Apply the concept of probability distributions which can describe real life Problems (Apply)
CO 4: Compare testing of hypothesis for small and large samples in real life problems. (Analyze)
CO 5: Analyze the design of experiments in the field of agriculture (Analyze)

Text Books

1. .R.K.Iyengar & R.K Jain , "Numerical Methods" New Age International Publishers , New Edition 2015. (CO1, CO2)
2. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015. (CO3, CO4, CO5)

Reference Books

1. Burden, R.L and Faires, J.D, "Numerical Analysis", 9th Edition, Cengage Learning, 2016.
2. Devore. J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, New Edition, 2017.
3. Gerald. C.F. and Wheatley. P.O. "Applied Numerical Analysis" Pearson Education, Asia, New Delhi, 2016.
4. Grewal. B.S. and Grewal. J.S., "Numerical Methods in Engineering and Science ", 10th Edition, Khanna Publishers, New Delhi, 2015.
5. Advanced Engineering Mathematics E. Kreyszig John Wiley & Sons 10th Edition, 2016.
6. Engineering Mathematics Srimanta Pal et al Oxford University Press 3 rd Edition, 2016

Web Resources:

1. Numerical Integration -https://archive.nptel.ac.in/content/storage/111/107/111107105/MP4/mod01lec01.mp4 https://youtu.be/YTHt4Sp8Hag
2. Numerical Solution of Ordinary Differential Equations -https://archive.nptel.ac.in/content/storage2/127/106/127106019/MP4/mod01lec01.mp4 https://youtu.be/m2p6hrQGaxQ
3. Probability and distributions - https://youtu.be/cp7_ZF2kNi4
4. Testing of hypothesis - https://youtu.be/8oNGkvuRP60
5. Design of experiments - https://youtu.be/KhjM8YI3agk

CO Vs PO Mapping and CO Vs PSO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	2	1	1				1	1			1			
2	3	2	1	1				1	1			1			
3	3	2	1	1				1	1			1			
4	3	2	1	1				1	1			1			
5	3	2	1	1				1	1			1			

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2										2		
2	3	2												
3	3	2												
4	3	2										2		
5	3	2										2		

ASSESSMENT PATTERN :

BLOOM'S CATEGORY	ASSESSMENT TESTS				END SEMESTER EXAMINATION
	CAT – 1	CAT -2	FAT - 1	FAT - 2	
REMEMBER	10	10	5	5	10
UNDERSTAND	30	10	10	10	10
APPLY	60	40	10	10	50
ANALYZE	0	40	0	0	30
EVALUATE	0	0	0	0	0
CREATE	0	0	0	0	0

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 (CO 1) : (Apply)

1) (i) Find the y(3) in the following table using Lagrange's interpolation formula

X	0	1	2	4
Y	1	3	9	81

ii) By dividing the range into 10 equal parts evaluate $\int_0^{\pi} \vec{sin} nx\, dx$

2) Find $y(0.1)$ using Runge-Kutta (R.K) method given that $\frac{dy}{dx} = y^2 + xy;\ y(0)=1$

COURSE OUTCOME 2 (CO 2) : (Apply)

1) A random variable 'X' has the following probability function

X	0	1	2	3	4	5	6	7	8
p(x)	a	3a	5a	7a	9a	11a	13a	15a	17a

(i) Determine the value of 'a'
(ii) Find $P(X < 3), P(X \geq 3), P(0 < X < 5)$
(iii) Find the distribution function of X.

2) If X is a continuous random variable with probability density function

$$f(x) = \begin{cases} kx^2, & -1 < x < 1 \\ 0, & else\ where \end{cases}$$

then find (i)The value of k
(ii)The mean and variance of X
(iii) $P(\frac{1}{3} \leq x < 4)$

COURSE OUTCOME 3 (CO 3) : (Apply)

1) Derive Mean and Variance of a Binomial distribution
2) The weekly wages of 1000 workmen are normally distributed around a mean of Rs. 70 with Standard Deviation of Rs. 5. Estimate the number of workers whose weekly wages will be (i) Between Rs. 69 and 72 (ii) less that Rs. 69 (iii) more than Rs 72.

COURSE OUTCOME 4 (CO 4) : (Analyze)

1. A random sample of 10 boys had the following I.Q.'s 70, 120, 110, 101, 88, 83, 95, 98, 107, 100. Do these data support the assumption of a population mean I.Q of 100 ? Find a reasonable range in which most of the mean I.Q values of samples of 10 boys lie.

2. To verify whether a course in accounting improved performance, a similar test was given to participant both before and after the course. The marks are

Before :	44	40	61	52	32	44	70	41	67	72	53	72
After :	53	38	69	57	46	39	73	48	73	74	60	78

What the course useful?

3. Two batches each of 12 animals are taken for test of inoculation. One batch was inoculated and the other batch was not inoculated. The numbers of dead and surving animals are given in the following table in the both cases. Can the inoculation be regarded as effective against the disease?

	Dead	Survived
Inoculated	15	85
Not inoculated	25	75

COURSE OUTCOME 5 (CO 5): (Analyze)

1. An experiment was designed to study the performance of 4 different detergents for cleaning fuel injectors. The following "cleanness "readings were obtained with specially designed equipment for 12 tanks of gas distributed over 3 different models of engines:

	Engine 1	Engine 2	Engine 3	Total
Detergent A	45	43	51	139
Detergent B	47	46	52	145
Detergent C	48	50	55	153
Detergent D	42	37	49	128
Total	182	176	207	565

Perform the ANOVA and test at 0.01 level of significance whether there are differences in the detergents or in the engines.

2. A variable trial was conducted on wheat with 4 varieties in a Latin Square Design . The plan of the experiment and the per plot yield are given below.:

C	25	B	23	A	20	D	20
A	19	D	19	C	21	B	18
B	19	A	14	D	17	C	20
D	17	C	20	B	21	A	15

Analyze data and interpret the result.

21ME3601	ENGINEERING THERMODYNAMICS	L	T	P	C
		3	1	0	4

Prerequisites for the course

Engineering Physics and Engineering Chemistry

Objectives

- Impart knowledge on the basics and application of zeroth and first law of thermodynamics.
- Impart knowledge on the second law of thermodynamics in analysing the performance of thermal devices.
- Impart knowledge on availability and applications of second law of thermodynamics
- Teach the various properties of steam through steam tables and Mollier chart.
- Impart knowledge on the macroscopic properties of ideal and real gases.

UNIT I	BASICS, ZEROTH AND FIRST LAW	9+3

Basics: Thermodynamic system - types, surrounding, universe – state, path, process - Quasi-static, reversible and irreversible processes - Path and point functions - Intensive and extensive properties - total and specific quantities - Thermodynamic Equilibrium - Heat and work transfer - sign convention, P-V diagram. Zeroth law – Concept of temperature and Temperature Scales. First law – application to closed and open systems – steady and unsteady flow processes.

UNIT II	SECOND LAW AND ENTROPY	9+3

Heat source and sink - Statements of second law and its corollaries - Carnot cycle, performance - Heat Engine - Reversed Carnot cycle - Refrigerator - Heat pump. Clausius inequality - Concept of entropy - T-s diagram - Entropy change for pure substance - principle of increase in entropy - Applications of II Law. Availability and Irreversibility for open and closed system.

UNIT III	PROPERTIES OF PURE SUBSTANCES	9+3

Formation of steam - P-v, T-s, h-s diagrams. Determination of properties of steam using Steam Table and Mollier Chart – Ideal and actual Rankine cycles, Cycle Efficiency Improvement Methods.

UNIT IV	IDEAL AND REAL GASES, THERMODYNAMIC RELATIONS	9+3

Properties of Ideal gas, real gas - comparison. Equations of state for ideal and real gases. vander Waal's relation - Reduced properties - Compressibility factor - Principle of Corresponding states - Generalized Compressibility Chart. Maxwell relations - Tds Equations - heat capacities relations - Energy equation, Joule-Thomson experiment - Clausius-Clapeyron equation.

UNIT V	PSYCHROMETRY	9+3

Dalton's Law - Psychrometric properties - Psychrometric chart – air-vapour mixture property calculations using chart and expressions - Psychrometric processes –sensible heating and cooling – humidification and dehumidification - evaporative cooling - adiabatic mixing. Simple applications

Total Periods	45+15 =60 Hours

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10MARKS CAT 2 – 10MARKS Descriptive Questions	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

C202.1: Understand the zeroth and first law of thermodynamics, temperature scales and calculate the property changes in closed and open engineering systems.
C202.2: Apply the second law of thermodynamics in analysing the performance of thermal devices through energy and entropy calculations.
C202.3: Evaluate various properties of steam and performance parameters of Rankine cycle.
C202.4: Understand the properties of gases and its thermodynamic relations.
C202.5: Analyse the properties of air-vapour mixtures and understand the various psychrometric processes.

Text Books

1. Nag.P.K., "Engineering Thermodynamics", 6th Edition, Tata McGraw Hill (2017), New Delhi
2. Natarajan, E., "Engineering Thermodynamics: Fundamentals and Applications", 2nd Edition (2014), Anuragam Publications, Chennai

Reference Books

1. Cengel, Y and M. Boles, Thermodynamics - An Engineering Approach, Tata McGraw Hill,8th Edition, 2015.
2. Chattopadhyay, P, "Engineering Thermodynamics", 2nd Edition Oxford University Press, 2016.
3. Rathakrishnan, E., "Fundamentals of Engineering Thermodynamics", 2nd Edition, Prentice Hall of India Pvt. Ltd, 2006.
4. Claus Borgnakke and Richard E. Sonntag, "Fundamentals of Thermodynamics", 7th Edition, Wiley Eastern, 2009.
5. Venkatesh. A, "Basic Engineering Thermodynamics", Universities Press (India) Limited, 2007.

Web Resources

1. https://archive.nptel.ac.in/courses/112/105/112105123/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C202.1	3		2	1										3
C202.2	3	2	1				1							3
C202.3	2	2	1	1			1							3
C202.4	3	2	1	1										3
C202.5	2	2	1	1			1							3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10	5	5	10
UNDERSTAND	10	10	5	5	10
APPLY	30	30			30
ANALYZE	30	30	10	10	30
EVALUATE	20	20	5	5	20
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Understand the zeroth and first law of thermodynamics, temperature scales and calculate the property changes in closed and open engineering systems (Understand, Apply, Analyze, Evaluate)

1. A piston and cylinder machine contains a fluid system which passes through a complete cycle of four processes. During the cycle, the sum of all heat transfers is -170kJ. The system completes 100 cycles per minute. Complete the following table showing the method for each item, and compute the net rate of work input in kW. (An)

Process	Q (kJ/min)	W (kJ/min)	ΔE (kJ/min)
a-b	0	2,170	------
b-c	21,000	0	------
c-d	-2,100	------	-36,600
d-a	-------	------	------

2. Air flows steadily at the rate of 0.5 kg/s through an air compressor entering at 7m/s velocity, 100 kPa pressure and 0.95 m^3/kg, volume and leaving at 5m/s, 700kPa and 0.19 m^3/kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. The cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW.
   (a). Compute the rate of shaft work input to the air in kW.
   (b).Find the ratio of the inlet pipe diameter to the outlet pipe diameter.(E)

COURSE OUTCOME 2: Apply the second law of thermodynamics in analyzing the performance of thermal devices through energy and entropy calculations (Apply, Analyze, Evaluate)

1. A reversible heat engine operating between reservoirs at 900K and 300K drives a reversible refrigerator operating between reservoirs at 300K and 250K. The heat engine receives 1800kJ heat from 900K reservoir. The net output from the combined engine refrigerator is 360kJ. Find the heat transferred to the refrigerator and the net heat rejected to the reservoir at 300K. (An)

2. Two kg of air at 500 kPa, 80°C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings which is at 100 kPa, 5°C. For this process, Determine:

   (i) The maximum work

   (ii) The change in availability

   (iii) The irreversibility.(E)

COURSE OUTCOME 3: Calculate various properties of steam and performance parameters of Rankine cycle.(Remember, Apply, Analyze)

1. Explain the phase transformation that takes place when ice (solid) is heated continuously till superheated steam is obtained. Name the different states involved. Sketch the transformation on a 'temperature' Vs 'heat added' diagram. **(**R)

2. In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35bar and the exhaust pressure is 0.2 bar. The flow rate of steam 9.5 kg/s. Determine (i)the pump work (ii)the turbine work (iii)Rankine efficiency (iv)Condenser heat flow (v)Work ratio (vi)Specific steam consumption. (An)

COURSE OUTCOME 4: Understand the properties of gases and its thermodynamic relations(Remember, Understand)

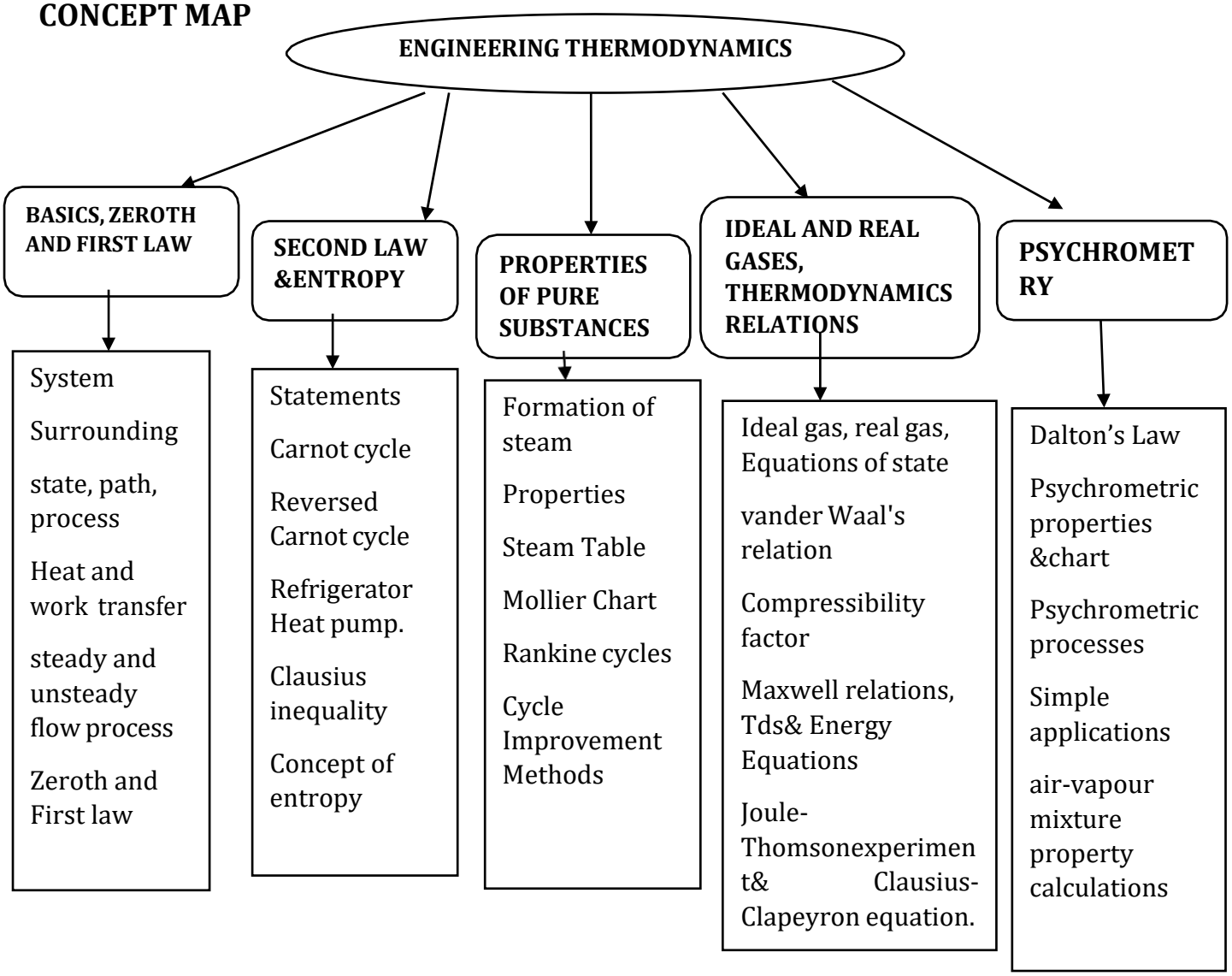
1. Derive Joule Thomson cooefficient and prove that joule Thomson coefficient for ideal gas is zero. **(**R)
2. Deduce the expression for variousthermodynacicTds relations of ideal and real gases. **(**U).

COURSE OUTCOME 5: Calculate the properties of air-vapour mixtures and understand the various psychrometric processes (Apply, Analyze, Evaluate)

1. Air at 20°C,40% RH is mixed adiabatically with air at 40°C, 40% RH in the ratio of 1kg of the former with 2kg of the latter (on dry basis). Find the final condition of air.(An)

2. An air – water vapour mixture at 20°C and 50% relative humidity at a presence of 1.013 bar is heated at constant pressure to a temperature of 35°C. calculate a)The initial and final specific humidity b).Final relative humidity c).Dew point temperature d).Heat transferred per kg of dry air.(E)

CONCEPT MAP


ENGINEERING THERMODYNAMICS
BASICS, ZEROTH AND FIRST LAW
System
Surrounding
state, path, process
Heat and work transfer
steady and unsteady flow process
Zeroth and First law
SECOND LAW &ENTROPY
Statements
Carnot cycle
Reversed Carnot cycle
Refrigerator Heat pump.
Clausius inequality
Concept of entropy
PROPERTIES OF PURE SUBSTANCES
Formation of steam
Properties
Steam Table
Mollier Chart
Rankine cycles
Cycle Improvement Methods
IDEAL AND REAL GASES, THERMODYNAMICS RELATIONS
Ideal gas, real gas, Equations of state
vander Waal's relation
Compressibility factor
Maxwell relations, Tds& Energy Equations
Joule-Thomsonexperiment& Clausius-Clapeyron equation.
PSYCHROMETRY
Dalton's Law
Psychrometric properties &chart
Psychrometric processes
Simple applications
air-vapour mixture property calculations

21ME3602	FLUID MECHANICS AND MACHINERY	L	T	P	C
		2	1	0	3

Prerequisites for the course

- Engineering physics

Objectives

- Introduce the properties of the fluid, behaviour of fluids under static conditions,
- Impart basic knowledge of the dynamics of fluids and boundary layer concepts.
- Convey the methods of dimensional analysis and model studies
- Expose to the basic principles of hydraulic machine (turbines) and to design Pelton wheel.
- Familiarize with the working principle of pump along with construction of performance curves.

UNIT I	FLUID PROPERTIES AND FLOW CHARACTERISTICS	8+2

Properties of fluids- Pressure Measurements-Buoyancy and floatation-Flow characteristics- Eulerian and Lagrangian Principle of fluid flow– concept of control volume and system – Reynold's transportation theorem- continuity equation, energy equation and momentum equation-Applications.

UNIT II	FLOW THROUGH PIPES	7+2

Reynold's experiment -Laminar flow through circular conduits and circular annuli – Darcy, Weisbach equation – Friction factor and Moody diagram –Minor losses - Hydraulic and energy gradient –Pipes in series and parallel – loss of energy in pipes – Equivalent pipes. Boundary layer concepts – types of boundary layer thickness

UNIT III	DIMENSIONAL ANALYSIS AND MODEL STUDIES	5+2

Fundamental dimensions – Dimensional homogeneity – Rayleigh's method and Buckingham Pi theorem – Dimensionless parameters – Similitude and model studies.

UNIT IV	HYDRAULIC TURBINES	8+2

Impact of jets - Velocity triangles - Theory of roto-dynamic machines - Classification of turbines – Pelton wheel, Francis turbine (inward and outward) and Kaplan turbine- Working principles - Work done by water on the runner - Efficiencies – Draft tube - Specific speed - Performance curves for turbines – Governing of turbines.

UNIT V	HYDRAULIC PUMPS	7+2

Classification of pumps- Centrifugal pumps– working principle - Heads and efficiencies– Velocity triangles- Work done by the impeller - performance curves - Reciprocating pump working principle – indicator diagram and it's variations – work saved by fitting air vessels – cavitations in pump.

Total Periods	35+10 = 45 Hours

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test(20 Marks)**	**End Semester Exams (60Marks)**
CAT 1 - 10 Marks CAT 2 -10 Marks DESCRIPTIVE QUESTIONS	1.Descriptive type questions, and 2.Multiple choice questions,	1.Descriptive type questions.

Course Outcomes

Upon completion of the course, the students will be able to:

C203.1: Calculate the fluid properties using continuity, energy and momentum equation.

C203.2: Estimate the major loss in flow through pipes using Darcy Weisbach equation.

C203.3: Discover the relationship among the parameters involved in the given fluid phenomenon and to predict the performances of prototype by model studies.

C203.4: Construct the performance curves for both impulse and reaction turbines.

C203.5: Construct the characteristic curves for centrifugal and reciprocating pumps using empiricalrelations.

Text Books

1. Modi P.N. and Seth, S.M. Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, (2017).
2. Victor L.Streeter, Wylie E. Benjamin and Bedford W. Keith W, "Fluid Mechanics",Tata McGraw-Hill Publishing CompanyLtd, New Delhi, 9th Edition, 2017.

Reference Books

1. Bansal, R.K., "Fluid Mechanics and Hydraulics Machines", Laxmi publications (P) Ltd, New Delhi, 5th Edition, 2013.
2. White, F.M., "Fluid Mechanics", Tata McGraw-Hill, New Delhi, 5th Edition, 2013.
3. Ramamirtham, S., "Fluid Mechanics, Hydraulics and Fluid Machines", Dhanpat Rai and Sons, New Delhi, 2012.

Web Resources

1. https://onlinecourses.nptel.ac.in/noc21_ce56/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C203.1	3	2	2	-								1		3
C203.2	2	3	1											3
C203.3	2	3	1									1		3
C203.4	2	3	1											3
C203.5	2	3	1											3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	5	5	20
UNDERSTAND	30	30	10	10	30
APPLY	50	50	10	10	50
ANALYZE					
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

C203.1: List the various fluid properties and apply control volume concept to fluid mechanics problems – (Apply)

1. Define specific gravity and mention the specific gravity of Mercury. [**R**]

2. The temperature of lubricant circulated in the engine gets raised during working stroke. What happens to its viscosity? [**U**]

3. Water flows through a pipe AB 1.2 m diameter at 3 m/s and then passes through a pipe BC 1.5 m diameter. At C the pipe branches. Branch CD is 0.8 m in diameter and carries one – third of the flow in AB. The flow velocity in the branch CE is 2.5 m/s. Find the volume rate of flow at AB, the velocity in BC, the velocity in CD and the diameter of CE. [**Ap**]

C203.2:Estimate the major loss in flow through pipes using Darcy Weisbach equation. (Apply)

1. Enumerate the various losses that occur in the fluid flowing through the pipe. [**R**]

2. Mention the governing equation for minor losses that occur in a pipe having an obstacle formed due to scaling in boiler tubes. [**U**]

3. Three pipes of 400 mm, 200 mm and 300 mm diameters have lengths of 400 m, 200 m, and 300 m respectively. They are connected in series to make a compound pipe. The ends of this compound pipe are connected with two tanks whose difference of water levels is 16 m. if co-efficient of friction for these pipes is same and equal to 0.005, determine the discharge through the compound pipe neglecting first the minor losses and then including them. [**Ap**]

C203.3:Discover the relationship among the parameters involved in the given fluid phenomenon and to predict the performances of prototype by model studies. (Apply)

1. Name a few fluid properties and state its dimensions. [**R**]

2. Explain the term dimensional homogeneity. **[U]**

3. The resisting force R of a supersonic plane during flight can be considered as dependent upon the length of the aircraft l, velocity V, air viscosity μ, air density ρ and bulk modulus of air K. Express the functional relationship between these variables and the resisting force. [**Ap**]

C203.4: Describe the working principle and construct performance curves for both impulse and reaction turbines–(Apply)

1. With a neat sketch represent the velocity triangle for a hydraulic turbine. [**R**]

2. Explain the difference between the impulse and reaction turbines. [**U**]

3. Determine the power given by the jet of water to the runner of a Pelton wheel which is having tangential velocity as 20 m/s. the net head on the turbine is 50 m and discharge through the jet water is 0.03 m3/s. the side clearance angle is 15° and take Cv as 0.975. [**Ap**]

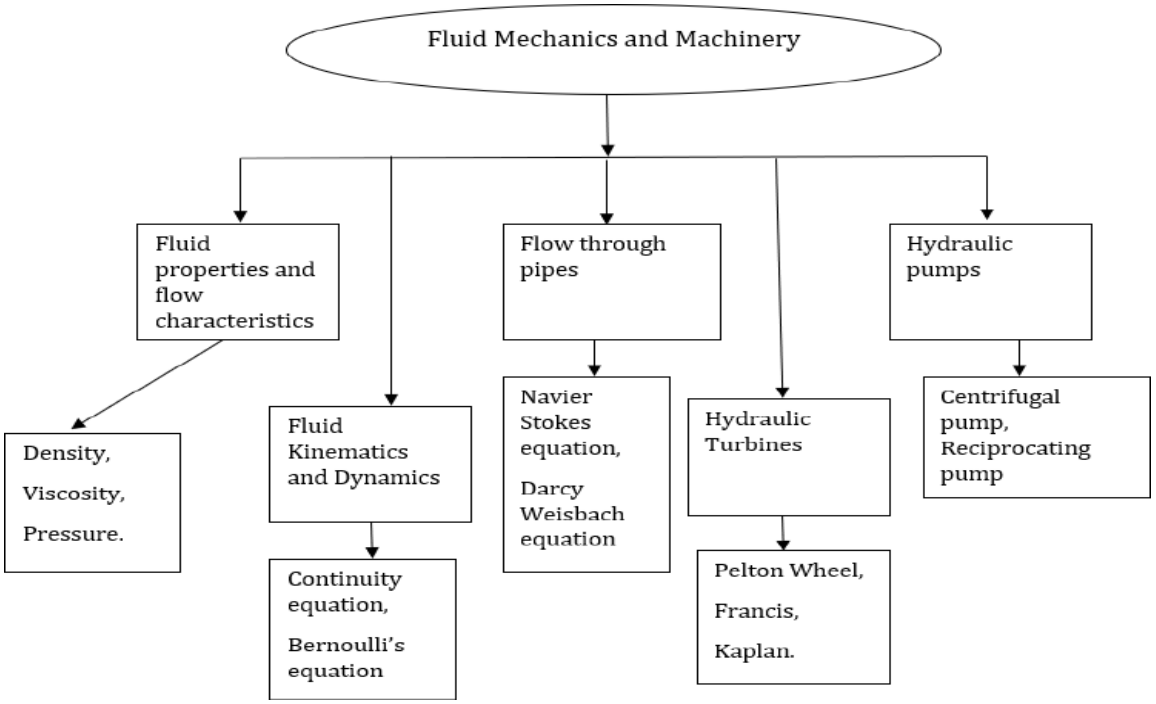
C203.5: Construct the characteristic curves for centrifugal and reciprocating pumps using empirical relations-(Apply)

1. Define manometric efficiency. [R]

2. What happens to overall efficiency when mechanical efficiency is doubled and manometric efficiency is halved? [**U**]

3. The internal and external diameters of the impeller of a centrifugal pump are 200 mm and 400 mm respectively. The pump is running at 1200 rpm. The vane angles of the impeller at inlet and outlet are 20 and 30 respectively. The water enters the impeller radially and velocity of flow is constant. Determine the work done by the impeller per unit weight of water. [**Ap**]

CONCEPT MAP



21ME3501	ENGINEERING MATERIALS AND METALLURGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Physics

Objectives

- Explain the principles of constitution of alloys, phase diagrams, and Iron carbide Equilibrium Diagram.
- Classify various types of Heat treatment process and its applications.
- Discuss the properties and applications of Ferrous and Nonferrous metals.
- Summarize the properties of Non-metallic materials and applications.
- Select the suitable materials for various Engineering applications.

UNIT I	ALLOYS AND PHASE DIAGRAMS	9

Constitution of alloys – Solid solutions, substitutional and interstitial – phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Stress strain diagram for mild steel, Cast iron ,plastic, glass and aluminium, Iron – carbon equilibrium diagram. Classification of steel and cast Iron microstructure, properties and application

UNIT II	HEAT TREATMENT	9

Definition – Full annealing, stress relief, recrystallisation and spheroidising – normalising, hardening and tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR – Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburizing, Nitriding, cyaniding, carbonitriding – Flame and Induction hardening – Vacuum and Plasma hardening. Surface treatment process – shot blasting – sand blasting

UNIT III	FERROUS AND NON-FERROUS METALS	9

Effect of alloying additions on steel-α and β stabilisers– stainless and tool steels – HSLA, Maraging steels – Cast Iron – Grey, white, malleable, spheroidal – alloy cast irons, Copper and copper alloys – Brass, Bronze and Cupronickel – Aluminium and Al-Cu – precipitation strengthening treatment – Bearing alloys, Mg–alloys, Ni–based super alloys and Titanium alloys

UNIT IV	NON-METALLIC MATERIALS	9

Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PP, PS, PVC, PMMA, PET, PC, PA, ABS, PI, PAI Polymers – Urea and Phenol formaldehydes) – Engineering Ceramics – Properties and applications of Al_2O_3, SiC, Si_3N_4, PSZ and SIALON –Composites-Classifications – Metal Matrix and FRP – Applications of Composites

UNIT V	MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS	9

Mechanisms of plastic deformation, slip and twinning – Types of fracture – Testing of materials under tension, compression and shear loads – Hardness tests (Brinell, Vickers and Rockwell), hardness tests, Impact test lzod and Charpy, fatigue and creep failure mechanisms.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 Marks CAT 2 - 10 Marks Descriptive Questions	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

C204.1 Explain alloys and phase diagram, Iron-Iron carbon diagram and steel classification for material development
C204.2 Explain isothermal transformation, continuous cooling diagrams and different heat treatment processes for material development
C204.3 Clarify the effect of alloying elements on ferrous and non-ferrous metals.
C204.4 Summarize the properties and applications of non metallic materials.
C204.5 Explain/demonstrate the testing of mechanical properties.

Text Books

1. Williams D Callister, "Material Science and Engineering" Wiley India Pvt Ltd, Revised Indian Edition (2014)
2. Avner, S.H., "Introduction to Physical Metallurgy", McGraw Hill Book Company, 2017.

Reference Books

1. Kenneth G.Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, (2010)
2. Raghavan.V, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd., (2015)
3. U.C.Jindal, "Engineering Materials and Metallurgy", 1st Edition, Dorling Kindersley, (2012)
4. George E. Dieter, Jr, "Mechanical Metallurgy", Create Space Independent Publishing Platform, (2014).

Web Resources

https://nptel.ac.in/courses/113106032/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C204.1	3	3											2	3
C204.2	3	2	1	2									2	3
C204.3	3	2	1	2									2	3
C204.4	3	2											2	3
C204.5	3	2	1	1	1								2	3

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	30	20	10	10	20
UNDERSTAND	50	30	10	10	30
APPLY	20	50	5	5	50
ANALYZE					
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Explain alloys and phase diagram, Iron-Iron carbon diagram and steel classification for material development (Remember and Understand)

1. Construct the Iron-Carbon equilibrium phase diagram and discuss the different phase that takes place in it. (**U)**

2. Classify the types of steel and explain its micro structure properties and application (**U)**

COURSE OUTCOME 2: Explain isothermal transformation, continuous cooling diagrams and different heat treatment processes for material development (Remember, Understand and Apply)

1. Construct the TTT diagram and explain the following heat treatments applied to an eutectoid steel: Austempering, Martempering and Hardening (**U)**

2. Explain Case hardening Classified as nitriding, cyaniding and carbonitriding (**A)**

COURSE OUTCOME 3: Clarify the effect of alloying elements on ferrous and non-ferrous metals(Remember and Understand)

1. Describe the stainless steels with respect to composition, properties and Applications. (**U)**

(ii)Write short notes on HSLA Steel. (**U)**

2. Discuss different types of copper alloys and their properties and applications. (**R)**

(ii)Write short notes on bearing alloys. (**U)**

COURSE OUTCOME 4: Summarize the properties and applications of non metallic materials.(Remember, Understand and Apply)

1. Describe the properties and applications of the following polymers **i)** PVC ii) PS iii) PET iv) PA. **(R)**

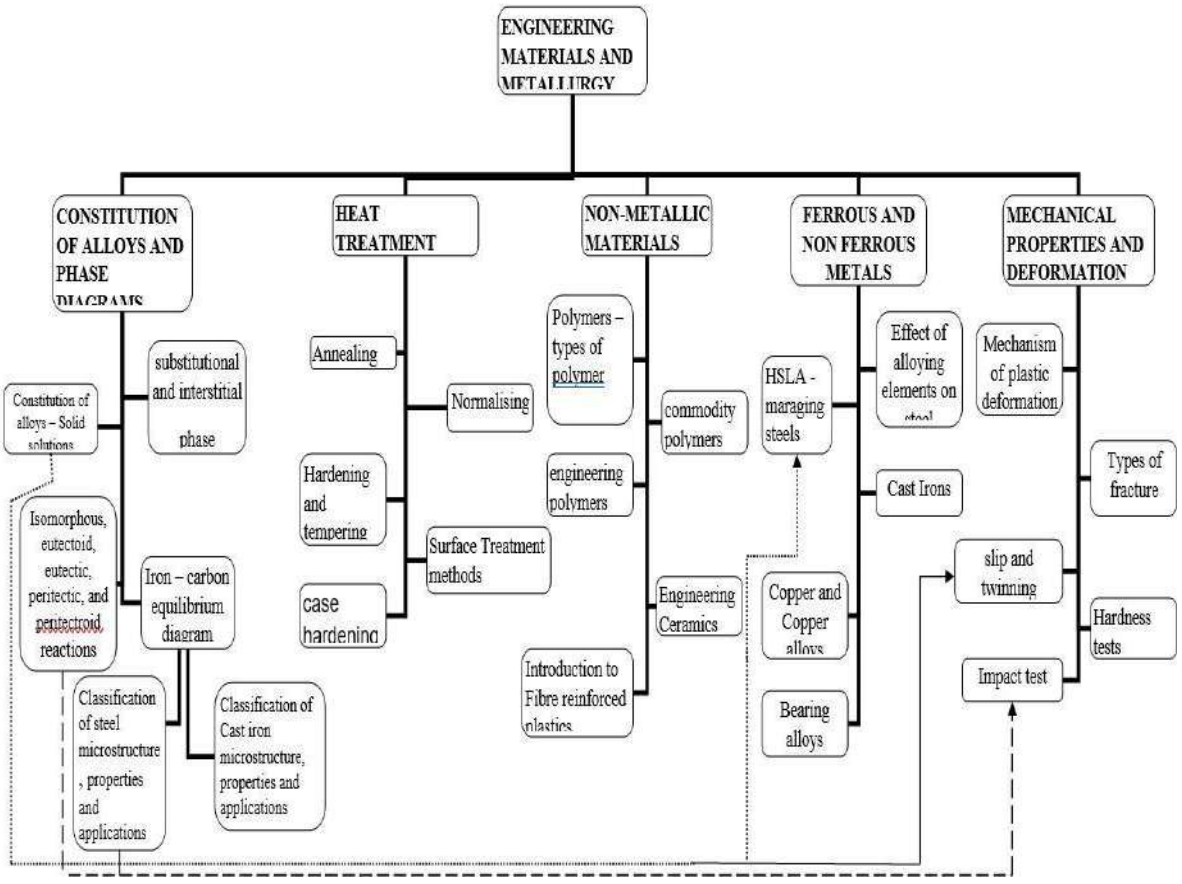
2. Explain the following Engineering Ceramics**:** a) AL_2O_3 b) SiC c) Si_3N_4 **(U)**

COURSE OUTCOME 5: Explain/demonstrate the testing of mechanical properties. (Remember, Understand and Apply)

1. Explain Brinell hardness testing and its applications**(U)**

2. Write down the procedure for preparing Charpy and Izod specimens for impact testing and also explain how testing is performed? **(A)**

CONCEPT MAP



21ME3603	MANUFACTURING TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering physics

Objectives

- To introduce the concepts of basic manufacturing processes and fabrication techniques, such as metal casting, metal joining, metal forming and powder metallurgy
- To Understand the concept and basic mechanics of metal cutting, working of standard machine tools

UNIT I	CASTING AND METAL JOINING	10

Production and Manufacturing –. Different types of castings, design of patterns, moulds and cores; solidification and cooling; Defects in castings. Fusion welding processes: Manual metal arc welding Tungsten arc welding Thermit welding, Friction Stir Welding, Weld defects, Principles of brazing, soldering and adhesive bonding.

UNIT II	FORMING PROCESS	9

Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; Powder metallurgy-production of metal powders-stages in powder metallurgy

UNIT III	METAL CUTTING	8

Mechanics of machining, orthogonal metal cutting, merchant's circle, forces in machining, Types of chip, single point and multi-point cutting tools – tool geometry and materials, tool wear, tool life, cutting fluids and Machinability – economics of machining

UNIT IV	MACHINE TOOLS AND OPERATIONS	9

Centre lathe, NC/CNC machines, reciprocating machine tools: Shaper, Slotter; Milling: Types ofmilling machines, up milling, down milling, milling cutters, operations; Drilling: Column and radial drilling machines, machining time calculations; Reaming, tapping and boring;

UNIT V	ABRASIVE PROCESSES AND GEAR CUTTING	9

Abrasive processes: Grinding wheel designation and selection; Types of grinding processes: Cylindrical grinding, surface grinding, centreless grinding; Honing, lapping; Gear cutting: Forming, generation, shaping and hobbing; Cost comparison.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Course Outcomes
Upon completion of the course, the students will be able to:
C205.1 Identify the different metal casting processes, defects and different metal joining processes **C205.2** Define the various hot working , cold working methods of metals and sheet metal making processes **C205.3** Depict the basic concepts of metal cutting and perform cutting force and tool life calculations. **C205.4**Demonstrate the operational features of the centre lathe CNC Machines and the working principle of shaper, milling and drilling machine tools **C205.5** Identify various finishing processes and explain the working principle of gear cutting machine tools
Text Books
1. Hajra Chouldhary S.K and Hajra Choudhury A.K., "Elements of workshop Technology", Volume I, Media promoters and Publishers Private Limited, Mumbai, (2014) 2. Hajra Choudhury S.K and Hajra Choudhury A.K., "Elements of Workshop Technology", Volume II, Media Promoters, (2014) 3. Rao P.N "Manufacturing Technology – Metal Cutting and Machine Tools", 3rd Edition, Tata McGraw-Hill, New Delhi, (2013)
Reference Books
1. Sharma, P.C., "A Text book of production Technology", S.Chand and Co. Ltd., (2014) 2. Rajput R.K., "A Textbook of Manufacturing Technology", Laxmi puplication, NewDelhi, (2014) 3. "Production Technology"HMT McGraw-Hill Education (India) Pvt Limited, 01-May-2001
Web Resources 1. https://nptel.ac.in/courses/112104195 2. https://nptel.ac.in/courses/112107144 3. https://nptel.ac.in/courses/112105127

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C205.1	2	2	1	1									3	3
C205.2	2	2	2										3	2
C205.3	2	2	1										3	
C205.4	2	2	2										3	
C205.5	2	2	2										3	2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	5	5	20
UNDERSTAND	60	60	10	10	60
APPLY	20	20	10	10	20
ANALYZE					
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 : Identify the different metal casting processes, defects and different metal joining processes (Remember, Understand)

1. What is the principle of thermit welding? Explain the same with a neat diagram.(R)
2. Explain in detail the working principle of centrifugal casting. (U)
3. What are the Defects in Welding and Casting? (U)

COURSE OUTCOME 2 : Define the various hot working , cold working methods of metals and sheet metal making processes (Remember, Understand)

4. Explain the classifications of forging process based on the process used? (U)
5. Explain in detail with neat sketch. (i) Bending; (ii) Deep Drawing. (R)

COURSE OUTCOME 3 : Depict the basic concepts of metal cutting and perform cutting force and tool life calculations. (Remember, Understand, Apply)

6. What are the assumption made in drawing Merchant's circle. (R)
7. Discuss the purpose of cutting fluids. (R)

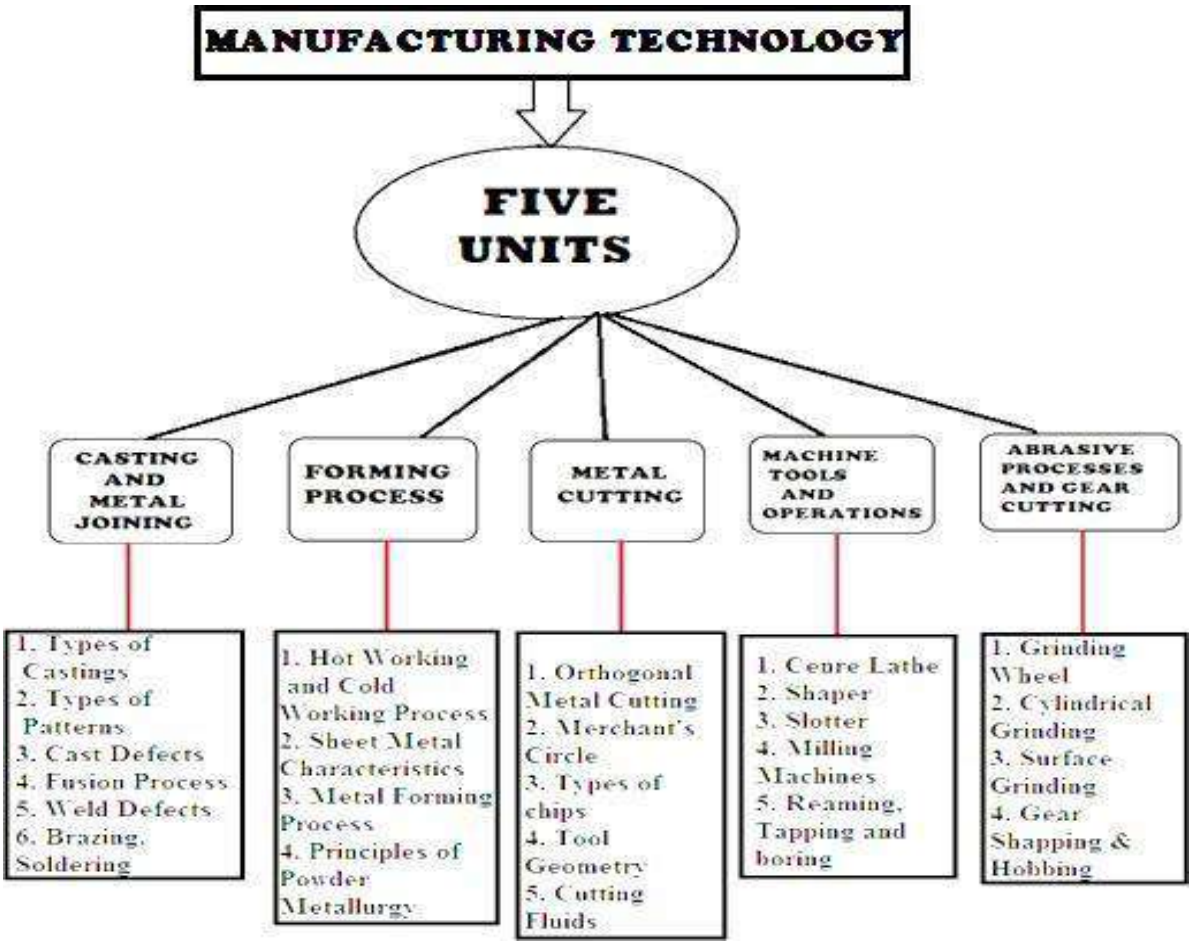
COURSE OUTCOME 4 : Demonstrate the operational features of the centre lathe CNC Machines and the working principle of shaper, milling and drilling machine tools (Remember, Understand, Apply)

8. Explain the different machining operations performed on lathe with sketches. (U)
9. Describe of crank and slatted link mechanism used in shaper with nearsketches. (U)

COURSE OUTCOME 5 : Identify various finishing processes and explain the working principle of gear cutting machine tools (Remember, Understand)

10. Explain the gear hobbing processes with sketches. (U)
11. Discuss the factors influencing the selection of grinaing wheel. (U)
12. Explain the centreless grinding operation with sketches. (U)

CONCEPT MAP



21PT3902	VERBAL ABILITY	L	T	P	C
		0	0	2	1

Preamble:

This course is developed to enhance the Verbal competency of the students as Verbal Ability is commonly a part of the various competitive exams conducted. This course equips the students in all the aspects of grammar and helps to enhance comprehensive abilities and Analytical skills.

Prerequisites for the course

- Foundational English

Objectives

1. To help the student understand the importance of having his language skills kept ready for effective use.
2. To provide a host of varied opportunities for the student to hone his acquired language skills basic components, namely, Grammar, Vocabulary, Spelling and Comprehension.

Module I	6
Articles, Tenses, Voices, Preposition, Conjunctions, Subject-verb agreement, Adverbials.	
Module II	6
Parts of speech, Simple, Complex & Compound Sentences, Direct & Indirect Speech, Kinds of Sentences, Degrees of Comparison, Clauses.	
Module III	6
Reading Comprehension, Analogies, Synonyms & Antonyms, Idioms and Phrases.	
Module IV	6
Para-jumbles, Phrasal verbs, Modifiers, Punctuations, Misspelled words.	
Module V	6
Verbal syllogism, figures of speech, Word completion, Sentence Completion, One word Substitutes	
Total Periods	**30**

Suggested Assessment Activities:

- MCQ test through Google forms or other online test platforms.

  Eg. JavaPoint - Verbal Ability https://www.javatpoint.com/verbal-ability

Suggestive Assessment Methods		
Continuous Assessment Test -1 (30 Marks)	**Continuous Assessment Test -2 (30 Marks)**	**Model Exam (40 Marks)**
MULTIPLE CHOICE QUESTIONS	**MULTIPLE CHOICE QUESTIONS**	**MULTIPLE CHOICE QUESTIONS**

Outcomes

Upon completion of the course, the students will be able to:

CO1: Identify the grammatical errors in a sentence.

CO2: Frame sentences using the correct syntax.

CO3: Understand the concepts stated in a sentence or paragraph and analyze using verbal reasoning.

CO4: Construct sentences logically and make the texts semantically meaningful as a whole.

CO5: Interpret and analyze texts on a deeper level.

Text Books

1. Wren, P.C., Martin, H, Prasada Rao, N.D.V. (1973–2010). High School English Grammar & Composition. New Delhi: Sultan Chand Publishers
2. Kumar, Sanjay, Pushp Latha. (2018) English Language and Communication Skills for Engineers, India: Oxford University Press.

Reference Books

1. Guptha S C, (2012) Practical English Grammar & Composition, 1 st Edition, India: Arihant Publishers
2. Steven Brown, (2011) Dorolyn Smith, Active Listening 3, 3 rd Edition, UK: Cambridge University Press.

Web Resources:

1. Indiabix : https://www.indiabix.com/online-test/verbal-ability-test/
2. All India Exams : https://www.allindiaexams.in/online-test/online-verbal-ability-test/all
3. faceprep: https://www.faceprep.in/verbal-ability/

CO Vs PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1										3	1	
2										3	1	
3										3	1	
4										2		1
5										2		1

COURSE CONTENT AND SCHEDULE

S.NO	TOPIC	NO OF HOURS REQUIRED
	Module I	
1	Articles	1
2	Tenses	1
3	Voices	1
4	Preposition	1
5	Conjunctions	1
6	Subject-verb agreement, Adverbials	1
	Module II	
7	Parts of Speech	1
8	Simple, Complex & Compound Sentences	1
9	Direct & Indirect Speech	1
10	Kinds of Sentences	1
11	Degrees of Comparison	1
12	Clauses	1
	Module III	
13	Reading Comprehension	1
14	Analogies	1
15	Synonyms	1
16	Antonyms	1
17	Idioms And Phrases	2
	Module IV	
18	Para Jumbles	1
19	Phrasal Verbs	2
20	Modifiers	1

21	Punctuations	1
22	Misspelled words	1
Module V		
23	Verbal Syllogism	2
24	Figures of Speech	1
25	Word Completion	1
26	Sentence Completion	1
27	One word Substitutes	1

21HS1103	TAMIL HERITAGE	L	T	P	C
		2	0	0	1

Preamble:
This course is offered to equip students to create awareness of the contribution of Tamil people to Indian culture by highlighting the characteristics of Tamil language and literature and exhibiting Tamil culture through traditional arts such as performing arts and fine arts.

Prerequisites for the course:
The prerequisite knowledge required to study this course is basic knowledge in English and Tamil Heritage.

UNIT I	LANGUAGE AND LITERATURE	6

Language Families in India-Dravidian Languages –Tamil as Classical Language –Classical Literature in Tamil – Secular Nature of Sangam Literature –Distributive Justice in Sangam Literature Management Principles in Thirukural - Tamil Land Bakthi Literature Azhwars and Nayanmars-Forms of minor Poetry development of Modern literature in Tamil-Contribution of Bharathiyar and Bharathidhasan.

UNIT II	HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE	6

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making- Massive Terracotta sculptures, Village Deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III	FOLK AND MARTIAL ARTS	6

Therukoothu, Karakattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance-Sports and Games of Tamils.

UNIT IV	THINAI CONCEPT OF TAMILS	6

Flora and Fauna of Tamils & Agam and Puram Concept from Tholkappiyam and Sangam Literature -Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age-Export and Import during Sangam Age-Overseas Conquest of Cholas.

UNIT V	CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE	6

Contribution of Tamils to Indian Freedom Struggle-The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement – Role of Siddha Medicine in Indigenous Systems of Medicine–Inscriptions & Manuscripts–Print History of Tamil Books.

	Total Periods	30

Course Outcomes:

CO1	To widen the knowledge on the characteristics of Tamil language and literature.
CO2	To explore the traditional Tamil fine arts and its techniques of Tamil Heritage.
CO3	To evaluate the various types of performing arts and their cultural context.
CO4	To get an insight on the lifestyle and living techniques of Tamil ancestors.
CO5	To recognise and perceive the role played by Tamils in the unity and development of India.

CO PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO 1								1	2	3	1	3
CO 2								1	3	2	3	2
CO 3								1	3	2	1	2
CO 4								3	2	2	3	2
CO 5								2	3	3	2	3

TEXT-CUM-REFERENCE BOOKS

1. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL–(in print)
2. Social Life of the Tamils- The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
3. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D.Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
4. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
5. Keeladi-'Sangam City Civilization on the banks of river Vaigai'(Jointly Published by:Department of Archaeology &TamilNadu Text Book and Educational Services Corporation, Tamil Nadu)
6. Studies in the History of India with Special Reference to TamilNadu (Dr.K.K.Pillay) (Published by: The Author)
7. Porunai Civilization(Jointly Published by:Department of Archaeology &TamilNadu Text Book and Educational Services Corporation,Tamil Nadu)
8. Journey of Civilization Industo Vaigai(R.Balakrishnan)(Published by:RMRL)–Reference Book.

21HS1103	தமிழர் மரபு	L	T	P	C
		2	0	0	1

முன்னுரை(Preamble)

இப்பாடத்திட்டம் பொறியியல் பயிலும் முதலாம் ஆண்டு மாணவர்களின் முதலாம் பருவத்திற்கு உரியது. தமிழ் மொழி மற்றும் இலக்கியத்தின் தன்மைகளை எடுத்துரைத்து மரபுக் கலைகளான நிகழ்த்து கலைகள் மற்றும் நுண்கலைகள் வழியாகத் தமிழ்ப் பண்பாட்டை புலப்படுத்தி இந்திய பண்பாட்டிற்கு தமிழர்கள் ஆற்றிய பங்கினை மாணவர்கள் அறியச் செய்தல்.

பாடநெறிக்கான முன்நிபந்தனைகள்(Prerequisites for the course)

தமிழ் மொழியில் எழுத படிக்க தெரிந்திருத்தல் அவசியம்.

அலகு I	மொழி மற்றும் இலக்கியம்	6

இந்திய மொழிக் குடும்பங்கள்- திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழ் காப்பியங்கள் தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - சிற்றிலக்கியங்கள்- தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி- தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II	மரபு- பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை- சிற்பக்கலை	6

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள்- பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள்- தேர் செய்யும் கலை- சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள்- குமரி முனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள்- மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு..

அலகு III	நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்	6

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்

அலகு IV	தமிழர்களின் திணைக் கோட்பாடுகள்	6

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்க காலத்தில் தமிழகத்தில் எழுத்தறிவும் , கல்வியும் - சங்க கால நகரங்களும் துறைமுகங்களும் - சங்க காலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல் கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V	இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு	6

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில் சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ் புத்தகங்களின் அச்சு வரலாறு

Total Periods	**30**

எதிர்பார்க்கும் படிப்பின் முடிவுகள்

CO1	மாணவர்கள் தமிழ் மொழி மற்றும் இலக்கியத்தின் தன்மைகள் குறித்து அறிந்து கொள்வார்.
CO2	தமிழ் மரபு சார்ந்த நுண்கலைகளையும் அதன் நுட்பங்களையும் புரிந்து கொள்வர்.
CO3	நிகழ்த்து கலைகளின் வகைகளையும் அதன் பண்பாட்டுச் சூழலையும் அறிந்து கொள்வர்.
CO4	பழந்தமிழரின் வாழ்க்கைச் சூழல்களை அறிந்து கொள்வர்.
CO5	இந்திய ஒருமைப்பாட்டிற்கும் வளர்ச்சிக்கும் தமிழர்கள் ஆற்றிய பங்கு குறித்து அறிவர்.

CO PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO 1								**1**	**2**	**3**	**1**	**3**
CO 2								**1**	**3**	**2**	**3**	**2**
CO 3								**1**	**3**	**2**	**1**	**2**
CO 4								**3**	**2**	**2**	**3**	**2**
CO 5								**2**	**3**	**3**	**2**	**3**

TEXT-CUM REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே. கே பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித்தமிழ் - முனைவர் இல. சுந்தரம் (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்க கால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு).
4. பொருநை - ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறை வெளியீடு)

21ME3611	Computer Aided Machine Drawing Laboratory	L	T	P	C
		0	0	4	2

Prerequisites for the course

Computer Aided Engineering Graphics

Objectives

- Apply Indian Standards in drawing practices of machine components.
- Show the limits, fits and tolerances in the production drawings of machine components.
- Prepare assembly drawings using standard CAD packages.

Assembly Drawings

DRAWING STANDARDS (2) **C207.1**
Code of practice for Engineering Drawing, BIS specifications – Welding symbols, riveted joints, keys, fasteners

ASSEMBLY CONCEPTS: Assembly requirements, bill of materials; Methods of assembly-bolts, nuts, studs, screws and pins; Methods of axial and radial retention of parts of an assembly; Assembly of parts with emphasis on assembly sequence and appropriate fits. (4) **C207.2**

FITS AND TOLERANCES: Limits, fits and tolerances; Need, types, representation of tolerances on drawing, calculation of minimum and maximum clearances and allowances; Geometric tolerance: uses, types of form and position tolerances, symbols, method of indicating geometric tolerances on part drawings; Surface finish symbols - methods of indicating the surface roughness; Blue print reading exercises; Preparation of production drawing. (5) **C207.3**

S.No	List of Experiments	CO
1	Shaft couplings	**C207.4**
2	Plummer block	**C207.4**
3	Sleeve and cotter joint	**C207.4**
4	Screw jack	**C207.4**
5	Universal Joint	**C207.4**
6	Machine Vice	**C207.4**

S.No.	List of Projects	CO
1.	Basic 2D models (Chess coins, Bowl, etc- **level 1**)	**C207.5**
2.	Isometric models (Table, Chair, etc – **level 2**)	**C207.5**
3.	CAD Model and Real Model based on the outcome of the level 1	**C207.5**

	and 2 projects. – (level 3)	

Total periods:45

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	**End Semester Exams (40 Marks)**
Lab experiment - 40 Marks Model lab with project 20 Marks	Practical Exam

Course Outcomes

Upon completion of the course, the students will be able to:

C207.1	Apply the drawing standards in the part drawing
C207.2	Apply the part assembly guidelines in creating the 3D Models.
C207.3	Analyze fits and tolerance and interpret the production drawings.
C207.4	Design and develop assembly drawing for simple machine components.
C207.5	Design and develop the complete assembly of product.

Laboratory Requirements

Hardware:

1. Intel i5 core due processor with 4GB ram with 500GB hard disk – 30 Nos.
2. Laser Printer – 1 No.

Software:

Drafting package – AutoCAD – Adequate license (Open source)

Reference Books

1. MACHINE DRAWING [IN FIRST-ANGLE PROJECTION METHOD] By N. D. Bhatt, V. M. Panchal 50th Edition: 2016.
2. K.L. Narayana, P. Kannaiam and K. Venkata Reddy," Machine Drawing", published by New Age International Publishers,2019.
3. N. Siddeshwar, P. Kanniah, V.V.S. Sastri," Machine Drawing", published by McGrawHill, 2017

Web Resources

1. **https://nptel.ac.in/courses/112102304**

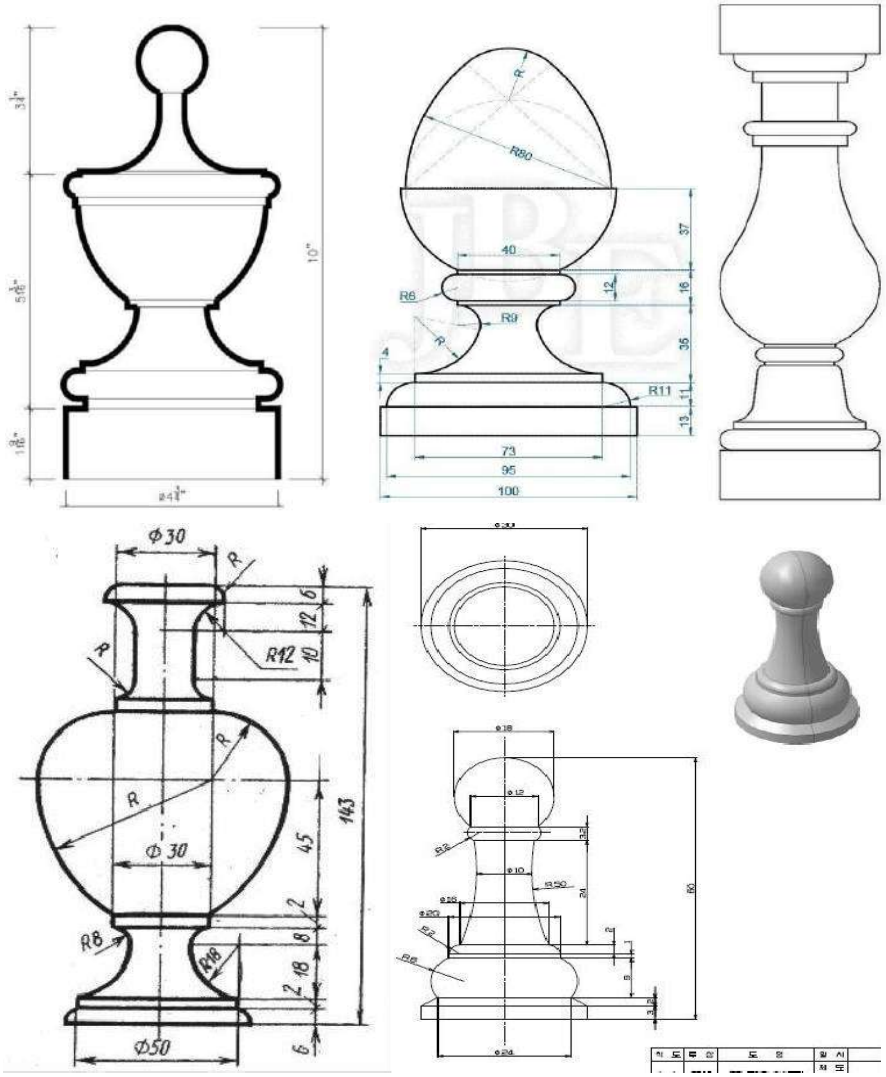
CO Vs PO Mapping and CO Vs PSO Mapping

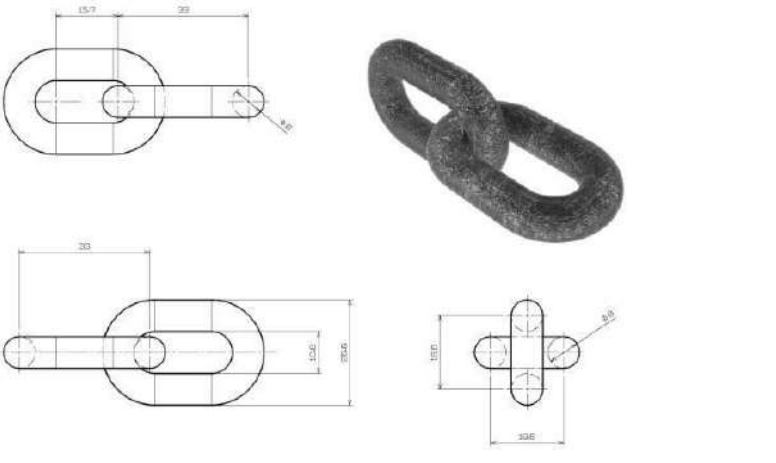
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
207.1	2	3											3	2
207.2	2	3											3	2
207.3	2	3											3	2
207.4	1	1	2		3				1				3	2
207.5	1	1	2		3				1				3	2

COURSE LEVEL ASSESSMENT QUESTIONS(LIST OF PROJECTS)

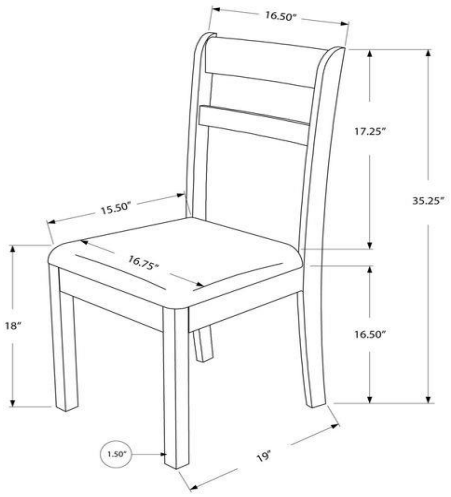
Level 1

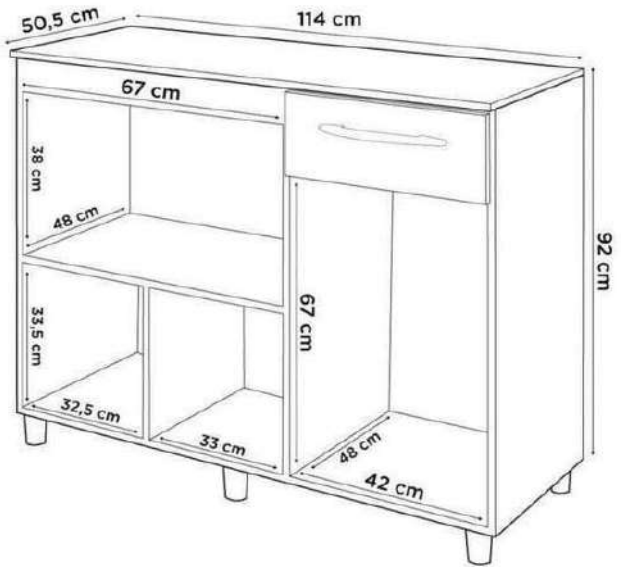
1. Draw any one component as shown below with necessary comments (Assume suitable dimensions).

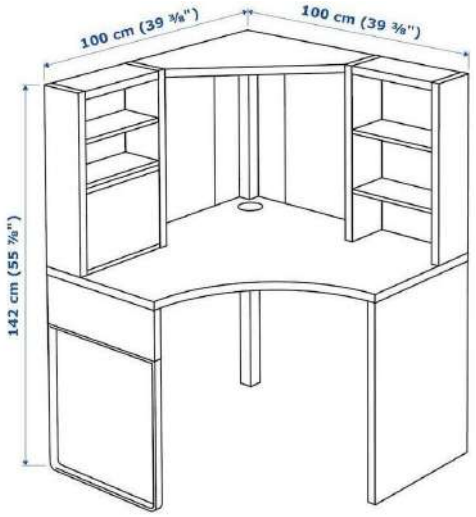

Φ30
R12
Φ30
Φ50
143
R80
R6
R9
R11
40
73
95
100



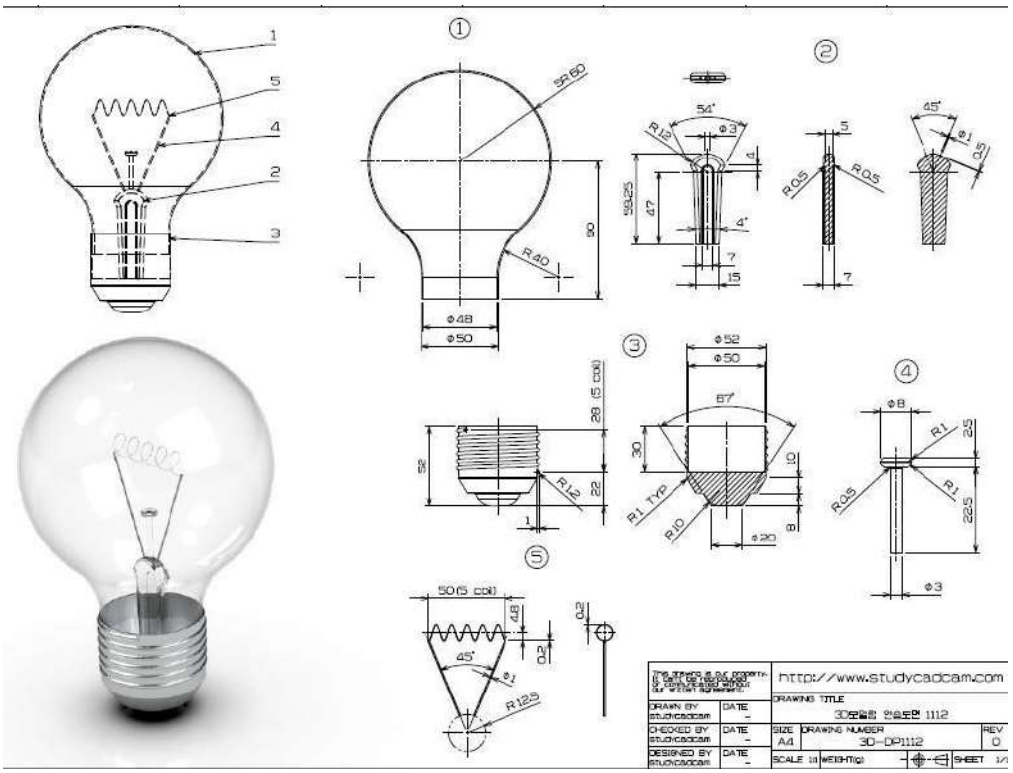
2. Draw the isometric view of any one component given below (Assume suitable dimensions).

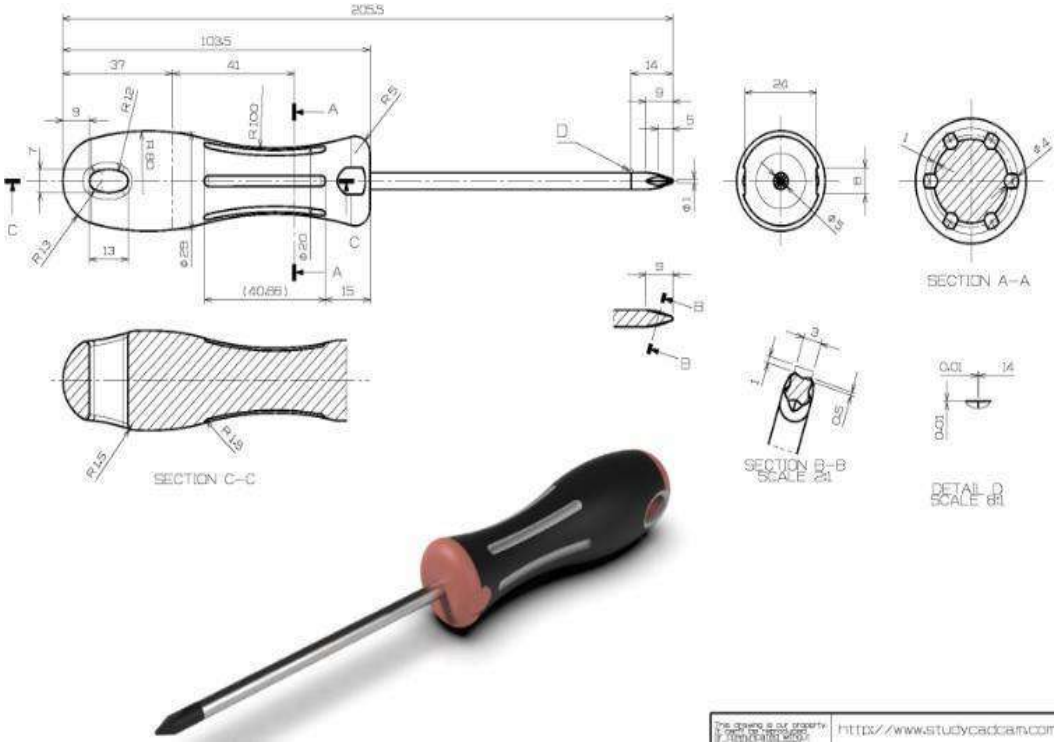


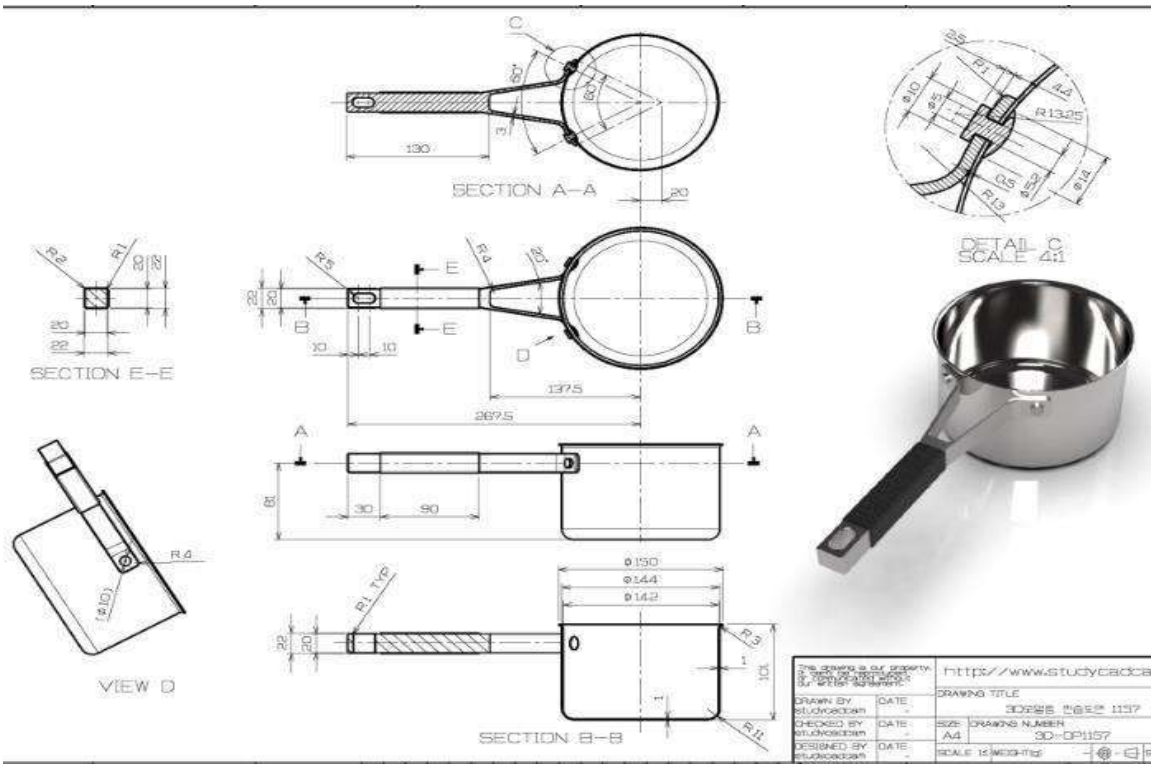




3. Assemble the parts and draw views – any one (Assume suitable dimensions).


http://www.studycadcam.com
DRAWING TITLE
DRAWING NUMBER
3D-DP1112
SIZE
A4
SCALE
WEIGHT(g)
SHEET


SECTION A-A
SECTION B-B
SCALE 2:1
SECTION C-C
DETAIL D
SCALE 8:1
http://www.studycadcam.com

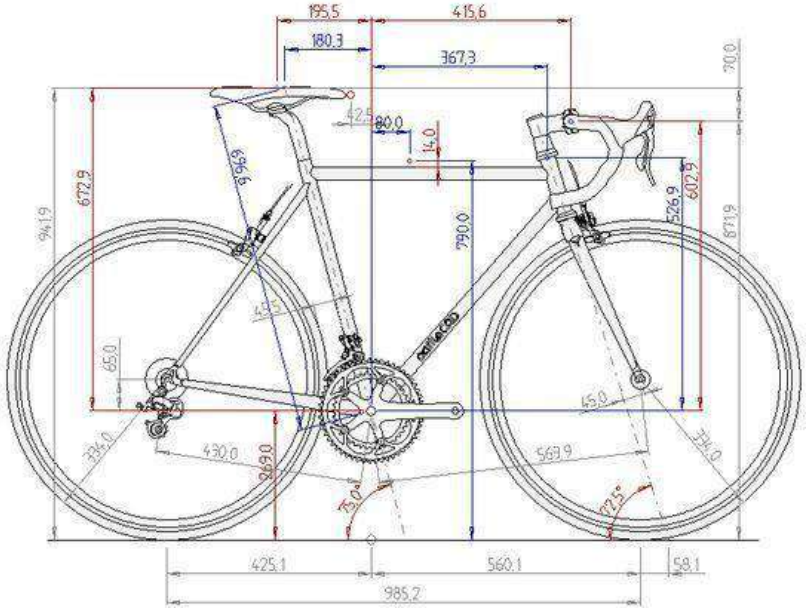


Level 2 (any one Project)

1. Design and drafting of Gear train

In this project-based course, Student will learn to develop a Gear train design assembly using AutoCAD software. By developing this project, the will learn to design: Gear Shafts, Spur Gears, Bearing Housing, Bearings and Assembly of a gear train.

2. Design and Drafting of Bi-Cycle as per the dimensions given



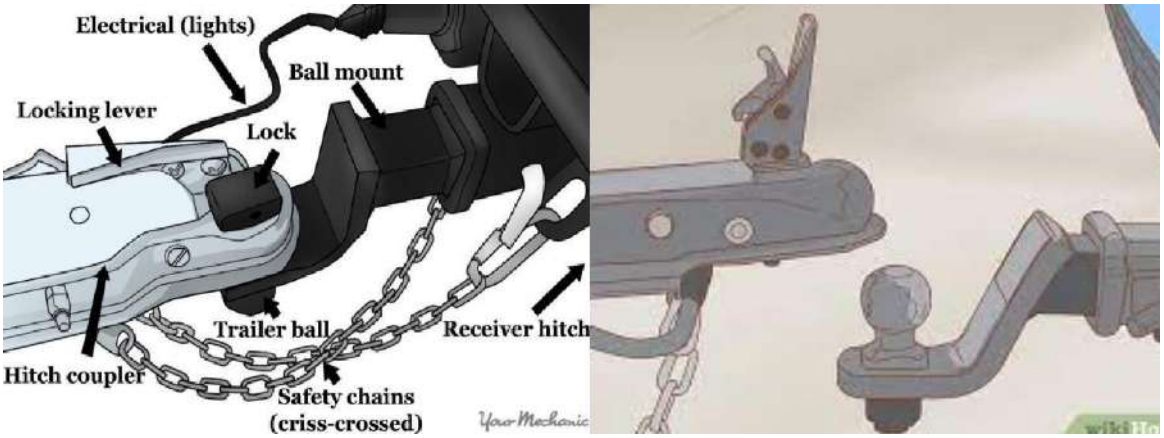
This project course introduces you to the concept of designing Mechanisms that can be applied in real-time.Mechanisms are the base of every design, from simple toys to vehicles to spaceships.

Level 3

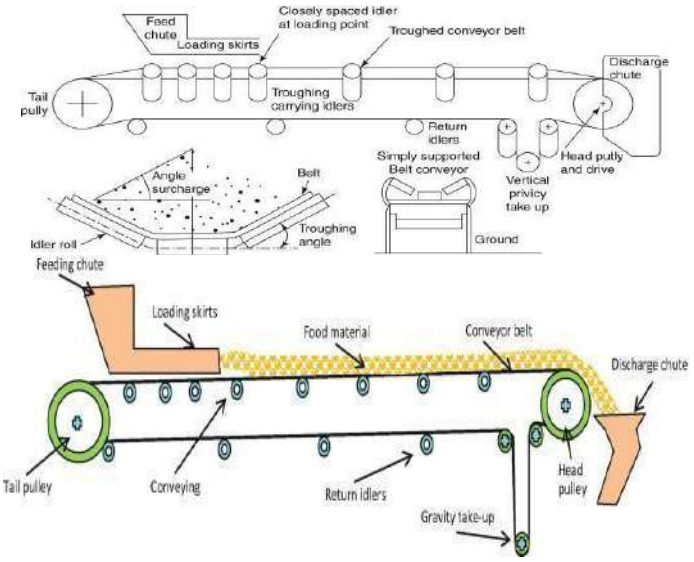
Students are asked to do own projects (both CAD Model and Real Working Model) based on the outcome of the level 1 and 2 projects.

Example Projects:

1. Design and draw the mechanism for car towing.



2. Design and draw the model for material handling of lime stone or food materials



21ME3612	MANUFACTURING TECHNOLOGY LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Engineering Practices Laboratory

Objectives

- To practice the moulding process and welding operations.
- To practice different types of sheet metal operations.
- To perform various machining operations like facing, turning, knurling, thread cutting, shaping, grinding, and milling.
- To obtain the knowledge of different gear manufacturing processes.

S.No	List of Experiments	COs
`1	Prepare a Mould by using Solid/Split/Loose-piece Patterns	**1**
2	Fabrication of Tray/Funnel in sheet metal	**2**
3	Prepare a Tee joint by Gas Tungsten Arc Welding (GTAW)	**3**
4	Step Turning, Knurling and Taper Turning Operations on circular parts using Centre Lathe.	**4**
5	External Thread Cutting Operation on circular parts in Centre Lathe.	**4**
6	Shaping - Hexagonal head on circular parts using shaper machine	**4**
7	Grinding Components using Surface Grinding Machine	**4**
8	Grinding Components using Cylindrical Grinding Machine	**4**
9	Spur gear cutting using milling machine	**4**
10	Measurement of cutting forces in Milling / Turning Process	**4**
11	Generating gears using hobbing / Shaping machine	**5**
	Total Periods	**45**

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	End Semester Exams (40 Marks)
Lab experiment - 40 Marks Model lab with project 20 Marks	Practical

Course Outcomes

Upon completion of the course, the students will be able to:

C208.1. Make a mould using different types of patterns.
C208.2. Create objects using sheet metal.
C208.3. Perform the Welding Process for the given materials.
C208.4. Perform different machining processes in lathe, shaper, grinders and milling machines and Measure their Cutting forces.
C208.5. Perform different gear generating process based on requirements.

Laboratory Requirements
1.Moulding Table 12"X12" 2.Moulding Box 3.Various Patterns for Casting 4.Various Foundry Tools 5. Arc welding transformer with cables and holders 5 Nos. 6. Welding booth with exhaust facility 5 Nos. 7. Welding accessories like welding shield, chipping hammer, Wire brush, etc., 5 Sets 8. Anvil 1 No. 9. Sheet metal tools 10. Standard working tools 15 sets 11. Centre lathe 7 Nos. 12. Shaping machine 1 No 13. Horizontal Milling Machine 2 No 14. Vertical Milling Machine 1 No 15. Surface Grinding Machine 1 No 16. Cylindrical Grinding Machine 1 No 17. Lathe Tool Dynamometer 1 No 18. Milling Tool Dynamometer 1No 19. Gear Hobbing Machine 1 No 20.Tool Makers Microscope 1 No 21. Gear Shaping machine 1 No

Reference Books
1. Hajra Choudhury S.K., Hajra Choudhury A.K., Nirjhar Roy, "Elements of Workshop Technology - Vol. I", 14th Edition, MediaPromoters& Publishers Private Limited, Mumbai, 2008. 2. Hajra Choudhury S.K., Nirjhar Roy, "Elements of Workshop Technology-Volume-2", 15th Edition, Media Promoters &PublishersPvt Ltd, Mumbai, 2010.
Web Resources **1. http://vlabs.iitkgp.ac.in/psac/newlabs2020/vlabiitkgpAM/#**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C208.1	2	2								1			3	2
C208.2	2	2								1			3	
C208.3	2	2								1			3	2
C208.4	1	1	1	1						1			3	3
C208.5	2	2								1			3	

21ME3613	Fluid Mechanics and Machines Laboratory	L	T	P	C
		0	0	4	2

Prerequisites for the course

Fluid Mechanics and Machinery

Objectives

- Compute the rate of flow through pipes using various flow measuring devices such as Venturi meter, orifice meter and rotameter.
- Discuss the performance characteristics of turbines and pumps.
- Demonstrate the basic principles of fluid mechanics and working of hydraulic machines

S.No	List of Experiments	CO
1	Determination of the Coefficient of discharge of given Orifice meter	**C209.1**
2	Determination of the Coefficient of discharge of given Venturi meter.	**C209.1**
3.	Calculation of the rate of flow using Rotameter.	**C209.1**
4	Determination of friction factor for a given set of pipes.	**C209.1**
5	Conducting experiments and drawing the characteristic curves of centrifugal Pump	**C209.2**
6	Conducting experiments and drawing the characteristic curves of reciprocating pump.	**C209.3**
7	Conducting experiments and drawing the characteristic curves of Gear pump.	**C209.2**
8	Conducting experiments and drawing the characteristic curves of Pelton wheel.	**C209.4**
9	Conducting experiments and drawing the characteristics curves of Francis turbine.	**C209.5**
10	Conducting experiments and drawing the characteristic curves of Kaplan turbine	**C209.5**

Total Periods : 45

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	End Semester Exams (40 Marks)
Lab experiment - 40 Marks Model lab with project 20 Marks	Practical Exam

Course Outcomes

At the end of the course, the students will be able to

C209.1. Perform test on Orifice, Venturi and Rota meter to determine the coefficient of discharge

C209.2. Draw the characteristics of curve of Centrifugal and Gear pump

C209.3. Analysis the performance of Reciprocating pump

C209.4. Perform the test on impulse turbine (Pelton) and draw its characteristics curve

C209.5. Draw the characteristics curve for reaction turbine like Francis and Kaplan turbine

Laboratory RequirementsFor a Batch of 30 Students

S.No.	NAME OF THE EQUIPMENT	Qty.
1	Orifice meter setup	1 No
2	Venturi meter setup	1 No
3	Rotameter setup	1 No.
4	Pipe Flow analysis setup	1 No.
5	Centrifugal pump	1 No
6	Reciprocating pump setup	1 No.
7	Gear pump setup	1 No.
8	Pelton wheel setup	1 No
9	Francis turbine setup	1 No
10	Kaplan turbine setup	1 No

Reference Books

1. Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 2019**.**

2. Bansal, R.K., "Fluid Mechanics and Hydraulic Machines", Laxmi Publications (P) Ltd., 2019.

Web Resources

1. https://fm-nitk.vlabs.ac.in/
2. https://me.iitp.ac.in/Virtual-Fluid-Laboratory/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C209.1	1	1	3	3			1					1	3	1
C209.2	1	1	3	3			1					1	2	1
C209.3	1	1	3	3			1					1	2	1
C209.4	1	1	3	3			1					1	2	1
C209.5	1	1	3	3			1					1	2	1

SEMESTER IV

21ME4601	CNC MACHINES AND AUTOMATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Manufacturing Technology

Objectives

- Demonstrate the construction and tooling of CNC machine.
- Prepare simple part programme for different operations.
- Illustrate the interfacing of sensors and actuators with PC.
- Make use of the Internet of things.

UNIT I	CONSTRUCTIONAL DETAILS AND TOOLING	8

Design features, specification Chart of CNC machines, use of slideways, balls, rollers and coatings, motor and lead screw, swarf removal, safety and guarding devices, various cutting tools for CNC machines, overview of tool holder, different pallet systems and automatic tool changer system, management of a tool room.

UNIT II	PART PROGRAMMING	10

Part programming and basic concepts of part programming, NC words, part programming formats, simple programming for rational components, part programming using canned cycles, subroutines and do loops, tool off sets, cutter radius compensation and wear compensation.

UNIT III	AUTOMATION AND NC SYSTEM	9

Role of computer in automation, emerging trends in automation, automatic assembly, manufacture of magnetic tape, manufacture of printed circuit boards, manufacture of integrated Circuits, Overview of FMS, Group technology, CAD/CAM and CIM.

UNIT IV	REAL TIME INTERFACING	9

Data acquisition systems, virtual instrumentation, interfacing of sensors/actuators with PC, condition monitoring, adaptive control, HMI and SCADA systems.

UNIT V	INDUSTRIAL IOT	9

IoT architecture, M2M Architecture; Cloud: Types, edge analytics, fog computing; Augmented reality and virtual reality, big data analytics, predictive analytics.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60Marks)**
CAT 1 - 10 Marks CAT 2 -10 Marks DESCRIPTIVE TYPE	1. Descriptive type questions, 2. Multiple choice questions.	1. Descriptive type questions.

Course Outcomes

Upon completion of the course, the students will be able to:

C210.1: Construct a tool room for appropriate function taking into account the safety and guarding devices.

C210.2: Prepare a part programming using canned cycles, subroutines and do loops.

C210.3: Analyze the difference between FMS, Group technology, CAD/CAM and CIM

C210.4: Complete the interfacing of sensors/actuators with PC, condition monitoring, adaptive control, HMI and SCADA systems

C210.5: Select the suitable IoT for automation

Text Books

1. CNC Machines – Programming and Applications by M Adithan and BS Pabla; New Age International (P) Ltd., Delhi.
2. Mikell P Groover , "Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Education, 2016.

Reference Books

1. Alasdair Gilchrist , "Industry 4.0: The Industrial Internet of Things", 1 st Edition, Apress, 2017.
2. Sanjay Gupta and Joseph John , "Virtual instrumentation using Lab VIEW", Tata McGraw-Hill Publications Co. Ltd, 2017.
3. CNC Machine by Bharaj; Satya Publications, New Delhi.

Web Resources

1. **https://nptel.ac.in/courses/112104288**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PS O 2
C210.1	3												3	
C210.2	2	3											3	
C210.3	2				3								3	
C210.4	2				3								3	
C210.5	2				3								3	

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	20	20	5	5	20
UNDERSTAND	30	30	15	10	30
APPLY	50	30	5	5	30
ANALYZE		20		5	20
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

C210.1: Construct a tool room for appropriate function taking into account the safety and guarding devices – Apply

1. Explain the usage of slideways, rollers and coating. [**R**]

2. Enumerate the different cutting tools for CNC machines. [**U**]

3. Sketch the specification chart of CNC machine. [**Ap**]

C210.2: Prepare a part programming using canned cycles, subroutines and do loops. (Apply)

1. Explain the basic concepts of part programming. [**R**]

2. Summarize the simple programming for rational components. [**U**]

3. Construct the part programming using canned cycles, subroutines and do loops for automatic tool changer. [**Ap**]

C210.3: Analyze the difference between FMS, Group technology, CAD/CAM and CIM. (Analyze)

1. Mention the various FMS components. [**R**]

2. Enumerate the types of FMS in an automated industry. [**U**]

3. Compare and contrast FMS, Group technology and CAD/CAM. [**Ap**]

C210.4: Complete the interfacing of sensors/actuators with PC, condition monitoring, adaptive control, HMI and SCADA systems - Apply

1. Mention the components of data acquisition system. [**R**]

2. Paraphrase the interfacing procedure for sensors or actuators with PC. [**U**]

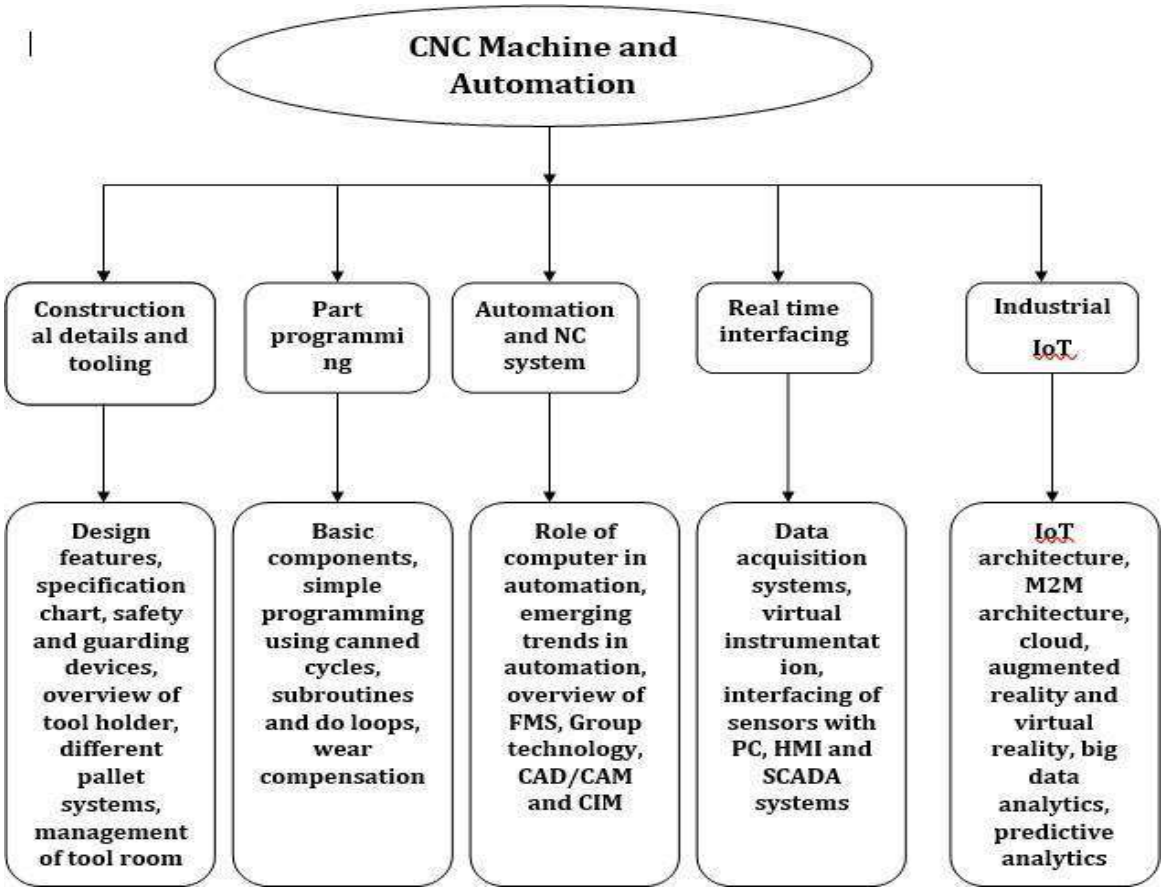
3. Sketch the adaptive control of automation system in a production system. [**Ap**]

C210.5: Select the suitable IoT for automation - Analyze

1. Describe the types of cloud in an Industrial IoT. [**U**]

2. Sketch the components of M2M architecture.[**Ap**]

3. Compare and contrast the AR and VR . [**An**]



21ME4602	STRENGTH OF MATERIALS	L	T	P	C
		2	1	0	3

Prerequisites for the course

Engineering Mechanics

Objectives

- Explain the concepts of stress, strain and deformation of solids
- Examine the stresses and deformation induced in thin cylindrical and spherical shells.
- Calculate the stresses and deformation in circular shaft and helical spring due to torsion.
- Compute the effect of component dimensions and shape on stresses and deformations.

UNIT I	STRESS, STRAIN AND DEFORMATION OF SOLIDS		7+2

Stability- Strength- Stiffness- Tensile- Compressive and Shear stresses - Strain – Poisson's ratio – Lateral Strain - Simple and Compound bars – Relation between Elastic Constants – Thermal Stresses. Strain Energy: Uniaxial Loads - Gradually Applied Load - Suddenly Applied Load and Impact Load.

UNIT II	ANALYSIS OF STRESSES IN TWO DIMENSIONS		7+2

State of stresses at a point – Normal and tangential stresses on inclined planes - Mohr's circle for plane stress and plane strain – Principal planes and stresses - Plane of maximum shear stress - –Hoop and longitudinal stresses in thin cylinders and shells – under internal pressure – deformation of thin cylinders and shells.

UNIT III	TORSION IN SHAFTS AND SPRINGS		7+2

Analysis of torsion of circular bars – Bars of Solid and hollow circular section – Stepped shaft – Twist and torsion stiffness. Springs- Classification – Leaf springs, closed coil helical springs - Application of various springs – Maximum shear stress in spring – Deflection of helical coil springs under axial loads.

UNIT IV	BEAMS - LOADS AND STRESSES		7+2

Beams – types of supports – simple and fixed, types of load – concentrated, uniformly distributed and uniformly varying load, combination of above loading. Bending moment, shear force diagram for simply supported, cantilever and over hanging beams – Point of contra flexure. Bending and shear stresses - concept of shear centre.

UNIT V	DEFLECTION OF BEAMS AND COLUMNS		7+2

Elastic Curve of Neutral Axis of the Beam Under Normal Loads – Evaluation of Beam Deflection and Slope - Double Integration Method and Macaulay's Method. Columns: End Condition – Equivalent Length of Column – Euler's Equation – Slenderness Ratio – Rankine's Formula for Columns.

Total Periods		**35+10= 45 Hours**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**		**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE TYPE	1. Assignment 2. Online Quizzes		1. Descriptive Questions

	3.Problem-Solving Activities		

Course Outcomes

Upon completion of the course, the students will be able to:

C211.1 Categorize the stresses and strains for various engineering components with different loading conditions.

C211.2 Determine the effect of the two-dimensional stresses under various loading combinations on structural parts and thin cylinders.

C211.3 Analyse pure torsion on solid and hollow circular shafts and Design of Leaf and closed coil helical springs.

C211.4 Construct the shear force and bending moment diagrams for simply supported, cantilever and over hanging beams.

C211.5 Evaluate slope and deflection of beams and buckling of columns using analytical methods

Text Books

1. Rajput R.K. "Strength of Materials". 7th Edition, S.Chand & Co., New Delhi, 2018.
2. Bansal R.K., "A Text book of strength of material", Laxmi publication, New Delhi, (2014)

Reference Books

1. Popov E.P., "Engineering Mechanics of Solids", Prentice-Hall of India, New Delhi, (2010)
2. Beer F.P. and Johnston R., "Mechanics of Materials", McGraw-Hill Book Co, (2012)
3. Timoshenko S.P. "Elements of Strength of Materials". 10th Edition, Tata McGraw Hill Publishing Company, New Delhi, 2010.
4. Don H. Morris, William F. Riley and Leroy D. Sturges, "Mechanics of Materials", John Wiley and Sons Inc., (2008)
5. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, Low Price Edition, (2013)

Web Resources

1. https://nptel.ac.in/courses/112107146
2. https://nptel.ac.in/courses/112106141

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C211.1	2	2	2									1	3	2
C211.2	2	2	2									1	3	2
C211.3	2	2	2	1								1	3	2
C211.4	2	2	2		2							1	3	2
C211.5	2	2	2		2							1	3	2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10			10
UNDERSTAND	20	20	5	5	20
APPLY	50	50	15	15	50
ANALYZE	20	20	5	5	20
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 : Analyze the stresses in simple, compound bars, and thermal stresses (Analyze)

1. Define a composite bar. How will you find the stresses and load carried by each member of a composite bar? (A)
2. Find an expression for the total elongation of a bar due to its own weight, when the bar is fixed at its upper end and hanging freely at the lower end.(An)

COURSE OUTCOME 2 : Determine the effect of the two-dimensional stresses under various loading combinations on structural parts and thin cylinders. (Apply)

1. Show that in thin cylinder shells subjected to internal fluid pressure, the circumferential stress is twice the longitudinal stress. (A)
2. While resigning cylindrical vessel, which stress should be used for calculating the thickness of the cylindrical vessel? (A)
3. Find the maximum shear stress in a plane using morhs circle and principal plane method. (A)

COURSE OUTCOME 3 : Illustrate the deflection of shafts due to torsion and deformation of different types of springs (Apply)

1. Find an expression for the strain energy stored by the close-coiled helical spring when subjected to axial load W. (A)

2. A solid shaft of 20 cm diameter is used to transmit torque. Find the maximum torque transmitted by the shaft if the maximum shear stress induced in the shaft is 50 N/mm^2. (A)

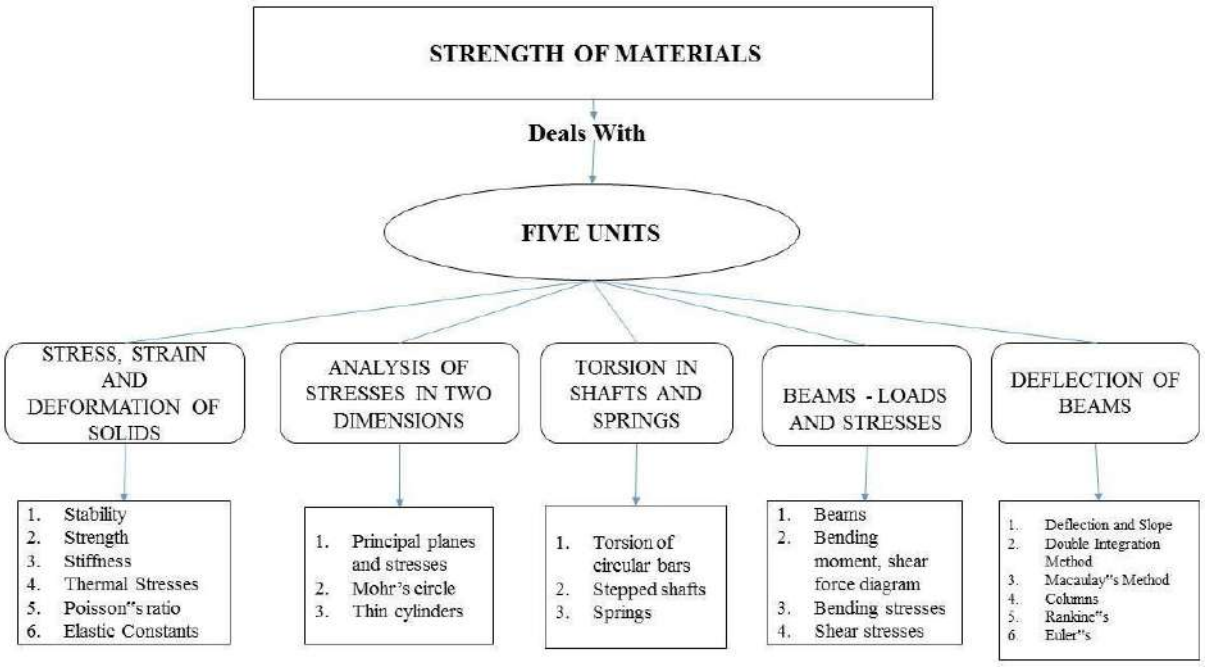
COURSE OUTCOME 4 : Determine shear force, bending moment and stress distribution of various types of beams with different support (APPLY)

1. How many points of contraflexure you will have for simply supported beam overhanging at one end only? (A)
2. Draw the shear force and bending moment diagrams for a simply supported beam of Length L which is subjected to a clockwise couple μ at the centre of the beam. (A)

COURSE OUTCOME 5 : Evaluate the deflection of beams and columns using various approaches (APPLY)

1. Determine: (i) slope at the left support (ii) deflection under the load and (iii) maximum deflection of a SSB of length 5 m, which is carrying a point load 5 kN at a distance of 3 m from the left end. Take E = 2 x 10^5 N/mm^2 and I = 1 x 10^8 mm^4. (A)
2. Calculate the safe load on a hollow cast iron (one end rigidly fixed and other hinged) of 15 cm external diameter, 10 cm internal diameter and 10 m in length. Use Euler's formula with a factor of safety of 5 and E = 95 kN/mm^2. (A)

CONCEPT MAP



21ME4603	THERMAL ENGINEERING	L	T	P	C
		2	1	0	3

Prerequisites for the course

Engineering Chemistry, Engineering Thermodynamics

Objectives

After undergoing this course, the students will be able to:

- Apply the thermodynamic concepts on engines, nozzles, turbines, compressors, Refrigeration and air conditioning systems
- Perform simple analysis on work absorbing and work producing devices to calculate the performance

UNIT I	GAS POWER CYCLES	7+2

Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency – Comparison of cycles

UNIT II	INTERNAL COMBUSTION ENGINE COMBUSTION AND PERFORMANCE	9

IC engine – Classification, working, components and their functions. Ideal and actual: Valve and port timing diagrams, p-v diagrams – two stroke & four stroke, and SI & CI engines. Desirable properties and qualities of fuels, Air-fuel ratio. Performance parameters and calculations. Morse and Heat Balance tests. Multipoint Fuel Injection system and Common Rail Direct lnjection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging – Emission Norms

UNIT III	STEAM NOZZLE AND TURBINE	6+3

Types and shapes of nozzles Flow of steam through nozzles, Critical pressure ratio, Variation of mass flow rate with pressure ratio. Effect of friction. Meta stable flow. Turbines: Types, Impulse and reaction principles, Velocity diagrams, Work done and efficiency – optimal operating conditions. Multi-staging, compounding and governing

UNIT IV	AIR COMPRESSOR	6+3

Classification and comparison, working principle, work of compression – with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency. Multistage air compressor with Intercooling. Working principle and comparison of rotary compressors with reciprocating air compressors

UNIT V	REFRIGERATION AND AIR – CONDITIONING	7+2

Vapour compression refrigeration cycle, Effect of Superheat and Sub-cooling, Performance calculations, working principle of air cycle, vapour absorption system, and thermoelectric refrigeration. Air conditioning systems, concept of RSHF, GSHF and ESHF, Cooling load calculations.

Total Periods	35+10 =45 Hours

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 Marks CAT 2 – 10 Marks DESCRIPTIVE TYPE	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

C212.1 State and compare the processes and performances of different gas power cycles.
C212.2 Explain the functioning and features of IC engines, components and auxiliaries and to calculate the performance parameters of IC Engines
C212.3 Calculate the velocity and design parameters in steam nozzles and to carry out performance analysis on steam turbines
C212.4 Understand the types and working of compressors and to solve problems in single stage and multi stage air.
C212.5 Solve problems in refrigeration and air conditioning system
C212.6 Execute the thermodynamics principles to different thermal devices and to arrive at the design parameters.

Text Books

1. Khurmi R.S, Gupta J.K. "A Text Book on Thermal Engineering", S.Chand 15th Edition, (2018)
2. Rajput R.K., "Thermal Engineering", S. Chand Publishers, (2017)

Reference Books

1. Nag.P.K., "Engineering Thermodynamics", 5th Edition, Tata McGraw-Hill, New Delhi, (2013)
2. Ganesan V., "Internal Combustion Engines", Tata McGraw Hill Publishing Co., New York, (2012)
3. Ballaney P.L. "Thermal Engineering", Khanna publishers, 24th Edition, (2012)
4. Mahesh M.Rathore, "Thermal Engineering", 1st edition, Tata Mc Graw Hill Publications, (2010)
5. Sarkar B.K. "Thermal Engineering", Tata Mc Graw Hill Publishers, (2007)
6. Rudramoorthy R, "Thermal Engineering", Tata Mc Graw Hill , New Delhi, (2003)

Web Resources

1. https://nptel.ac.in/courses/112106133

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C212.1	3	2	1	1										3
C212.2	3	2	1				1							3
C212.3	2	1	1	1			1							3
C212.4	2	2	1	1										3
C212.5	2	2	1	1			1							3
C212.6	2	1	1	1										3

BLOOOMS LEVEL ASSESSMENT PATTERN

BLOOM'S CATEGORY	FORMATIVE ASSESSMENT TEST		CONTINUOUS ASSESSMENT TEST		END SEMESTER EXAMINATION
	FAT1	FAT2	CAT – 1	CAT -2	
Remember	5	5	30	20	20
Understand	15	10	50	40	30
Apply	5	10	20	40	40
Analyze					10
Evaluate					
Create					
Total	25	25	100	100	100

ASSESSMENT QUESTIONS – SAMPLE

COURSE OUTCOME 1: State and compare the processes and performances of different gas power cycles**. (Remember, Understand, Apply)**

1. Define Compression ratio

2. State the effect of increase in cut off ratio on the efficiency of Diesel Engine.

3. Determination of efficiency, work done, mean effective pressure of gas power cycle.(Numerical Problem)

COURSE OUTCOME 2: Explain the functioning and features of IC engines, components and auxiliaries and to calculate the performance parameters of IC Engines **(Remember, Understand, Apply)**

1.State the primary difference in two stroke and four stroke engine.

2.What is meant by value overlapping

3.Numerical problems to determine the performance parameters from the test data of an internal combustion engine.

COURSE OUTCOME 3: Calculate the velocity and design parameters in steam nozzles and to carry out performance analysis on steam turbines **(Remember, Understand, Apply)**

1. Define Critical Pressure ratio.

2. What is the effect of friction on the quality of steam?

3. Determination of area ratio or mass flow rate from the given steam condition.

COURSE OUTCOME 4: Understand the types and working of compressors and to solve problems in single stage and multi stage air. **(Remember, Understand, Apply)**

1. Define isothermal efficiency of a reciprocating compressor.

2. Why clearance volume doesn't have any effect on the volumetric efficiency of an air compressor?

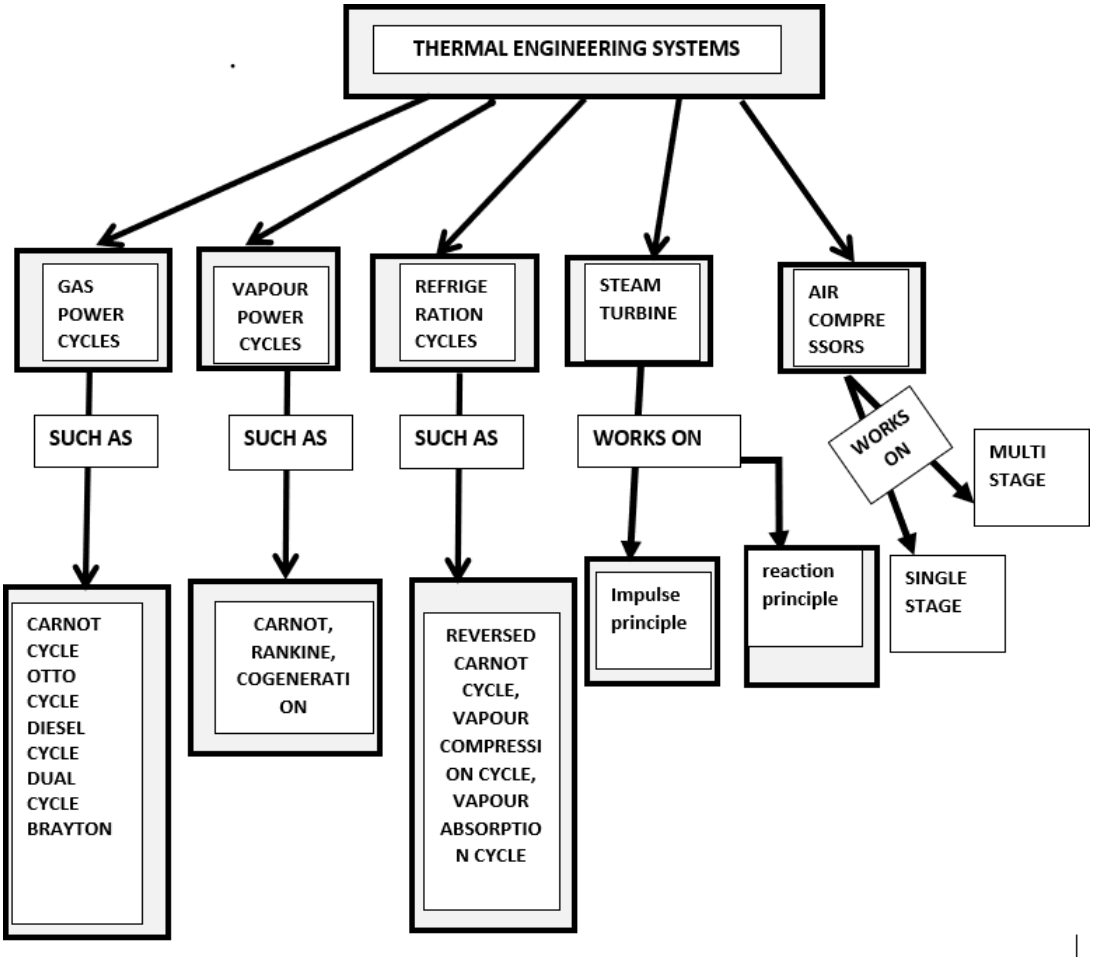
3. Calculation of the energy required to compress air for a given pressure ratio, stages and air outlet condition.

COURSE OUTCOME 5: Solve problems in refrigeration and air conditioning system **(Remember, Understand, Apply)**

1. Define Ton of Refrigeration

2. What is the effect of super heat on the COP of a refrigerator

3. Numerical Calculation on determining the COP of refrigeration system for various cases.



21ME4604	THEORY OF MACHINES	L	T	P	C
		3	1	0	4

Prerequisites for the course

Engineering Mechanics

Objectives

- To impart students' knowledge about forces acting on machine parts.
- To enable students to understand the fundamental concepts of machines.
- To facilitate students to understand the functions of cams, gears and fly wheels.
- To make students to get an insight into balancing of rotations and reciprocating masses and the concepts of vibration.

UNIT I	ANALYSIS OF BASIC MECHANISMS	9+3

Introduction - Terminologies, Degree of Freedom - Study of planar mechanisms and their inversions. Displacement, velocity and acceleration analysis of plane mechanisms.

UNIT II	KINEMATICS OF CAMS, GEARS AND GEAR TRAINS	10+3

Cams with different Follower Motion, Gear terminologies - Law of gearing - Interference and undercutting - Epicyclic gear train.

UNIT III	FORCE ANALYSIS AND BALANCING	10+3

D'Alembert's Principle, Dynamic Analysis of planar Mechanism. Turning Moment Diagrams - Fly Wheels . Static and Dynamic Balancing of Rotating Masses, Balancing of Reciprocating Masses.

UNIT IV	VIBRATIONS	10+3

Free vibration of single degree of freedom systems, effect of damping, Equations of motion, resonance, critical speeds of shafts. Forced vibration, Harmonic Forcing, Transmissibility, vibration isolation.

UNIT V	MECHANISMS FOR CONTROL & GYROSCOPE	6+3

Governors- types and its characteristics, Gyroscopic Effects on the Movement of Air Planes and Ships – Gyroscope Stabilization.

	Total Periods	45+15

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE TYPE	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

C213.1 Apply different mechanisms for designing machines and Compute velocity, acceleration of various planar mechanisms.

C213.2 Apply the principles for analysing cams, gears and gear trains.
C213.3 Analyse dynamic forces acting on mechanism and Balance rotating and reciprocating masses
C213.4 Analyse free, forced and damped vibrations of mechanical systems.
C213.5 Analyse and characterize the effects of governor and gyroscopic effects on aeroplanes, ships.

Text Books

1. S. S. Rattan, "Theory of Machines", Tata McGraw Hill, 2015
2. Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2017.

Reference Books

1. Joseph Edward Shigley and John Jospeh Uicker JR, Theory of Machines and Mechanisms SI Edition, Oxford University Press, 2014
2. R L Norton, Kinematics and Dynamics of Machinery, McGraw-Hill Education, 2017.
3. R L Norton, Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, McGraw-Hill Higher Education, 2011.
4. Khurmi R.S., "Theory of Machines", 14th Edition, S Chand Publications, (2005)

Web Resources

1. https://nptel.ac.in/courses/112106270
2. https://nptel.ac.in/courses/112104121
3. https://onlinecourses.nptel.ac.in/noc20_me21/preview
4. https://nptel.ac.in/courses/112101096

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C213.1	2	2	2									1	3	
C213.2	2	2	2									1	3	
C213.3	1	2	2	1								1	3	2
C213.4	2	2	2		2							1	3	2
C213.5	1	2	3										3	

BLOOMS LEVEL ASSESSMENT PATTERN

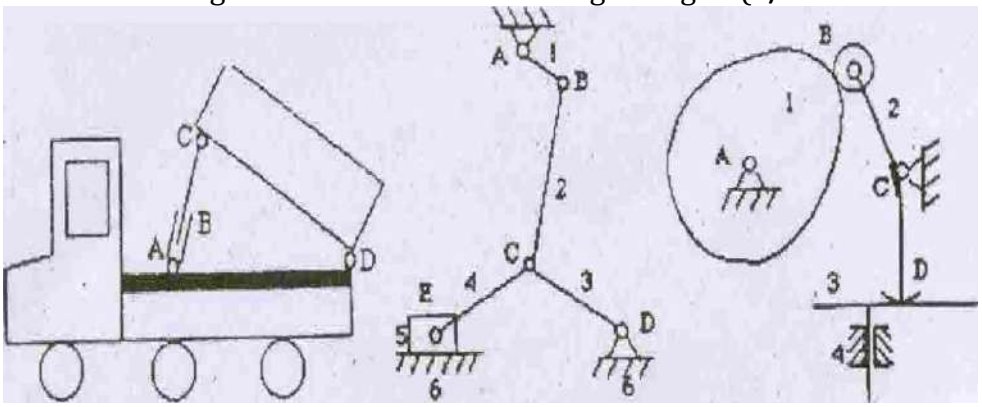
BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	10	10			20
UNDERSTAND	20	10	5	5	20
APPLY	60	50	10	5	40

ANALYZE	10	30	10	15	20
EVALUATE					
CREATE					

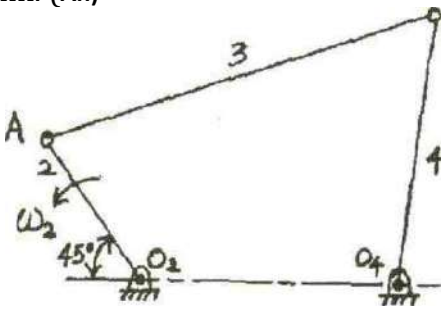
COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 ; Apply different mechanisms for designing machines and Compute velocity, acceleration of various planer mechanisms. (Apply)

1. Determine the degree of freedom for following linkages. **(A)**



2. For the four-bar linkage shown below examine the acceleration of A and B and the angular acceleration of links 3 and 4, Crank 2 has a constant angular velocity, ω_2 = 200 rad/s counter clockwise direction. The linkage $A0_2$ = 150 mm; BA = 450 mm, $B0_4$ = 300 mm, $0_4 0_2$ = 200 mm. **(An)**

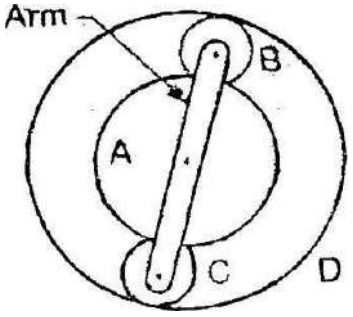


COURSE OUTCOME 2 : Apply the principles for analysing cams, gears and gear trains. (Apply)

1. A cam operates on offset roller follower. The least radius of the cam is 50 mm, roller diameter is 30 mm, and offset is 20 mm, the cam rotates at 360 rpm. The angle of ascent is 48°, angle of dwell is 42° and angle of descent is 60°. The motion is to be SHM during ascent and uniform acceleration and deceleration during decent. Construct the cam profile. **(A)**

2. State and prove law of gearing and thus derive expression for velocity of sliding. **(A)**

3. An epicyclic gear train is shown in the below figure. How many revolutions do the arm makes? (a). When A makes one revolution in CW and D makes 1/2 revolution in the opposite sense, (b). When A makes one revolution in CW and D remains stationary, (c). The number of teeth in gears A and D are 40 and 90 respectively. **(An)**



COURSE OUTCOME 3: Analyse dynamic forces acting on mechanism and Balance rotating and reciprocating masses (Analyse)

1. List the uses of turning moment diagrams? **(R)**
2. A multi-cylinder engine is to run at a speed of 600 r.p.m. On drawing the turning moment diagram to a scale of 1mm=250 N-m and 1mm=3O, the areas above and below the mean torque line in mm2 are: +160, -172, +168, -191, +197, -162. The speed is to be kept within ± 1% of the mean speed of the engine. Calculate the necessary moment of inertia of the flywheel. Determine the suitable dimensions of a rectangular flywheel rim if the breadth is twice its thickness. The density of the cast iron is 7250 kg/m3 and its hoop stress is 6 MPa. Assume that the rim contributes 92% of the flywheel effect. **(A)**
3. Four masses A, B, C and D revolve at equal radii and are equally spaced along a shaft. The mass B is 7 kg and the radii of C and D make angles of 90° and 240° respectively with the radius of B. Examine the magnitude of the masses A, C and D and the angular position of A so that the system may be completely balanced. **(An)**

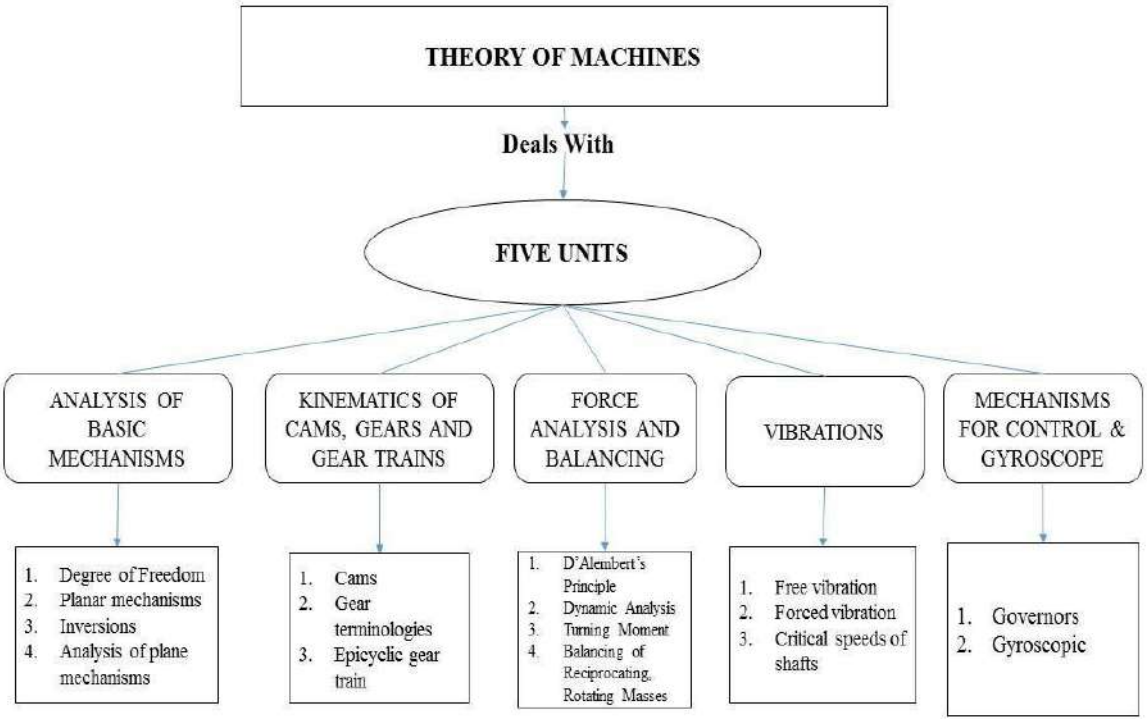
COURSE OUTCOME 4 : Analyse free, forced and damped vibrations of mechanical systems. (Analyse)

1. A machine of weighs 18 kg and is supported on springs and dashpots. The total stiffness of the springs is 12 N/mm and damping is 0.2 N/mm/s the system is initially at rest and a velocity of 120 mm/s is imparted to the mass. Determine (1) the displacement and velocity of mass as a function of time (2) the displacement and velocity after 0.4s. (b) Describe the types of vibrations with simple sketch. **(A)**
2. A shaft of 100 mm diameter and 1 m long is fixed at one end and other end carries a flywheel of mass 1 tonne. Taking young's modulus for the shaft material as 200 GN/m^2. Examine the natural frequency of longitudinal and transverse vibrations. **(An)**
3. A vertical shaft 25 mm diameter and 0.75 m long, is mounted in long bearings and carries a pulley of mass 10 kg midway between the bearings. The centre of the pulley is 0.5 mm from the axis of the shaft. Solve (a) the Whirling Speed (b) the bending stress in the shaft, when it is rotating at 1700 rpm. **(A)**

COURSE OUTCOME 5: Analyse and characterize the effects of governor and gyroscopic effects on aeroplanes, ships. (Analyse)

1. A ship is propelled by a turbine rotor which has a mass of 5 tonnes and a speed of 2100 rpm. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Examine the gyroscopic effect in the following conditions: (i) the ship sails at a speed of 30 km/hr and steers to the left in curve having 60 m radius; (ii) the ship pitches 6° above and 6° below the horizontal position. The bow is descending with its maximum velocity. the motion due to pitching is simple harmonic and a periodic time is 20 seconds.(iii) the ship rolls and at a certain instant it has an angular velocity of 0.03 rad/sec clockwise when viewed from stern. **(An)**
2. In a spring controlled governor, the curve of the controlling force is a straight line. When balls are 400 mm apart, the controlling force is 1200 N and when 200 mm apart, the controlling force is 450 N.at what speed will the governor run when the balls are 250 mm apart? What initial tension on the spring would be required for isochronism and what would then be the speed? Take masses of each ball to be 10 kg. **(A)**
3. Define Stability of a governor. **(R)**

CONCEPT MAP



21GE2M02	ENVIRONMENTAL AND SUSTAINABLE ENGINEERING	L	T	P	C
		2	0	0	0

Preamble

To inculcate knowledge on the environment and all sorts of biotic and abiotic components related to its ecosystem, climate changes and challenges faced due to global warming and the importance of renewable sources of energy. Inspire students to find ways in contributing personally and professionally thereby rectifying environmental and social problems.

Prerequisites for the course

- Basic theoretical concepts of biological science in higher secondary level.
- Basic theoretical concepts of Engineering Chemistry.

Objectives

- To make the students conversant with the interdisciplinary and holistic nature of the environment.
- To make the students understand the impacts of environmental degradation and to minimise vulnerability to future disasters.
- To enrich the students with the significance of natural resources and environment on the quality of life.
- To have an increased awareness among students to create a quest on issues in areas of sustainability.
- To have a thorough understanding of the concepts of sustainable habitat.

UNIT I	ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY	7

Environment: Definition, Scope and Importance of environment studies. Ecosystem: Structure and function of an ecosystem - Producers - Consumers – Decomposers- Types – Characteristic features: Forest ecosystem - Desert ecosystem - Pond ecosystem-Ocean ecosystem.

Biodiversity - Value of biodiversity - Hot-spots of biodiversity- Threats to biodiversity - Endangered and Endemic species - Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Field study of common plants, insects, birds; Field study of simple ecosystems – pond, river, hill slopes, etc.

UNIT II	ENVIRONMENTAL POLLUTION & DISASTER MANAGEMENT	6

Pollution: Definition - Causes - Effects - Control measures of air pollution - Water pollution: (Sewage water treatment by activated sludge and trickling filter process) - Marine pollution - Noise pollution.

Disaster management: Causes - Effects - Control measures of Floods - Earthquake - Cyclone.

Field study of local polluted sites – Urban / Rural / Industrial / Agricultural.

UNIT III	NATURAL RESOURCES	6

Forest resources: Use - Overexploitation - Deforestation - case studies. Water resources: Use - Overutilization of surface and groundwater - Water conservation: Rainwater harvesting- Conflicts over water. Mineral resources: Use - Exploitation -Environmental effects of extracting and using

mineral resources - Case studies. Food resources: Effects of Modern Agriculture - Fertilizer-Pesticide problems (Eutrophication, Blue baby syndrome, Biomagnification) - Water logging - Salinity - case studies. Energy resources: Renewable (Solar, Wind) - Non renewable energy sources.

UNIT IV	**SUSTAINABILITY**	**6**

Introduction, Need and concept of sustainability, Social- Environmental and Economic Sustainability Concepts, Sustainable Development, Challenges for Sustainable Development. Environmental legislations in India - Water Act, Air Act.

UNIT V	**SUSTAINABLE HABITAT**	**5**

Basic concepts of sustainable habitat, Environment Impact Assessment (EIA) - Procedures of EIA in India, Green Engineering, Social and technological change, Industrial Processes: Pollution Prevention, Industrial Ecology.

Total Periods	**30**

Suggestive Assessment Methods

Continuous Assessment Test (100 Marks)	**Formative Assessment Test**	**End Semester Exams**
WRITTEN TEST CAT 1 50 MARKS AND CAT 2 50 MARKS	NA	NA

Outcomes

Upon completion of the course, the students will be able to:

1	Extract the knowledge on the interdisciplinary and holistic nature of the environment. (Understand)
2	Discover the problems related to environmental degradation. (Apply)
3	Sketch the significance of natural resources on the quality of life. (Apply)
4	Solve the issues in areas of sustainability. (Apply)
5	Articulate knowledge on the concepts of sustainable habitat (Apply)

Text Books

1. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2006.
2. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education, 2004.

Reference Books

1. Nibin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
2. G. Tyler Miller and Scott E. Spoolman, "Environmental Science", Cengage Learning India PVT, LTD, Delhi, 2014.

Web Resources

. NPTEL Lecture: https://www.youtube.com/watch?v=hihFHam_wNE
. NPTEL Lecture: https://www.youtube.com/watch?v=DNUYxyaYh3g

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	1				2	3					2		
2	3	2				2	3					2		
3	3		1	1		2	3					2		
4	3	2	1	1		2	3					2		
5	3	2	1	1		2	3					2		

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Students will be able to demonstrate the knowledge on the interdisciplinary and holistic nature of the environment. (Remember)

1. Describe the Multidisciplinary nature of Tirunelveli District.
2. Demonstrate the regulation of Ecosystem

COURSE OUTCOME 2: Students will be able to identify the problems related to environmental degradation. (Understand)

1. Demonstrate the control measures of Air and water Pollution
2. Account the problem and suitable remedial measures for floods in the rainy season.

COURSE OUTCOME 3: Students will be able to understand the significance of natural resources on the quality of life. (Understand)

1. Highlight the control and effects of deforestation.
2. Label the role of individual in conservation of natural resources

COURSE OUTCOME 4: Students will be able to identify the issues in areas of sustainability. (Remember)

1. Outline the term "sustainable development"
2. Compare the major limitations of the Air act, 1972 and Water act, 1980.

COURSE OUTCOME 5: Students will be able to acquire knowledge on the concepts of sustainable habitat. (Remember)

1. Narrate the concept and procedure for Environment Impact Assessment.
   Elucidate the prevention of pollution from various industries.

21PT3901	APTITUDE - I	L	T	P	C
		0	0	2	1

Prerequisites for the course

- Basic Maths

Objectives

- Expose the undergraduate students to solve aptitude problems using different methods and practices.
- Expose the undergraduate students to understand and make decisions with mathematical, statistical, and quantitative information.

UNIT I	MODULE I	6

Number system, Number series, HCF and LCM of Numbers, Factors and Decimals.

UNIT II	MODULE II	6

Square roots and cube roots, Indices and surds, Simplification and approximation, Problems on ages and numbers.

UNIT III	MODULE III	6

Percentage, Profit, loss and discount, Average, Ratio and Proportion.

UNIT IV	MODULE IV	6

Partnership and share, Alligation and mixtures, Chain rule, Mensuration.

UNIT V	MODULE V	6

Pipes and cisterns, simple interest, Compound interest, Growth and depreciation.

Total Periods	30

Suggestive Assessment Methods

Continuous Assessment Test -1 (30 Marks)	Continuous Assessment Test -2 (30 Marks)	Model Exam (40 Marks)
MULTIPLE CHOICE QUESTIONS	MULTIPLE CHOICE QUESTIONS	MULTIPLE CHOICE QUESTIONS

Outcomes

Upon completion of the course, the students will be able to:

CO1: Solve various concepts of number systems and their techniques in solving the HCF, LCM, Factors and Decimals.
CO2: Analyse the profit, loss and discount of real time situations and solve the average, ratio and proportion problems.
CO3: Solve the Problems on ages, Square roots, cube roots, Indices, surds, Simplification and approximation.
CO4: Solve the problems on Partnership, share, Alligation, mixtures, Chain rule, Mensuration.
CO5: Solve the problems on Pipes and cisterns, simple interest, Compound interest, Growth and depreciation.

Text Books
1. Dr. R S Aggarwal, A Modern Approach to Verbal and Non Verbal Reasoning, Revised Edition, S Chand Publications. 2. Abhijit Guha, Quantitative Aptitude for Competitive Examinations, Fourth Edition, Mc Graw Hill Publications.
Reference Books
1. U. Mohan Rao, Quantitative Aptitude for Competitive Examinations, Scitech Publications Pvt Ltd, India. 2. Dinesh Khattar, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, Third Edition, Pearson Education Pvt Ltd, India, 2016. 3. Arun Sharma, How to prepare for Logical Reasoning for CAT & other Management Exams, Fifth Edition, Mc Graw Hill Publications. 4. Jaikishan and Premkishan, How to Crack Test of Reasoning in all Competitive Examinations, Revised Edition, Arihant Publications.
Web Resources 1. https://pdf.bankexamstoday.com/raman_files/Quant%20Formula.pdf 2. https://ugcportal.com/raman-files/QT-TRICKS.pdf 3. https://www.javatpoint.com/aptitude/quantitative#speed-and-distance 4. https://www.indiabix.com/aptitude/questions-and-answers/

CO Vs PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	2	1										2
2	2	1										2
3	3	1										2
4	3	1										2
5	2	1										3

COURSE CONTENT AND SCHEDULE

S.NO	TOPIC	NO OF HOURS REQUIRED
UNIT I – MODULE I		
1	Number system	**2**
2	Number series	**1**
3	HCF of Numbers	**1**
4	LCM of Numbers	**1**
5	Factors and Decimals	**1**
UNIT II – MODULE II		
1	Square roots	**1**
2	Cube roots	**1**
3	Indices and Surds	**2**
4	Simplification and Approximation	**2**

5	Problems on ages and numbers	**1**
UNIT-III MODULE III		
1	Percentage	**1**
2	Profit, loss and discount	**2**
3	Average	**1**
4	Ratio and Proportion	**2**
UNIT-IV MODULE IV		
1	Partnership and share	**2**
2	Alligation and mixtures	**2**
3	Chain rule	**1**
4	Mensuration	**1**
UNIT-V MODULE V		
1	Pipes and cisterns	**1**
2	Simple interest	**2**
3	Compound interest	**1**
4	Growth and depreciation	**2**

21HS2103	TECHNOLOGY IN TAMIL CULTURE	L	T	P	C
		2	0	0	1

Preamble:

This course is offered to develop technical thinking based on Tamil tradition and to acquaint students with the fundamentals of various technologies through Tamil culture and history.

Prerequisite: The prerequisite knowledge required to study this course is basic knowledge in English and Tamil Heritage.

UNIT I	WEAVING AND CERAMIC TECHNOLOGY	6

Weaving Industry during Sangam Age–Ceramic technology–Black and Red Ware Potteries (BRW) – Graffition Potteries

UNIT II	DESIGN AND CONSTRUCTION TECHNOLOGY	6

Designing and Structural construction House & Designs in household materials during Sangam Age – Building materials and Hero Stones of Sangam Age– Details of Stage Constructions in Silapathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal -Chetti Nadu Houses, Indo –Saracenic architecture at Madras during British Period.

UNIT III	MANUFACTURING TECHNOLOGY	6

Art of Ship Building - Metallurgical studies- Jewells making - Iron industry - Iron smelting, steel - Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads -Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gemstone types described in Silapathikaram

UNIT IV	AGRICULTURE AND IRRIGATION TECHNOLOGY	6

Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea – Fisheries – Pearl-Conceiving-Ancient Knowledge of Ocean-Knowledge Specific Society.

UNIT V	SCIENTIFIC TAMIL & TAMIL COMPUTING	6

Development of Scientific Tamil – Tamil computing–Digitalization of Tamil Books–Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sekai Project.

Total Periods	30

Course Outcomes:

At the end of the course the students will be able to

CO1	To learn the techniques adopted in Industries of ancient Tamil culture.
CO2	To assess the technical competence of ancient Tamil.
CO3	To achieve the ability to think about various production technologies in Tamil Culture.
CO4	To explore the recovery and development of agricultural and water management technical skills of Tamil culture.
CO5	To enumerate the technical development that Tamil has achieved in the field of science and computer.

CO PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO 1								1	2	3	1	3
CO 2								1	3	2	3	2
CO 3								1	3	2	1	2
CO 4								3	2	2	3	2
CO 5								2	3	3	2	3

TEXT-CUM-REFERENCEBOOKS

1. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL–(in print)
2. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
3. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
4. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
5. Keeladi-'Sangam City Civilization on the bank of river Vaigai'(Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
6. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published By: TheAuthor)
7. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu) Journey of Civilization Industo Vaigai (R.Balakrishnan) (Published by:RMRL)–Reference Book

21HS2103	தமிழரும் தொழில்நுட்பமும்	L	T	P	C
		2	0	0	1

முன்னுரை(Preamble)

இந்தப் பாடத்திட்டம் பொறியியல் பயிலும் முதலாம் ஆண்டு மாணவர்களின் இரண்டாம் பருவத்திற்குரியது. தமிழ் மரபு சார்ந்த தொழில்நுட்ப சிந்தனையை வளர்த்து பல்வேறு தொழில்நுட்பங்களின் அடிப்படை கூறுகளைத் தமிழரின் பண்பாடு மற்றும் வரலாற்றின் மூலம் மாணவர்களை அறியச் செய்தல்.

பாடநெறிக்கான முன்நிபந்தனைகள்(Prerequisites for the course)

தமிழ் மொழியில் எழுத படிக்க தெரிந்திருத்தல் அவசியம்.

அலகு I	நெசவு மற்றும் பானைத் தொழில்நுட்பம்	6

சங்க காலத்தில் நெசவுத்தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பாண்டங்களில் கீறல் குறியீடுகள்

அலகு II	வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்	6

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்து பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத்தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல் , மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாட்டு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக்கலை

அலகு III	உற்பத்தித் தொழில் நுட்பம்	6

கப்பல் கட்டும் கலை - உலோகவியல் - நகைத் தொழில்நுட்பம் - இரும்பு தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்று சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள் கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்பு துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்

அலகு IV	வேளாண்மை மற்றும் நீர் பாசன தொழில்நுட்பம்	6

அணை , ஏரி, குளங்கள், மதகு - சோழர்காலக் குமிழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்து குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்

அலகு V	அறிவியல் தமிழ் மற்றும் கணினித் தமிழ்	6

அறிவியல் தமிழின் வளர்ச்சி - கணினித் தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணைய கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

Total Periods	30

எதிர்பார்க்கும் படிப்பின் முடிவுகள்:

CO1	மாணவர்கள் பண்டைத் தமிழரின் தொழில்நுட்பங்களை அறிந்து கொள்வர்.
CO2	பண்டைத் தமிழரின் தொழில்நுட்பத் திறனை மதிப்பிடுதல்.
CO3	தாய் மொழியில் பல்வேறு உற்பத்தி தொழில்நுட்பங்களைக் குறித்து சிந்திக்கும் திறனை அடைவார்.
CO4	தமிழரின் வேளாண்மை மற்றும் நீர் மேலாண்மை தொழில்நுட்ப திறன்களை மீட்டு உருவாக்கம் செய்தல் குறித்து அறிதல்.
CO5	அறிவியல் மற்றும் கணினி துறையில் தமிழ்ப் பெற்றுள்ள தொழில் நுட்ப வளர்ச்சியை அறிதல்.

CO PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12
CO 1		1			1		1	1	2	1		3
CO 2		2	2		2	1	3	2	1	2		2
CO 3		2	3	1	2	1	1	1	2	1		2
CO 4			2				2	1	2	2		2
CO 5			2				1	2	1	3		1

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே. கே பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித்தமிழ் - முனைவர் இல. சுந்தரம்(விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்க கால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு).
4. பொருநை - ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறை வெளியீடு)

21ME4605	METROLOGY AND INSTRUMENTATION	L	T	P	C
		3	0	2	4

Prerequisites for the course

Manufacturing Technology I and II

Objectives

1. Acquire knowledge on various Metrological equipments available to measure the dimension of the components.
2. Acquire knowledge on the correct procedure to be adopted to measure the dimension of the components.
3. Understand different measurement equipments and their use in industry for quality inspection.

UNIT I	BASICS OF MEASUREMENT SYSTEM	9

Definition of metrology, accuracy, precision and sensitivity, Abbe's principle; Three stages of generalized measurement system, mechanical loading, factors considered in selection of instruments, commonly used terms, uncertainity, traceability, error analysis and classification, sources of error. – Reliability and Calibration – Readability and Reliability.

UNIT II	LINEAR AND ANGULAR MEASUREMENT	9

Linear Measuring Instruments – Types – Classification – concepts of interchangeability and selective assembly – Angular measuring instruments – Types – Bevel protractor clinometers angle gauges, sine bar – Angle alignment telescope – Autocollimator – Applications.

UNIT III	COMPARATORS AND GEOMETRICAL MEASUREMENT	9

Comparators - mechanical, electrical, optical and pneumatic; Roundness measurement, limit gauge, design of plug gauge, Taylor's principle, three basic types of limit gauges; Pitch and Gear Measurement, Components of surface texture: Roughness, lay, waviness, Ra and Rz, surface roughness meter – Basics of GD & T

UNIT IV	ADVANCES IN METROLOGY	9

Basic concept of lasers– laser Interferometers – types – DC and AC Lasers interferometer – Applications – Straightness – Alignment. Basic concept of CMM – Types of CMM – Constructional features – Probes – Applications – Basic concepts of Machine Vision System – Elements – Applications.

UNIT V	INDUSTRIAL MEASUREMENTS	9

Position sensors: Potentiometer, LVDT; Proximity sensors- types; Vibration sensors - seismic instrument; Torque sensors; Strain gauges; Temperature sensors: Resistance temperature detector, thermistor, thermocouples, and thermopiles, optical pyrometer; Pressure Measurement: Elastic transducers, pressure cell, bulk modulus pressure gauge Flow measurement: Turbine type meter, hotwire anemometer, magnetic flow meter.

S.No	List of Experiments	CO
1	Measurement of linear dimensions using Comparators, angle measurement using bevel protractor and sine bar	**C216.2**
2	Calibration and use of measuring instruments – Vernier caliper, micrometer, Vernier height gauge – using gauge blocks	**C216.2**
3	Measurement of gear parameters – disc micrometers, gear tooth vernier caliper	**C216.3**
4	Non-contact (Optical) measurement using Toolmaker's microscope / Profile projector	**C216.3**
5	Measurement of force and torque	**C216.5**
6	Machine tool metrology -Testing of straightness of a machine tool guide way using Autocollimator	**C216.2**
	Total Periods	**45 Theory +15 Lab**

Laboratory Requirements

(For a batch of 30 Students)

1. Micrometer
2. Vernier Caliper
3. Vernier Height Gauge
4. Vernier depth Gauge
5. Slip Gauge Set
6. Gear Tooth Vernier
7. Sine Bar
8. Profile Projector / Tool Makers Microscope
9. Mechanical / Electrical / Pneumatic Comparator
10. Force Measuring Setup
11. Torque Measuring Setup

Suggestive Assessment Methods

Continuous Assessment Test (20Marks)	**Lab Components Assessments (20 Marks)**	**End Semester Exams (60 Marks)**
Descriptive Questions CAT 1 – 10 MARKS CAT 2 – 10 MARKS	Model practical with project (10 Marks) and LabExperiment (20 Marks)	**Descriptive Questions**

Course Outcomes

Upon completion of the course, the students will be able to:

C216.1: Describe the concepts of measurements to apply in various metrological instruments.
C216.2: Outline the principles of linear and angular measurement tools used for industrial applications
C216.3: Explain the principles of comparators and geometrical measurement tools used for industrial applications.
C216.4 :Discuss advance measuring techniques of mechanical properties in industrial applications
C216.5: Discuss various measuring instruments for measuring the industrial components.

Text Books

1. Gupta I C , "A text book of Engineering Metrology", Dhanpat Rai Publications, New Delhi, 2018.
2. Beckwith T G, Roy D, Marangoni, John H Lienhard , "Mechanical Measurements", Prentice Hall, 2007.

Reference Books

1. Alan S Morris, Reza Langari , "Measurement and Instrumentation: Theory and Application",Academic Press, 2015.
2. Venkateshan S P , "Mechanical Measurements", John Wiley & Sons, 2015.
3. Holman J P , "Experimental Methods for Engineers", Tata McGraw Hill Publications Co Limited, 2011.

Web Resources

1. https://nptel.ac.in/courses/112106179/
2. https://home.iitk.ac.in/~jrkumar/download/Lecture-4.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C216.1	3	1	1			2						1	3	2
C216.2	3	1	1			2						1	3	2
C216.3	3	1	1			2						1	3	2
C216.4	3	1	1		2	2						1	3	2
C216.5	3	1	1		2	2						1	3	2

BLOOMS LEVEL ASSESSMENT PATTERN

BLOOMS CATEGORY	CAT 1	CAT 2	FAT 1	FAT 2	END SEM EXAM
REMEMBER	40	30	5	5	30
UNDERSTAND	40	50	10	10	50
APPLY	20	20	10	10	20
ANALYZE					
EVALUATE					
CREATE					

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 Describe the concepts of measurements to apply in various metrological instruments. – (Remember, Understand)

1. What are the factors affecting the measuring system?(R)

2. What is the difference between allowance and tolerance?(U)

3. Explain the classification of various measuring methods. (U)

Course Outcome 2 : Outline the principles of linear and angular measurement tools used for industrial applications – (Remember, Understand)

1. Give a brief note on slip gauges and what are the safety precaution to be followed in the use of slip gauge blocks and also explain the type of limit gauge with neat sketches (U)

2. Explain the working principle of SINE BAR. (U)

3.Explain the classification of linear measuring instruments. (U)

Course Outcome 3 : Explain the principles of comparators and geometrical measurement tools used for industrial applications. (Remember, Understand)

1. Define straightness of a line in two planes (U)

2. List out the reasons for the occurrence of progressive errors in screw threads.(U)

3. Explain the various methods by which roundness is measured. (U)

Course Outcome 4 Discuss advance measuring techniques of mechanical properties in industrial applications (Remember, Understand)

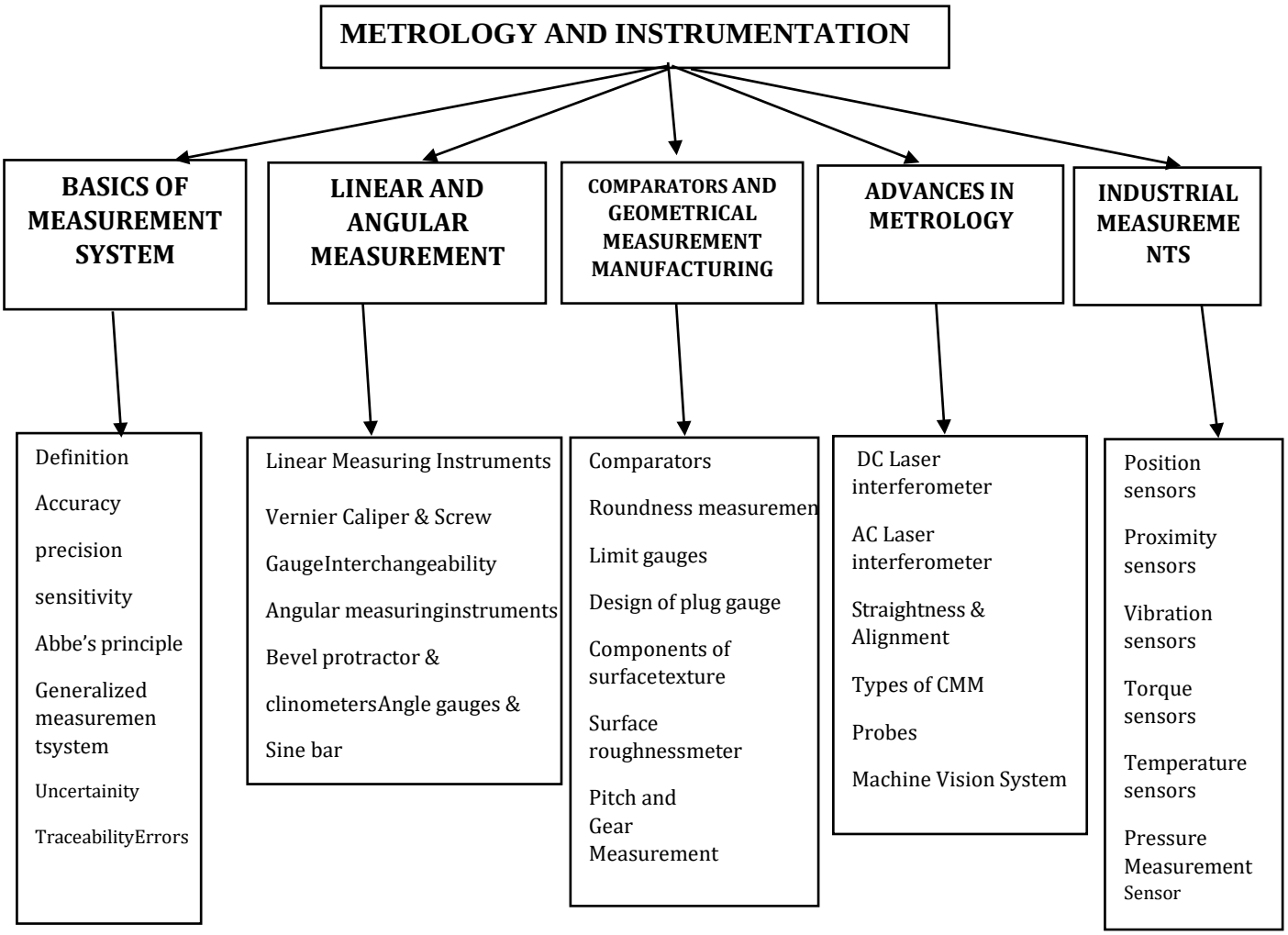
1. Explain the working principle of DC Laser interferometer with neat diagram.(U)

2. With a neat sketch explain the dimensional measurements using laser gauge.(U)
3. Discuss the need, types and constructional features of coordinate measuring machine.(U)

Course Outcome 5 :Discuss various measuring instruments for measuring the industrial components. (Remember, Understand)

1. Explain the method of measuring force using strain gauge load cell. (U)
2. With neat sketch explain how metallic strips are used for temperature measurements. (U)
3. Explain with neat diagram the purpose and operating principle of a venturi meter. (U)

CONCEPT MAP


METROLOGY AND INSTRUMENTATION
BASICS OF MEASUREMENT SYSTEM
LINEAR AND ANGULAR MEASUREMENT
COMPARATORS AND GEOMETRICAL MEASUREMENT MANUFACTURING
ADVANCES IN METROLOGY
INDUSTRIAL MEASUREMENTS
Definition
Accuracy
precision
sensitivity
Abbe's principle
Generalized measuremen tsystem
Uncertainity
TraceabilityErrors
Linear Measuring Instruments
Vernier Caliper & Screw
GaugeInterchangeability
Angular measuringinstruments
Bevel protractor &
clinometersAngle gauges &
Sine bar
Comparators
Roundness measuremen
Limit gauges
Design of plug gauge
Components of surfacetexture
Surface roughnessmeter
Pitch and
Gear
Measurement
DC Laser interferometer
AC Laser interferometer
Straightness & Alignment
Types of CMM
Probes
Machine Vision System
Position sensors
Proximity sensors
Vibration sensors
Torque sensors
Temperature sensors
Pressure Measurement Sensor

21ME4611	THERMAL ENGINEERING LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Thermal Engineering

Objectives

- Get practical exposure to fuel properties, measurement methods, performance testing methods of internal combustion engines and reciprocating air compressor

Sl.No	List of Experiments	CO
1	Valve Timing and Port Timing diagrams	C217.1
2	Performance Test on 4 – stroke Diesel Engine	C217.2
3	Heat Balance Test on 4 – stroke Diesel Engine	C217.2
4	Morse Test on Multi-cylinder Petrol Engine	C217.2
5	Retardation Test on a Diesel Engine	C217.2
6	Determination of Flash Point and Fire Point of various fuels / lubricants	C217.3
7	Study on a Steam Generator	C217.4
8	Study on steam Turbine	C217.4
9	Performance test on a reciprocating air compressor	C217.5
10	Determination of COP of a refrigeration system	C217.6
11	Experiments on Psychrometric processes	C217.6

Total Periods :45

Suggestive Assessment Methods

Lab Components Assessments (50 Marks)	End Semester Exams (50 Marks)
Model Lab 30 Marks Experimental Marks 20 Marks	Practical

Course Outcomes

Upon completion of the course, the students will be able to:

C217.1: Draw the valve timing and port diagram using four stroke and two stroke engine model
C217.2: Evaluate the performance of IC engine with various type of loading
C217.3 : Determine the thermal properties of fuels and lubricants
C217.4 : Conduct test to evaluate the performance of steam generator and turbine
C217.5 : Conduct test to evaluate the performance of reciprocating air compressor
C217.6 : Determine the performance of refrigeration system and also explain the various psychrometric properties.

Laboratory Requirements

- I.C Engine – 2 stroke and 4 stroke model
- 4-stroke Diesel Engine with mechanical loading
- 4-stroke Diesel Engine with hydraulic loading
- 4-stroke Diesel Engine with electrical loading
- Multi-cylinder Petrol Engine
- Apparatus for Flash and Fire Point
- Steam Boiler with turbine setup
- Single/two stage reciprocating air compressor
- Refrigeration test rig
- Air-conditioning test rig

Reference Books

1. Nag.P.K., "Engineering Thermodynamics", 5th Edition, Tata McGraw-Hill, New Delhi, (2013)
2. Ganesan V., "Internal Combustion Engines", Tata McGraw Hill Publishing Co., New York, (2012)
3. Ballaney P.L. "Thermal Engineering", Khanna publishers, 24th Edition, (2012)

Web Resources

1. https://nptel.ac.in/courses/112106133

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C217.1	2		2									3	3	2
C217.2	2	2	2									1	2	3
C217.3	2	3											2	3
C217.4	2		2									2	2	3
C217.5	2	3											2	3
C217.6	2		2									2	2	3

21ME4612	STRENGTH OF MATERIALS LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Strength of materials

Objectives

- Determine experimental data include universal testing machines and torsion equipment.
- Determine experimental data for spring testing machine, compression testing machine, impact tester, hardness tester.
- Determine deflection of a beam.

S.No	List of Experiments	CO
1	Izod Impact Test	C218.1
2	Charpy Impact Test	C218.1
3.	Direct Shear Test on Mild Steel Rod	C218.2
4	Direct Shear Test on Aluminium Rod	C218.2
5	Brinell Hardness Test	C218.3
6	Rockwell Hardness Test	C218.3
7	Tensile Test on Mild Steel	C218.4
8	Tensile Test on Cast Iron	C218.4
9	Compression Test on Mild Steel	C218.4
10	Compression Test on Cast Iron	C218.4
11	Torsion Test on Mild Steel	C218.5
12	Deflection test on beams	C218.5
13	Compression test on helical springs	C218.5
14	Microscopic Examination of (i) Hardened samples and (ii) Hardened and tempered samples.	C218.5

Total Periods : 45

Suggestive Assessment Methods

Lab Components Assessments (60 Marks)	End Semester Exams (40 Marks)
EXPERIMENTATION –40 Marks Model Exam with project – 20 Marks	Practical Exam

Course Outcomes

Upon completion of the course, the students will be able to:

C218.1. Compute impact strength for given specimen

C218.2. Compute shear strength for given specimen

C218.3. Examine the hardness for various metal specimen

C218.4. Conduct performance study for Mechanical Properties and Performance of Materials such as tensile , compression strength

C218. 5. Examine the Mechanical Properties for beams, springs and tempered.

Laboratory Requirements

1. Universal Tensile Testing machine with double shear attachment - 40 Ton Capacity -1 No
2. Torsion Testing Machine (60 NM Capacity) – 1 Nos
3. Impact Testing Machine (300 J Capacity) – 1 Nos
4. Brinell Hardness Testing Machine – 1 Nos
5. Rockwell Hardness Testing Machine – 1 Nos
6. Spring Testing Machine for tensile and compressive loads (2500 N) – 1 Nos
7. Metallurgical Microscopes – 3 Nos
8. Muffle Furnace (800 °C) – 1 Nos
9. Deflection of beams – 1 Nos

Reference Books

1. Ramamrutham S., "Strength of Materials", Dhanpatrai Publishing company, (2012)
2. Bansal R.K., "A Text book of strength of material", Laxmi publication, New Delhi, (2014)McGraw-Hill, (2014)

Web Resources

1. https://sm-nitk.vlabs.ac.in/
2. https://nptel.ac.in/courses/112107146

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C218.1	2	2	1	2								1	3	
C218.2	2	2	1	2								1	3	
C218.3	2	2	1	2								1	3	
C218.4	2	2	1	1								1	3	
C218.5	2	2	1	1								1	3	

21ME4613	KINEMATICS AND DYNAMICS LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Theory of machines

Objectives

- Interpret the practical knowledge of mechanism behind the various dynamics systems including balancing of masses, governors, cams, gyroscopes, gear trains and speed reducers.
- Interpret the knowledge on the spring mass vibration systems and compound pendulum.

S.No	List of Experiments	CO
1	a) Study of gear parameters. b) Experimental study of velocity ratios of simple, compound, Epicyclic and differential gear trains	C219.1
2	a) Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double rocker, Oscillating cylinder Mechanisms. b) Kinematics of single and double universal joints.	C219.1
3.	Determination of Mass moment of inertia of Fly wheel and Axle system.	C219.2
4	Determination of Mass Moment of Inertia using bifilar suspension and compound pendulum.	C219.2
5	Determination of Mass Moment of Inertia of axisymmetric bodies using Turn Table apparatus.	C219.2
6	Motorized gyroscope – Study of gyroscopic effect and couple	C219.3
7	Governor - Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and Hartnell Governors.	C219.3
8	Cams – Cam profile drawing, Motion curves and study of jump phenomenon	C219.3
9	Single degree of freedom Spring Mass System – Determination of natural Frequency and verification of Laws of spring – Damping coefficient determination	C219.4
10	Transverse vibration of Free-Free beam – with and without concentrated masses.	C219.4
11	Determination of transmissibility ratio using vibrating table.	C219.4
12	Whirling of shafts – Determination of critical speeds of shafts with concentrated loads.	C219.5
13	Determination of torsional natural frequency of single and Double Rotor systems.- Undamped and Damped Natural frequencies.	C219.5
14	Balancing of rotating masses and Balancing of reciprocating masses.	C219.5

Total Periods : 45

Suggestive Assessment Methods	
Lab Components Assessments (60 Marks)	**End Semester Exams (40 Marks)**
EXPERIMENTATION –40 Marks Model Exam with project – 20 Marks	**Practical Exam**

Outcomes

Upon completion of the course, the students will be able to:

C219.1. Explain gear parameters, kinematics of mechanisms in various Mechanisms.

C219.2. Determine mass moment of inertia for axisymmetric bodies and mechanical elements.

C219.3. Conduct performance study for stability control mechanisms like governor and motorised gyroscope and to study cam jump phenomenon

C219.4. Compute frequency for free vibration, damping coefficient and transmissibility ratio.

C219.5. Compute torsional frequency, critical speeds of shafts, balancing mass of rotating and reciprocating masses.

Laboratory Requirements

Cam follower setup

Motorised gyroscope.

Governor apparatus - Hartnell governors.

Whirling of shaft apparatus

Dynamic balancing machine.

Torsional Vibration of single rotor and two rotor system setup.

Spring mass vibration system.

Turn table apparatus.

Compound pendulum setup

Transverse vibration setup of a) cantilever

Gear Models

Kinematic Models to study various mechanisms.

Reference Books

1. F.B.Sayyad, "Dynamics of Machinery", McMillan Publishers India Ltd., Tech-Max Educational resources, (2011)

2. Rattan, S.S, "Theory of Machines", 4th Edition, Tata McGraw-Hill, (2014)

Web Resources

1.: https://nptel.ac.in/courses/112104114/

2.: https://www.youtube.com/watch?v=GGIYpsUpWL0

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C219.1		2	2	2		2						1	3	
C219.2		2	2	2		2						1	3	
C219.3		2	2	2		2						1	3	
C219.4		2	2	2		2						1	3	
C219.5		2	2	2		2						1	3	

SEMESTER V

21ME5601	HEAT AND MASS TRANSFER (Use of standard HMT data book & Steam tables permitted)	L	T	P	C
		2	1	0	3

Prerequisites for the course

Engineering Physics and Engineering Thermodynamics

Objectives

1. To understand the mechanisms of heat transfer under steady and transient conditions.
2. To understand the concepts of heat transfer through extended surfaces.
3. To learn the thermal analysis and sizing of heat exchangers and to understand the basic concepts of mass transfer.

UNIT I	CONDUCTION	9

General Differential equation of Heat Conduction – Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction in simple geometries – plane wall, cylindrical and spherical shells – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Heat Capacity Analysis – Semi Infinite and Infinite bodies – Chart Solutions.

UNIT II	CONVECTION	9

Combined Natural and Forced Convection - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates, Cylinders and spheres and Internal flow through tubes

UNIT III	PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS	9

Introductory concepts of Boiling & Condensation – Regimes of boiling. Heat Exchangers – Types & Practical applications – Use of LMTD – Effectiveness – NTU method – Overall Heat Transfer Coefficient – Fouling Factor.

UNIT IV	RADIATION	9

Terminology and laws – Black Body & Grey Body – Radiation from real surfaces – view factor – Electrical Analogy – Radiation through shields & gases.

UNIT V	MASS TRANSFER	9

Introduction to mass transfer – Mass transfer by molecular diffusion – Fick's Law of Diffusion – Mass Transfer in Convection – Mass transfer coefficient, numerical problems – Analogy of Heat and Mass Transfer.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 -10 Marks CAT 2 -10 Marks Descriptive Questions	1.Assignment/ Tutorial 2.Online Quizzes 3.Problem –Solving Activities	1.Descriptive Type Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Apply heat conduction equations to different surface configurations under steady state and transient conditions to solve problems **(Apply)**

CO2: Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems **(Apply)**

CO3: Illustrate the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems **(Apply)**

CO4: Interpret the basic laws for radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems **(Apply)**

CO5: Apply diffusive and convective mass transfer equations and correlations to solve mass transfer problems **(Apply)**

Text Books

1. Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, (2010)
2. YunusA. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 5th Edition (2015)

Reference Books

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, (2014)
2. Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, (2012)
3. Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, (2011)
4. Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., (2020)
5. R.C.Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, (2009)
6. S.P. Venkateshan, "Heat Transfer", Ane Books, New Delhi, 2014

Web Resources

1. https://nptel.ac.in/courses/112101097/
2. .https://www.udemy.com/course/heat-and-mass-transfer/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1	PO12	PSO 1	PSO2
CO1	3	3		1									2	3
CO2	3	3											2	3
CO3	3	3	2	1									2	3
CO4	3	3		1										2
CO5	3	3											2	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Apply heat conduction equations to different surface configurations under steady state and transient conditions to solve problems (Apply)

1. Define Fourier's Law of conduction (R)
2. State few practical examples for transient heat conduction(U)
3. A long rod is exposed to air at 298°C. It is heated at one end. At steady state conditions, the temperatures at two points along the rod separated by 120 mm are found to be 130°C and 110°C respectively. The diameter of the rod is 25 mm OD and its thermal conductivity is 116 W/m°C. Calculate the heat transfer coefficient at the surface of the rod and also the heat transfer rate. (A)

COURSE OUTCOME 2: Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems. (Apply)

1. Define Newton's Law of cooling (R)
2. Differentiate viscous sub layer and buffer layer (U)
3. Air at 27°C and 1 atmospheric pressure flow over a flat plate at a speed of 2 m/s. Calculate boundary layer thickness at distance 40 cm from leading edge of the plate (A)

COURSE OUTCOME 3: Explain the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems. (Apply)

1. Define LMTD (R)
2. Distinguish pool boiling from forced convection boiling (U)
3. Sketch and plot the LMTD distribution graph for condensers & evaporators (A)

COURSE OUTCOME 4: Explain basic laws for radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems. (**Apply)**

1. Define Planck's distribution law (R)
2. What are the required radiation properties of materials used as radiation Shield (U)
3. Calculate the maximum emissive power for an industrial furnace in the form of black body and emitting radiation at 2500°C (A)

COURSE OUTCOME 5: Apply diffusive and convective mass transfer equations and correlations to solve mass transfer problems (Apply)

1. Define Molar concentration (R)
2. Indicate the heat and mass transfer analogy (U)
3. Air at 1 atm and 25oC containing small quantities of iodine, flows with a velocity of 6.2 m/s inside a 35 mm diameter tube. Calculate the mass transfer coefficient for iodine. The thermo physical properties of air are: V=15.5 x 10-6 m^2/s ; D=0.82 x 10-5 m^2/s (A)

21ME5602	Design of Machine Elements and Joints (Use of Databook is permitted)	L	T	P	C
		2	1	0	3

Prerequisites for the course

Engineering Mechanics, Strength of Materials

Objectives

- To familiarize the various steps involved in the Design Process
- To understand the principles involved in evaluating the shape and dimensions of a component to satisfy functional and strength requirements.
- To learn to use standard practices and standard data
- To learn to use catalogues and standard machine components

UNIT I	MACHINE DESIGN CONCEPTS	10

Introduction to Machine Design – General Considerations in Machineelements Design – Machine Design Process/Procedure–Selection of Materialsbased on mechanical properties – Fits and tolerances, Standardization – Preferred Numbers- Determination of Loads, Types of Stresses and Deflection in simple machine parts- crane hook & C frame – Factor of safety, Design for Static Load – Theories of Failure- Design for Fluctuating loads – Fatigue failure theories – Goodman equation – Soderberg equation.

UNIT II	SHAFTS AND COUPLINGS	8

Design of Shafts – combined twisting moment and bending moment -combined twisting moment, bending moment and axial loads. Design of Keys and splines. Design of Couplings– Rigid and Flexible Couplings.

UNIT III	DESIGN OF JOINTS	9

Design of Welded joints – Lap and Butt joints – Welded joints subjected totransverse and eccentric loads. Riveted Joints – Design of different types of riveted joints –Pressure vessels – Structural Joints – Riveted joints subjected to eccentric loads. Design ofThreaded Joints – Bolted Joints in simple Tension and Shear – Eccentrically Loaded Bolted Joints. Design of Cotter Joints and Knuckle Joints

UNIT IV	ENERGY STORING ELEMENTS	9

Design of Helical Coil Springs – Tension and Compression springssubjected to axial loads and eccentric loads- Design of parallel and concentric springs subjected toaxial loads - Design of Leaf Springs - Design of Flywheels for IC engines and Punching presses.

UNIT V	IC ENGINE COMPONENTS & BEARINGS	9

Design of Piston, Connecting Rod & Crank shafts – Sideand Centre Crank. Design of Sliding Contact and Rolling Contact Bearings, Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs- Selection of Rolling Contact bearings.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT – I (10 Marks) CAT – II (10 Marks) Descriptive Questions	Assignment, Multiple Choice Questions	Descriptive type questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Apply the concepts of Design of simple machine elements subjected to static and fatigue Loading. **(Apply)**

CO2: Apply the concepts of Design of shafts, keys and couplings under different loading conditions for mechanical applications. .**(Apply)**

CO3: Apply the concepts of Design of welded joints, riveted joints and threaded joints subjected to different loading conditions. .**(Apply)**

CO4: Apply the concepts of Design of helical coil springs, leaf springs and flywheels for mechanical applications. .**(Apply)**

CO5: Apply the concepts of Design of piston, connecting rod and crank shaft for an automobileengine and sliding contact bearings and anti-friction bearings. .**(Apply)**

Text Books

1.V.B. Bhandari, "Design of Machine Elements", Fourth Edition, McGraw Hill Education India Pvt. Ltd., 2017.

2. R.S. Khurmi, J.K. Gupta, "Machine Design", Eurasia Publishing House (Pvt.) Ltd, Ram Nagar, New Delhi-110 055, 2005

Reference Books

1. Alfred Hall, Halowenko, A and Laughlin, H., "Machine Design", Tata McGraw-Hill BookCo.(Schaum's Outline), 2010
2. Ansel C. Ugural, "Mechanical Design of Machine Components", Second Edition, CRC Press, 2015.
3. Sundararajamoorthy T. V. Shanmugam .N, "Machine Design", Anuradha Publications, Chennai, 2015.
4. Alfred Hall, Alfred Holowenko, Herman Laughlin and S Somani, "Schaum's Outline -Machine Design", McGraw Hill Education India Pvt. Ltd., 2017.
5. Robert C. Juvinall and Kurt M. Marshek, "Machine Component Design", Wiley India Edition,2016..
6. PSG College, "Design Data: Data Book of Engineers", Kalaikathir Achchagam, 2019

Web Resources

1. https://nptel.ac.in/courses/112/105/112105125/
2. https://nptel.ac.in/courses/112/105/112105124/

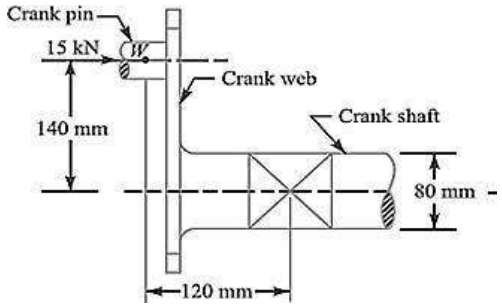
CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	3	1					1				3	
2	2	1	3	1					1	1			3	
3	2	1	3	1					1	1			3	
4	2	1	3	1					1	1			3	
5	2	1	3						1	1			3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Apply the concepts of Design of simple machine elements subjected to static and fatigue Loading. (Apply)

1. An overhang crank with pin and shaft is shown in figure. A tangential load of 15 kN acts on the crank pin. Determine the maximum principal stress and the maximum shear stress at the centre of the crankshaft bearing.(A)



2. Determine the diameter of a circular rod made of ductile material with a fatigue strength (complete stress reversal), σ-1 = 265 MPa and a tensile yield strength of 350 MPa. The member is subjected to a varying axial load from Wmin = – 300 × 103 N to W_{max} = 700 × 103 N and has a stress concentration factor = 1.8. Use factor of safety as 2.0.(A)

3. The load on a bolt consists of an axial pull of 10 kN together with a transverse Shear force of 5 kN. Find the diameter of bolt required according to,

- Maximum principal stress theory. (A)
- Maximum shear stress theory.
- Maximum principal strain theory.
- Maximum strain energy theory.
- Maximum distortion energy theory.

COURSE OUTCOME 2: Apply the concepts of Design of shafts, keys and couplings under different loading conditions for mechanical applications (Apply)

1. A hollow shaft of 0.5 m outside diameter and 0.3 m inside diameter is used to drive a propeller of a marine vessel. The shaft is mounted on bearings 6 metre apart and it transmits 5600 kW at 150 r.p.m. The maximum axial propeller thrust is 500 kN and the shaft weighs 70 kN. Determine: The maximum shear stress developed in the shaft, and the angular twist between the bearings. (A)

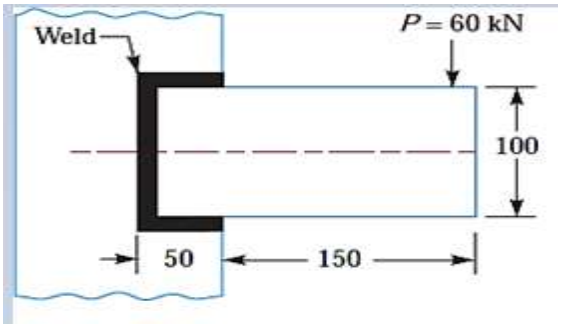
2. Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions: Power to be transmitted = 40 kW; speed of the motor shaft = 1000 r.p.m.; diameter of the motor shaft = 50 mm; diameter of the pump shaft = 45 mm. The bearing pressure in the rubber bush and allowable stress in the pins are to be limited to 0.45 N/mm2 and 25 MPa respectively.(A)

3. Design a shaft and flange for a Diesel engine in which protected type of flange coupling is to be adopted for power transmission. The following data is available for design: Power of engine = 75 kW; speed of engine = 200 r.p.m.; maximum permissible stress in shaft = 40 MPa; maximum permissible twist in shaft = 1° in length of shaft equal to 30 times the diameter of shaft; maximum torque = 1.25 × mean torque; pitch circle diameter of bolts = 3 × diameter of shaft; maximum permissible stress in bolts = 20 MPa.

Find out: 1. Diameter of shaft, 2. number of bolts, and 3. diameter of bolts. (A)

COURSE OUTCOME 3: Apply the concepts of Design of welded joints, riveted joints and threaded joints subjected to different loading conditions (Apply)

1. A rectangular steel plate is welded as a cantilever to a vertical column and supports a single concentrated load P, as shown in Figure. Determine the weld size if shear stress in the same is not to exceed 140 MPa. (A)



2. A steam engine cylinder of size 300 mm × 400 mm operates at 1.5 N/mm2 pressure. The cylinder head is connected by means of 8 bolts having yield point stress of 350 MPa and endurance limit of 240 MPa. The bolts are tightened with an initial preload of 1.8 times the steam lead. The joint is made leak-proof by using soft copper gasket which renders the effect of external load to be half. Determine the size of bolts, if factor of safety is 2 and stress concentration factor is 3. (A)

3. A pressure vessel has an internal diameter of 1 m and is to be subjected to an internal pressure of 2.75 N/mm2 above the atmospheric pressure. Considering it as a thin cylinder and assuming efficiency of its riveted joint to be 79%, calculate the plate thickness if the tensile stress in the material is not to exceed 88 MPa. Design a longitudinal double riveted double strap butt joint with equal straps for this vessel. The pitch of the rivets in the outer row is to be double the pitch in the inner row and zig-zag riveting is proposed. The maximum allowable shear stress in the rivets is 64 MPa. You may assume that the rivets in double shear are 1.8 times stronger than in single shear and the joint does not fail by crushing. Make a sketch of the joint showing all calculated values. Calculate the efficiency of the joint. (A)

COURSE OUTCOME 4: Apply the concepts of Design of helical coil springs, leaf springs and flywheels for mechanical applications (Apply)

1. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm^2.Neglect the effect of stress concentration. (A)

2. A truck spring has 12 numbers of leaves, two of which are full length leaves. The spring supports are 1.05 m apart and the central band is 85 mm wide. The central load is to be 5.4 kN with a permissible stress of 280 MPa. Determine the thickness and width of the steel spring leaves. The ratio of the total depth to the width of the spring is 3. Also determine the deflection of the spring. (A)

3. A multi-cylinder engine is to run at a speed of 500 r.p.m. On drawing the crank effort diagram to scale 1 mm = 2500 N-m and 1 mm = 3º, the areas above and below the mean

torque line is in mm2 as below: + 160, – 172, + 168, – 191, + 197, – 162.The speed is to be kept within ± 1% of the mean speed of the engine. Design a suitable rim type C.I. flywheel for the above engine. Assume rim width as twice the thickness and the overhang of the flywheel from the centre of the nearest bearing as 1.2 metres. The permissible stresses for the rim in tension are 6 MPa and those for shaft and key in shear are 42 MPa. The allowable stress for the arm is 14 MPa. (A)

COURSE OUTCOME 5: Apply the concepts of Design of piston, connecting rod and crank shaft for an automobile engine and sliding contact bearings and anti-friction bearings. (Apply)

1. Determine the dimensions of an I-section connecting rod for a petrol engine from the following data: Diameter of the piston = 110 mm; Mass of the reciprocating parts = 2 kg; Length of the connecting rod from centre to centre = 325 mm; Stroke length = 150 mm; R.P.M. = 1500 with possible over speed of 2500; Compression ratio = 4: 1; Maximum explosion pressure = 2.5 N/mm2. (A)

2. Design a side crankshaft for a 500 mm × 600 mm gas engine. The weight of the flywheel is 80 kN and the explosion pressure is 2.5 N/mm2. The gas pressure at maximum torque is 0.9 N/mm2 when the crank angle is 30º. The connecting rod is 4.5 times the crank radius. (A)

3. Design a cast iron piston for a single acting four stroke engine for the following data: Cylinder bore = 100 mm; Stroke = 125 mm; Maximum gas pressure = 5 N/mm2; Indicated mean effective pressure = 0.75 N/mm2; Mechanical efficiency = 80% ; Fuel consumption = 0.15 kg per brake power per hour ; Higher calorific value of fuel = 42 × 103 kJ/kg ; Speed = 2000 r.p.m. Any other data required for the design may be assumed. (A)

4. Design a suitable journal bearing for a centrifugal pump from the following available data: Load on the bearing = 13.5 kN; Diameter of the journal = 80 mm; Speed = 1440 r.p.m.; Bearing characteristic number at the working temperature (75°C) = 30 ; Permissible bearing pressure intensity = 0.7 N/mm2 to 1.4 N/mm2; Average atmospheric temperature = 30°C. Calculate the cooling requirements, if any. (A)

5. A ball bearing subjected to a radial load of 4000 N is expected to have a satisfactory life of 12 000 hours at 720 r.p.m. with a reliability of 95%. Calculate the dynamic load carrying capacity of the bearing, so that it can be selected from manufacturer's catalogue based on 90% reliability. If there are four such bearings each with a reliability of 95% in a system, what is the reliability of the complete system? (A)

21ME5603	AUTOMOBILE ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering

Objectives

- To understand the construction and working principle of various parts of an automobile
- To have the practice for assembling and dismantling of engine parts and transmission system

UNIT I	VEHICLE STRUCTURE AND ENGINES	9

Types of automobiles vehicle construction and different layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines –components – functions and materials, variable valve timing (VVT).

UNIT II	ENGINE AUXILIARY SYSTEMS	9

Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS).

UNIT III	TRANSMISSION SYSTEMS	9

Clutch– types and construction, gear boxes– manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

UNIT IV	STEERING, BRAKES AND SUSPENSION SYSTEMS	9

Steering geometry and types of steering gear box– Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control.

UNIT V	ALTERNATIVE ENERGY SOURCES	9

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles– Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels – Electric and Hybrid Vehicles, Fuel Cell

Note: Practical Training in dismantling and assembling of Engine parts and Transmission Systems should be given to the students.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT – I 10 Marks CAT – II 10 Marks Descriptive Questions	Slip Test, Assignment, Case study etc	Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Recognize the various parts of the automobile and their functions and materials **(Remember)**
CO2: Describe the engine auxiliary systems and engine emission control **(Understand)**
CO3: Distinguish the working of different types of transmission systems **(Apply)**
CO4: Enumerate the Steering, Brakes and Suspension Systems **(Apply)**
CO5: Predict possible alternate sources of energy for IC Engines **(Understand)**

Text Books

1. 1. Jain K.K. and Asthana R.B, "Automobile Engineering" Tata McGraw Hill Publishers, New Delhi, (2002)
2. Kirpal Singh, "Automobile Engineering", Vol 1 & 2, Seventh Edition, Standard Publishers, New Delhi, 13th Edition (2014)

Reference Books

1. Ganesan V. "Internal Combustion Engines", Third Edition, Tata McGraw-Hill, (2012)
2. Heinz Heisler, "Advanced Engine Technology," SAE International Publications USA, (1998)
3. Joseph Heitner, "Automotive Mechanics," Second Edition, East-West Press, (1999)
4. Martin W, Stockel and Martin T Stockle , "Automotive Mechanics Fundamentals," The Good heart - Will Cox Company Inc, USA , (1978)
5. Newton , Steeds and Garet, "Motor Vehicles", Butterworth Publishers, (1989).

Web Resources

1. https://nptel.ac.in/courses/107/106/107106088/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	1	1			1					1		3
2	3	1	1	1			1					1		3
3	3	1	1	1			1					1		3
4	3	1	1	1			1					1		3
5	3	1	1	1			1					1		3

COURSE LEVEL QUESTIONS

1. **COURSE OUTCOME 1:** Recognize the various parts of the automobile and their functions and materials **(Remember)**
   1. List major types of automobiles according to the fuel used. (R)
   2. Point out the stresses to which the frame members are subjected to? (R)

2. **COURSE OUTCOME 2:** Describe the engine auxiliary systems and engine emission control **(Understand)**
   1. Explain with a sketch the working of a Unit injector system (Understand)
   2. Describe the construction and operation of a Simple Carburetor.(Understand)

3. **COURSE OUTCOME 3:** Distinguish the working of different types of transmission systems **(Apply)**
   1. Illustrate how does the front axle differ from a rear axle. Explain with sketches. (Apply)

2. Compare hydraulic, mechanical, electrical and vaccum method of operating clutches (Understand)

4. **COURSE OUTCOME 4:** Enumerate the Steering, Brakes and Suspension Systems **(Apply)**
   1. Explain the principle of operation of a power steering system with a neat sketch. (Understand)
   2. Examine the operation of antilock braking systems. (Apply)

5. **COURSE OUTCOME 5:** Predict possible alternate sources of energy for IC Engines **(Understand)**
   1. Explain the reasons for using alternate fuels in IC Engines. (Understand)
   2. Explain the two methods by which hydrogen can be used in IC engine. (Understand)

21PT3904	REASONING	L	T	P	C
		0	0	2	1

Prerequisites for the course

- Foundational English
- Verbal Ability

Objectives

To strengthen the interpersonal skills and branding it to social network by the effective use of social media and social interactions

UNIT I	Interpersonal Skill	6

Interpersonal Communication, Peer Communication, Image Building and Personal Branding, Delegation and compliance, Responsibility, Creation of accountability

UNIT II	Social Media	6

Effective use of social media, Types of social media, Moderating personal information, Social media for Job/Profession, Networking on social media, Maximizing network with social media

UNIT III	Social Interaction	6

Event management, Event management methods, Effective techniques for better event management, Influencing skill, Building relationships, Persistence and resilience

UNIT IV	Non Verbal Communication	6

Proximecs, Types of Proximecs, Rapport building, Negotiation Skill, Effective negotiation strategies. Conflict resolution, Styles of conflict resolution

UNIT V	Reasoning Ability	6

Analytical Reasoning Data Arrangement (Linear and circular & Cross Variable Relationship), Ordering/ranking/grouping, Selection Decision table

Total Periods	30

Suggestive Assessment Methods

Continuous Assessment Test-1 (30 Marks)	Continuous Assessment Test-2 (30 Marks)	Model Exam (40 Marks)
1. DESCRIPTIVE QUESTIONS 2. MULTIPLE CHOICE QUESTIONS	1. DESCRIPTIVE QUESTIONS 2. MULTIPLE CHOICE QUESTIONS	1. DESCRIPTIVE QUESTIONS 2. MULTIPLE CHOICE QUESTIONS

Outcomes
Upon completion of the course, the students will be able to: **CO1:** Improve their interpersonal skills through proper communication. **CO2:** Acquire wide knowledge on social Media and its interaction **CO3:**Understanding the various strategies for building relationships among peers **CO4:**Improve negotiation skills in academic and social contexts **CO5:** Interpret the analytic data in decision table.
Text Books
1. ETHNUS, Apti mithra, 2013, First Edition, McGraw-Hill Education Pvt. Ltd. 2. Mark G. Frank, David Matsumoto, Hyi Sung Hwang, Nonverbal Communication: Science and Applications, 2012, 1 st Edition, Sage Publications, New York.
Reference Books
1. Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler, Crucial Conversations: Tools for Talking When Stakes are High, 2001,1st edition McGraw Hill Contemporary, Bangalore. 2. Dale Carnegie, How to Win Friends and Influence People, Latest Edition,2016. Gallery Books, New York
Web Resources 1. https://www.fresherslive.com/online-test/logical-reasoning-test/questions-and-answers 2. https://www.indiabix.com/non-verbal-reasoning/questions-and-answers/ 3. https://www.indiabix.com/logical-reasoning/questions-and-answers/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	1	2	2									
2		2		2		2			1		3	
3	1			1	1		2			1	2	2
4	1	2	2		3			3	2			
5	2		2	2		2			2		1	

COURSE CONTENT AND LECTURE SCHEDULE

S.NO	TOPIC	NO OF HOURS REQUIRED
	UNIT I Interpersonal Skill	
1	Interpersonal Communication	**1**
2	Peer Communication	**1**
3	Image Building and Personal Branding	**1**
4	Delegation and compliance	**1**
5	Responsibility	**1**
6	Creation of accountability	**1**
	UNIT II Social Media	
1	Effective use of social media	**1**

2	Types of social media	**1**
3	Moderating personal information	**1**
4	Social media for Job/Profession	**1**
5	Networking on social media	**1**
6	Maximizing network with social media	**1**
UNIT III Social Interaction		
1	Event management	**1**
2	Event management methods	**1**
3	Effective techniques for better event management	**1**
4	Influencing skill	**1**
5	Building relationships	**1**
6	Persistence and resilience	**1**
UNIT-IV Non Verbal Communication		
1	Proximecs, Types of proximecs	**1**
2	Rapport building	**1**
3	Negotiation Skill	**1**
4	Effective negotiation strategies	**1**
5	Conflict resolution	**1**
6	Styles of conflict resolution	**1**
UNIT-V Reasoning Ability		
1	Analytical Reasoning Data Arrangement (Linear and circular & Cross Variable Relationship),	**2**
2	Ordering/ranking/grouping,	**2**
3	Selection Decision table	**2**

21ME5604	MECHATRONICS AND INTERNET OF THINGS	L	T	P	C
		3	0	2	4

Prerequisites for the course

Metrology and Instrumentations, Fundamentals of Electrical and Electronics Science

Objectives

To impart knowledge about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.

UNIT I	INTRODUCTION TO MECHATRONICS SYSTEM	9

Automation - Concepts of Mechatronics approach – Elements of an Automated System - Mechanical Actuation System-Hydraulic & Pneumatic Actuation System, Electrical Actuation System- Control system – Sensor - measurement of Displacement - Velocity - Force - Temperature - Pressure – Flow.

UNIT II	MICRO PROCESSOR AND INTERFACING CIRCUITS	9

Architecture of 8085 – Addressing Modes – Instruction Set – Simple Programming-Architecture of 8051 – I/O Pins Ports and Circuits- Programming in Embedded C: Data types, Control loops- time delay, I/O, Logic operations -Applications LED, ADC/DAC and stepper motor - Introduction to Arduino controller.

UNIT III	PROGRAMMABLE LOGIC CONTROLLER & SCADA	9

Introduction – Basic structure – Input and output processing – Programming – Mnemonics – Timers, counters, and internal relays – Data handling – Selection of PLC. Introduction to SCADA - Applications.

UNIT IV	INTRODUCTION TO INTERNET OF THINGS	9

Introduction, Physical Design of IoT, Logical Design of IoT, Functional blocks of IoT, IoT Design Methodology - IoT applications and case studies- Home Automation, Agriculture, Industry

UNIT V	MECHATRONIC SYSTEM DESIGN	9

Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Engine Management system – Automatic car park barrier- Automated Assembly System- automated inspection-Automated health monitoring system

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Lab components (30 Marks)	End Semester Exams (50 Marks)
CAT – I 10 Marks CAT – II 10 Marks Descriptive Questions	Model Lab – 10 Marks Experiment Marks – 10 Marks	Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the interdisciplinary applications of Electronics, Electrical, Mechanical, Computer and fluid systems**. (Apply)**

CO2: Explore the architecture of Microprocessor, Microcontroller and Programmable Peripheral Interface and various interfacing techniques. **(Apply)**

CO3: Utilize the application of programmable logic controllers and SCADA to the industries. **(Apply)**

CO4: Apply the basic concepts of IoT. **(Apply)**

CO5: Apply engineering design of automation to assembly, inspection and monitoring process. **(Apply)**

Text Books
1. Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”, Pearson Education Limited, 2015. 2. Ramesh Gaonkar “Microprocessor Architecture, Programming, and Applications with the 8085” Penram International Publishing, 2017 3. Sudip Misra, Anandarup Mukherjee, Arijit Roy Introduction to IoT 9th Edition, Cambridge University Press, 2016
Reference Books
1. Bradley D.A, Dawson D, Buru N.C and Loader A.J, “Mechatronics”, Chapman and Hall, 1993. 2. Clarence W, de Silva, "Mechatronics" CRC Press, First Indian Re-print, 2013 3. K. P. Ramachandran, G. K.Vijayaraghavan, and M.S.Bala-Sundram, “Mechatronics: Integrated Mechanical Electronic Systems”, Wiley India Pvt. Ltd., New Delhi 2008. 4. Dr Kamlesh Lakhwani ,Kumar Gianey, Joseph Kofi Wireko , Kamal Kant Hiran “Internet of Things (IoT): Principles, Paradigms and Applications of IoT, BPB Publications, 2015
Web Resources 1. https://nptel.ac.in/courses/112103174/ **(Mechatronics and IoT)** 2. https://nptel.ac.in/courses/112/107/112107298/ **(Mechatronics and IoT)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	1	3	2	1	1						1	3	
2	1	1	3	2	1	1						1	3	
3	1	1	3	2	1	1						1	3	
4	1	1	3	2	1	1						1	3	
5	1	1	3	2	1	1						1	3	

S.No	List of Experiments	CO
1	Measurement of displacement, temperature, and speed	**CO1**
2	Design and demonstration of simple automation system using hydraulic/Pneumatics system	**CO1**
3	Assembly language programming of 8085 – Addition – Subtraction – Multiplication – Division – Sorting (any two operations)	**CO2**
4	I/O port programming in 8051 using embedded C.	**CO2**
5	PLC programming to control a valve	**CO3**
6	To interface LED/Buzzer with Arduino/Raspberry Pi and write a Program to turn ON LED for 1 sec after every 2 seconds	**CO4**
7	Design of home/industrial automation system using Node MCU or ESP32	**CO5**

Total Practical Periods	**30**

Sl. No.	NAME OF THE EQUIPMENT	Qty.
1	Basic Pneumatic Trainer Kit with manual and electrical controls/ PLC Control each	1 No.
2	Basic Hydraulic Trainer Kit	1 No
3	Hydraulics and Pneumatics Systems Simulation Software	10 No
4	8051 - Microcontroller	5 Nos
6	Ardino UNO	10 Nos
7	ESP 32	10 Nos
8	Data Cables for Ardino UNO + ESP 32	20 Nos
9	DHT Sensors	5 No
10	PIR Sensors	5 No
11	IR Sensors	5 Pair

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Interpret the interdisciplinary applications of Electronics, Electrical, Mechanical, Computer and fluid systems **(Apply)**

1. Explain the working principles of stepper motor. (U)
2. Is Washing machine working under a closed loop System? Justify your answer (A)

COURSE OUTCOME 2: Explore the architecture of Microprocessor, Microcontroller and programming for simple applications. **(Apply)**

1. Explain the instruction set of 8085 Microprocessor (Understand)
2. Explain how 8051 microcontrollers can be used to display a four-digit number in seven segment LEDs with minimum power (Apply)

COURSE OUTCOME 3: Utilize the application of programmable logic controllers and SCADA to the industries. **(Apply)**

1. Create a ladder diagram for the following application:
   A pneumatic system with double solenoid valve controls two double acting cylinders A and B. The sequence of cylinder operations are as follows: Cylinder A extends followed by cylinder B extending, then cylinder B retracts and finally the cycle is

completed by the cylinder A retracting. Explain the logic of the PLC circuit used (Apply)

2.Draw the ladder diagram and PLC program for the following logic gate.
a) AND b) OR c) NAND d) NOT e) XOR (f) XNOR (Remember)

COURSE OUTCOME 4: Explain the basic concepts of IoT **(Apply)**

1. With Suitable example, explain in detail about IoT levels and deployment templates. (Apply)
2. Discuss the steps involved in IoT design methodology (Understand)

COURSE OUTCOME 5: Apply engineering design of automation to assembly, inspection and monitoring process. **(Apply)**

1. Develop an automation system for a pick and place robot (Apply)

2. Mention the applications of IoT in health care domain (Understand)

21ME5611	HEAT AND MASS TRANSFER LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Engineering Physics , Engineering Thermodynamics

Objectives

1. To study the heat transfer phenomena to estimate the relevant coefficient.
2. To study and analyse the performance of refrigeration systems.

S.No	List of Experiments	CO
1	Thermal conductivity measurement using guarded plate apparatus.	CO1
2	Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.	CO1
3	Determination of heat transfer coefficient under natural convection from a vertical cylinder.	CO2
4	Determination of heat transfer coefficient under forced convection from a tube.	CO2
5	Determination of Thermal conductivity of composite wall.	CO1
6	Determination of Thermal conductivity of insulating powder.	CO1
7	Heat transfer from pin-fin apparatus (natural & forced convection modes)	CO2
8	Determination of Stefan – Boltzmann constant.	CO3
9	Determination of emissivity of a grey surface.	CO3
10	Effectiveness of Parallel / counter flow heat exchanger.	CO4
11	Performance test in a Fluidized Bed cooling tower	CO5
12	Study of the regimes of pool boiling and determination of critical heat flux	CO4
13	Study on Heat conduction in Cartesian & Cylindrical coordinates system	CO1
14	Study of electrical analogy for Thermal Radiation Systems	CO3
15	Experiment on convective heat transfer through flat plate solar collector	CO2

Total Periods :45

Suggestive Assessment Methods

Continuous Assessment (60 Marks)	End Semester Exams (40 Marks)
Lab experiment 40 Marks **Model lab with project -20 Marks**	**Practical Exam**

Course Outcomes

Upon completion of the course, the students will be able to:

1. Analyse and interpret heat transfer parameters by conducting experiments on conduction experimental setups.
2. Analyse and interpret heat transfer parameters by conducting experiments on natural and forced convection apparatus.
3. Analyse and interpret heat transfer parameters by conducting experiments on radiation apparatus.
4. Analyse and interpret heat transfer parameters by conducting experiments on heat exchanger test setups and Study of boiling & condensation.

5. Analyse and interpret heat transfer parameters by conducting experiments on a Fluidized Bed Cooling Tower & Study of Mass Transfer

Laboratory Requirements

(Requirements for a batch of 30students)

Heat and Mass Transfer Laboratory

S.No.	Description of Equipment	Quantity Required (R)
1.	Guarded plate apparatus	1
2.	Lagged pipe apparatus	1
3.	Natural convection-vertical cylinder apparatus	1
4.	Forced convection inside tube apparatus	1
5.	Composite wall apparatus	1
6.	Thermal conductivity of insulating powder apparatus	1
7.	Pin-fin apparatus	1
8.	Stefan-Boltzmann apparatus	1
9.	Emissivity measurement apparatus	1
10.	Parallel/counter flow heat exchanger apparatus	1
11	Fluidized Bed Cooling Tower	1
12	Flat Plate Solar Collector	1

Reference Books

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, (2014)
2. Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, (2012)
3. Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, (2002)

Web Resources

1. http://htv-au.vlabs.ac.in/

CO Vs PO Mapping and CO Vs PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3				1				1		3
CO2	3	3	3	3				1				1		3
CO3	3	3	3	3				1				1		3
CO4	3	3	3	3				1				1		3
CO5	3	3	3	3				1				1		3

21ME5612	CAD / CAM LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Engineering Graphics, Computer Aided Machine Drawing

Objectives

1. To gain practical experience in handling 3D modelling and assembling using modelling software systems.
2. To study the features of CNC Machine Tool.
3. To expose students to modern control systems (Fanuc, Siemens etc.,)
4. To know the application of various CNC machines like CNC lathe, CNC Vertical Machining center, CNC EDM and CNC wire-cut and studying of Rapid prototyping and tooling.

S.No	Experiments	CO
	3D GEOMETRIC MODELLING (27)	
1	Introduction of 3D Modelling Software	CO 1
2	Design of 3D Assembly Model of I.C. Engine Connecting rods.	CO 2
3	Design of 3D Assembly Model of Footstep bearing.	CO 2
4	Design of 3D Assembly Model of Screw Jack.	CO 2
5	Design of 3D Assembly Model of Machine Vice.	CO 2
6	Design of 3D Assembly Model of Universal Joint	CO 2
7	Design of 3D Assembly Model of Flange Coupling	CO 2
8	Design of 3D Assembly Model of Plummer Block	CO 2
9	Design of 3D Assembly Model of Lathe Tailstock	CO 2
	MANUAL PART PROGRAMMING (15)	
1	Part Programming – CNC Machining Center (8) a) Linear Cutting b) Circular Cutting c) Cutter Radius Compensation. d) Canned Cycle Operations.	CO3
2	Part Programming CNC Turning Center (7) a) Straight, Taper and Radius Turning b) Thread Cutting c) Rough and Finish Turning Cycle d) Drilling and Tapping Cycle	CO4
3	a) Study of CNC EDM and CNC wire-cut b) Study of Rapid prototyping and tooling	CO5

S.No.	List of Projects	Related Experiment	CO
	CAD		
1.	LEVEL 1 Industrial based 3D modelling components	CAD EXERCISES	CO2

2.	LEVEL 2 Production based assembly modelling	CAD EXERCISES	CO2
	CAM		
1.	LEVEL 1 Industrial based CNC programming for CNC lathe	CAM EXERCISES	CO3
2.	LEVEL 2 Industrial based CNC programming for CNC Milling machine	CAM EXERCISES	CO4
Projects from both CAD and CAM is mandatory.			

Suggestive Assessment Methods	
Continuous Assessment(60 Marks)	**End Semester Exams (40 Marks)**
Lab experiment 40 Marks **Model lab with project -20 Marks**	**Practical Exam**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1:Interpret the fundamentals of the Computer Aided Design which will equip them to pursue higher studies
CO2: Illustrate any solid part modelling by using modelling software package
CO3: Write the part programming of CNC milling
CO4: Write the part programming of CNC lathe
CO5: Interpret the fundamentals of EDM, wire-cut and Rapid prototyping and tooling

Text Books

1. Ibrahim Zeid, "Mastering CAD/CAM", Tata McGraw- Hill Inc., New Delhi, 2008
2. Radhakrishnan P and Subramanyan S, —CAD/CAM/CIM||, New Age International (P) Ltd., 2008

Reference Books

1. PN RAO, "CAD/CAM: Principles and Applications", Tata McGraw Hill, 2004
2. D.Evangeline, S.Anitha,"Computer Graphics and Multimedia Insights, Mathematical Models and Programming Paradigms" PHI publications 2016
3. Zhuming Bi, Xiaoquin Wang, "Computer Aided Design and Manufacturing", Wiley, 2020

Web Resources

1. **http://vlabs.iitkgp.ernet.in/vlabs/rtvlab1/cadprg.html**
2. **http://vlabs.iitkgp.ac.in/cim/#**

HARDWARE		
1.	Computer Server	1
2.	Computer nodes or systems (High end CPU with at least 1 GB main memory) networked to the server	30
3.	A3 size plotter	1
4.	Laser Printer	1
5.	CNC Lathe	1
6.	CNC milling machine	1
SOFTWARE		
7.	Any High end integrated modeling and manufacturing CAD/ CAM software	15 licenses

8.	CAM Software for machining centre and turning centre (CNC Programming and tool path simulation for FANUC / Sinumeric and Heidenhain controller)	15 licenses
9.	Licensed operating system	Adequate

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	1	1			1					3	
2	2	2	3	2	1			1					3	
3	2	2	2	1	1			1					3	
4	1	1	2	2	1			1					3	
5			2	2	2			1					3	

SEMESTER VI

21ME6601	Design of Transmission Systems (Use of PSG Design Data Book permitted)	L	T	P	C
		2	1	0	3

Prerequisites for the course

Strength of Materials, Design of machine Elements.

Objectives

- To gain knowledge on the principles and procedure for the design of Mechanical power Transmission components.
- To understand the standard procedure available for Design of Transmission of Mechanical elements
- To learn to use standard data and catalogues

UNIT I	INTRODUCTION, BELTS & CHAIN DRIVES	9

Need of Power transmission - Requirements of Transmission system - Types and Classifications of Transmission systems – Specification of a Transmission Element - Design of Flat belts and pulleys – Selection of V belts and pulleys –Design of Transmission chains and Sprockets.

UNIT II	PARALLEL AXIS GEARS	9

Speed ratios and number of teeth-Force analysis – Tooth stresses – Dynamic effects – Fatigue strength – Factor of safety – Gear materials – Design of straight tooth spur & helical gears based on strength and wear considerations – Pressure angle in the normal and transverse plane – Equivalent number of teeth– forces for helical gears.

UNIT III	INCLINED AXIS GEARS	9

Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits – terminology. Thermal capacity, materials – forces and stresses, efficiency, estimating the size of the worm gear pair. Cross helical: Terminology –helix angles – Estimating the size of the pair of cross helical gears.

UNIT IV	GEARBOXES	9

Geometric progression – Standard step ratio – Ray diagram, kinematics layout – Design of sliding mesh gear box – Design of multi speed gear box for machine tool applications – Constant mesh gear box – Speed reducer unit – Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.

UNIT V	CLUTCHES AND BRAKES	9

Design of plate clutches –axial clutches – cone clutches – internal expanding rim clutches – Electromagnetic clutches. Band and Block brakes – external shoe brakes – Internal expanding shoe brake.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 & CAT 2 each 10 marks Descriptive type questions	Assignment, MCQ	Descriptive Type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret basic concepts, selection and design of power transmission systems such as flat belt, V belt drives & Pulleys and chain drives. **(Apply)**

CO2: Calculate power transmission between parallel shaft and design spur & helical gears. **(Apply)**

CO3: Interpret transmission between intersecting shafts and design the bevel, worm and cross helical gears. **(Apply)**

CO4: Prepare kinematic layout and structural arrangement of the gear boxes. **(Apply)**

CO5: Design the clutches and brakes. **(Apply)**
Text Books
1. Bhandari V, "Design of Machine Elements", 4th Edition, Tata McGraw-Hill Book Co, 2016. 2. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 9th Edition, Tata McGraw-Hill, 2011.
Reference Books
1. Alfred Hall, Halowenko, A and Laughlin, H., "Machine Design", Tata McGraw-Hill BookCo.(Schaum's Outline), 2010 2. AnselUgural, "Mechanical Design – An Integral Approach", 1st Edition, Tata McGraw-Hill Book Co, 2003. 3. Sundararajamoorthy T. V. Shanmugam .N, "Machine Design", Anuradha Publications, Chennai, 2015. 4. Orthwein W, "Machine Component Design", Jaico Publishing Co, (2003) 5. Prabhu. T.J., "Design of Transmission Elements", Mani Offset, Chennai, (2000) 6. R.S. Khurmi, J.K. Gupta, "Machine Design", Eurasia Publishing House (Pvt.) Ltd, Ram Nagar, New Delhi-110 055, 2005.
Web Resources 1. https://nptel.ac.in/courses/112106137/ 2. www.aulibrary.com/machine design 3. https://nptel.ac.in/courses/112/105/112105124/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	3	1									3	
2	2	1	3	1									3	
3	2	1	3	1									3	
4	2	1	3	1									3	
5	2	1	3	1									3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret basic concepts, selection and design of power transmission systems such as flat belt, V belt drives & Pulleys and chain drives. **(Apply)**

1. Design a flat belt drive for a fan running at 360rpm which is driven by a 10 KW at1440 rpm motor. The belt drive is open type and the distance between the pulley Centres is 2000 mm. The diameter of a driven pulley is 1 m. (A)
2. Design a V-belt drive to transmit 10kW at 400 rpm. The speed ratio is 3. Centre distance between the pulleys is 600 mm and the drive is crusher. (A)
3. A truck equipped with 9.5 KW engine uses a roller chain of the final drive to the rear axle. The driving sprocket runs at 900 rpm and driven sprocket at 400 rpm with a center distance of approximately 600 mm. select a suitable the roller chain. (A)

COURSE OUTCOME 2: Calculate power transmission between parallel shaft and design spur & helical gears. **(Apply)**

1. Design a pair of straight spur gear drive for a stone crusher, the gears are made of C40 steel. The pinion is to transmit 30 KW at 1200 rpm. The gear ratio is 3. The gear is to work 8 hours/day 6days in a week for 3 years. (A)
2. A helical gear with 30-degree helix angle has to transmit 35kW at 1500 rpm with a speed reduction ratio 2.5. If the pinion has 24 teeth determine the necessary module, pitch diameter and face width for 20-degree full depth teeth. Assume 15Ni 2Cr 1 Mo15 material for both pinion and wheel. (A)
3. For intermittent duty of an elevator, two cylindrical gears made of alloys steel 40 Ni 2 Cr 1 Mo 28 and have to transmit12.5 kw at a pinion speed of 1200 rpm. Design a gear pair for the following specifications: Gear ratio: 3.5, pressure angle 20°, involute full depth, helix angle 15°. Gears are expected to work 6 hrs a day for 10 years. Minimum number of teeth on pinion can be taken as 20 and IS quality 8. (A)

COURSE OUTCOME 3: Interpret transmission between intersecting shafts and design the bevel, worm and cross helical gears. **(Apply)**

1. Design a Bevel gear drive to transmit 4 KW. Speed ratio = 4. driving shaft speed 225 rpm. The drive is non-reversible. Assume a life of 25000 hours. (A)
2. Design a bevel gear to transmit 3.5 KW with driving shaft speed is 200 rpm. Speed ratio requires is 4. The drive is non- reversible. Pinion is made of steel and wheel made of CI. Assume a life of 25,000 Hrs. (A)
3. Design the worm gear drive and determine the power loss by heat generation of Hardened steel worm rotates at 1440 rpm and transmits 12 KW to a phosphor bronze gear with gear ratio of 16. (A)

COURSE OUTCOME 4: Prepare kinematic layout and structural arrangement of the gear boxes. **(Apply)**

1. Design a 9-speed gear box for the following data. Minimum speed: 180rpm, Maximum speed: 1800rpm. Using standard step ratio, draw the speed diagram, kinematic layout. Also find the number of teeth on each gear. (A)
2. Design 12 speed gear box for a minimum speed of 160 rpm and a maximum speed of 2000 rpm. The input speed of motor is 1600 rpm. Draw the speed diagram, kinematic diagram and indicate the number of teeth on each gear. (A)
3. In a milling machine, 18 different speeds in the range of 35 rpm and 650 rpm are required. Design a three-stage gear box with a standard step ratio. Sketch the layout of the gear box, indicating the number of teeth n each gear. The gear box receives 3.6 kW from an electric motor running at 1,440 rpm. Sketch also the speed diagram. (A)

COURSE OUTCOME 5: Design the clutches and brakes. **(Apply)**

1. A plate clutch with maximum diameter 60mm has maximum lining pressure of 0.35 MPa. The power to be transmitted at 400 rpm is 135 KW and μ =0.3. Find inside diameter and spring force required to engage the clutch. Springs with spring index 6 and material spring steel with safe shear stress 600 MPa are used. Find the diameters

if 6 spring are used. (A)

2. A multi disc wet clutch is to be designed for a machine tool driven by an electric motor of 12.5 KW running at 1440 rpm. Space restrictions limit the outside disc diameter to 100mm. Determine the appropriate value of inside diameter, total number of discs and clamping force. (A)
3. Design a differential band for a winch lifting a load of 20 KN through a steel wire rope wound around a barrel of 600 mm dm. The brake drum, keyed to barrel shaft is 800 mm diameter and the angle of lap of the band over the drum is about 240 degrees. Operating arms of the brake are 50 mm and 250 mm. The length of operating level is 1.6m. (A)

21ME6602	FINITE ELEMENT ANALYSIS	L	T	P	C
		2	1	0	3

Prerequisites for the course

Matrices and Advanced Calculus, Strength of Materials, Fluid Mechanics and Machinery, Heat and Mass Transfer.

Objectives

- To introduce the concepts of solving of engineering problems and to appreciate the use of Finite Element Analysis.

UNIT I	STATIC ANALYSIS USING ONE DIMENSIONAL SPAR ELEMENTS	12

Mathematical modelling of Field Problems in Engineering, Approximate methods of analysis (Descriptive Only), Basic concepts of FEM, General procedure of FEM,discretization of domain, basic types of elements; Formulation of element stiffness matrices and load vectors: 1D linearspar and quadratic spar elements, plane truss element, treatment of boundary conditions and temperature effects;Solution of problems.

UNIT II	STATIC ANALYSIS USING ONE DIMENSIONAL BEAM ELEMENTS	8

Beam element : Hermite shape functions, formulation of element stiffness matrix and load vectors; Beams on elastic foundation; Problems using one dimensional beamelement.

UNIT III	STATIC ANALYSIS USING TWO DIMENSIONAL ELEMENTS	9

Isoparametric formulation, 2D triangular and quadrilateral elements, element stiffness matrices and load vectors, plane stress and plane strain, Temperature effects; problems using two dimensional elements; Introduction to higher order elements.

UNIT IV	DYNAMIC ANALYSIS	8

Equations of motion for dynamic problems using one dimensional spar, truss and beam elements, formulation of consistent and lumped mass matrices, Natural frequencies of longitudinal vibration and mode shapes, Transverse Natural frequencies of beam.

UNIT V	HEAT TRANSFER AND FLUID FLOW ANALYSIS	8

Basic equations of heat transfer, finite element formulation and solution of one-dimensional heat transfer problems involving steady state heat conduction and convection. Basic equations of fluid flow, finite element formulation of one-dimensional flow through porous media and Inviscid fluid flow through pipes, Network flow analysis

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT – I - 10 Marks CAT 2 – 10 Marks Descriptive type questions	Assignment, MCQ, Case Studies	Descriptive type questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Apply one dimensional spar elements to solve field problems. **(Apply)**
CO2: Exercise the one-dimensional beam elements to field problems. **(Apply)**
CO3: Apply the two-dimensional elements to solve the field problems. **(Apply)**
CO4: Explore the applications of one-dimensional elements to solve dynamics problems. **(Apply)**
CO5: Analyze the applications of one-dimensional element for heat transfer and fluid flow problems **(Analyze)**

Text Books

1. Seshu P., "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd. NewDelhi, (2013)
2. Reddy J.N., "An Introduction to the Finite Element Method", McGraw-Hill Edition, (2018)

Reference Books

1. Bhavikatti S.S., "Finite Element Analysis", New Age International Publishers, (2015)
2. TirupathiR.Chandrupatla, Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", Cambridge University Press (2021)
3. Daryl L. Logan, "A First Course in the Finite Element Method." Cengage Learning (2016)
4. S.S Rao," The Finite Element Method in Engineering", Elsevier Science, (2011)
5. Robert D. Cook, Malkus, Plesha, Witt, "Concepts And Applications Of Finite Element Analysis",4th Edition 2007

Web Resources

1. https://nptel.ac.in/courses/112/103/112103295/
2. https://nptel.ac.in/courses/112/104/112104193/
3. https://nptel.ac.in/courses/112/106/112106135/

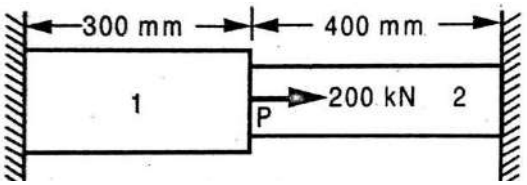
CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1	1									2	1
2	3	3	1	1									2	1
3	3	3	1	1									2	1
4	3	3	1	1									2	1
5	3	3	2	1									2	1

COURSE LEVEL ASSESSMENT QUESTIONS

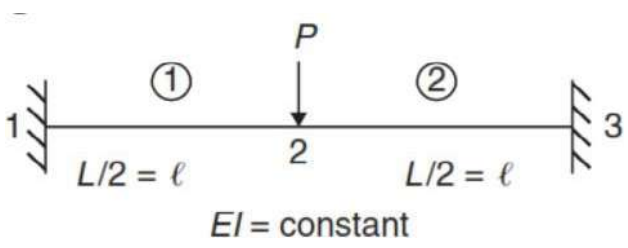
COURSE OUTCOME 1: Apply one dimensional spar elements to solve field problems. (Apply)

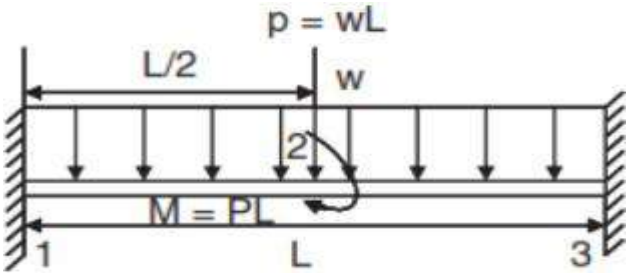
1. Explain the steps involved in finite element analysis. (U)
2. Consider a bar as shown in Fig. An axial load of 200KN is applied at point p. Take A1=2400mm2, $E_1=70x10^9N/mm^2$, $A_2=600mm^2$, $E_2=200X10^9N/mm^2$. Calculate the following, (i) nodal displacement at point p, (ii) stress in each element (iii) reaction force (A)



COURSE OUTCOME 2: Exercise the one dimensional beam elements to field problems (Apply)

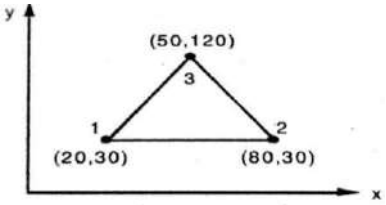
1.Analyze the beam shown in fig using FEM (A)



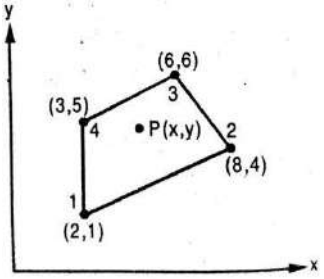


COURSE OUTCOME 3: Apply the two dimensional elements to solve the field problems (Apply)

1. Determine the stiffness matrix for the CST element shown in Fig. The co-ordinates are given in mm. Assume plane strain conditions. E=210GPa,ν=0.25 and t=10mm.(A)



2. For the isoparametric quadrilateral element as shown in fig., the Cartesian co-ordinates of point P are (6,4). The loads 10KN and 12KN are acting in x and y direction on that point P. Evaluate the nodal forces. (A)



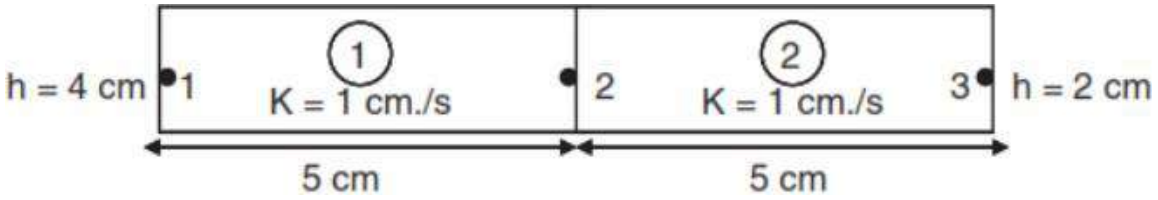
COURSE OUTCOME 4: Explore the applications of one dimensional elements to solve dynamics problems (Apply)

1. Determine the natural frequencies of transverse vibration for a beam fixed at both ends. The beam may be modelled by two elements, each of length L and cross-sectional area A. The use of symmetry boundary condition is optional. (A)

2. Set up the system of equations governing the free transverse vibrations of a simply supported beam modeled by two finite elements. Determine the natural frequency of the system.(A)

COURSE OUTCOME 5: Analyze the heat transfer and fluid flow problems using one dimensional elements (Analyze)

1. Analyse the one-dimensional flow through porous media over the section shown in the figure by using finite element method. (An)



2. Find the flow rates in each of the elements (pipes) in the network as shown in Figure 6.35. The diameters of the pipe are 10, 10, 10, 10, 10, 10, 12, 12, 12 mm, respectively. The lengths are 1,000, 1,000, 1,000, 1,000, 1,000, 1,000, 1,500, 1,500, 1,500 mm, respectively. The flow rates at each node out of the network are [+125, –25, –25, –25, –25, –25] cubic cm/min. The liquid flowing is water. If the pressure head at node 1 is 2 m expressed in terms of the height of liquid that is flowing, find the pressure heads, (H), at each of the remaining nodes and the flow rates in the pipe. The friction factor may be taken as 0.02.(A)

21HS3101	ETHICS AND VALUES	L	T	P	C
		3	0	0	3

Preamble:
The course is designed with the purpose of helping students in developing a holistic perspective about life. It opens the space for the student to explore his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the society and as a unit in nature.

Prerequisites for the course

Nil

Objectives

1. To help students distinguish between values and skills.
2. To help students identify what they 'really want to be' in their life and profession.
3. To help students understand the meaning of happiness and prosperity for a human being.
4. To facilitate the students to understand harmony at all the levels of human living, and live accordingly.
5. To facilitate the students in applying the understanding of harmony in existence in their profession and lead an ethical life

MODULE I	Course Introduction - Need, Basic Guidelines, Content and Process for Value Education	9

1. Understanding the need, basic guidelines, content and process for Value Education
2. Self-Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfill the above human aspirations: understanding and living in harmony at various levels

Suggested Activities:
Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking

MODULE II	Understanding Harmony in the Human Being - Harmony in Myself	9

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
2. Understanding the needs of Self ('I') and 'Body'-Sukh and Suvidha (happiness and physical facility)
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
4. Understanding the characteristics and activities of 'I' and harmony in 'I'
5. Understanding the harmony of I with the Body: Sanyam(control) and Swasthya (Health); correct appraisal of Physical needs, meaning of Prosperity in detail
6. Programs to ensure Sanyam and Swasthya

Suggested Activities:
Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss programs for ensuring health vs dealing with disease.

MODULE III	Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship	9

1. Understanding harmony in the Family- the basic unit of human interaction
2. Understanding values in human-human relationship; meaning of Nyaya (justice) and program for its fulfillment to ensure Ubhay-tripti (mutual happiness)
3. Trust (Vishwas) and Respect (Samman) as the foundational values of relationship
4. Understanding the meaning of Vishwas; Difference between intention and competence
5. Understanding the meaning of Samman (respect), Difference between respect and differentiation; the other salient values in relationship
6. Understanding the harmony in the society (society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva (Resolution, Prosperity, fearlessness, co-existence) as comprehensive Human Goals

Suggested Activities:

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss scenarios. Elicit examples from students' lives. Pay a visit to the old age home / orphanage / physically & mentally challenged asylum and support them in catering their needs to ensure mutual happiness

MODULE IV	**Understanding Harmony in the Nature and Existence – Whole existence as Coexistence**	**9**

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature
3. Understanding Existence as Coexistence (Sah-astitva) of mutually interacting units in allpervasive space
4. Holistic perception of harmony at all levels of existence

Suggested Activities:

Include practice sessions to discuss human beings as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc. Submit a video documentary highlighting the ways of humans creating an imbalance in nature and ways to prevent it.

MODULE V	**Implications of the above Holistic Understanding of Harmony on Professional Ethics**	**9**

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
4. Competence in Professional Ethics:

a) Ability to utilize the professional competence for augmenting universal human order,
b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, technologies and management models

5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order

Suggested Activities:

Include a presentation session on identifying human inventions that are non ecofriendly and brainstorming to come up with ecofriendly production systems or ecofriendly alternatives.

	Total Periods	**45**

Suggestive Assessment Method	**FAT (20 Marks)**	**ESE (60 Marks)**
CAT (30 Marks)		

Written Assessment MCQ / written exam	Activity / Presentation in the classroom / on or off campus activities	Written Examination

Course Outcomes

Upon completion of the course, the students will be able to:

CO1 - Understand the significance of value inputs in a classroom and start applying them in their life and profession

CO2 - Distinguish between values and skills, happiness and accumulation of physical facilities, the Self and the Body, Intention and Competence of an individual, etc.

CO3 - Understand the value of harmonious relationship based on trust and respect in their life and profession

CO4 - Understand the role of a human being in ensuring harmony in society and nature.

CO5 - Distinguish between ethical and unethical practices, and start working out the strategy to actualize a harmonious environment wherever they work.

Text Books

1. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics.

Reference Books

1. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
2. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
3. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
4. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limits to Growth – Club of Rome's report, Universe Books.
5. A Nagraj, 1998, JeevanVidyaEkParichay, Divya Path Sansthan, Amarkantak

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1								3						
2								3						
3								3						
4								3				2		
5								3				2		

SUGGESTED COURSE LEVEL ASSESSMENT QUESTIONS:

COURSE OUTCOME 1 (CO 1) : Need, Basic Guidelines, Content and Process for Value Education

1) Explain the process of value education.

2) Illustrate the content of value education.

3) What should be the content of value education to make it complete? How do values relate to our day to day living?

4) Explain the content of self – exploration?

5) "Mutual fulfilment in human relationships is something we want, we aspire for." Explain

6) What is value education? Why is there a need for value education?

7) How does value education help in fulfilling one's aspirations?

8) What are the basic guidelines for value education?
9) Write a short note on the need for value education in today's scenario.
10)Values and skill complement each other. Elaborate.

COURSE OUTCOME 2 (CO 2) : Understanding Harmony in the Human Being - Harmony in Myself

1) Distinguish between Sukh and Suvidha in detail taking needs of yourself as an example
2) How can we ensure harmony in self ('I')?
3) The needs of the self are qualitative. Illustrate.
4) 'The need for physical facilities is temporary' – explain the meaning of this statement with any two examples.
5) Do you think that human beings are a sum-total of sentiments and physical aspects, the 'self' and the 'body'? Explain your answer using examples.
6) 'Human being is the co-existence of the Self and the Body' – elaborate on this statement.
7) Explain how activities in 'I' are continuous.
8) "I am the seer, doer and enjoyer. The body is my instrument" – Explain.
9) Explain the relation between the self and the body. What is the responsibility of the self towards the body?
10)Define Sanyam and Swasthya. How are they helpful in keeping harmony between self and body?

COURSE OUTCOME 3 (CO 3) :Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

1) Define trust. or How is 'trust' the foundation value of relationships?
2) Define 'affection'. or How does affection lead to harmony in the family?
3) How can you say that love is the complete value?
4) What is the meaning of justice in human relationships? How does it follow from family to world family?
5) 'Discrimination leads to acrimony in relationships'. Explain. What problems are created when we discriminate?
6) What values are necessary in human relationships? Explain each briefly.
7) What is the basis of 'respect' for a human being? Do you see that other human beings are also similar to you? Explain.
8) Explain the comprehensive human goal. How does fearlessness follow from right understanding and prosperity?
9) Critically examine the state of society today in terms of fulfillment of comprehensive human goals.
10)What is the comprehensive human goal? Explain how this is conducive to sustainable happiness and prosperity for all.

COURSE OUTCOME 4 (CO 4) : Understanding Harmony in the Nature and Existence – Whole existence as Coexistence

1) What is sanskaar? Explain its effects or the conformance of the human order.
2) Explain the harmony in nature

3) Define harmony in nature and how you will create it. Explain with examples.
4) What are the four orders of nature? Briefly explain them.
5) Present the difference and similarity between a human being and an animal. Give examples to support your answer.
6) "Other than human order, the three orders are mutually fulfilling to each other". Explain with examples.
7) 'Existence is coexistence'. Give your opinion.
8) How is the activity in human order different from that of animal and plant order?
9) Explain the concept of holistic perception of harmony in existence.
10)Explain how there is recyclability and self regulation in nature.

COURSE OUTCOME 5 (CO 5) : Implications of the above Holistic Understanding of Harmony on Professional Ethics.

1) How does right understanding provide the basis for ethical human conduct? Give two examples.
2) What is ethical human conduct? Explain in terms of values, policies and character with appropriate examples.
3) What do you understand about the definitiveness of ethical human conduct? Why is this definiteness desirable?
4) Describe briefly the criteria for evaluation of holistic technology. Support your answer with an example.
5) Give a critical review of the current management models in the profession.
6) Elaborate on the meaning of swatwa (innateness), swatantrata (self organization) and swarajya (self expression). How are they related?
7) What do you mean by professional ethics?
8) What do you understand by competence in professional ethics? Give two examples of its implications in industry.
9) What are the implications of value based living at all four levels of living? Explain.
10)What is utility value and artistic value? How are both important in human life? Explain with example

21PT3903	SOFT SKILLS- APTITUDE II	L	T	P	C
		0	0	2	1

Prerequisites for the course

- Basic Maths

Objectives

- Expose the undergraduate students to solve aptitude problems using different methods and practices.
- Expose the undergraduate students to critique and evaluate quantitative arguments that utilize mathematical, statistical, and quantitative information.

UNIT I	MODULE I	6
Time, Speed and distance, Time and work, Problems on Trains		
UNIT II	**MODULE II**	**6**
Clocks, Blood Relations, Number Puzzles, Logical Puzzles.		
UNIT III	**MODULE III**	**6**
Concepts on Syllogisms, Problems involving Coding and Decoding methods Elementary algebra, Progression.		
UNIT IV	**MODULE IV**	**6**
Permutation and combination, Probability, Geometry, Calendar		
UNIT V	**MODULE V**	**6**
Boats and Streams, Races. Data interpretation, Data sufficiency.		

Total Periods	**30**

Suggestive Assessment Methods

Continuous Assessment Test -1 (30 Marks)	Continuous Assessment Test -2 (30 Marks)	Model Exam (40 Marks)
MULTIPLE CHOICE QUESTIONS	MULTIPLE CHOICE QUESTIONS	MULTIPLE CHOICE QUESTIONS

Outcomes

Upon completion of the course, the students will be able to:

CO1: Solve various concepts of Time, Speed and distance, Time and work and Problems on Trains
CO2: Analyse the problems on Clocks, Blood Relations, Number Puzzles, Logical Puzzles.
CO3: Analyse the Concepts on Syllogisms, Problems involving Coding and Decoding methods Elementary algebra and Progression
CO4: Solve the problems on Permutation and combination, Probability, Geometry and Calendar
CO5: Solve the problems on Boats and Streams, Races. Data interpretation and Data sufficiency.

Text Books

1. Dr. R S Aggarwal, A Modern Approach to Verbal and Non Verbal Reasoning, Revised Edition, S Chand Publications.
2. Abhijit Guha, Quantitative Aptitude for Competitive Examinations, Fourth Edition, Mc Graw Hill Publications.

Reference Books

1. U. Mohan Rao, Quantitative Aptitude for Competitive Examinations, Scitech Publications Pvt Ltd, India.
2. Dinesh Khattar, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, Third

Edition, Pearson Education Pvt Ltd, India, 2016.
3. Arun Sharma, How to prepare for Logical Reasoning for CAT & other Management Exams, Fifth Edition, Mc Graw Hill Publications.
4. Jaikishan and Premkishan, How to Crack Test of Reasoning in all Competitive Examinations, Revised Edition, Arihant Publications.

Web Resources

1. https://pdf.bankexamstoday.com/raman_files/Quant%20Formula.pdf
2. https://ugcportal.com/raman-files/QT-TRICKS.pdf
3. https://www.javatpoint.com/aptitude/quantitative#speed-and-distance
4. https://www.indiabix.com/aptitude/questions-and-answers/

CO Vs PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	2	1										2
2	2	1										2
3	3	1										2
4	3	1										2
5	2	1										3

COURSE CONTENT AND SCHEDULE

S.NO	TOPIC	NO OF HOURS REQUIRED
	UNIT I – MODULE I	
1	Time, Speed and distance	**2**
2	Time and work	**2**
3	Problems on Trains	**2**
	UNIT II – MODULE II	
1	Clocks	**2**
2	Blood Relations	**1**
3	Number Puzzles	**2**
4	Logical Puzzles	**1**
	UNIT-III MODULE III	
1	Concepts on Syllogisms	**2**
2	Problems involving Coding methods	**1**
3	Problems involving Decoding methods	**1**
4	Elementary algebra	**1**
5	Progression	**1**
	UNIT-IV MODULE IV	
1	Permutation and combination	**2**
2	Probability	**1**

3	Geometry	**1**
4	Calendar	**2**
UNIT-V MODULE V		
1	Boats and Streams	**1**
2	Races	**1**
3	Data interpretation	**2**
4	Data sufficiency	**2**

21ME6611	FINITE ELEMENT ANALYSIS LABORATORY	L	T	P	C
		0	0	4	2

Prerequisites for the course

Basic knowledge in Design the component in CAD software.
Basic knowledge in Strength of materials, Engineering Mechanics, Thermodynamics.

Objectives

1. To give exposure to software tools needed to analyze engineering problems.
2. Analyzing the force, stress, deflection in mechanical components.
3. Analyzing thermal stress and heat transfer in mechanical components.
4. Analyzing the vibration behaviour for mechanical components.
5. Analyzing the modal, harmonic, and transient concepts in mechanical components.
6. Analyzing the fluid flow parameters for pipes, nozzle, etc.

S. NO	LIST OF EXPERIMENTS	CO
	STATIC STRUCTURAL ANALYSIS	
1.	Force and Stress analysis of Trusses	CO1
2.	Stress and deflection analysis in beams with different support conditions.	CO1
3.	Stress analysis of flat plates with a circular hole.	CO1
4.	Stress analysis of axi – symmetric components I section, Pressure vessel.	CO1
5.	Stress analysis of a bicycle frame	CO1
6.	Buckling analysis of columns	CO1
	MODAL ANALYSIS	
7.	Modal analysis of Beams	CO2
8.	Modal analysis of a Centrifugal pump base frame	CO2
	THERMALANALYSIS	
9.	Thermal stress analysis of cylindrical shells.	CO3
10.	Thermal stress analysis of a Plate.	CO3
11.	Conductive Heat Transfer Analysis of a plate	CO3
12.	Convective Heat Transfer Analysis of a plate	CO3
	VIBRATION ANALYSIS	
13.	Vibration analysis of spring-mass systems.	CO4
14.	Harmonic analysis of simple systems.	CO4
15.	Transient analysis of simple systems.	CO4
	FLUID FLOW ANALYSIS	
16.	Fluid flow analysis of pipes	CO5

17.	Fluid flow analysis of nozzle	CO5
18.	Fluid flow analysis of diffuser	CO5
19.	Couple-field analysis	CO5
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Methods (60 Marks)		**End Semester Exams (40 Marks)**
Lab Experiments 40 **MODEL LAB WITH PROJECT 20**		PRACTICAL EXAM

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Analyze the force, stress, deflection in mechanical components. **(Analyze)**
CO2: Modal analysis is performed on mechanical components. **(Analyze)**
CO3: Analyze thermal stress and heat transfer in mechanical components. **(Analyze)**
CO4: Analyze the vibration of mechanical components**. (Analyze)**
CO5: Analyze the fluid flow for mechanical components. **(Analyze)**

Laboratory Requirements for a batch of 30 students

Finite Element Analysis Software, Computers with necessary accessories.
Recommended FEA software: FEMAP - 30 license
Computers Requirements:
1. Intel i5 core due processor with 4GB ram with 500GB hard disk − 30 Nos.
2. Laser Printer − 1 No

Text Books

1. Nitin S.Gokhale, Practical Finite Element Analysis 2008, Finite To Infinite

Web Resources

1. https://extendedstudies.ucsd.edu/courses-and-programs/intro-to-femap-and-ansys-finite-element-modeling
2. https://www.femto.eu/stories/femap-intro-videos/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2			2	1					1	1	1	2	1
2	2			2	1					1	1	1	2	1
3	2			2	1					1	1	1	2	1
4	2			2	1					1	1	1	2	1
5	2			2	1					1	1	1	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Analyze the force, stress, deflection in mechanical components. (Analyze)

1. Determine the nodal deflections, reaction forces, and stress for the truss system shown in figure 1 (E = 200 GPa, A = 3250 mm2). (An)

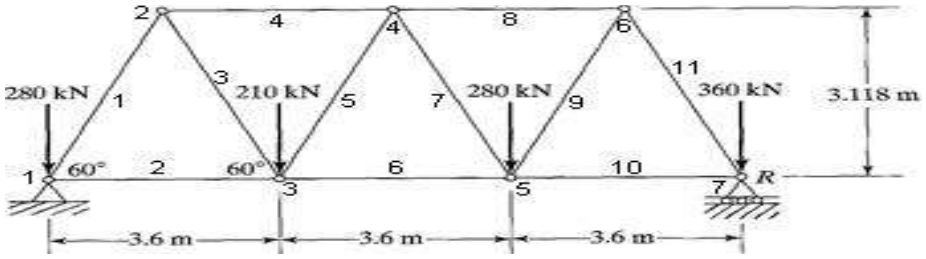


Figure 1

2. Determine the nodal deflections, reaction forces, and stress for the cantilever beam shown in Figure 2 and find the maximum deflection. Assume rectangular c/s area of 0.2 m * 0.3 m, Young's modulus of 210 GPa, Poisson's ratio 0.27.(An)

Figure 2

COURSE OUTCOME 2: Modal analysis is performed on mechanical components. (Analyze)

1. To determine the amplitude and frequency of a given 2D components as shown in Figure 3.(An)

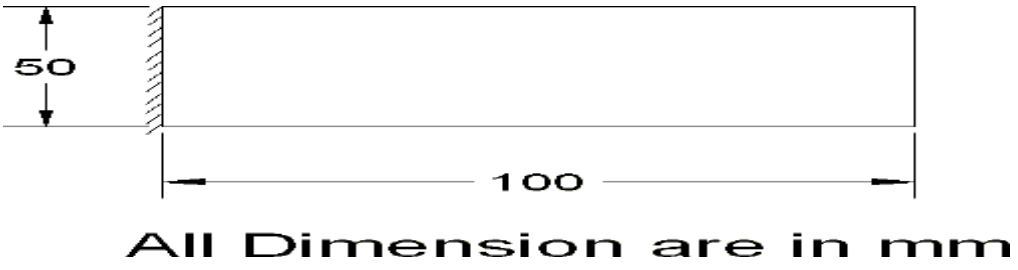


Figure 3

2. To determine the amplitude and frequency of a given beam components as shown in (Figure 4) using Finite Element Analysis based ANSYS/FEMAP software. Take Young's modulus 2.068e11, Poisson's Ratio: 0.3. (An)

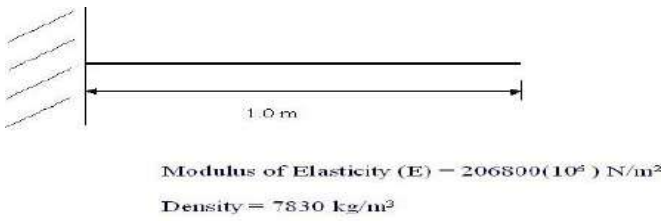


Figure 4

COURSE OUTCOME 3: Analyze thermal stress and heat transfer in mechanical components. (Analyze)

1. To determine the Thermal deformations at various points of a 2D component due to the Temperature load applied over it is shown below in figure 5..(An)

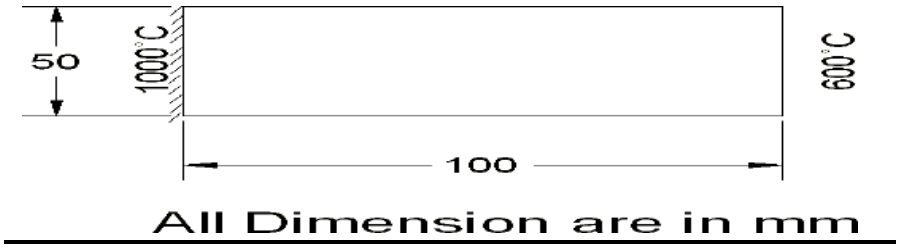


Figure 5

2. To determine the thermal deformations at various points of a shell component due to the temperature load applied it. It is shown below in Figure 6. (An)

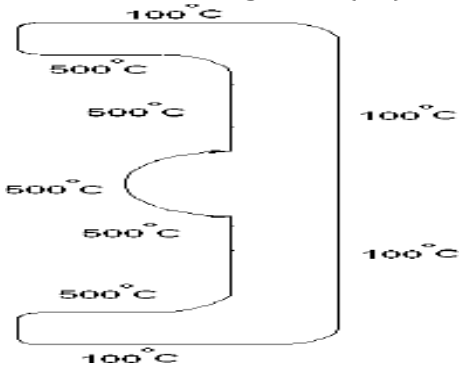


Figure 6

COURSE OUTCOME 4: Analyze the vibration of mechanical components. (Analyze)

1. Consider the bar shown in the Figure 7 below. Conduct a harmonic response test by applying a cyclic load (harmonic) at the end of the bar. The frequency of the load will be varied from 1 - 100 Hz. Modulus of elasticity = 200 GPa, Poisson's ratio = 0.3, Density = 7800 Kg/m^3. .(An)

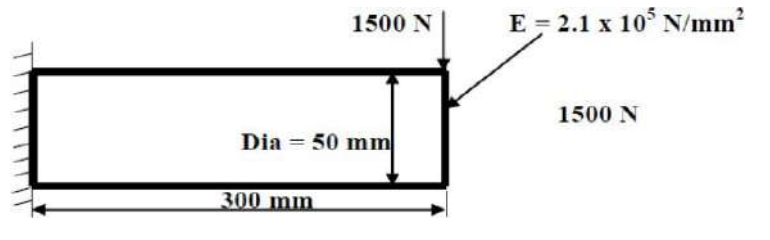


Figure 7

COURSE OUTCOME 5: Analyze the fluid flow for mechanical components. (Analyze)

1. The problem to be considered is shown schematically in Figure 8. A cold fluid at 293.15 K flows into the pipe through a large inlet, and mixes with a warmer fluid at 313.15 K that enters through a smaller inlet located at the elbow. The pipe dimensions, the fluid properties and boundary conditions are given in SI units. **Note:** Since the geometry of the mixing elbow is symmetric, only half of the elbow needs to be modeled. (An)

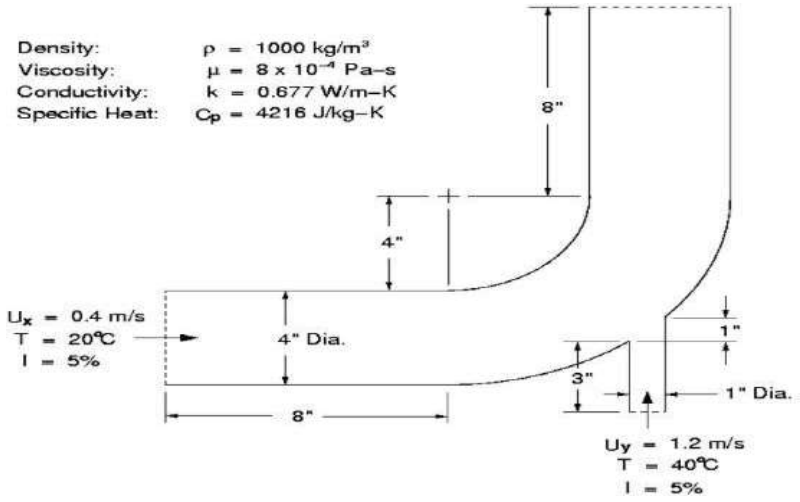


Figure 8

21ME6612	Design and Fabrication Project	L	T	P	C
		0	0	4	2

Prerequisites for the course

All courses

Objectives

1. To develop skills to formulate a technical project.
2. To use new tools, algorithms and techniques required to carry out the projects.
3. To develop prototype/model/simulation relevant to the study.

GUIDELINE FOR REVIEW AND EVALUATION

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member. The Design and Fabrication Project should be a theoretical study/analysis / prototype design / modeling and simulation or a combination of these. A comprehensive project report should be prepared after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The developed work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

Total Periods	**45**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Identify an innovate or creative idea / concept / solution to a problem **(Apply)**
CO2: Perform detailed literature survey related to concept / idea **(Understand)**
CO3: Implement basic prototype to demonstrate the concept. **(Analyse)**
CO4: Analyze and evaluate the functionality of the developed mechanism **(Analyse)**
CO5: Demonstrate the project work in the form of oral presentation, report and technical/patent/paper publications. **(Apply)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 2	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 3	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 4	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 5	2	2	2	1	1	1	1	1	1	1	1	3	3	3

SEMESTER VII

21HS7101	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

Preamble

This course is crucial for engineering students. It promotes excellence, continuous improvement, and collaboration, which strive to integrate technical skills with quality principles, customer satisfaction, and organizational effectiveness. TQM prepares the students for industry challenges.

Prerequisites for the course

Knowledge of quality concepts, communication abilities, and a commitment to continuous learning.

Objectives

- To understand the need for quality and its evolution over time.
- To understand the quality principles and its performance.
- To equip with a thorough understanding of quality management tools and techniques.
- To enable them to effectively implement these tools and techniques to optimize quality management practices.
- To understand the standards, and benefits of ISO registration, and provide an overview of ISO related standards.

UNIT I	INTRODUCTION	9

Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Customer focus - Customer orientation, Customer satisfaction, Customer complaints, Customer retention.

UNIT II	TQM PRINCIPLES	9

Leadership - Quality Statements, Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen.

UNIT III	TQM TOOLS AND TECHNIQUES I	9

The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types.

UNIT IV	TQM TOOLS AND TECHNIQUES II	8

Quality Circles - Cost of Quality - Quality Function Deployment (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.

UNIT V	QUALITY MANAGEMENT SYSTEM	10

Introduction— How are standards developed? - Benefits of ISO Registration—ISO 9000 Series of Standards - ISO 9001 Requirements—Implementation— Documentation—Internal Audits—Registration. Environmental Management System: ISO 14000 Series Standards—Concepts of ISO 14001 - Benefits of EMS. ISO 45001 and related standards — Occupational health and safety, ISO/IEC 27000 family — Information security management - ISO 31000 - Risk management - ISO 26000 - Social responsibility - ISO 20121 - Sustainable events

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)

WRITTEN TEST	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	WRITTEN TEST

Course Outcomes

Upon completion of the course, the students will be able to:

1	Familiarized with the basic concept and framework of Total Quality management.
2	Understand the contribution of Quality Gurus in TQM Journey
3	Provide a comprehensive understanding of the traditional tools and equipping with the knowledge and skills to drive quality improvement initiatives effectively.
4	Explain the various types of Techniques and foster their ability to drive organizational improvement and enhance quality management practices.
5	Apply various Quality Systems and Auditing on implementation of TQM.

Text Books

1. Dale H.Besterfiled, Carol B.Michna,Glen H. Besterfield,Mary B.Sacre,Hemant Urdhwareshe and Rashmi Urdhwareshe, "Total Quality Management", Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression, 2013.
2. Poornima M., Pearson publication, rd Edition, Total Quality Management 2017

Reference Books

1. Subburaj Ramasamy, Total Quality Management, Mc Graw Hill Publications
2. Sunil Luthra, Dixit Garg, Ashish Agarwal, Sachin K. Mangla, Total Quality Management (TQM): Principles, Methods, and Applications, Publisher: CRC Press, 2020; ISBN 1000194493,
3. D.R. Kiran, Total Quality Management: Key Concepts and Case Studies, Publisher Butterworth-Heinemann, 2016, ISBN 0128110368,
4. W. Edwards Deming, The Essential Deming: Leadership Principles from the Father of Quality, Editors Joyce Orsini, Diana Deming Cahill, Publisher: McGraw Hill Professional, 2012, ISBN: 0071790217, 9780071790215

Web Resources

1. NPTEL :: Management - NOC:Total Quality Management - I
2. http://www.notesengine.com/dept/cse/7sem/anna-university-7-sem-cse-notes.html
3. http://www.vidyarthiplus.com/vp/Thread-GE2022-Total-Quality-Management-Lecture-Notes- Lonely-Edition
4. http://freshupdates.in/lecture-notes/anna-university-total-quality-management-lecture-notes/
5. http://www.iannauniversity.com/2012/06/ge2022-total-quality-management-lecture.html
6. https://www.iso.org/popular-standards.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1		3		2					3					3
CO2						3			3	2	3			3
CO3	3	3		3		2								3
CO4		3		3						2				3
CO5	1	3		3		3		2	3	3	3	3		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to familiarized with the basic concept and framework of Total Quality management.

1. Describe Deming's philosophy for quality management.
2. Elaborate on TQM framework and importance of each element.

COURSE OUTCOME 2: Students will be able to Understand the contribution of Quality Gurus in TQM Journey

1. Briefly explain about recognition and reward system along with its effects.
2. Enumerate the Japanese 5S as applicable to services and manufacturing company.

COURSE OUTCOME 3: Students will be able to provide a comprehensive understanding of the traditional tools and equipping with the knowledge and skills to drive quality improvement initiatives effectively.

1. Evaluate the purpose and methodology of construction of an Ishikawa diagram with an example.
2. Analyze the three main types of benchmarking. In what circumstances would each type be more appropriate?

COURSE OUTCOME 4: Students will be able to explain the various types of Techniques and foster their ability to drive organizational improvement and enhance quality management practices.

1. Draw the house of quality for a product of your choice and describe the QFD methodology.
2. List and explain the various measures of performance in evaluating the success of an organization.

COURSE OUTCOME 5: Students will be able to apply various Quality Systems and Auditing on implementation of TQM.

1. Discuss the various elements of ISO 9000-2000 quality system.
2. Estimate the role of audit checklist for quality management system.

21ME7911	Technical Comprehension	L	T	P	C
		0	0	4	2

Prerequisites for the course

All Courses

Objectives

To encourage the students to comprehend the knowledge acquired from the first Semester to Sixth Semester of B.E. Degree Course through periodic exercise

Suggestive Assessment Methods

Students will be assessed 100% internally through weekly test with objective type questions on all the subject related topics

Outcomes

Upon completion of the course, the students will be able to:

CO1: Recollect the knowledge acquired during the earlier semesters **(Remember)**
CO2: Apply fundamental principle of mechanical engineering concepts to solve real life problems. **(Apply)**
CO3: Present technical topics and discuss about them. **(Understand)**
CO4: Interpret experimental data with relevance **(Apply)**
CO5: Simplify the decision-making skills **(Understand)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	3			2						1		3
CO2	3	3	3			2						1		3
CO3	2					2				3		1		3
CO4	3		2	2										3
CO5	3							2						3

SEMESTER VIII

21ME8901	Project Work/Internship based Project	L	T	P	C
		0	0	20	10

Prerequisites for the course

All Courses

Objectives

1. To use new tools, algorithms and techniques required to fabricate real time project.
2. To give guidance on the various procedures for theoretical and experimental validation of the product and analyse the cost effectiveness.
3. To provide guidelines to prepare technical report of the project.

Method of Evaluation

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member. The Project Work Phase – 2 should be Fabricated product/ testing setup of an experimentation unit/ apparatus/ small equipment. The product should be Theoretically/Experimentally verifiable based on principles used in the concept. It should have valid database/algorithm, output reports, research findings and future scope. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

Outcomes

Upon completion of the course, the students will be able to:

CO1: Design and develop the real time working model after conducting experimentation **(Create)**
CO2: Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project. **(Apply)**
CO4: Test and validate through conformance of the developed product **(Analyze)**
CO4: Demonstrate the results and analyze the cost effectiveness of the product **(Analyze)**
CO5: Demonstrate the project work in the form of oral presentation, report and technical/patent/paper publications. **(Apply)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 2	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 3	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 4	2	2	2	1	1	1	1	1	1	1	1	3	3	3
CO 5	2	2	2	1	1	1	1	1	1	1	1	3	3	3

PROFESSIONAL ELECTIVE I

21ME5701	APPLIED HYDRAULICS AND PNEUMATICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Fluid Mechanics and Machinery

Objectives

- To provide the knowledge on the application of fluid power in process, construction and manufacturing Industries.
- To develop a measurable degree of competence in the design, construction and operation of fluid power circuits

UNIT I	FUNDAMENTALS OFFLUID POWER SYSTEMS	9

Introduction to Fluid power –Advantages and Applications– Fluid Properties – Pascal's Law and its Application – Losses in Pipes – Valves and Fittings– Pumping Theory – Pump Classification – Gear – Vane and Piston Pumps – Pump Performance – Characteristics and Selection – Sizing of Pumps.

UNIT II	HYDRAULIC ACTUATORS AND COMPONENTS	9

Hydraulic Actuators: Cylinders – Single acting, Double acting special cylinders like tanden, Rodless, Telescopic, Cushioning mechanism–Direction control, Flow control and Pressure control valves-Types, Construction and Operation-Applications –Reservoirs, Accumulators, Intensifiers, Pressure Switches-Classification and functions- Applications–Fluid Power ANSI Symbol.

UNIT III	DESIGN OF HYDRAULIC CIRCUITS	9

Industrial hydraulic circuits- Regenerative, Pump Unloading, Double-pump, Pressure Intensifier, Air- over oil,Sequence, Reciprocation, Synchronization, Fail-safe, Speed control, Hydrostatic transmission, Electro hydraulic servo system, Mechanical Hydraulic servo systems

UNIT IV	PNEUMATIC SYSTEMS AND COMPONENTS	9

Pneumatic Components: Properties of air – Compressors – Filter, Regulator, Lubricator – Air control valves, Quick exhaust valves, pneumatic actuators. Design of Pneumatic circuit – Cascade Circuit Design Method (Two / Three Cylinder Circuits) – Electro Pneumatic System – Elements – Ladder diagram–Introduction to Fluid Logic Devices and pneumatic logic circuits–Applications

UNIT V	TROUBLE SHOOTING AND APPLICATIONS	9

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems–Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools- Low-costAutomation – Hydraulic and Pneumatic power packs

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:
CO1 Describe the basics of fluid power system and its applications in industry (**Understand**) **CO2** Identify appropriate actuators and control valves for fluid power applications (**Understand**) **CO3** Illustrate a hydraulic circuit for real time applications (**Apply**) **CO4** Demonstrate the concepts of pneumatic system and its logic circuits (**Apply**) **CO5** Examine the troubleshooting of fluid power circuits for engineering applications (**Apply**)
Text Books
1. Anthony Esposito, "Fluid Power with Applications", 7th Edition, Pearson Higher Education, New York, 2015. 2. Majumdar S. R, "Pneumatic Systems – Principles and Maintenance", 2nd Edition, Tata McGraw-Hill, New Delhi, 2015.
Reference Books
1. Majumdar, S.R , "Oil Hydraulic Systems: Principles and Maintenance", 28th Edition,McGraw-Hill, 2017. 2. James R.Daines, Hydraulics and Pneumatics, 2ndEdition, The Goodheart-Willcox Company,Inc., 2013. 3. Srinivasan. R, "Hydraulic and Pneumatic Control", IInd Edition, Tata McGraw - Hill Education,2012.
Web Resources **1. https://nptel.ac.in/courses/112106300** **2. https://nptel.ac.in/courses/112105046**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	2	2									3	
2	2	2	2	2									3	
3	2	2	2	2									3	
4	2	2	2	2									3	
5	2	2	2	2									3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe the basics of fluid power system and its applications in industry (Understand)

1. Differentiate between hydraulics and pneumatics. (R)
2. Explain the construction and working principle of radial piston pump with neat sketch. (U)

COURSE OUTCOME 2: Identify appropriate actuators and control valves for fluid power applications (Understand)

1. List the significance of directional control valves. (R)
2. Describe single acting cylinder and cylinder cushioning with a neat sketch (U)

COURSE OUTCOME 3: Illustrate a hydraulic circuit for real time applications (Apply)

1. Differentiate between electro hydraulic servo valve and mechanical servo valves (R)
2. Discuss the hydrostatic transmission with suitable sketches and applications. (U)
3. Examine a hydraulic circuit for synchronizing two cylinder with flow control valves (A)

COURSE OUTCOME 4: Demonstrate the concepts of pneumatic system and its logic circuits (Apply)

1. List the basic components of pneumatic system. (R)
2. Explain the graphical symbol and Explain the construction and working principle of FRL Unit (U)
3. Examine a pneumatic circuit for the following sequence using cascade method A+B+B-A- where the + cylinder extraction and - cylinder retraction (A)

COURSE OUTCOME 5: Examine the troubleshooting of fluid power circuits for engineering applications (Apply)

1. List the problems caused by the contaminants in the hydraulic system. (R)
2. Describe hydraulic and pneumatic power packs with suitable sketches and illustrations (U)
3. Examine a pneumatic circuit to actuate a shaping machine ram. Incorporate the following features in the circuit. (a) rapid tool approach (b) slow cutting (c) rapid tool retraction / return (A)

21ME5702	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Physics, Engineering Materials and Metallurgy

Objectives

- To know the mechanical behavior of both metallic and non-metallic materials under different loading and temperature conditions.

UNIT I	BASIC CONCEPTS OF MATERIAL BEHAVIOR	9

Elasticity in metals and polymers– Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity – Griffith's theory– Ductile, brittle transition in steel – High temperature fracture, creep – Larson Miller parameter – Deformation and fracture mechanism maps.

UNIT II	BEHAVIOUR UNDER DYNAMIC LOADS	9

Stress intensity factor and fracture toughness – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law. - Safe life, Stress life, strain-life and fail - safe design approaches -Effect of surface and metallurgical parameters on fatigue.

UNIT III	SELECTION OF MATERIALS	9

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

UNIT IV	MODERN METALLIC MATERIALS	9

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials.

UNIT V	CREEP BEHAVIOUR AND TESTING	9

Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametetric methods of extrapolation. Deformation Mechanism Maps according to Frost/Ashby.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes
Upon completion of the course, the students will be able to:
CO1 Define the mechanisms involved in elastic and plastic behavior of materials. (**Understand**) **CO2** Explain the components under different loading by considering the fracture. (**Understand**) **CO3** Discuss the materials usage for the design of engineering structures. (**Understand**) **CO4** Examine the usage of modern materials in real time applications. **(Apply)** **CO5** Predict the different testing techniques in alloys. **(Apply)**
Text Books
1. George E.Dieter, Mechanical Metallurgy, (12th edition), McGraw Hill, 2012 2. Thomas H. Courtney, Mechanical Behavior of Materials, (7th edition), McGraw Hill, 2015 3. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (34th edition), Butterworth-Heiremann, 2013.
Reference Books
1. Ashby M.F., materials selection in Mechanical Design 2nd Edition, Butter worth 1999 2. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (8th Edition) Jaico, 2013. 3. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999
Web Resources **1. https://onlinecourses.nptel.ac.in/noc22_mm04/preview** **2. https://onlinecourses.nptel.ac.in/noc22_mm25/preview**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	2										3	
2	2	2	2										3	
3	2	2	2										3	
4	2	2	2										3	
5	2	2	2										3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Define the mechanisms involved in elastic and plastic behavior of materials. (Understand)

1. What is Larsen-Miller parameter? (R)
2. Explain the Griffith's theory of brittle fracture with relevant diagram. (U)

COURSE OUTCOME 2: Explain the components under different loading by considering the fracture. (Understand)

1. State Paris law. (R)
2. Write short notes on Fracture toughness. (U)

COURSE OUTCOME 3: Discuss the materials usage for the design of engineering structures. (Understand)

1. Mention the properties to be considered while selecting materials for auto components (R)
2. Explain the method of selection of materials on the basis of service requirements. (U)
3. With a case study explain the selection of materials for aero applications. (A)

COURSE OUTCOME 4: Examine the usage of modern materials in real time applications. (Apply)

1. Name any two materials which exhibit shape memory effect. (R)
2. Write short notes on TRIP steel. (U)
3. Explain the strengthening mechanism used in Maraging steel (A)

COURSE OUTCOME 5: Predict the different testing techniques in alloys. (Apply)

1. Draw the different levels of creep. (R)
2. Explain structural metallurgical aspects of creep failure mechanism. (U)

21ME5703	ADVANCED I.C. ENGINES	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering

Objectives

- To understand the underlying principles of operation of different IC Enginesand components.
- To provide knowledge on pollutant formation, control, alternate fuel etc.

UNIT I	SPARK IGNITION ENGINES	9

Mixture requirements – Fuel injection systems –Monopoint, Multipoint & Direct injection – Stagesof combustion – Normal and Abnormal combustion – Knock – Factors affecting knock – Combustion chambers.

UNIT II	COMPRESSION IGNITION ENGINES	9

Diesel Fuel Injection Systems – Stages of combustion – Knocking – Factors affecting knock –Direct and Indirect injection systems – Combustion chambers – Fuel Spray behavior – Spray structure and spray penetration – Air motion – Introduction to Turbocharging.

UNIT III	POLLUTANT FORMATION AND CONTROL	9

Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling Emissions –Catalytic converters, Selective Catalytic Reduction and Particulate Traps – Methods of measurement –Emission norms and Driving cycles.

UNIT IV	ALTERNATE FUELS	9

Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel –Properties, Suitability, Merits and Demerits – Engine Modifications.

UNIT V	RECENT TRENDS	9

Air assisted Combustion, Homogeneous charge compression ignition engines –Variable Geometry turbochargers – Common Rail Direct Injection Systems – Hybrid Electric Vehicles –NOx Adsorbers – Onboard Diagnostics.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	Assignment, Multiple Choice Questions	Descriptive questions

Outcomes
Upon completion of the course, the students will be able to:
CO1: Discuss the basic fundamentals of SI engines **(Understand)** **CO2:** Describe the basic fundamentals of CI engines **(Understand)** **CO3:** Describe the various forms of pollutants and various emission control methods in IC Engines **(Understand)** **CO4:** Interpret the various forms of alternative fuel **(Apply)** **CO5:** Predict the recent technologies implemented in Automobiles **(Apply)**
Text Books
1. Kirpal Singh, "Automobile Engineering Vol.2", Standard Publishers, New Delhi, (2014) 2. Ganesan V., "Internal Combustion Engines", Tata McGraw Hill, (2012)
Reference Books
1. Heinz Heisler, ‘‘Advanced Engine Technology’’, SAE International Publications, USA, (2005) 2. John B. Heywood, ‘‘Internal Combustion Engine Fundamentals’’, Tata McGraw-Hill, (1988) 3. Gupta H.N., ‘‘Fundamentals of Internal Combustion Engines’’, Prentice Hall of India, (2006) 4. Ultrich Adler, ‘‘Automotive Electric/Electronic Systems’’, Published by Robert Bosh GmbH, (1995) 5. Mathur. R.B. and R.P. Sharma, ‘‘Internal Combustion Engines’’, Dhanpat Rai & Sons (2007)
Web Resources https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/102104057/lec29.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2		1		2	2						2	3
2	1	1	1			2	2						2	3
3	1					2	2					2	2	3
4	1					2	2					2	2	3
5	1		1			2	2					1	2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Discuss the basic fundamentals of SI engines (Understand)

1. Explain the stages of combustion in SI engines elaborating the flame front propagation. . (U)
2. Explain briefly the various factors that influence the flame speed in S.I engines. (U)

3. Describe the requirements of an S.I engine combustion chamber and explain the various types of combustion chambers. (R)

COURSE OUTCOME 2: Describe the basic fundamentals of CI engines (Understand)

1. Explain with the aid of a schematic diagram, explain the combustion process in a C.I engine. . (U)
2. Explain the factors affecting the delay period in C.I engines and summarize them. . (U)

COURSE OUTCOME 3: Describe the various forms of pollutants and various emission control methods in IC Engines (Understand)

1.Explain the functioning of a three way catalytic converter, with a sketch. Mention the limitations of a catalytic converter. . (U)
2. What is a driving cycle? Discuss its significance with regard to emissions. . (U)
3. What are the methods to reduce particulate matter emissions? (U)

COURSE OUTCOME 4: Interpret the various forms of alternative fuel (Apply)

1. Compare the properties of gasoline, methanol and ethanol as engine fuels and explain how they influence combustion and emission characteristics of engine. (A)
2. Write on the following: (A)
(i) Production of biodiesel from non-edible oil (ii) Production of Ethanol from Sugarcane

COURSE OUTCOME 5: Predict the recent technologies implemented in Automobiles (Apply)

1. Describe the features of homogenous charge compression ignition engine and common rail direct injection engine with neat sketches. (U)
2. Examine the necessity of pressure pick, charge amplifier in an IC engine. (A)

21ME5704	ALTERNATIVE FUELS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering

Objectives

- To learn about the types of alternative fuels and energy sources for IC engines
- To understand different sources of alternative fuels, production and storage methods.
- To teach the alternative fuels used in internal combustion engines and their performance and emission characteristics.
- To provide the knowledge of zero emission vehicles using newest technologies.

UNIT I	ALCOHOL AS FUELS	9

Introduction to alternative fuels – Need for alternative fuels – Availability of different alternative fuels for SI and CI engines. Alcohols as fuels. Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines.Flex-fuel, Blending, dual fuel operation, surface ignition and oxygenated additives.Nano additives for SI and CI engines, Performance emission and combustion characteristics in CI and SI engines.

UNIT II	BIODIESEL AS FUEL	9

Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, Pyrolysis process, preheating Transesterification and emulsification of Vegetable oils –Biodiesel– Performance, Emission and Combustion Characteristics in diesel engines.

UNIT III	HYDROGEN AS ENGINE FUEL	9

Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen.Recent development of hydrogen technologies.

UNIT IV	BIOGAS, NATURAL GAS AND LPG AS FUELS	9

Production methods of Biogas – Natural gas and LPG – processing and usage. Properties studies. CO_2 and H2S scrubbing in Biogas, Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines.

UNIT V	ELECTRIC, HYBRID AND FUEL CELL VEHICLES	9

Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles. System components, Electronic control system – Different configurations of Hybrid vehicles. Power split device. High energy and power density batteries –Hyperloop technology – Basics of Fuel cell vehicles.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	Assignment, Multiple Choice Questions	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the various alternative fuels available **(Apply)**

CO2: Examine the different methods of vegetable oils **(Apply)**

CO3: Describe the production methods of hydrogen fuel in IC Engines **(Understand)**

CO4: Discuss the production methods of biogas, natural gas etc. **(Understand)**

CO5: Examine the recent types of vehicles in Automobiles **(Apply)**

Text Books

1. Thipse S. S., Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House, 2010.
2. Devaradjane. Dr. G., Kumaresan. Dr. M., "Automobile Engineering", AMK Publishers, (2013)
3. Gerhard Knothe, Jürgen Krahl, Jon Gerpen, The Biodiesel Handbook, 2nd Edition,Academic Press and AOCS Press (2010)

Reference Books

1. Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka, Handbook of Alternative Fuel Technologies, 2nd edition, CRC Press, 2014.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, 2nd edition, John Wiley & Sons, Ltd, 2012.
3. Ganesan V, Internal Combustion Engines, McGraw-Hill Education India Pvt. Ltd, 2012.
4. Michael F. Hordeski, Alternative Fuels: The Future of Hydrogen, The Fairmont Press, Inc, 2013.

Web Resources

1. https://www.coursera.org/lecture/planet-earth/5-e-2-alternative-energy-resources-mUwAL
2. https://nptel.ac.in/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2				2	2						2	3
2	1	2				2	2					1	2	3
3	1	2	1			2	2						2	3
4	1	2				2	2				1	1	2	3
5	1	1	1			2	2						2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Interpret the various alternative fuels available (Apply)

1. Evaluate the Performance emission and combustion characteristics in CI and SI engines.(A)
2. With a schematic layout explain the production methods of methanol. (U)

COURSE OUTCOME 2: Examine the different methods of vegetable oils (Apply)

1. Draw and explain the pyrolysis process for producing plastic oil (U)
2. Illustrate the transesterification process for biodiesel production for non-edible oil.(A)

COURSE OUTCOME 3: Describe the production methods of hydrogen fuel in IC Engines (Understand)

1. How the hydrogen energy is useful to run the engine? (U)
2. What are the merits and demerits of using hydrogen as a fuel? (R)

COURSE OUTCOME 4: Discuss the production methods of biogas, natural gas etc. (Understand)

1. Name three methods generally employed for extracting energy from Biomass and explain any two in detail(R)
2. Explain the concept of H_2S scrubbing in bio gas:(U)

COURSE OUTCOME 5: Examine the recent types of vehicle in Automobiles (Apply)

1. Predict the modifications required for LPG usage in a gasoline car. Also explain how the LPG system works?(A)
2. Explain briefly the working principle of fuel cells(R)

21ME5705	MAINTENANCE ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, CNC Machines and automation, Metrology and Instrumentation.

Objectives

1. To enable the student to understand the principles, functions and practices adapted in industry for the successful management of maintenance activities.
2. To explain the different maintenance categories like Preventive maintenance condition monitoring and repair of machine elements.
3. To illustrate some of the simple instruments used for condition monitoring in industry.

UNIT I	PRINCIPLES AND PRACTICES OF MAINTENANCE PLANNING	9

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability –Maintenance organization – Maintenance economics.

UNIT II	MAINTENANCE POLICIES – PREVENTIVE MAINTENANCE	9

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repairs cycle - Principles and methods of lubrication – TPM.

UNIT III	CONDITION MONITORING	9

Condition Monitoring – Cost comparison with and without CM – On-load testing and offload testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis

UNIT IV	REPAIR METHODS FOR BASIC MACHINE ELEMENTS	9

Repair methods for beds, slideways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location

UNIT V	REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT	9

Repair methods for Material handling equipment - Equipment records –Job order systems -Use of computers in maintenance.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT – I 10 Marks CAT – II 10 Marks DESCRIPTIVE QUESTIONS	MCQ Assignment Slip Test	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Summarize the industrial maintenance concepts. **(Understand)**

CO2: Compare the maintenance engineering approaches employed in all fields of industries**. (Understand)**

CO3: Identify the different maintenance categories Preventive maintenance condition monitoring and repair of machine elements**.(Understand)**

CO4: Interpret the various instruments used for condition monitoring in industry. **(Apply)**

CO5: Construct the safety norms and concepts of industries**. (Apply)**

Text Books

1. Srivastava S.K., "Industrial Maintenance Management", S. Chand and Co., (2022)
2. Venkataraman .K "Maintancence Engineering and Management", PHI Learning, Pvt. Ltd., (2007)

Reference Books

1. Bhattacharya S.N., "Installation, Servicing and Maintenance", S. Chand and Co., (2013)
2. White E.N., "Maintenance Planning", I Documentation, Gower Press, (2022)
3. Garg M.R., "Industrial Maintenance", S. Chand & Co., (2022)
4. Higgins L.R., "Maintenance Engineering Hand book", 7th Edition, McGraw Hill, (2008)
5. Armstrong, "Condition Monitoring", BSIRSA, (1988)
6. Davies, "Handbook of Condition Monitoring", Chapman & Hall, (1996)
7. "Advances in Plant Engineering and Management", Seminar Proceedings -IIPE, (1996)

Web Resources

1. https://nptel.ac.in/courses/112/107/112107143/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	1	2		1	2	1					1	1		3
2	1	2		1	2	1					1	1		3
3	1	2		1	2	1					1	1		3
4	1	2		1	2	1					1	1		3
5	1	2		1	2	1					1	1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Summarize the industrial maintenance concepts. (Understand)

1. What are the objectives of maintenance organization and what different types of organizationsare in use in Indian industries?(U)
2. What is equipment availability and what are the three basic approaches to define and quantityavailability.(U)

COURSE OUTCOME 2: Compare the maintenance engineering approaches employed in all fields of industries. (Understand)

1. What are all the steps involved in preventive maintenance why preventive maintenance is better than reactive maintenance.(U)
2. Distinguish between fixed time maintenance and connect based maintenance. Give the merits and demerits.(U)

COURSE OUTCOME 3: Identify the different maintenance categories Preventive maintenance condition monitoring and repair of machine elements.(Understand)

1. What is leakage monitoring?Explain some of the leakage mediums used for condition monitoring.(U)
2. What is wear debris analysis what are the three wear debris analysis techniques commonly used and compare their performance and uses?(U)

COURSE OUTCOME 4: Interpret the various instruments used for condition monitoring in industry. (Apply)

1. Discover the procedure for the repair cycle of gears and lead screw.(A)
2. Construct failure analysis for an industry? Explain their development.(A)

COURSE OUTCOME 5: Construct the safety norms and concepts of industries. (Apply)

1. Explain various hydraulic and pneumatic equipment used in material handling purpose. How to maintain it.(U)
2. Prepare the maintenance procedure for various small equipment for material handling purpose like chain block chain, rope, trolley, and R.G.B.(A)

21ME5706	PRINCIPLES OF MANAGEMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course:

Nil

Objectives

1. To enable the students to study the evolution of Management.
2. To study the functions and principles of management and to learn the application of the principles in an organization

UNIT I	INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS	9

Definition of Management – Science or Art – Manager Vs Entrepreneur - Types of managers – Managerial roles and skills – Evolution of Management: Scientific, Human Relations, System, Contingency and Information Technology approaches – Types of Business organization: Sole proprietorship, Partnership, Company, Public and Private sector Enterprises - Organization culture and Environment – Current trends and issues in Management

UNIT II	PLANNING	9

Nature and purpose of planning – planning process – types of planning – objectives – setting objectives – policies – Planning premises – Strategic Planning – Planning Tools and Techniques – Decision making: steps and process.

UNIT III	ORGANIZING	9

Nature and purpose – Formal and informal Organization – Organization chart – Organization structure: Types – Line and Staff Authority – Departmentalization – Delegation of authority – Centralization and Decentralization – Job Design – Human Resource Management – HR Planning, Recruitment, selection, Training and Development, Performance Management, Career planning and Management.

UNIT IV	DIRECTING	9

Foundations of individual and group behaviour – Motivation: theories &Techniques – Job satisfaction – Job enrichment – Leadership: Types & Theories – Communication: Process, Types &Barriers – Effective communication – Communication and IT.

UNIT V	CONTROLLING	9

System and process of controlling – Budgets, Budgetary and Non-Budgetary control techniques – Use of computers and IT in Management control – Productivity problems and management – control and performance – direct and preventive control – Reporting.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT – I 10 Marks CAT – II 10 Marks DESCRIPTIVE QUESTIONS	MCQ Assignment Slip Test	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Describe the terms management, and organization, also identify the type of business organization and its culture. **(Understand)**

CO2: Apply the set objectives for strategic management using planning tools and techniques to make decision**. (Apply)**

CO3: Sketch the organization chart and structure, demonstrate whether the organization is centralized or decentralized and illustrate human resource management principles. **(Apply)**

CO4: Discuss the motivational theories to direct the employees for better communication and job satisfaction**. (Understand)**

CO5: Predict the budgetry and non - budgetry techniques, application of computers, direct and preventive controlling techniques and reporting**.(Apply)**

Text Books

1. Stephen P. Robbins & Mary Coulter, "Management", Prentice Hall (India) Pvt. Ltd., 15th Edition, (2021)
2. JAF Stoner, Freeman R.E and Daniel R. Gilbert "Management", 6th Edition, Pearson Education, (2018)

Reference Books

1. Stephen A. Robbins & David A. Decenzo& Mary Coulter, "Fundamentals of Management", 10th Edition, Pearson Education, (2022)
2. Robert Kreitner& Mamata Mohapatra, "Management", Biztantra, (2011)
3. Harold Koontz & Heinz Weihrich, "Essentials of Management", Tata McGraw Hill, (2015)
4. Tripathy PC & Reddy PN, "Principles of Management", Tata McGraw Hill, (2022)

Web Resources

1. https://nptel.ac.in/courses/122108038/

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1						2		3	2		2	1		3
2						2		3	2		2	1		3
3						2	1	3	2		2	1		3
4						2	1	3	2		2	1		3
5						2	1	3	2		2	1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe the terms management, and organization, also identify the type of business organization and its culture. (Understand)

1. Explain in detail about the different types of business organization. (U)
2. Enlighten the relevance of environmental factors that affects global business. (U)

COURSE OUTCOME 2: Apply the set objectives for strategic management using planning tools and techniques to make decision (Apply)

1. Demonstrate the 7 habits of highly effective people. Explain them in brief. (A)
2. Explain in brief the 14-point principles of Deming on the concept of good leadership. (R)

COURSE OUTCOME 3: Sketch the organization chart and structure, demonstrate whether the organization is centralized or decentralized and illustrate human resource management principles (Apply)

1. Explain the detail about Line and staff organization with an example. Discuss its merits and demerits? (U)
2. Illustrate the differences between Formal and Informal Organization. (A)
3. Sketch the organogram of your own institution taking it as a reference of study. (A)

COURSE OUTCOME 4: Discuss the motivational theories to direct the employees for better communication and job satisfaction (Understand)

1. Evaluate the various styles of Leadership. (U)
2. Explain the different components of communication. (U)

COURSE OUTCOME 5: Predict the budgetary and non - budgetary techniques, application of computers, direct and preventive controlling techniques, and reporting (Apply)

1. How would you show your understanding about usage of use of computers and IT in Management control? (U)
2. Construct the steps involved in controlling and requirements for effective control. (A)

21ME5707	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Physics, Engineering Mechanics, Engineering Materials and Metallurgy
Strength of Materials

Objectives

- To provide students with a basic understanding of the composition and uses of composite
- materials, their structural and mechanical properties.
- To develop the student's skills in understanding the different manufacturing methods
- available for composite materials.
- To illuminate the knowledge and analysis skills in applying mechanics to the composite materials.

UNIT I	BASICS OF FIBERS, MATRICES AND COMPOSITES	9

Basics of Fibers: Definition – Need – General Characteristics and Applications.**Fibers:** Glass-Carbon- Ceramic-Aramid-Polymer and Natural Fibers.**Matrices:** Polymer- Ceramic and Metal Matrices – Characteristics of Fibers and Matrices- Fiber Surface Treatments- Fillers andAdditives.

UNIT II	COMPOSITE MANUFACTURING	9

Hand Layup – Spray up - Bag Molding – Compression Molding – Pultrusion – Filament Winding – Resin Film Infusion - Elastic ReservoirMolding - Tube Rolling - **Processing of Metal Matrix Composites** (MMC) – Diffusion Bonding – Stir Casting– Squeeze Casting and Powder Metallurgy Technique.

UNIT III	NANOCOMPOSITES	9

Nanocomposites: Nano particle dispersion in polymer matrix, Polymer- nanoclaycomposites and polymer-carbon nanotubes composites; **Functionally graded and Hierarchical Composites:** Classification i.e. Natural and Man-made, Uniaxial andbi-axial property gradient, Application in various industrial sectors.

UNIT IV	MICRO AND MACRO MECHANICS OF LAMINATE	9

Micromechanical Analysis of a LaminaVolume and Mass Fractions, Density, and Void Content-Prediction of engineering propertiesusing micromechanics-Material properties of the fiber and matrix.

Macro mechanical analysis of a lamina -linear elastic stress-strain characteristics of FiberReinforced material: Stress and deformations in Fiber-Reinforced materials-Maxwell-Bett reciprocal theorem- Stress-strain relations- Effects of free thermal strains and moisture strains.

UNIT V	CLASSICAL LAMINATION THEORY & THEORIES OF FAILURES	9

Classical Laminate Theory: Force and Moment Resultants -Laminate stiffness matrix: ABD Matrix-Classification of laminates and theireffect on the ABD Matrix-Elastic couplings.

Theories of Failures of Laminates: Maximum stress and strain criterion- Tsai-Hill, Tsai-Wucriterion - Interlaminar stresses - Impact resistance.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Define and classify the fundamentals of fibers, matrices, additives, and composites. **(Understand)**

CO2 Describe the various manufacturing processes involved in the fabrication of composite material. **(Understand)**

CO3 Describe the various techniques for suitable composite material with required enhanced Properties. **(Understand)**

CO4 Analyze composite laminates using the fundamentals of Classical Lamination Theory. **(Analyze)**

CO5 Apply failure criteria on composite structures subjected to various types of loading. **(Apply)**

Textbooks

1. M.Balasubramanian, Composite materials processing, 1st edition, CRC press, 2013.
2. Mallick P.K., "Fiber Reinforced Composites: Materials, Manufacturing and Design", 3rd Edition, CRC Press Taylor andFrancis, New York, 2007.

Reference Books

1. Bhagwan D. Agarwal, Lawrence J. Broutman& Chandrashekhar K., "Analysis and Performance of Fiber Composites", 4th Edition, John Wiley & Sons, New York, 2017.
2. Ever J. Barbero, Introduction to Composite Materials Design, 2nd edition, CRC Press, 2010.
3. K.K. Chawla, Composite Materials, 3rd edition, Springer-Verlag, New York, 2012.

Web Resources

1. https://archive.nptel.ac.in/courses/101/106/101106038/
2. https://archive.nptel.ac.in/courses/105/108/105108124/
3. https://archive.nptel.ac.in/courses/112/103/112103308/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											2	1
CO2	3	2											2	1
CO3	3	2											2	1
CO4	2	2	2										2	1
CO5	2	2	2									1	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 (Understand)

1. Combination of properties can be achieved in composites. Justify this statement & Explain. **(Understand)**
2. Compare matrix and dispersed phases in a composite material. What should be the important mechanical characteristics of matrix and dispersed phases for FRCs? **(Understand)**
3. State whether the following statements are true or false and give reasons:**(Understand)**
   - Aramid fibers are commonly used as reinforcements for metal and ceramic matrices.
   - Carbon fiber has poor compressive properties.
4. Bulk material is stronger than fibrous material.**(Understand)**
   - Glass fiber is an anisotropic material.
   - Glass fiber is an amorphous material.
   - Whiskers are not widely used for making composites.

COURSE OUTCOME 2 (Understand)

1. Explain the criteria for selecting a process to manufacture FRP products. **(Understand)**
2. Compare hand lay-up and RTM processes. **(Understand)**
3. Explain the fabrication process for MMC. **(Understand)**

COURSE OUTCOME 3 (Understand)

1. Explain the nanoclay composites and its applications. **(Understand)**
2. Describe the functionally graded composites and their applications. **(Understand)**

COURSE OUTCOME 4(Analyse)

1. Analyse the weight fraction and volume fraction of fibers in the glass/epoxy composites. The following data is obtained from the burnout test.
   weight of the empty crucible = 46.5401 gm
   weight of crucible and composite piece = 49.1201 gm
   weight of crucible and glass fiber = 48.3420 gm.
   The density of glass fiber is 2600 kg/$m^3$and 1300 kg/m^3**(**Analyse**)**

2. Calculate the ratio of fiber stress to matrix stress and matrix stress to composite stress for Vf = 15%, 30 %, 45 % and 70 %. Take Ef =250 G Pa and Em = 15 G Pa Analyse

3. Calculate the strains in the xy directions for the composite subjected to the loading as shown in the figure. The composite is made of boron-epoxy. Take the data given for 0o unidirectional E-glass-epoxy as: E11 = 200 GPa; E22 = 20 GPa; G12 = 6.5 GPa; ν 12 = 0.2**.(Apply)**

COURSE OUTCOME 5 .(Apply)

1. Determine A, B, and D matrices for the 2-ply laminate as shown in the figure. Assume both the laminae have identical stiffness matrix Q as follows:**(Apply)**

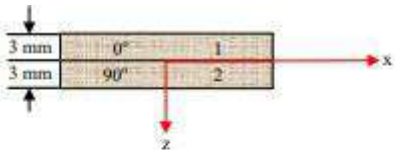


Fig.(i): Figure showing the laminate orientation

$$[Q] = \begin{bmatrix} 130 & 2.5 & 0 \\ 2.5 & 10 & 0 \\ 0 & 0 & 3.5 \end{bmatrix} GPa$$

2. The material properties are, E1= 147 GPa, E2= 15 GPa, G12= 12 GPa and ν 12 = 0.3 . For the lamina with orientation [45°], Calculate the lamina stresses due to the load of N_{XX} = 100 kN/m. Verify for failure through the different failure criteria, if the strength values are**(Apply)**

σ_{LU} = 1200 MPa
σ_{TU} = 60 MPa
τ_{LTU}= 90 Mpa

21ME5708	POLYMER TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

- To impart knowledge on mixing devices, extrusion moulding.
- To know the importance of Injection moulding and special moulding techniques.
- To understand the basic concepts in mould design

UNIT I	MIXING DEVICES	9

Additives and Mixing process, different types of mixing devices – twin drum tumblers, ribbon blenders, Z-blade Mixer, high speed mixer, ball mill, two roll mill, Banbury mixer, internal mixing and screw mixing – twin screw compounding machines-differences between mixing conditions for rubbers and plastics

UNIT II	CALENDERING AND EXTRUSION	9

Processing methods based on extruder (granule production, profile production, film blowing, blow moulding, extrusion stretch blow molding) – extrusion coating process (sheet coating and wire covering) – rubber extrusion-hot feed and cold feed extrusion of rubber – calendaring of rubber compounds and PVC pastes – equipment and processes

UNIT III	INJECTION MOULDING	9

Injection moulding machines and its components – moulds, multi cavity moulds, mould clamping devices, mould clamping force, injection blow moulding, reaction injection moulding

UNIT IV	OTHER MOULDING TECHNIQUES	9

Thermoforming – vacuum forming, Pressure forming and matched mould forming – Rotation moulding – Compression moulding – Transfer moulding

UNIT V	BASIC CONCEPTS IN MOULD DESIGN	9

Types of moulds – Feed system – ejector system – ejection techniques – mould cooling – CAD / CAM applications

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
2 Test Each 10 Marks Descriptive Questions	Multiple Choice Questions (MCQ)	1 test of 60 Marks Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. Enumerate the various basic processing methods employed for Plastics. (Understand)
CO2. Enumerate the principles of calendaring and extrusion processes. (Understand)
CO3. Apply the principles of injection moulding in manufacturing of components (Apply)
CO4. Apply the other moulding techniques in production of components(Apply)
CO5. Apply the basic concepts in design of mould system and evaluate the applications of CAD / CAM (Apply)

Text Books

1. D.H. Morton-Jones, Polymer Processing, Springer verlaggmbh (2014)
2. Myer Kutz, "Applied Plastics Engineering Handbook: Processing and Materials", Elsevier, UK, (2016)

Reference Books

1. Sinha R., "Outlines of Polymer Technology: Manufacture of Polymers", PHI, New Delhi, (2004)
2. Crawford R.J. Plastics Engineering, Butterworth - Heinemann, 3rd Edition, (2005)
3. Fried helm Hansen, Plastics Extrusion Technology, 2nd Edition, Hanser Publishers, (1997)
4. Peter Powell, A. Jan IngenHouz, Engineering with Polymers, Stanley Thomas Publishers Ltd., 2nd Edition. (1998)
5. Richard G.Griskey, Polymer Process Engineering, Chapman and Hall, (1995)
6. Tim A. Osswald Georg Menges "Material Science of Polymers for Engineers", Hanser Publications, (2012)
7. Michael L. Berins, "Plastic Engineering Handbook of the Society of the Plastics Industry", Kluwer Academic Publishers, Netherland, (1991)
   Charles A. Harper, "Handbook of Plastic Processes", John Wiley, NJ, (2006)

Web Resources

https://nptel.ac.in/courses/113105028/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	3	1					1						3	
2	3					2	1						2	3
3	3	2	1			1							3	2
4	3					1	1						2	3
5	1				2	2	1					2	3	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Enumerate the various basic processing methods employed for Plastics (Understand)

1. Review the following mixing devices with their all salient features.
   a). High speed mixer b). Ball mill c). Two roll mill d). Banbury Mixer **(Remember)**
2. Build a mixing device which have the key components of vertical vessel with a screw and state its functions and applications with neat portrayal **(Understand)**
3. Correlate the various mixing conditions for vulcanized rubbers and plastics **(Understand)**

COURSE OUTCOME 2: Enumerate the principles of calendaring and extrusion processes (Understand)

1. Apply the suitable polymer production technology to produce 'plastic pellets' **(Understand)**
2. Select the suitable production method of 'Shampoo Bottle' and label the component and process **(Understand)**
3. Check whether the high-tension wires from heavy voltage towers insulated in our country. If, not rank the issues caused by it. And label a best solution with detailed processes. **(Understand)**

COURSE OUTCOME 3: Apply the principles of injection moulding in manufacturing of components (Apply)

1. Choose the best mould which can be used in the production of 'bottle caps' in large quantity and discuss the process. **(Apply)**
2. Apply the suitable polymer production technology to produce 'plastic storage containers' **(Apply)**
3. Select the often-utilized molding method of strong, lightweight parts that are easily painted and elaborate the process. **(Apply)**

COURSE OUTCOME 4: Apply the other moulding techniques in production of components (Apply)

1. Apply the rules, facts and techniques for the production of 'Interior Door Panels.' **(Apply)**
2. Select the suitable production method of 'equipment panels' and label the component and process **(Apply)**
3. Apply the rules, facts and techniques for the production Microwave & Deep Freeze Containers **(Apply)**

COURSE OUTCOME 5: Apply the **basic concepts in design of mould system and evaluate the applications of CAD / CAM (Apply)**

1. With suitable sketch, explain the ejector system in mould design. **(Remember)**
2. Check whether CAD/CAM software can be used in mould design of polymer manufacturing, If yes, explain the basic concepts in mould design **(Understand)**
3. Design the mold which is used when the part of the runner system is on a different plane to the injection location and explain **(Apply)**

21ME5709	PROFESSIONAL ETHICS FOR ENGINEERS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

To enable the students to create an awareness on Engineering Ethics and Human Values to instil Moral and Social Values and Loyalty and to appreciate the rights of others

UNIT I	HUMAN VALUES	9

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

UNIT II	ENGINEERING ETHICS	9

Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles – Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

UNIT III	ENGINEERING AS SOCIAL EXPERIMENTATION	9

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.

UNIT IV	SAFETY, RESPONSIBILITIES AND RIGHTS	9

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

UNIT V	GLOBAL ISSUES	9

Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership –Code of Conduct – Corporate Social Responsibility.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Apply the value of ethics with sustained lifelong learning to strengthen autonomous professional decision.

CO2 Apply the moral issues, ethical dilemmas, and corporate professionalism through identification of suitable professional body.

CO3 Analyze the environment and lives of world community as a responsible engineer.

CO4 Evaluate the duties and responsibilities of employee/corporate.

CO5 Analyze ethical problems supported by established experiments around the world and provide solution as a professional expert

Textbooks

1. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, (2004)
2. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, New Delhi, (2003).

Reference Books

1. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, New Delhi, (2003)
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, "Engineering Ethics – Concepts and Cases", Cengage Learning, (2009)
3. Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers", Oxford University Press, Oxford, (2001)
4. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, (2003)
5. Laura P. Hartman and Joe Desjardins, "Business Ethics: Decision Making for Personal Integrity and Social Responsibility" Mc Graw Hill education, India Pvt. Ltd., New Delhi, (2013)
6. World Community Service Centre, "Value Education", Vethathiri publications, Erode, (2011)

Web Resources

1. https://nptel.ac.in/courses/110105097/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						2		3		1		2	2	2
CO2						2		3		1		2	2	2
CO3						3	2	3		1		2	2	2
CO4						3	2	3	2	1		2	2	2
CO5						3	3	3	3	1		2	2	2

21ME5710	INTRODUCTION TO AIRCRAFT SYSTEM	L	T	P	C
		3	0	0	3

Prerequisites for the course

Fluid Mechanics and
Machinery,Thermal
Engineering
Fundamentals of Electrical and Electronics Engineering

Objectives

- To understand the different component systems and functions.
- To Understand the basic properties and principles behind the flight
- To make the student understand the concept of theory of airfoils and wing sections.

UNIT I	INTRODUCTION TO AIRCRAFTS	9

Evolution and history of flight; Basic components of an aircraft: Structural members, aircraft axis system, aircraft motions, control surfaces and high lift devices; Types of aircrafts: Conventional design configurations based on power plant location, wing location, intake location, tail unit arrangements,
landing gear arrangements.

UNIT II	BASIC PRINCIPLES OF FLIGHT	9

Significance of speed of sound, air speed and ground speed, properties of atmosphere, Bernoulli‟s equation, forces on the airplane, airflow over wing section, pressure distribution over a wing section, generation of lift and drag, pitching moments, types of drag, lift curve, drag curve, lift/drag ratio curve,
factors affecting lift and drag.

UNIT III	AIRCRAFT SYSTEMS	9

Environmental control systems(ECS), pneumatic systems, hydraulic systems, fuel systems, landing gear systems, engine control systems, ice and rain protection systems, cabin pressurization and air conditioning systems, steering and brakes systems, auxiliary power unit; Electrical and electronic systems: Avionics, flight controls, autopilot and flight management systems, navigation systems,
communication, information systems, radar system

UNIT IV	AEROFOIL STABILITY AND CONTROL	9

Aerofoil nomenclature, types of aerofoil, center of pressure and its effects; Wing section: Aerodynamic center, aspect ratio, effects of speed, air density on lift and drag; Degree of stability: Lateral, longitudinal and directional stability and controls of aircraft; Effects of flaps and slats and lift coefficients, control tables, stalling, landing, gliding turning, speed of sound, mach number, shock
waves..

UNIT V	AIRCRAFT PERFORMANCE AND MANEUVRES	9

Power curves, maximum and minimum speeds of horizontal flight, effects of changes of engine power,
effects of altitude on power curves, forces acting on an aeroplane during a turn, loads during a turn,correct and incorrect angles of bank.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. Demonstrate the types & classifications of aircraft components and control systems **(Understand)**
CO2. Interpret the basic concepts of flight & Physical properties of Atmosphere **(Understand)**
CO3. Describe the principle and working of different aircraft systems. **(Understand)**
CO4. Determine dynamic longitudinal stability, lateral and directional dynamic stability. **(Apply)**
CO5. Calculate the forces and moments that are acting on an aircraft, variation of thrust, power, SFC with velocity and altitude. **(Apply)**

Text Books

1. Anderson, J.D., Introduction to Flight, McGraw-Hill; 8th edition , 2015
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2004.

Reference Books

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley &Son:, Inc, NY, 1988.
2. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 2010
3. Kermode, A.C. Flight without Formulae, Pearson Education; Eleven edition, 2011

Web Resources

https://nptel.ac.in/courses/101101083

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1				2	2					2	2	1
CO2	2	1				2	2					2	2	1
CO3	2	1				2	2					2	2	1
CO4	3	2	2									2	2	1
CO5	3	2	2									2	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Demonstrate the types & classifications of aircraftcomponents and control systems (Understand)

1. Explain primary and secondary flight control surfaces.and mention the different types of tail arrangements of an aircraft. . (U)

2. Draw three view of an aircraft and show all the major parts? Explain the major componentsand parts.. . (U)

COURSE OUTCOME 2: Interpret the basic concepts of flight & Physical properties of Atmosphere (Understand)

1. Explain the characteristics of an airfoil, when subjected to different angle of attacks. . (U)

2. Discuss the pressure distribution on an aerofoil? Sketch the pressure distribution on anaerofoil at various angle of attack.. . (U)

COURSE OUTCOME 3: Describe the principle and working of different aircraft systems. (Understand)

1. Explain the working of the typical hydraulic system used for the passenger aircraft. (U)
2. Describe aircraft engine ignition system and starting system operation with neat sketches.(U)

COURSE OUTCOME 4: Determine dynamic longitudinal stability, lateral and directional dynamic stability (Apply)

1. Discuss the dynamic stability aspects of an aircraft considering its linearized longitudinalequations of motion being analyzed under three degrees of freedom system. (A)

2. The characteristic equation of an airplane is $\lambda 2 - 0.5\lambda + 9.5 = 0$. Determine whether themotion is dynamically stable or unstable. . (A)

COURSE OUTCOME 5: Calculate the forces and moments that are acting on an aircraft, variation of thrust, power, SFC with velocity and altitude. (Apply)

1. Explain about the role of leading edge extension to improve the performance of aircraft at high angle of attack. . (U)

2. A flat plate is kept at 15^{o} angle of attack to a supersonic flow at Mach number 2.4. Solve the flow field around the plate and determine the inclination of slipstream direction usingshock expansion theory. (A)

PROFESSIONAL ELECTIVE II

21ME6701	MECHANICAL VIBRATIONS AND CONTROL	L	T	P	C
		3	0	0	3

Prerequisites for the course

Theory of Machines

Objectives

- To understand the Fundamentals of Vibration and its practical applications
- To understand the working principle and operations of various vibration measuring instruments
- To understand the various Vibration control strategies

UNIT I	FUNDAMENTALS OF VIBRATION	9

Introduction – Sources of Vibration – Mathematical Models – Displacement, velocity and acceleration – Review of single degree freedom systems – Vibration isolation -Vibrometers and accelerometers – Response to arbitrary and non-harmonic Excitations – Transient vibration – Impulse loads – Critical speed of shaft.

UNIT II	TWO DEGREE OF FREEDOM SYSTEM	9

Introduction – Free undamped and damped vibration – Forced vibration with Harmonic excitation system – Coordinate couplings and principal coordinates - Torsional vibration with two and three rotor systems.

UNIT III	MULTI-DEGREES OF FREEDOM SYSTEM AND CONTINUOUS SYSTEM	9

Multi degree freedom system – Influence coefficients and stiffness coefficients – Flexibility matrix and Stiffness matrix – Eigen values and Eigen vectors – Matrix iteration method –Approximate methods: Dunkerley, Rayleigh's, and Holzer method – Geared systems – Eigen values & Eigen vectors for large system of equations using Sub space, Lanczos method – Continuous system: Vibration of string, shafts and beams.

UNIT IV	VIBRATION CONTROL	9

Specification of Vibration Limits –Vibration severity standards – Vibration as condition Monitoring tool – Vibration Isolation methods – Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber – Damped Vibration absorbers – Static and Dynamic Balancing – Balancing machines – Field balancing – Vibration Control by Design Modification – Active Vibration Control

UNIT V	EXPERIMENTAL METHODS IN VIBRATION ANALYSIS	9

Vibration Analysis overview – Experimental Methods in Vibration Analysis – Vibration Measuring Instruments – Selection of Sensors – Accelerometer Mountings – Vibration Exciters – Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments, FFT analyzers – System Identification from Frequency Response – Testing for resonance and mode shapes.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. Demonstrate mathematical models of dynamical systems with single degree of freedom to determine their response to harmonic, transient and impulse loads. .**(Apply)**

CO2. Demonstrate mathematical models of dynamical systems with multiple degrees of freedom to calculate natural frequencies and mode shapes. .**(Apply)**

CO3. Determine the natural frequencies and mode shapes of continuous systems such as strings in transverse vibrations, bars in longitudinal vibrations, and circular shafts in torsional vibrations using analytical and numerical methods. **(Apply)**

CO4. Illustrate the severity of vibration and choose a suitable vibration isolation system, perform static and dynamic balancing and design suitable vibration absorber systems.**(Apply)**

CO5. Describe the vibration limits and able to select various vibration measuring instruments **(Understand)**

Text Books

1. Rao S S, "Mechanical Vibrations", 5th Edition, Prentice Hall, (2011)
2. Grover G K, "Mechanical Vibrations", Nem Chand and Brothers, Roorkee, (2009)

Reference Books

1. Thomson W, "Theory of Vibration with Applications", CRC Press, (2018)
2. Ashok Kumar Mallik, "Principles of Vibration control", Affiliated East-West Press (P) Ltd., New Delhi Press, (2014)
3. Lewis H Bell, "Industrial Noise Control Fundamentals and Applications", Marcel Dekkev Incl., New York, (2007)

Web Resources

https://nptel.ac.in/courses/112107087/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	3									1	3	
2	2	2	3									1	3	
3	2	2	3									1	3	
4	2		3			1	1					1	2	1
5	2		1			2	1					1	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Demonstrate mathematical models of dynamical systems with single degree of freedom to determine their response to harmonic, transient and impulse loads. (Apply)

1. Discuss general theory of seismic instruments and obtain the condition for using it as a vibrometer. (U)

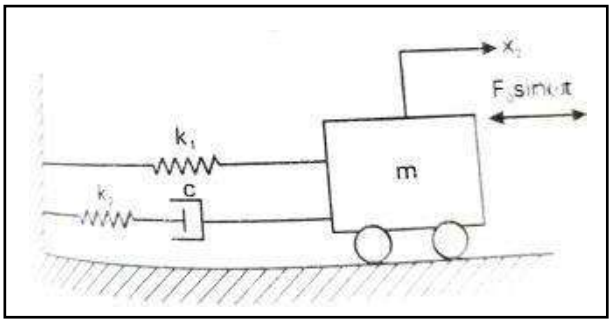
2. A shaft 1.5 m long supported in flexible bearings at the ends carries two wheels each of 50 kg mass. One wheel is situated at the centre of the shaft and the other at a distance of 375 mm from the centre towards left. The shaft is hollow of external diameter 75 mm and internal diameter 40 mm. The density of the shaft material is 7700 kg/m^3 and its modulus of elasticity is 200 GN/m^2. Find the lowest whirling speed of the shaft, taking into account the mass of the shaft. (A)

COURSE OUTCOME 2 Demonstrate mathematical models of dynamical systems with multiple degrees of freedom to calculate natural frequencies and mode shapes. (Apply)

1. A machine mounted on springs and fitted with a dashpot has a mass of 75 kg. There are three springs, each of stiffness 10 N/mm. The amplitude of vibrations reduces from 38.4 to 6.4 mm in two complete oscillations. Assuming that the damping force varies as the velocity, determine: 1. the damping coefficient, 2. the ratio of frequencies of damped and undamped vibrations and 3. the periodic time of damped vibrations. (A)
2. A mass of 10 kg is suspended from one end of helical spring; the other end is being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 Cos 50t (N) is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value of resonance? (A)

COURSE OUTCOME 3: Determine the natural frequencies and mode shapes of continuous systems such as strings in transverse vibrations, bars in longitudinal vibrations, and circular shafts in torsional vibrations using analytical and numerical methods. (Apply)

1. Figure shown a system subjected to vibration. Find an expression for the natural Frequency, locate the mode and draw mode shapes. (A)



2. State and proof Maxwell reciprocal theorem. Explain Dunkerley's method. (U)

COURSE OUTCOME 4: Illustrate the severity of vibration and choose a suitable vibration isolation system, perform static and dynamic balancing and design suitable vibration absorber systems (Apply)

1. A motor is mounted on a platform that is observed to vibrate excessively at an operating speed of 6000 rpm producing a 250-N force. Design a vibration absorber (undamped) to add to the platform. Note that in this case the absorber mass will only be allowed to move 2 mm because of geometric and size constraints. (A
2. A machine sorts bolts according to their size by moving a screen back and forth using a primary system of 2500 kg with a natural frequency of 400 cycle/min. Design a vibration absorber so that the machine-absorber system has natural frequencies below 160 cycles/min and above 320 rpm. (A)

COURSE OUTCOME 5: Describe the vibration limits and able to select and analyse by various vibration measuring instruments (Understand)

1. Explain the experimental modal analysis and the necessary basic equipments. (U)
2. Explain machine condition monitoring techniques. (U)

21ME6702	CONCEPT OF ENGINEERING DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Materials & Metallurgy, Strength of Materials and Design of Machine Elements & Joints

Objectives

1. To Study the various design requirements and get acquainted with the processes involved in product development.
2. To apply the design processes and scientific approaches to develop a successful product.
3. To provide the design solution through the social needs.

UNIT I	DESIGN TERMINOLOGY	9

Definition-various methods and forms of design-importance of product design-static and dynamic products-various design projects-morphology of design-requirements of a good design-concurrent engineering-computer aided engineering-codes and standards-product and process cycles-bench marking.

UNIT II	INTRODUCTION TO DESIGN PROCESSES	9

Basic modules in design process-scientific method and design method-Need identification, importance of problem definition-structured problem, real life problem- information gathering - customer requirements- Quality Function Deployment (QFD)- product design specifications-generation of alternative solutions- Analysis and selection-Detail design and drawings-Prototype, modeling, simulation, testing and evaluation

UNIT III	CREATIVITY IN DESIGN	9

Creativity and problem solving-vertical and lateral thinking-invention-psychological view, mental blocks-Creativity methods-brainstorming, synectics, force fitting methods, mind map, concept map-Theory of innovative problem solving (TRIZ) - conceptual decomposition creating design concepts.

UNIT IV	SOCIETAL ASPECTS IN PRODUCT DEVELOPMENT	9

Human factors in design, ergonomics, user friendly design-Aesthetics and visual aspects environmental aspects-marketing aspects-team aspects-legal aspects-presentation aspects

UNIT V	MATERIAL AND PROCESSES IN DESIGN	9

Material selection for performance characteristics of materials-selection for new designsubstitution for existing design-economics of materials-selection methods-recycling and material selection-types of manufacturing process, process systems- Design for Manufacturability (DFM) - Design for Assembly (DFA).

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
2 Test EACH 10marks Descriptive Questions	MCQ/Descriptive Questions	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Examine the various design requirements and get acquainted with the processes involved in product development. **(Apply)**
CO2: Apply the design processes to develop a successful product. **(Apply)**
CO3: Apply scientific approaches to provide design solutions. **(Apply)**
CO4: Design solution through relate the social needs and provide a solution. **(Apply)**
CO5: Apply the principles of material selection, costing and manufacturing in design. **(Apply)**

Text Books

1. Dieter. G. N., Linda C. Schmidt, "Engineering Design", McGraw Hill, 2013.
2. Horenstein, M. N., Design Concepts for Engineers, Prentice Hall, 2010.

Reference Books

1. Dhillon, B. S., Advanced Design Concepts for Engineers, Technomic Publishing Co., 1998.
2. Edward B. Magrab, Satyandra K. Gupta, F. Patrick McCluskey and Peter A. Sandborn, "Integrated Product and Process Design and Development", CRC Press, 2009.
3. James Garratt, "Design and Technology", Cambridge University Press, 1996.
4. Joseph E. Shigley, Charles R.Mische, and Richard G. Budynas, "Mechanical Engineering Design", McGraw Hill Professional, 2003.
5. Sumesh Krishnan and MukulSukla, Concepts in Engineering Design, Notion Press, 2016.

Web Resources

1. **https://nptel.ac.in/courses/107103002**
2. **https://nptel.ac.in/courses/107101087**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
1	2	3	2										2	1
2			3		2	2							2	1
3			3		2							2	2	1
4			3				2	2					2	1
5	2	2	3										2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to predict the various design requirements and get acquainted with the processes involved in product development (Apply)

1. List the various methods and forms of design (R)
2. Discuss about the requirements of a good design (U)

3. Describe the steps in benchmarking process (A)

COURSE OUTCOME 2: Students will be able to predict the suitable method forthe design processes to develop a successful product. (Apply)

1. Explain QFD with a suitable example (A)
2. Discuss the importance of problem definition (U)
3. State the importance of Prototype modeling, simulation, testing and evaluation (R)

COURSE OUTCOME 3: Students will be able to predict the scientific approaches to provide design solutions. (Apply)

1. Explain the creativity methods (R)
2. Discuss about theory of innovative problem solving (U)
3. How the innovative problem-solving technique is used in design creativity(A)

COURSE OUTCOME 4: Students will be able to predict the design solution through relate the human needs and provide a solution. (Apply)

1. Describe the design for environment (R)
2. Why the human factors is considered in design (U)
3. Derive a design process for aesthetics and visual aspects (A)

COURSE OUTCOME 5: Students will be able to predict the principles of material selection, costing and manufacturing in design. (Apply)

1. Explain material selection methods in detail (U)
2. List the benefits of design of experiments (R)
3. Discuss Design for Manufacturability (DFM) and Design for Assembly (DFA) with a suitable example (A)

21ME6703	FUNDAMENTALS OF COMBUSTION	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Chemistry, Engineering Thermodynamics

Objectives

1. To understand the fundamentals of combustion and to educate the different modes of combustion, flames and fuel burning characteristics

UNIT I	THERMODYNAMICS OF COMBUSTION	9

Combustion Thermodynamics – stoichiometry – Thermo-chemical equations – Heat of formation – Activation energy – multi-step reactions – Heat of reaction – first order, second order and third order reactions – Calculation of adiabatic flame temperature – Second law analysis for reacting flow – Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow

UNIT II	PREMIXED COMBUSTION	9

Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame

UNIT III	NON-PREMIXED COMBUSTION	9

Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion

UNIT IV	COMBUSTION IN GAS TURBINE ENGINES	9

Combustion in gas turbine combustion chambers – Recirculation – combustion efficiency, Factors affecting combustion efficiency – Fuels used for gas turbine combustion chambers – combustion stability – Flame holder types

UNIT V	EMISSION CONTROL TECHNOLOGIES	9

Chemical Emission from combustion, Quantification of emission, Emission control methods – Clean combustion technologies – Simulation on premixed, non-premixed combustion with emission levels

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 -10 Marks CAT 2 -10 Marks	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	1. DESCRIPTIVE QUESTIONS

Outcomes

Upon completion of the course, the students will be able to:

CO1. Apply the principles of physics, chemistry and thermodynamics to combustion **(Apply)**

CO2. Acquire the knowledge on laminar and turbulent premixed combustion and its characteristics **(Understand)**

CO3. Interpret combustion and its characteristics of gaseous, liquid and solid fuel **(Understand)**

CO4. Assimilate knowledge about combustion processes and strategies adapted in gas turbines. **(Apply)**

CO5. Identify novel combustion technologies that mitigate combustion driven emission. **(Remember)**

Text Books

1. S.R. Turns "An Introduction to Combustion Concepts and Applications", McGraw Hill, (2012).
2. Irvin Glassman "Combustion", Academic Press, (2015)

Reference Books

1. F.A.Williams "Combustion Theory", ABP, CRC press, (2018)
2. H.S.Mukunda "Understanding Combustion", Macmillan India, (2007)
3. C. K. Law "Combustion Physics", Cambridge University Press, (2010)
4. Mathur M.L. and Sharma R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard
5. Publishers & Distributors, Delhi, 2nd edition (2014)
6. Sutton G.P., "Rocket Propulsion Elements", John Wiley, (1993)

Web Resources

1. **https://nptel.ac.in/courses/101104070**
2. **https://nptel.ac.in/courses/101104072**

CO Vs PO Mapping and CO Vs PSO Mapping

CO 1	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	1	2	3										2	3
CO2	2	3											2	3
CO3		3		2									2	3
CO4	1	3	2										2	3
CO5					3							2	2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Apply the principles of physics, chemistry and thermodynamics to combustion (Apply)

1. A closed, fixed, adiabatic volume contains a stoichiometric mixture of 2 kmole of H_2 and 1 kmole of O_2 at 100 kPa and 298 K. Find the adiabatic flame temperature assuming the irreversible reaction (**A)**

$$2H_2 + O_2 \rightarrow 2H_2O$$

2. Consider a variant on the previous example in which the mixture is diluted with an inert, taken here to be N_2. A closed, fixed, adiabatic volume contains a stoichiometric mixture of 2 kmole of H_2, 1 kmole of O_2, and 8 kmole of N_2 at 100 kPa and 298 K. Find the adiabatic flame temperature and the final pressure, assuming the irreversible reaction **(A)**

$$2H_2 + O_2 + 8N_2 \rightarrow 2H_2O + 8N_2.$$

COURSE OUTCOME 2: Acquire the knowledge on laminar and turbulent premixed combustion and its characteristics (Understand)

1. Identify the effects of chemical and physical variables on burning velocity during premixed flame? **(U)**
2. Comparison between the Laminar and Turbulent premixed flame? **(U)**

COURSE OUTCOME 3: Interpret combustion and its characteristics of gaseous, liquid and solid fuel (Understand)

1. Characteristics for the liquid fuel to obtain the non-premixed combustion? **(U)**
2. Explain briefly about the solid fuel combustion? **(U)**

COURSE OUTCOME 4: Assimilate knowledge about combustion processes and strategies adapted in gas turbines (Apply)

1. The mass flow rate of air through an aircraft engine is 10 kg/s. The compressor outlet temperature is 400 K and the turbine inlet temperature is 1800 K. The heating value of the fuel is 42 MJ/kg and the specific heat at constant pressure is 1 kJ/kg-K. The mass flow rate of the fuel in kg/s is approximately. For a given inlet condition, if the turbine inlet temperature is fixed, what value of compressor efficiency given below leads to the lowest amount of fuel added in the combustor of a gas turbine engine? **(A)**
2. Identify the type of fuels used for gas turbine combustion chambers with it physical and chemical properties? **(U)**

COURSE OUTCOME 5: Identify novel combustion technologies that mitigate combustion driven emission (Remember)

1. Describe the types of technique used to reduce exhaust emission **(R)**
2. Recognize the chemical balance during the combustion of the liquid fuel? **(R)**

21ME6704	Fuel Cell Technology	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Physics, Engineering Chemistry

Objectives

1. To present a problem oriented in depth knowledge of fuel cell technology.
2. To address the underlying concepts, methods and application of fuel cell technology.
3. To enable students to describe the performance characteristics of fuel cell power plant and its components.
4. To outline the performance, design characteristics and operating issues for various fuel cells.
5. To impart sufficient knowledge to students about the working of fuel cell industry or R&D organization.

UNIT I	INTRODUCTION TO FUEL CELLS	9

Introduction – working and types of fuel cell – low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, hydrogen fuel cells – thermodynamics and electrochemical kinetics of fuel cells.

UNIT II	FUEL CELLS FOR AUTOMOTIVE APPLICATIONS	9

Fuel cells for automotive applications – technology advances in fuel cell vehicle systems – onboard hydrogen storage – liquid hydrogen and compressed hydrogen – metal hydrides, fuel cell control system – alkaline fuel cell – road map to market.

UNIT III	FUEL CELL COMPONENTS AND THEIR IMPACT ON PERFORMANCE	9

Fuel cell performance characteristics – current/voltage, voltage efficiency and power density, ohmic resistance, kinetic performance, mass transfer effects – membrane electrode assembly components, fuel cell stack, bi-polar plate, humidifiers and cooling plates

UNIT IV	FUELING	9

Hydrogen storage technology – pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers – reformer technology – steam reforming, partial oxidation, auto thermal reforming – CO removal, fuel cell technology based on removal like bio-mass.

UNIT V	FUEL CYCLE ANALYSIS	9

Introduction to fuel cycle analysis – application to fuel cell and other competing technologies like battery powered vehicles, SI engine fueled by natural gas and hydrogen and hybrid electric vehicle.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 -10 Marks CAT 2 -10 Marks	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	1. DESCRIPTIVE QUESTIONS

Outcomes
Upon completion of the course, the students will be able to:
CO1. Describe the fundamentals of fuel cell **(Understand)** **CO2.** Describe the performance of fuel cell systems **(Understand)** **CO3.** Illustrate the construction and operation of fuel cell stack and fuel cell system **(Apply)** **CO4.** Illustrate the modelling techniques for fuel cell systems **(Apply)** **CO5.** Classify the different methods of fuel processing for fuel cells **(Understand)**
Text Books
1. Andrew L. Dicks and David A. J. Rand, "Fuel Cell Explained", John Wiley & Sons. Inc., (2018) 2. Revankar shrip, "Fuel Cells: Principles, Design and Analysis", Auerbach publications, (2014). 3. Dushyant Shekhawat, "Fuel Cells: Technologies for fuel processing", North Holland Publishing Co., 2011.
Reference Books
1. Ohayre, "Fuel Cell Fundamentals", John Wiley & Sons Inc., 2016. 2. F. Barbir, PEM Fuel Cells: Theory and Practice (2nd Ed.) Elsevier/Academic Press, 2013. 3. Dushyant Shekhawat, "Fuel Cells: Technologies for fuel processing", North Holland Publishing Co., (2011) 4. Kevin Huang, "Solid Oxide Fuel Cell Technology: Principles, Performance and Operations", Woodhead Publishing Ltd., 2009.
Web Resources **1. https://archive.nptel.ac.in/courses/103/102/103102015/** **2. https://onlinecourses.nptel.ac.in/noc22_ch66/preview** **3. https://nptel.ac.in/courses/121106014**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO2
CO1		2	2	2									2	3
CO2	2	3			2								2	3
CO3		3	2	2									2	3
CO4	3	2											2	3
CO5	2	2	2										2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe the fundamentals of fuel cell (Understand)

1. Describe the types of fuel cell – low, medium and high temperature fuel cell? **(U)**
2. Compare between the low, medium and high temperature fuel cells? **(U)**

COURSE OUTCOME 2: Describe the performance of fuel cell systems (Understand)

1. Differentiate between the liquid hydrogen and compressed hydrogen? **(U)**
2. Explain briefly about the alkaline fuel with neat sketch? **(U)**

COURSE OUTCOME 3: Illustrate the construction and operation of fuel cell stack and fuel cell system (Apply)

1. Illustrate suitable sketch for the Fuel cell performance characteristics with respective to current/voltage & voltage efficiency? **(A)**
2. What are the main components of membrane electrode assembly components? **(U)**

COURSE OUTCOME 4: Illustrate the modelling techniques for fuel cell systems (Apply)

1. A company is developing a new car powered by a fuel cell system that runs on H2. You have been asked to consider generating the H2 by electrolysis with a fuel cell. The H2 tank to be used is 10 liters in volume and a fill-up requires a pressure of 34 atm. a) Calculate the current required to operate at a voltage of 1.8V. b) Calculate the rate of hydrogen production per membrane area and the total membrane area required to fill the tank in 2 minutes. Consider the following specifications of the system. 60% conversion of H2O Eo = 1.172 V The cathode pressure is maintained at 1 atm. The anode pressure is maintained at 1 atm Membrane thickness = 100 μm Membrane conductivity (σ) = 0.1 S/cm (S = 1/Ω) Electrolysis T = 373 K (assume water is in the gas phase). H2 storage tank T = 298 K **(A)**
2. Explain the different states of Hydrogen storage technology? **(U)**

COURSE OUTCOME 5: Classify the different methods of fuel processing for fuel cells (Understand)

1. Explain different methods of production of hydrogen and catalytic steam reforming in details. **(U)**
2. Discuss the technologies for hydrogen production? **(U)**
3. Explain a lay out of a fuel cell in automobile. **(U)**

21ME6705	INDUSTRIAL ENGINEERING & MANAGEMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To provide student with knowledge and skill sets required in the industrial management and engineering profession.
- To apply productivity techniques for achieving continuous improvement.
- To impart in the students, the ability to adopt a system approach to design, develop, implement, and innovate integrated systems.
- To enable the students to understand the interactions between engineering, society, and environment.

UNIT I	INTRODUCTION	9

Industrial Engineering–definition, history, primitive activities Applications in manufacturing and service sectors–functions of an Industrial Engineer Management approaches–FW Taylors scientific approach– Modern approach– Systems approach

UNIT II	PRODUCTIVITY	6

Definition – Factors affecting- Increasing productivity of resources - Kinds of productivity measures - Case study.

UNIT III	PLANT LAYOUT	12

Factors governing plant location, types of production layouts, advantages and disadvantages of process and product layouts, applications, quantitative techniques for optimal layout design, Introduction to software for plant layout design, Tools and techniques including computer-based layout design – CRAFT, ALDEP, CORELAP.

UNIT IV	RESOURCE MANAGEMENT	9

Concept of human resource management, personnel management and industrial relations, functions of personal management – Job evaluation, its importance and types, merit rating, quantitative methods, MTM, wage incentive plan, types

UNIT V	DECISION MAKING AND PROJECT MANGEMENT	9

Types of decisions – theories of decision making – steps involved in decision making – Quantitative methods in decision making PERT, CPM – differences and applications, critical path, determination of floats, project crashing, smoothing – simple numerical

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
2 Test EACH 10marks MCQ/Descriptive Questions	MCQ/Descriptive Questions	Descriptive Questions

Outcomes
Upon completion of the course, the students will be able to:
CO1: Summarize the basics of industrial engineering and its applications in production and service sector (Understand) CO2: Apply productivity techniques for continuous improvement in different functionalities of an industry. (Apply) CO3: Interpret the optimal layout design using software (Understand) CO4: Demonstrate the resource and personnel management requirements for an organization. (Apply) CO5: Prepare a decision-making plan on project management (Apply)
Text Books
1. Mart and Telsang,"Industrial Engineering and Management",S.Chand & Compagny Limited,(2006) 2. O.PKhanna,"Industrial Engineering and Management", Khanna publishers,(2017) 3. MIKhan, "Industrial Engineering",New age international(P)publishers ltd. (2007)
Reference Books
1. PhilipE.Hicks, Anthony Lal, "Introduction to industrial engineering and management science", McGraw Hill, (2001) 2. G,Nadhamuni Reddy, "Industrial Engineering and Management", New age international(P)publishers ltd., (2002). 3. V.Ravi,"IndustrialEngineering andManagement",PHILearningPvtLtd.,(2015)
Web Resources
1. https://nptel.ac.in/courses/112/107/112107142/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
1	2	1			2	1			1			2		3
2	2	1			2	1			1			2		3
3	2	1			2	1			1			2		3
4	2	1			2	1			1			2		3
5	2	1			2	1			1			2		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Summarize the basics of industrial engineering and its applications in production and service sector (Understand)

1. Explain any four fields of application of Industrial Engineering (U).
2. Write the role of an Industrial Engineer with respect to Management approaches (R).

COURSE OUTCOME 2: Apply productivity techniques for continuous improvement in different functionalities of an industry. (Apply)

1. Importance of Vision, mission and objectives statements for an organization (A)
2. How to formulate the management structure for a company (U)

COURSE OUTCOME 3: Interpret the optimal layout design using software (Understand)

1. Write down the types of production layouts (U)
2. Describe the importance of quantitative techniques for optimal layout design (U)

COURSE OUTCOME 4: Demonstrate the resource and personnel management requirements for an organization. (Apply)

1. Differentiate between personnel management and industrial relations (A)
2. Write notes on wage incentive plan. (U)

COURSE OUTCOME 5: Prepare a decision-making plan on project management (Apply)

1. Apply the theories of decision making differ from other methods (A)
2. Describe about project crashing, smoothing (A)

21ME6706	LEAN SIX SIGMA	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, Probability and Statistical Analysis

Objectives

To gain insights about the importance of lean manufacturing and six sigma practices

UNIT I	LEAN & SIX SIGMA BACKGROUND AND FUNDAMENTALS	9

Historical Overview – Definition of quality – What is six sigma – TQM and Six sigma – lean manufacturing and six sigma – six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments – implications of quality levels, Cost of Poor Quality (COPQ), Cost of Doing Nothing – assessment questions

UNIT II	THE SCOPE OF TOOLS AND TECHNIQUES	9

Tools for definition – IPO diagram, SIPOC diagram, Flow diagram, CTQ Tree, Project Charter – Tools for measurement – Check sheets, Histograms, Run Charts, Scatter Diagrams, Cause and effect diagram, Pareto charts, Control charts, Flow process charts, Process Capability Measurement, Tools for analysis – Process Mapping, Regression analysis, RU/CS analysis, SWOT, PESTLE, Five Whys, interrelationship diagram, overall equipment effectiveness, TRIZ innovative problem solving – Tools for improvement – Affinity diagram, Normal group technique, SMED, 5S, mistake proofing.

UNIT III	SIX SIGMA METHODOLOGIES	9

Design For Six Sigma (DFSS), Design For Six Sigma Method – Failure Mode Effect Analysis (FMEA), FMEA process – Risk Priority Number (RPN) – Six Sigma and Leadership, committed leadership – Change Acceleration Process (CAP) – Developing communication plan – Stakeholder.

UNIT IV	SIX SIGMA IMPLEMENTATION AND CHALLENGES	9

Tools for implementation – Supplier Input Process Output Customer (SIPOC) – Quality Function Deployment or House of Quality (QFD) – alternative approach –implementation – leadership training, close communication system, project selection – project management and team – champion training – customer quality index – challenges – program failure, CPQ vs six sigma, structure the deployment of six sigma – cultural challenge – customer/internal metrics.

UNIT V	EVALUATION AND CONTINUOUS IMPROVEMENT METHODS	9

Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
2 Test EACH 10marks MCQ/Descriptive Questions	MCQ/Descriptive Questions	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1**:** Describe the importance of Lean and six sigma (Understand)
CO2: Demonstrate the scope of tools and techniques. (Understand)
CO3: Illustrate Plan the resources using six sigma methodologies (Apply)
CO4: Apply QFD to face the implementation and challenges. (Apply)
CO5: Apply the process of evaluation and continuous improvement methods. (Apply)

Text Books

1. MichaelL.George,DavidRownalds,BillKastle,"WhatisLeanSixSigma",McGraw Hill(2012).
2. DennisP.Hobbs,"LEANManufacturingImplementation",APICS,(2009)

Reference Books

1. Thomas Pyzdek,"The Six Sigma Hand book",McGraw-Hill,(2010)
2. Fred Solei mannejed, "SixSigma, Basic Steps and Implementation",AuthorHouse,(2004)
3. ForrestW.Breyfogle,III,JamesM.Cupello,BeckiMeadows, "Managing Six Sigma:A PracticalGuide to Understanding, Assessing, and Implementing the Strategy That YieldsBottom-LineSuccess, John Wiley & Sons,(2010)
4. James P.Womack, DanielT.Jones, "Lean Thinking",Free Press Business,(2013)

Web Resources

https://nptel.ac.in/courses/112/104/112104188/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1			2				1		1	2	2	3
2	2	1			2				1		1	2	2	3
3	2	1			2				1		1	2	2	3
4	2	1			2				1		1	2	2	3
5	2	1			2				1		1	2	2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe the importance of Lean and six sigma (Understand)

1. Give a detailed report on how Six Sigma is related to TQM, lean manufacturing, and process tolerance. **(U)**
2. Enumerate the importance of cost of quality. **(U)**

COURSE OUTCOME 2: Demonstrate the scope of tools and techniques. (Understand)

1. How a Milestone tracker diagram helps in continuous improvement of a firm. **(A)**
2. Explain the relationship between lean manufacturing and six sigma **(U)**

COURSE OUTCOME 3: Illustrate Plan the resources using six sigma methodologies (Apply)

1. Describe Earned value management in detail **(U)**
2. Depict the process of FMEA with a sample form **(U)**

COURSE OUTCOME 4: Apply QFD to face the implementation and challenges. (Apply)

1. Demonstrate important is a customer to the firm and why is a quality index required? What are the various challenges faced? **(A)**
2. Enumerate the various principles of CPQ and Six sigma (**U)**

COURSE OUTCOME 5: Apply the process of evaluation and continuous improvement methods. (Apply)

1. How is Kaizen implemented in an organization? **(A)**
2. Differentiate inventory in progress and work in progress. **(U)**

21ME6707	COMPUTER INTEGRATED MANUFACTURING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, CNC Machines and Automation

Objectives

1.To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.

UNIT I	INTRODUCTION	9

Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control – Introduction to CAD/CAM – Concurrent Engineering – CIM concepts – Computerised elements of CIM system – Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance – Simple problems – Manufacturing Control – Simple Problems – Basic Elements of an Automated system – Levels of Automation – Lean Production and Just-In-Time Production

UNIT II	PRODUCTION PLANNING AND CONTROL AND COMPUTERISED PROCESS PLANNING	9

Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning – Control Systems – Shop Floor Control – Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP)

UNIT III	CELLULAR MANUFACTURING	9

Group Technology(GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems.

UNIT IV	FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDED VEHICLE SYSTEM (AGVS)	9

Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control – Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.

UNIT V	INDUSTRIAL ROBOTICS	9

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability – Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability

	Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Explain the basic concepts of CAD, CAM and computer integrated manufacturing systems (**Understand)**

CO2: Demonstrate the production planning and control and computerized process planning (**Apply)**

CO3: Differentiate the different coding systems used in group technology **(Understand)**

CO4: Explain the concepts of flexible manufacturing system (FMS) and automated guided vehicle (AGV) system**. (Understand)**

CO5: Determine the Classification of robots used in industrial applications. **(Apply)**

Text Books

1. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, (2015).
2. Radhakrishnan P, SubramanyanS.and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, (2018)

Reference Books

1. Gideon Halevi and Roland Weill, "Principles of Process Planning – A Logical Approach" Chapman & Hall, London, (2012)
2. Kant Vajpayee S, "Principles of Computer Integrated Manufacturing", Prentice Hall India.
3. Rao. P, N Tewari &T.K. Kundra, "Computer Aided Manufacturing", Tata McGraw Hill Publishing Company, (2017)

Web Resources

1. http://www.nptel.ac.in/courses/112102011/
2. http://nptel.ac.in/courses/110106044/
3. http://nptel.ac.in/courses/112107143/36
4. http://nptel.ac.in/courses/112103174/35

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2				2	2	1						3	2
2	2				2	2	1						3	2
3	2				2	2	1						3	2
4	2				2	2	1						3	2
5	2				2	2	1						3	2

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Explain the basic concepts of CAD, CAM and computer integrated manufacturing systems. (Understand)

1. Discuss about seven forms of waste in production and methods to eliminate them. (U)
2. Explain the hierarchical structure of computerized elements of CIM. (U)

COURSE OUTCOME 2: Demonstrate the production planning and control and computerized process planning. (Apply)

1. Define MRP. Explain the inputs to MRP and various MRP outputs. Also list the various benefits of MRP. (R)
2. Show in detail the phases of shop floor system**.** (A)

COURSE OUTCOME 3: Differentiate the different coding systems used in group technology. (Understand)

1. Discuss the production flow analysis in detail. (U)
2. Explain cellular manufacturing in detail. (U)

COURSE OUTCOME 4: Explain the concepts of flexible manufacturing system (FMS) and automated guided vehicle (AGV) system. (Understand)

1. Define FMS and explain in detail about the FMS components. (R)
2. Explain vehicle guidance technology in AVGs. (U)

COURSE OUTCOME 5: Determine the classification of robots used in industrial applications. (Apply)

1. Demonstrate the basic structure of a robotic system with neat sketch. (A)
2. Summarize what are robot end effectors? How do you classify them? (U)

21ME6708	FLEXIBLE MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, CNC Machines and Automation

Objectives

To understand the concepts and applications of flexible manufacturing systems.

UNIT I	PLANNING, SCHEDULING AND CONTROL OF FMS	9

Introduction to FMS – development of manufacturing systems – benefits – major elements – types of flexibility – FMS application and flexibility – single product, single batch, n – batch scheduling problem – knowledge-based scheduling system

UNIT II	COMPUTER CONTROL AND SOFTWARE FOR FMS	9

Introduction – composition of FMS – hierarchy of computer control –computer control of work center and assembly lines – FMS supervisory computer control – types of software specification and selection – trends.

UNIT III	FMS SIMULATION AND DATA BASE	9

Application of simulation – model of FMS – simulation software (Demonstration using Autodesk 360 fusion) – limitation – manufacturing data systems – data flow – FMS database systems – planning for FMS database

UNIT IV	GROUP TECHNOLOGY AND JUSTIFICATION OF FMS	9

Introduction – matrix formulation – mathematical programming formulation – graph formulation – knowledge-based system for group technology – economic justification of FMS – application of possibility distributions in FMS systems justification.

UNIT V	APPLICATIONS OF FMS AND FACTORY OF THE FUTURE	9

FMS application in machining, sheet metal fabrication, prismatic component production – aerospace application – FMS development towards factories of the future – artificial intelligence and expert systems in FMS – design philosophy and characteristics for future.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Enumerate the principles of flexible manufacturing systems. (Understand)

CO2: Discuss the concepts and applications of computers in flexible manufacturing systems. (Understand)

CO3: Apply the modern tools in database management of FMS. (Apply)

CO4: Illustrate the performance of group technology in FMS. (Apply)

CO5: Show the application of FMS and understand the future factory of FMS. (Apply)

Text books

1. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt., New Delhi, (2015)
2. H K Shivanand, M MBenal, V Koti, "Flexible Manufacturing Systems", New Age International publishers (2006)
3. Jha, N.K. "Handbook of flexible manufacturing systems", Academic Press Inc., (1991)

Reference Books

1. Kalpakjian, "Manufacturing Engineering and Technology", Addison-Wesley Publishsing Co., (2018)
2. Radhakrishnan P. and Subramanyan S., "CAD/CAM/CIM", Wiley Eastern Ltd., New Age International Ltd., (2018)
3. Raouf, A. and Ben-Daya, M., Editors, "Flexible manufacturing systems: Recent development", Elsevier Science, (1995)
4. Taiichi Ohno, "Toyota Production System: Beyond large-scale Production", Productivity Press (India) Pvt. Ltd. (2001)

Web Resources

1. https://nptel.ac.in/courses/110107116/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2				2	2	2						3	2
2	2				2	2	2						3	2
3	2				2	2	2						3	2
4	2				2	2	2						3	2
5	2				2	2	2						3	2

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Explain the principles of flexible manufacturing systems (Understand)

1. Discuss the major elements of FMS? State the applications of FMS. (U)
2. Explain different types of flexibility in manufacturing in FMS concept. (U)

COURSE OUTCOME 2: Discuss the concepts and applications of computers in flexible manufacturing systems. (Understand)

1. Explain various functions performed by computer control system in FMS implementation. (U)
2. Discuss the role of software and considerations for maintenance planning and reporting. (U)

COURSE OUTCOME 3: Apply the modern tools in database management of FMS (Apply)

1. Show the languages for the simulation of FMS and the selection of simulation software. (A)
2. Discuss input and output analysis in FMS simulation with a case study. (U)

COURSE OUTCOME 4: Illustrate the performance of group technology in FMS. (Apply)

1. Examine the sorting-based algorithm in grouping parts with an example. (A)
2. Discuss bond energy algorithm in grouping parts with an example. (U)

COURSE OUTCOME 5: Show the application of FMS and understand the future factory of FMS. (Apply)

1. Predict how is FMS applied in prismatic part production? Give a case study. (A)
2. Show the design philosophy for the FMS of the future? Discuss in detail. (A)

21ME6709	HYBRID VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Fundamentals of Electrical and Electronics Engineering, Automobile Engineering

Objectives

- To understand the vehicle architecture, power train modelling and the electrical motor characteristics in hybrid vehicles.
- To understand the energy storage technology and driving cycle simulation of hybrid vehicles.
- To Explicate the different train topologies and power flow control in hybrid vehicles

UNIT I	INTRODUCTION AND COMPONENTS OF HYBRID VEHICLES	9

Introduction: General Architectures- Vehicle System Components and Analysis- Controls of Hybrid Vehicle Components of Hybrid Vehicles: Prime Mover- Electric Motor with DC/DC Converter and Inverter- Energy Storage System-Transmission System in Hybrid Vehicle.

UNIT II	HYBRID VEHICLES SYSTEM MODELING	9

Internal Combustion Engine- Electric Motor- Battery System- Transmission System- Final Drive and Wheel- Vehicle Body- PID-Based Driver Model.

UNIT III	POWER ELECTRONICS AND ELECTRIC MOTOR DRIVES	9

Power Electronics: Power Electronic Devices- DC/DC Converter- DC–AC Inverter Electric Motor Drives: BLDC Motor and Control- AC Induction Motor and Control- Plug-In Battery Charger Design- Plug-in Hybrid Vehicle Battery System and Charging Characteristics.

UNIT IV	ENERGY STORAGES SYSTEM MODELING AND CONTROL	9

Methods of Determining State of Charge- Estimation of Battery Power Availability- Battery Life Prediction- Cell Balancing- Estimation of Cell Core Temperature- Battery System Efficiency.

UNIT V	SIMULATION OF DRIVING CYCLES	9

Simulation System - Typical Test - Driving Cycles - Preliminary Sizing of Main Components of Hybrid Vehicle- Fuel Economy and Emissions Simulation Calculations - Demonstration using MATLAB®, Simulink®, and Sim scape™.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Destructive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes
Upon completion of the course, the students will be able to:
CO1. Summarize about the layout and sub systems of hybrid vehicles **(Understand)** CO2. Interpret the architecture of various models of hybrid Vehicles Systems. **(Understand)** CO3. Classify and explain electronic devices and motor drives **(Understand)** CO4. Estimate the parameters influencing the energy storage Systems. **(Understand)** CO5. Infer the results from simulation of driving cycles **(Understand)**
Text books
1. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", 1st Edition, John Wiley & Sons, Inc., New Jersey, (2013).
Reference Books
1. Mehrdad Ehsani, YiminGao,Stefano Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles ", 2nd Edition, CRC Press, Boca Raton, (2018) 2. Iqbal Husain, "Electric and Hybrid Vehicles", 3rd Edition, CRC Press, Boca Raton, (2021)
Web Resources
1. https://archive.nptel.ac.in/courses/108/103/108103009/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	3	1			2	1	1					1	2	1
2	3	1			2	1	1					1	2	1
3	3	1			2	1	1					1	2	1
4	3	1				1	1					1		3
5	3	2				1	1					1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Summarize about the layout and sub systems of hybrid vehicles. (Understand)

1. Draw a general lay out of a EV and discuss the transmission characteristics. **(U)**
2. With a neat sketch, explain the configuration of Series hybrid electric drive train. **(U)**

COURSE OUTCOME 2: Explain the architecture of various models of hybrid Vehicles Systems. (Understand)

1. Explain the configuration of v/f-controlled induction motor drive with field weakening mode and constant-torque mode' **(U)**

2. A vehicle with power plant power output at the drive train considering all losses is 100kW. The maximum total resistance the vehicle experiences is 3.6 li. Calculate the velocity the vehicle can achieve in kmlh under this condition?. **(U)**

COURSE OUTCOME 3: Classify and explain electronic devices and motor drives . (Understand)

1. Draw the typical torque Vs speed envelope curves of drive train motors and show the continuous, intermittent and peak overload ratings **(U)**
2. Explain compound wound DC motor with neat circuit diagram and also write the voltage and circuit Diagram**(U)**

COURSE OUTCOME 4: Estimate the parameters influencing the energy storage Systems. (Understand)

1. Why an energy management control system is required in an HEV? Do you think an elaborate energy management system similar to that applied to a hybrid vehicle, is required in an electric vehicle? Explain **(U)**

2. Draw the block diagram of a general Ftuzy Logic controller (FLC) and show (5) thecorecomponentsoftheFLCandtheinputsandoutputsrelevanttoahybrid electric vehicle control'. **(U)**

COURSE OUTCOME 5: Infer the results from simulation of driving cycles. (Understand)

1.Explain the experimental modal analysis and the necessary basic equipments. **(U)**

2.A hybrid electric vehicle has two sources- an ICE with output power of 80kW and battery storage. The battery storage is a 150 Ah, Cio battery at 120V. (i) Calculate the battery energy capacity (ii). Without de-rating the Attr capacity, what is the maximum power that can be supported by the battery? (iii). What is the electrical motor power output if the total efficiency of power converter and motor combination is 98%. (iv). what is the maximum power that can be transmitted to the wheels if the transmission efficiency is 95%? **(U)**

21ME6710	ELECTRIC VEHICLE	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Physics, Engineering chemistry and Fundamentals of Electrical and Electronics Engineering

Objectives

1. To understand the concept of electric vehicles.
2. To study about the motors for electric vehicles.
3. To understand the drive train in electric vehicles.
4. To understand the concept of battery technology.
5. To study about sensors for electric vehicles.

UNIT I	INTRODUCTION TO ELECTRIC VEHICLES	9

Electric Vehicle – Need - Types – Cost and Emissions – End of life. Electric Vehicle Technology – layouts, cables, components, Controls.

UNIT II	ELECTRIC VEHICLE MOTORS	9

Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control. Induction motor, permanent magnet motor, switched reluctance motor.

UNIT III	ELECTRIC VEHICLE DRIVE TRAIN	9

Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing - Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives – Basic structure, Drive Convertor, Design.

UNIT IV	BATTERY	9

Batteries – overview and its types. Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics - Battery plug-in and life. Ultra-capacitor, Charging – Methods and Standards. Alternate charging sources – Wireless & Solar

UNIT V	SENORS	9

Sensors - Autonomous EV cars, Self-drive Cars, Hacking; Sensor less – Control methods- Phase Flux Linkage-Based Method, Phase Inductance Based, Modulated Signal Injection, Mutually Induced Voltage-Based, Observer-Based.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 -10 Marks CAT 2 -10 Marks	1.ASSIGNMENT 2. ONLINE QUIZZES 3.PROBLEM-SOLVING ACTIVITIES	1. DESCRIPTIVE QUESTIONS

Outcomes

Upon completion of the course, the students will be able to:

CO1. Describe about working principle of electric vehicles **(Understand)**

CO2. Apply the working principle and select various motors used in electric vehicles. **(Apply)**

CO3. Classify the types of drive train in electric vehicles **(Understand)**

CO4. Differentiate the types and working principle of battery **(Understand)**

CO5. Identify the various types and working principle of sensors **(Understand)**

Text Books

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2. Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007.
3. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.

Reference Books

1. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.
2. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
3. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
4. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
5. Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning, 2018.

Web Resources

1. https://archive.nptel.ac.in/courses/108/103/108103009/
2. https://nptel.ac.in/courses/108106170

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3					2				2				3
2	2		3							2			2	3
3	2		2			2				2				3
4	2		2			2				2				3
5	2		2			2				2				3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe about working principle of electric vehicles (Understand)

1. Describe the historical background of electrical vehicle in India? **(U)**
2. Discuss the components of the current electrical vehicles? **(U)**

COURSE OUTCOME 2: Apply the working principle and select various motors used in electric vehicles (Apply)

1. A vehicle powered by PM-DC motor is cruising at 36 kmph, the applied voltage is 25V, the BEMF is 24V and the winding resistance is 20 mΩ. How much current is the motor drawing? **(A)**
2. Comparison between the DC and BLDC motor? **(U)**

COURSE OUTCOME 3: Classify the types of drive train in electric vehicles (Understand)

1. Describe the working principle of brakes regenerative braking system? **(U)**
2. Comparison between series and parallel HEDT? **(U)**

COURSE OUTCOME 4: Differentiate the types and working principle of battery (Understand)

1. Describe briefly about the Battery technology in India with standard specification? **(U)**
2. State the working principle of the Lithium batteries for electric vehicle? **(U)**

COURSE OUTCOME 5: Identify the various types and working principle of sensors (Understand)

1. Describe the Autonomous EV cars? **(U)**
2. List of the latest sensors used in electric vehicles? **(U)**

PROFESSIONAL ELECTIVE III

21ME6711	PRODUCT DESIGN FOR SUSTAINABILITY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Materials & Metallurgy, Strength of Materials and Design of Machine Elements & Joints

Objectives

1. To understand the basic concepts of sustainability.
2. To gain knowledge about the tools and techniques for sustainable design.
3. To improve the design by assessing the customer needs.

UNIT I	BASIC CONCEPTS IN SUSTAINABILITY	9

Understanding the language of sustainable engineering design, construction and operation. Natural resources terminology. Carrying capacity. Sustainable development, corporate responsibility, biophysical constraints, environmental management.

UNIT II	TOOLS AND TECHNIQUES	9

Sustainable Engineering Design Tools – Life cycle analysis, carbon footprinting. Life cycle assessment (LCA), Types of LCA's: baseline, comparative, streamlined. LCA inventory analysis: process or input-output. Hybrid inventory analysis. Sustainable Product Design. Whole systems design. Lightweighting and materials reduction. Designing for a lifetime. Design for durability, repair and up-grade, disassembly and recycling. Energy use in design. Reducing energy losses in design.

UNIT III	PRINCIPLES FOR SUSTAINABLE BREAKTHROUGH DESIGN	9

Infrastructure for managing flows of materials, energy and activities; sustainable value creation approaches for all stakeholders, environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles, crowd sourcing, multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design, learning systems and experimentation; smart data systems, understanding variation.

UNIT IV	SUSTAINABLE DESIGN	9

Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, etc.

UNIT V	CUSTOMER AND USER NEEDS ASSESSMENT	9

Identification & breakdown structures that describe customers & stakeholders, green marketing, socially conscious consumerism, sources of customer information, collecting information, analyzing customer behavior, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
2 Test EACH 10marks Descriptive Questions	MCQ/Descriptive Questions	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Examine the concept of sustainability in terms of design, construction and development. (**Apply**)

CO2: Discover knowledge in engineering design tools and life cycle assessment. (**Apply**)

CO3: Apply sustainable value creation approaches, design changes & continual improvement. (**Apply**)

CO4: Predict the sustainable design, green engineering, flexible design etc. (**Apply**)

CO5: Design according to the customer needs. (**Apply**)

Text Books

1. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.

Reference Books

1. Clarke, Abigail & John K. Gershenson 2006. Design for the Life Cycle. Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University.
2. Ramaswamy, Rohit, 1996. Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall.
3. Schmitt, Brent, 2003. Customer Experience Management, Wiley and Sons.

Web Resources

1. https://nptel.ac.in/courses/107103081
2. https://archive.nptel.ac.in/courses/112/107/112107217/
3. https://ocw.mit.edu/courses/1-964-design-for-sustainability-fall-2006/pages/lecture-notes/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	1	2			2							2	1
2	2	1	2		1	1						1	2	1
3	2	1	2			2							2	1
4	2	1	2			2							2	1
5	2	1	2		1	2							2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to understand the concept of sustainability in terms of design, construction and development. (Remember, Understand and Apply)

1. What do you mean by sustainable engineering design (R)
2. Differentiate renewable and non-renewable resources (U)
3. "Sustainable development is the only way left for human survival" - Give your comments (A)

COURSE OUTCOME 2: Students will be able to gain knowledge in engineering design tools and life cycle assessment. (Remember, Understand and Apply)

1. Explain Life cycle assessment with different types (R)
2. Discuss the hybrid inventory analysis (U)
3. Write down the design procedure for repair and up-grade, disassembly and recycling (A)

COURSE OUTCOME 3: Students will be able to apply sustainable value creation approaches, design changes & continual improvement. (Remember, Understand and Apply)

1. State and explain environmental design characteristics (R)
2. Explain the smart data systems for sustainable development design (U)
3. Write the procedure of breakthrough design concepts for sustainability (A)

COURSE OUTCOME 4: Students will be able to carry out sustainable design, green engineering, flexible design etc. (Remember, Understand and Apply)

1. Write short notes on ecological succession (R)
2. State and explain green engineering (U)
3. Derive a design process for inverse manufacturing (A)

COURSE OUTCOME 5: Students will be able Design according to the customer needs. (Remember, Understand and Apply)

1. Differentiate customers and stakeholders (R)
2. How to analyze the behavior of customer (U)
3. Discuss the Kano model for understanding customer needs (A)

21ME6712	INDUSTRIAL TRIBOLOGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Mechanics,
Theory of Machines,
Design of Machine elements and joints
Metrology and Instrumentation

Objectives

- To introduce and expose students to the field and fundamentals in tribology and its applications.
- To understand the importance of friction and wear while designing components for functional applications
- To recognize the importance of lubrication in machine components and in the design of various types of bearings

UNIT I	SURFACES AND FRICTION	9

Topography of Engineering surfaces – Contact between surfaces – Sources of sliding Friction – Adhesion Ploughing – Energy dissipation mechanisms Friction Characteristics of metals – Friction of non-metals. Friction of lamellar solids – friction of Ceramic materials and polymers – Rolling Friction – Source of Rolling Friction – Stick slip motion – Measurement of Friction.

UNIT II	WEAR	9

Types of wear – Simple theory of Sliding Wear Mechanism of sliding wear of metals – Abrasive wear – Materials for Adhesive and Abrasive wear situations – Corrosive wear – Surface Fatigue wear situations – Brittle Fracture wear – Wear of Ceramics and Polymers – Wear Measurements.

UNIT III	LUBRICATION TYPES AND NANOSCALE TRIBOLOGY	9

Types and properties of Lubricants – Testing methods – Hydrodynamic Lubrication –Elasto hydrodynamic lubrication – Boundary Lubrication – Solid Lubrication Hydrostatic Lubrication – Interatomic Interactions, Atomic Force Microscope (AFM), Challenges of Tribological Testing at Small Scales

UNIT IV	FILM LUBRICATION THEORY	9

Fluid film in simple shear – Viscous flow between very close parallel plates – Shear stress variation Reynolds Equation for film Lubrication – High speed unloaded journal bearings – Loaded journal bearings – Reaction torque on the bearings – Virtual Co-efficient of friction – The Somerfield diagram.

UNIT V	SURFACE ENGINEERING AND MATERIALS FOR BEARINGS	9

Surface modifications – Transformation Hardening, surface fusion –Thermo chemical processes – Surface coatings – Plating and anodizing – Fusion Processes –Vapour Phase processes – Materials for rolling Element bearings – Materials for fluid film bearings – Materials for marginally lubricated and dry bearings.

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. Design according to different types of friction. **(Apply)**
CO2. Demonstrate various wearing mechanisms and measurements**. (Understand)**
CO3. Enumerate the properties and testing methods of various lubricants. **(Understand)**
CO4. Calculate shear stress, torque and co efficient of friction. **(Apply)**
CO5. Explain surface process and bearing materials. **(Understand)**

Text Books

1. A. Harnoy. "Bearing Design in Machinery", Marcel Dekker Inc, New York, (2003)

Reference Books

1. Cameron, "Basic Lubrication theory", Longman, U.K.., (2008)
2. E.P.Bowden and Tabor.D., "Friction and Lubrication", Heinemann Educational Books Ltd., (2001)
3. M.M.Khonsari and E.R.Booser, "Applied Tribology", John Willey & Sons, New York, (2001)
4. M.J.Neale (Editor), "Tribology Handbook", Newnes Butter worth, Heinemann, U.K., (1995)

Web Resources

https://nptel.ac.in/courses/112/102/112102014/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	3		2							1	3	
2	2	1	1		2	1						1	3	
3	2	1	1		2	1						1	3	
4	3	2	2									1	3	
5	3		2			1	2					1	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Design according to different types of friction. **(Apply)**

1. A 7.00kg block of wood is almost about to slide down a wooden wedge that has angle 30◦ with respect to the floor. The coefficient of static friction is 0.6910.691. What is the force of static friction? **(A)**
2. Explain the mechanism of rolling friction and compare it with sliding friction. **(U)**

COURSE OUTCOME 2: Demonstrate various wearing mechanisms and measurements. (Understand)

1.What are the classification of wear processes? Explain with example **(U)**
2.Explain the mechanism of sliding wear. **(U)**

COURSE OUTCOME 3: CO3. Enumerate the properties and testing methods of various lubricants. **(Understand)**

1.State various types of lubricants and their industrial applications **(U)**
2.Discuss the role of eccentricity in hydrodynamic lubrication of journal bearing.**(U)**

COURSE OUTCOME 4: Calculate shear stress, torque and co efficient of friction. **(Apply)**

1.A 360° hydrodynamic short journal bearing of is to be designed to support a radial load of 5.5 KN. The rotation of journal is 5000rpm. The eccentricity ratio is 0.6. If the viscosity of lubricating oil is 45×10 -9 Ns/mm2 and supplied at a rate of 0.5 l/min to the bearing, Determine the dimensions of the journal, bearings and minimum oil film thickness. Take l/d ratio as 0.4. **(A)**
2. Derive the equation of pressure distribution for hydrostatic step bearing. State the assumptions. **(U)**

COURSE OUTCOME 5: Explain surface process and bearing materials. **(Understand)**
1.Explain the experimental modal analysis and the necessary basic equipments. **(U)**
2.Explain machine condition monitoring techniques. **(U)**

21ME6713	Gas Dynamics and Jet Propulsion	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Thermodynamics, and Thermal Engineering

Objectives

1. To understand the basic difference between incompressible and compressible flow.
2. To understand the phenomenon of shock waves and its effect on flow.
3. To gain some basic knowledge about jet propulsion and Rocket Propulsion.

UNIT I	BASIC CONCEPTS AND ISENTROPIC FLOWS	9

Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts – Nozzle and Diffusers

UNIT II	FLOW THROUGH CONSTANT AREA DUCTS	9

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties

UNIT III	NORMAL AND OBLIQUE SHOCK	9

Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl– Meyer relations – Applications

UNIT IV	JET PROPULSION	9

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operation principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines – Scramjet engines

UNIT V	SPACE PROPULSION	9

Types of rocket engines – Propellants – feeding systems – Ignition and combustion – Theory of rocketpropulsion – Performance study – Staging – Terminal and characteristic velocity – Applications –space flights

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	MCQ Seminar Air crash investigation – case study	Descriptive Type

Outcomes
Upon completion of the course, the students will be able to:
CO1: Apply the basic concept of isentropic flow through variable area ducts **(Apply)** **CO2:** Interpret the variation of flow properties through constant area ducts with heat transfer and Friction **(Apply)** **CO3:** Enumerate the variation of flow parameters across the normal and oblique shocks **(Apply)** **CO4:** Apply the principle of different jet engine and numerical analysis of jet engine **(Apply)** **CO5:** Apply the principle of different rocket engine and numerical analysis of rocket engine **(Apply)**
Text Books
1. Anderson J.D., "Modern Compressible Flow", 3rd Edition, McGraw Hill, (2018) 2. Yahya S.M., "Fundamentals of Compressible Flow", New Age International (P) Limited, New Delhi, (2016)
Reference Books
1. Hill P., Peterson C., "Mechanics and Thermodynamics of Propulsion", Addison – Wesley Publishing company, (2012) 2. Zucrow N.J., "Principles of Jet Propulsion and Gas Turbines", John Wiley, New York, (2016) 3. Sutton G.P., "Rocket Propulsion Elements", John Wiley, (2012) 4. Ganesan V., "Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi, (2018) 5. Cohen. H., G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", Longman Group Ltd.,(2016)
Web Resources 1. https://nptel.ac.in/courses/112106166/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	3								1	3	
2	3	3	3	3								1	3	
3	3	3	3	3								1	3	
4	3	3	3	3								1		3
5	3	3	3	3								1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Apply the basic concept of isentropic flowthrough variable area ducts **(Apply)**

1. The Pressure, temperature and velocity of air at the entry of a diffuser are 0.7 bar, 345 K and 190 m/s respectively. The entry diameter of a diffuser is 15 cm and exit diameter is 35 cm. Determine the following. (1) Exit pressure (2) Exit velocity (3) Force exerted on the diffuser walls. Assuming isentropic flow and take $\gamma = 1.4$, $Cp = 1005$ J/kg K

2. An aircraft flies at a velocity of 700 kmph in an atmosphere where thepressure is 75 kPa and temperature is 5ºC. Calculate the Mach number andstagnation properties

COURSE OUTCOME 2: Interpret the variation of flow properties through constant area ducts with heat transfer and Friction **(Apply)**

1. Air at P1 = 3.4 bar, T1= 35 o C enters a circular duct a mach number of 0.14.The exit mach number is 0.6 and co-efficient of friction is 0.004.If the mass flow rate is 8.2 kg/s. Determine 1. Pressure temperature at the exit. 2. Diameter of the duct. 3. Length of the duct. 4. Stagnation pressure loss. 5. Verify the exit Mach number through exit velocity and temperature.

2. . Air enters a constant area duct at M1 = 3 ; P1 = 1atm and T1= 300K .Inside the heatadded per unit mass is Q = 3 x 10^5J/Kg . Calculate the flow properties M2, P2, T2, To2and Po2 at exit.

COURSE OUTCOME 3: Enumerate the variation of flow parameters across the normal and oblique shocks **(Apply)**

1. When a converging diverging nozzle is operated at off-design condition a normal shock occurs at a section where the cross sectional area is 18.75 cmin the diverging portion at inlet the nozzle the stagnation state is given as 0.21 MPa and 360C. The throat area is 12.5cmand exit area is 25cm. Estimate the exit Mach number, exit pressure loss in stagnation pressure for flow through nozzle.
2. Air flows adiabatically in a pipe. A normal shock wave is formed. The pressure andtemperature of air before the shock are 150 KN/m2and 25c respectively. Thepressure just after the shock is 350 KN/m2. Find, (i) Mach number before shock(ii) Mach number, static temperature and velocity of air after the shock wave.(iii) Increase in density of air(iv) Loss of stagnation pressure
(v) Change in entropy

COURSE OUTCOME 4: Apply the principle of different jet engine and numerical analysis of jet engine **(Apply)**

1. Explain in the construction and working details about Ramjet engine
2. An aircraft flies at 960kmph. One of its turbojet engines takes in 40kg/s of air and expandsthe gases to the ambient pressure. The air-fuel ratio is 50 and the lower calorific value of thefuel is 43MJ/kg. For maximum thrust power determine a) Jet velocity b)Thrust c) Specificthrust d)Thrust power e) Propulsive, thermal and overall efficiency f) TSFC

COURSE OUTCOME 5: Apply the principle of different rocket engine and numerical analysis of rocket engine **(Apply)**

1. Explain with a help of neat sketch the working of solid and liquid propellant rocket engine.
2. A rocket nozzle has a throat area of 18cm2and combustor pressure of 25bar. If the specific impulse is 127.42sec and the rate of flow of propellant is 44.145N/s, determine the thrustcoefficient, propellant weight flow coefficient, specific propellant consumption and characteristic velocity.

21ME6714	REFRIGERATION AND AIR CONDITIONING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering

Objectives

1. To understand the underlying principles of operations in different Refrigeration & Air conditioning systems and components.
2. To provide knowledge on design aspects of Refrigeration & Air conditioningsystems

UNIT I	INTRODUCTION TO REFRIGERATION	9

Basic Definitions, Heat pump and Refrigerating Machine, Best Refrigeration Cycle: The Carnot Principle, Gas as a Refrigerant in Reversed Carnot Cycle, Limitations of Reversed Carnot Cycle, Reversed Brayton or Bell Coleman Cycle, Application to Aircraft Refrigeration, Simple Numerical problems

UNIT II	VAPOUR COMPRESSION REFRIGERATION SYSTEM	9

Vapour compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – subcooling and super heating – effects of condenser and evaporator pressure on COP – multipressure system –low temperature refrigeration – Cascade systems – problems. Equipments: Type of Compressors,
Condensers, Expansion devices, Evaporators

UNIT III	OTHER REFRIGERATION SYSTEMS	9

Working principles of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration – Ejector refrigeration systems – Thermoelectric refrigeration- Air refrigeration – Magnetic – Vortex and Pulse tube refrigeration systems.

UNIT IV	REFRIGERANTS AND SYSTEM COMPONENTS	9

Refrigerants: Primary and Secondary refrigerants, Designation of Refrigerants, Desirable propertiesof refrigerants, Selection of a Refrigerant, Ozone Depletion Potential and Global Warming Potentialof CFC Refrigerants. Thermodynamic requirements, Comparison between different refrigerants,Substitutes for CFC refrigerants, Secondary Refrigerants.
Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators,A brief look at other components of the system.

UNIT V	AIR-CONDITIONING	9

Basic Processes in Conditioning of Air, Psychrometric Processes in Air-Conditioning Equipment, Simple Air-Conditioning/system and State and Mass Rate of Supply Air, Summer Air Conditioning,
Winter Air Conditioning. Loading Calculation and Applied Psychometrics: PreliminaryConsiderations, Internal Hear Gains, System Heat Gains, Break-up of Ventilation Load and Effective
Sensible Heat Factor, Cooling Load Estimate. Psychrometric Calculations for Cooling, Selection of Air-Conditioning Apparatus for Cooling and Dehumidification, Building Requirements and Energy Conservation in Air Conditioned Buildings

Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ Seminar	Descriptive

Outcomes

Upon completion of the course, the students will be able to:

CO1: Illustrate the principles, nomenclature and applications of refrigeration systems including air refrigeration system **(Apply)**

CO2: Enumerate vapour compression refrigeration system and identify methods for performance Improvement **(Apply)**

CO3: Describe the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo-acoustic refrigeration systems **(Apply)**

CO4: Identify suitable refrigerant and equipment's for various refrigerating systems **(Apply)**

CO5: Compute and Interpret cooling and heating loads in an air-conditioning system **(Apply)**

Text Books

1. Arora, C.P., "Refrigeration and Air Conditioning", 3rdedition, McGraw Hill, New Delhi, (2010)

Reference Books

1. Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, (2009)
2. Stoecker, W.F. and Jones J.W., "Refrigeration and Air Conditioning", McGraw Hill, New Delhi, (1986)
3. ASHRAE Hand book, Fundamentals, (2010) 4. Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, (2001)

Web Resources

1. https://nptel.ac.in/courses/112106166/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	1	1								1	3	
2	3	3	1	1								1	3	
3	3	3	1	1								1	3	
4	3	3	1	1								1		3
5	3	3	1	1								1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Illustrate the principles, nomenclature and applications of refrigeration systems including air refrigeration system **(Apply)**

1. An air refrigerator used for food storage provides 50 tons of refrigeration.The temperature of air entering the compressor is 7 ◦ C and thetemperature before entering into expander is 27 ◦ C .Assuming 30 % morepower is required than theoretical, find (a).Actual C.O.P of the cycle(b).KW capacity required to run the compressor

2. In a refrigeration plant working on Bell Coleman cycle, air is compressedto 5 bar from 1 bar. Its initial temperature is 10 ◦ C. After compression,the air is cooled up to 20 ◦ C in a cooler before expanding to a pressure of1 bar. Determine the theoretical C.O.P of the plant and net refrigeratingeffect. Take Cp = 1.005 KJ/Kg K and Cv = 0718 KJ/Kg K.

COURSE OUTCOME 2: Enumerate vapor compression refrigeration system and identify methods for performance Improvement **(Apply)**

A refrigeration machine using R-12 as refrigerant operates between thepressures 2.5 bar and 9 bar. The compression is isentropic and there is noundercooling in the condenser. The vapour is in dry saturated condition atthe beginning of the compression. Estimate theoretical C.O.P. If the actual C.O.P is 0.65 of theoretical valve, calculate the net cooling produced perhour. The refrigerant flow is 5 kg/min. The properties table for the refrigerants need to be added

COURSE OUTCOME 3: Describe the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo-acoustic refrigeration systems **(Apply)**

1. Explain with a neat sketch the working of lithium-bromide vapour absorption system

2. Explain thermo-electric refrigeration system with sketch

COURSE OUTCOME 4: Identify suitable refrigerant and equipment's for various refrigerating systems **(Apply)**

1. What is an azetrope? Give some examples to indicate its importance
2. Name the different refrigerants generally used. State the desirable properties of refrigerants.

COURSE OUTCOME 5: Compute and Interpret cooling and heating loads in an air-conditioning system **(Apply)**

1. A room 7m × 4m× 4m is occupied by an air-water vapour mixture at380C. The atmospheric pressure is 1 bar and the relative humidity is70%. Determine the humidity ratio, dew point, mass of dry air and massof water vapour. If the mixture of air-water vapour is further cooled atconstant pressure until the temperature is 100C. Find the amount of watervapour condensed

2. A room has a sensible heat gain of 24 KW and a latent heat gain of 5.2KW and it has to be maintained at 26 ◦ C DBT and 50 % RH.180 m3/min of air is delivered to the room. Determine the state of supply of air.

21ME6715	INDUSTRY 4.0	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives: The main learning objective of this course is to prepare the students for

1. An introduction to Industry 4.0, its building blocks, its applicationsand advantages compared to conventional production techniques
2. Getting deep insight intohow intelligent processes, big data, and artificial intelligence can be used to build up the productionof the future.

UNIT I	INTRODUCTION TO INDUSTRY 4.0	8

Definition, developments in USA, Europe and China, comparison of industry 4.O factory and today's factory, basic principles and technologies of a smart factory including IoT, IIoT, and IoS.

UNIT II	CYBER PHYSICAL PRODUCTION SYSTEM	10

Cyber physical systems – definition, demarcation to embedded systems and ubiquitous computing, core elements of cyber physical production system, control theory and real – time requirements, self organization principles, communication in cyber physical systems. Design methods for this system including modelling, programming, model – integrated development and applications.

UNIT III	DIGITAL TWINS AND AUGMENTED REALITY	9

Basic concepts of digital twins, benefits, impact and challenges. Features and implementation of digital twins, types and case studies of usage of digital twins. Augmented Reality an overview, its application in integrated design and manufacturing, training shop floor workers, supporting complex assembly operations, service and maintenance.

UNIT IV	ROLE OF DATA, INFORMATION, KNOWLEDGE AND COLLABORATION IN FUTURE ORGANIZATIONS	9

Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0.

UNIT V	BUSINESS ISSUES IN INDUSTRY 4.0	9

Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive type

Outcomes
Upon completion of the course, the students will be able to:
CO1 Illustrate the drivers and enablers of Industry 4.0 **(Apply)** CO2 Demonstrate the smartness in Smart Factories, Smart cities, smart products and smart services. **(Apply)** CO3 Show the various systems used in a manufacturing plant and their role in an Industry 4.0 world. **(Apply)** CO4 Demonstrate the power of Cloud Computing in a networked economy. **(Apply)** CO5 Illustrate the opportunities, challenges brought about by Industry 4.0 and how organisations and individuals should prepare to reap the benefits. **(Apply)**
Textbooks
1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016. 2. Jesús Hamilton Ortiz, William Gutierrez Marroquin and Leonardo Zambrano Cifuentes .P, "Industry 4.0: Current Status and Future Trends", Open Access Peer-Reviewed Chapter, 2020.
Reference Books
1. Alp Ustundag, Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer, 2018. 2. Diego Galar Pascual, Pasquale Daponte, Uday Kumar, "Handbook of Industry 4.0 and SMART Systems", 1st Edition, CRC Press. 2020.
Web Resources 1. https://youtu.be/wgWRLu8p90M 2. https://youtu.be/eKiepu2D-XQ 3. https://youtu.be/-2Cd38P6YO0 4. https://youtu.be/XiDmSjsOFTk 5. https://youtu.be/De8MQWbhu3k

CO Vs PO and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1				3					2				3
CO 2	1				3					2				3
CO 3	1				3					2				3
CO 4	1				3					2				3
CO 5	1				3					2				3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1

1. Illustrate the developments of Industry 4.O in USA. **(Understand)**
2. Compare and contrast the industry 4.O factory and today's factory. **(Understand)**
3. Identify the technology applied in a smart factory like General Motors, USA. **(Apply)**

COURSE OUTCOME 2

1. Explain briefly the demarcation of embedded system with ubiquitous computing system.**(Understand)**
2. Sketch the core elements of cyber physical production system and control theory applicable to that and explain in detail.**(Apply)**
3. Draft a program to integrate the machine and computer for shop floor activity in a production centre.**(Apply)**

COURSE OUTCOME 3

1. Explain in detail the digital twins with an example. **(Understand)**
2. Sketch the basic configuration of augmented reality in manufacturing environment. **(Apply)**
3. Illustrate the application of AR in supporting assembly operation in an industry. **(Apply)**

COURSE OUTCOME 4

1. Explain how data is considered to be a new resource for organization. **(Understand)**
2. Describe the role of cloud computing in Industry 4.O with an example. **(Understand)**
3. Review the resource based development in various world renowned firms like Toyota in adapting Industry 4.O. **(Apply)**

COURSE OUTCOME 5

1. Enumerate the various opportunities and challenges in running an organization currently. **(Understand)**
2. Identify the skills to be acquired by the man power to get encapsulated in present industrial scenario.**(Apply)**
3. Develop a strategy for competing in an industry 4.O world. **(Apply)**

21ME6716	INDUSTRIAL ROBOTICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Basic Mathematics: Matrices, and Differential equations
Theory of Machines,
Mechatronics,
Applied Hydraulics and Pneumatics

Objectives: The main learning objective of this course is to prepare the students for

1. Explaining the concepts of industrial robots with respect to its classification, specifications and coordinate systems. Reviewing the need and application of robots in different engineering fields.
2. Exemplifying the different types of robot drive systems as well as robot end effectors.
3. Applying the different sensors and image processing techniques in robotics toimprove the ability of robots.
4. Developing robotic programs for different tasks and analyzing the kinematics motions of robot.
5. Implementing robots in various industrial sectors and interpolating the economic analysis of robots.

UNIT I	FUNDAMENTALS OF ROBOT	8

Robot - Definition - Robot Anatomy – Co-ordinate Systems, Work Envelope Types and Classification- Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load- Robot Parts and their Functions-Need for Robots-Different Applications.

UNIT II	ROBOT DRIVE SYSTEMS AND END EFFECTORS	10

Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, Applications and Comparison of all these Drives, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

UNIT III	MACHINE VISION	9

Camera, Frame Grabber, Sensing and Digitizing Image Data Signal Conversion, Image Storage, Lighting Techniques, Image Processing and Analysis-Data Reduction, Segmentation, Feature Extraction, Object Recognition, Other Algorithms, Applications, Inspection, Identification, Visual Serving and Navigation.

UNIT IV	ROBOT KINEMATICS AND ROBOT PROGRAMMING	9

Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Jacobians, Velocity and Forces-Manipulator Dynamics, Trajectory Generator, Expert system, Manipulator Mechanism Design-Derivations and problems. Lead through Programming, Robot programming Languages-VAL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs.

UNIT V	IMPLEMENTATION AND ROBOT ECONOMICS	9

RGV, AGV; Implementation of Robots in Industries-Various Steps; Safety Considerations for Robot Operations - Economic Analysis of Robots.

	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1 Illustrate the need and application of robots in different engineering fields. **(Apply)**
CO2 Show the different types of robot drive systems as well as robot end effectors. **(Apply)**
CO3 Apply the different image processing techniques in robotics to improve the ability of robots. **(Apply)**
CO4 Prepare robotic programs for different tasks and analyze the kinematics motions of robot. **(Apply)**
CO5 Demonstrate robots in various industrial sectors and interpolate the economic analysis of robots. **(Apply)**

Textbooks

1. Fu. K.S, Gonzalez. R.C, Lee. C.S.G "Robotics – Control, Sensing, Vision, and Intelligence", McGraw Hill, 2015.
2. GrooverMikell .P, "Industrial Robotics -Technology Programming and Applications", McGraw Hill, 2014.

Reference Books

1. Deb S.R., "Robotics Technology and Flexible Automation" Tata McGraw Hill Book Co., 2013.
2. Maja J Mataric, "The Robotics Primer "Universities Press. 2013.
3. Craig J.J., "Introduction to Robotics Mechanics and Control", Pearson Education, 2009.

Web Resources

1. https://archive.nptel.ac.in/noc/courses/noc20/SEM2/noc20-me56/
2. https://onlinecourses.nptel.ac.in/noc20_de11/preview

CO Vs PO and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3		1	2					2		1		3	
CO2	3		2	2					2		1		3	
CO3	3	2	2	2					2		1		3	
CO4	3		2	2					2		1		3	
CO5	3		2	2					2		1		3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1

1. With a neat sketch explain the anatomy of robot. **(Understand)**
2. Enumerate the future applications of robotics. **(Understand)**
3. Sketch and explain the four basic robot configurations classified according to the coordinate system. **(Apply)**

COURSE OUTCOME 2

1. Differentiate pneumatic drive system with hydraulic drive system.**(Understand)**
2. Compare and contrast the various electrical drives especially Stepper motor and A.C. Servo motors.**(Understand)**
3. Discuss in detail about Vacuum grippers along with their advantages and disadvantages.**(Apply)**

COURSE OUTCOME 3

1. Explain in detail the triangulation method of range sensing with a neat sketch. **(Understand)**
2. Sketch the four different approaches adopted for construction of artificial skins and explain them in detail. **(Understand)**
3. Apply the first principles of engineering specialization in resolving forces and moments between the end effectors. **(Apply)**

COURSE OUTCOME 4

1. For the vector v = 25i + 10j + 20 k, perform a translation by a z distance of 8 in the x direction, 5 in the y direction, and Θ in the z direction. The translation transformation would be **(Apply)**

$$H=Trans(a,b,c)\begin{bmatrix}1 & 0 & 0 & 8\\ 0 & 1 & 0 & 5\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

2. It is desired to determine the values to which the angles Θ_1 and Θ_2 must be set in order to achieve a certain point in space for the manipulator shown in Fig. 4.1. The length of joint 1, L_1 = 30.48 cm, the length of joint L_2 = 25.4 cm. The point Pw which the robot must achieve is defined by the coordinates x = 15.7 and y = 12.6. Using the reverse transformation methods, determine the angles. **(Apply)**

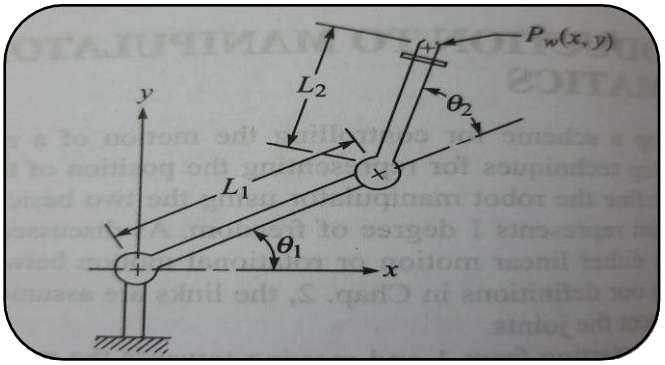


Fig. 1 – A two dimensional 2 – degree of freedom manipulator

3. A jointed – arm robot of configuration VVR is to move all three axes so that the first joint is rotated through 50^0, the second joint is rotated through 90^0 and the third joint is rotated through 25^0. Maximum speed of any of these rotational joints is 10^0/s. Ignore the effects of acceleration and deceleration. **(Apply)**

COURSE OUTCOME 5

1. Elucidate the different levels of safety sensor systems in robotics as prescribed by the National Bureau of Standards. **(Understand)**

2. Data have been collected for a certain robot model on times between breakdowns and it has been determined that the mean time between failures is 324 hours. Repairing the robot has required an average of 6.5 hours, according to the records of the maintenance department. Calculate the robot's availability.**(Apply)**

3. Suppose the present MTBF of a particular robot is 200 hours and the MTTR when breakdowns occur is 8 hrs. A preventive maintenance program is to be initiated in the plant which is expected to increase the MTBF to 300 hrs and reduce the MTTR to 6 hrs. Determine the effect of the PM program on the availability of the robot. **(Apply)**

21ME6717	MODERN MACHINING PROCESSESS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, Engineering Physics & Engineering Chemistry

Objectives

To learn about various modern machining processes, the various process parameters and their influence on performance and their applications

UNIT I	INTRODUCTION AND MECHANICAL ENERGY BASED PROCESSES	9

Unconventional machining Process – Need – classification – merits, demerits and applications. Abrasive Jet Machining – Water Jet Machining – Abrasive Water Jet Machining – Ultrasonic Machining. (AJM, WJM, AWJM and USM). Working Principles – equipment used – Process parameters – MRR – Applications

UNIT II	THERMAL AND ELECTRICAL ENERGY BASED PROCESSES	9

Electric Discharge Machining (EDM) – Wire cut EDM – Working Principle-equipments-Process Parameters-Surface Finish and MRR – electrode / Tool – Power and control Circuits-Tool Wear – Dielectric – Flushing –– Applications. Laser Beam machining and drilling, (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining (EBM). Principles – Equipment –Types – Beam control techniques – Applications - Ion Beam Machining - Plasma Assisted Polishing

UNIT III	CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES	9

Chemical machining and Electro-Chemical machining (CHM and ECM)- Etchants – Maskant – techniques of applying maskants – Process Parameters – Surface finish and MRR – Applications. Principles of ECM – equipments-Surface Roughness and MRR Electrical circuit – Process Parameters – ECG and ECH – Applications - Electrochemical arc machining

UNIT IV	ADVANCED NANO FINISHING PROCESSES	9

Abrasive flow machining, chemo-mechanical polishing, magnetic abrasive finishing, magneto rheological finishing, magneto rheological abrasive flow finishing their working principles, equipment's, effect of process parameters, applications, advantages and limitations

UNIT V	RECENT TRENDS IN NON-TRADITIONAL MACHINING PROCESSES	9

Recent developments in non-traditional machining processes, their working principles, equipments, effect of process parameters, applications, advantages and limitations. Comparison of non-traditional machining processes

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Enumerate the need for unconventional machining processes and its classification and summarize the various mechanical energy based processes **(Understand)**

CO2: Discover various thermal energy and electrical energy based unconventional machining processes **(Apply)**

CO3: Summarize various chemical and electro-chemical energy based unconventional machining processes **(Understand)**

CO4: Summarize the various nano abrasives based unconventional machining processes **(Understand)**

CO5: Enumerate various recent trends based unconventional machining processes **(Remember)**

Text Books

1. Vijay.K. Jain 'Advanced Machining Processes' Allied Publishers Pvt. Ltd., New Delhi, 2010
2. Pandey P.C. and Shan H.S. "Modern Machining Processes" Tata McGraw-Hill, New Delhi, 2013.
3. Bijoy Bhattacharyya and BiswanthDoloi "Modern Machining Technology" Tata McGraw-Hill, New Delhi, 2019.

Reference Books

1. Benedict. G.F. "Non-traditional Manufacturing Processes", Marcel Dekker Inc., New York, 2017
2. Paul De Garmo, J.T.Black, and Ronald. A.Kohser, "Material and Processes in Manufacturing" Prentice Hall of India Pvt. Ltd., 8th Edition, New Delhi , 2001.

Web Resources

1. https://nptel.ac.in/courses/112/105/112105212/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2		2								3	
CO2	2	1	2		2								3	
CO3	2	1	2		2								3	
CO4	2	1	2		2								3	
CO5	2	1	2		2								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Enumerate the need for unconventional machining processes and its classification (Understand)

1. Identify the principle of AJM. Mention some of the applications and limitations (Remember)
2. Discuss in detail about the arrangement of USM process and its process parameters (Understand)

COURSE OUTCOME 2: Discover various thermal energy and electrical energy based unconventional machining processes (Apply)

1. Describe the mechanism of material removal in EDM. (Apply)
2. List out the process capabilities, advantages and limitations of LBM process (Remember)

COURSE OUTCOME 3: Summarize various chemical and electro-chemical energy based unconventional machining processes (Understand)

1. Discuss various parameters that influence the performance of CH process (Remember)
2. Sketch the schematic arrangement of ECH process and its working (Understand)

COURSE OUTCOME 4: Summarize various nano abrasives based unconventional machining processes (Understand)

1. Discuss about the process capabilities of AFM and the process parameters of AFM in improving machining quality (Understand)
2. List out the important process parameters that control the material removal rate in micro-LBM? Explain any four factors (Remember)

COURSE OUTCOME 5: Enumerate recent trends based unconventional machining processes (Remember)

1. Describe the comparison of non-traditional machining process (Remember)
2. List out the process parameters that influence the micro-USM process (Remember)

21ME6718	SOLID STATE JOINING PROCESSES	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

To learn about various solid state joining process, tool materials & industrial applications.

UNIT I	OVERVIEW OF JOINING PROCESSES	8

Fundamental principles and classifications of fusion and solid-state joining processes, ultrasonic welding, ultrasonic spot welding, explosion welding process, Magnetically Impelled Arc Butt (MIAB) welding; Resistance welding processes: Spot welding, seam welding, projection welding, high-frequency resistance welding, resistance butt welding, flash butt welding; Brazing, adhesive bonding, clinching, self-pierce riveting.

UNIT II	DIFFUSION JOINING PROCESSES	7

Principles and applications; Diffusion brazing, braze welding, diffusion welding; Diffusion bonding of metals to ceramics; Solid-state deposition welding processes; Pressure non-fusion welding processes: Cold welding, electromagnetic pulse welding, pressure gas welding, hot pressure welding, forge welding; Roll bonding.

UNIT III	FRICTION WELDING (FW) PROCESS	10

Process parameters, applications, metallurgical, mechanical and tribological characterizations; Spin welding, rotary drive FW , inertia welding, friction taper stitch welding, radial FW, friction plunge welding, third-body FW; Friction seam welding, linear and angular FW, orbital FW, friction brazing, friction stud welding; Study of friction welds and joint quality of FW.

UNIT IV	FRICTION STIR WELDING	10

Fundamentals and taxonomy, materials; Heat generation, metallurgical and mechanical characterizations, inspection; Material flow, material change during solid-state joining and its impact, environmental and energy benefits, micro FSW and its applications; Friction stir riveting, friction stir spot welding (FSSW) – process parameters, hybrid FSW, underwater FSW, ultrasonic assisted FSW, and electrically assisted FSW; Friction stir diffusion welding, thermal stir welding; Weld defects; Friction stir processing and friction surfacing.

UNIT V	TOOL MATERIALS AND INDUSTRIAL APPLICATIONS	10

FSW tools: Material selection, tool geometry, pin geometry, load bearing ability, tool wear, deformation and failure, tool cost; FSW of aluminum alloys, magnesium alloys, titanium, steels; Dissimilar metal FSW; Welding of plastics and welding of non-metals; Industrial applications: Shipbuilding, automotive, aerospace, railways and other industry sectors.

	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Classify various joining processes and identify welding symbols, joints and edge preparation **(Understand)**

CO2: Identify various solid state joining methods and its equipment's **(Understand)**

CO3: Illustrate friction welding, process parameters and its types **(Apply)**

CO4: Identify welding defects and their causes, destructive and non-destructive testing of welds **(Understand)**

CO5: Discuss various tool materials in solid state joining process and industrial applications **(Understand)**

Text Books

1. R.S.Paramar , "Welding Processes and Technology", 3rd Edition, Khanna Publishers, New Delhi, 2010.
2. Daniela Lohwasser, Zhan Chen , "Friction Stir Welding From Basics To Applications", Woodhead Publishing, 2010.

Reference Books

1. Rajiv Sharan Mishra, ParthaSarathi De, Nilesh Kumar , "Friction Stir Welding and Processing: Science and Engineering", 1st Edition, Springer International Publishing, 2014.
2. Bekir Sami Yilbas, Ahmet Z. Sahin , "Friction Welding: Thermal and Metallurgical Characteristics", Springer Science, 2014.
3. P.Asadi, M.K. Besharati-Givi , "Advances in Friction-Stir Welding and Processing", Woodhead Publishing, 2014.
4. Nilesh Kumar, Rajiv S. Mishra, Wei Yuan , "Friction Stir Welding of Dissimilar Alloys and Materials", Elsevier, 2015.

Web Resources

1. https://nptel.ac.in/courses/112107213

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	1								3	
CO2	2	2	2		1								3	
CO3	2	2	2	2	2								3	
CO4	2	1	1	3	1								3	
CO5	2	3	1	1	1								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Classify various joining processes and identify welding symbols, joints and edge preparation (Understand)

1. Discuss the principle of MIAB. Mention some of the applications and limitations (Understand)
2. Explain the arrangement of USW process and its limitations (Understand)

COURSE OUTCOME 2: Identify various solid state joining methods and its equipment's (Understand)

1. List out the applications of diffusion welding process. (Remember)
2. Discuss the process capabilities, advantages and limitations of pressure non-fusion welding process (Understand)

COURSE OUTCOME 3: Illustrate friction welding, process parameters and its types (Apply)

1. Differentiate between linear and angular FW (Understand)
2. Demonstrate the schematic arrangement of friction taper stitch welding and its working (Apply)

COURSE OUTCOME 4: Identify welding defects and their causes, destructive and non-destructive testing of welds (Understand)

1. List out the defects involved in welding process (Understand)
2. Discuss about the material changes during solid state joining process and its impacts (Understand)

COURSE OUTCOME 5: Discuss various tool materials in solid state joining process and industrial applications (Understand)

1. Enumerate the tools involved in FSW (Remember)
2. Discover the industrial applications related to solid state joining process (Understand)

21ME6719	ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course

NIL

Objectives

To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively

UNIT I	ENTREPRENEURSHIP & SKILLS FOR SUCCESSFUL ENTREPRENEURS	9

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth - Communication Skills - Creativity and Problem solving – Innovation - Negotiation Skills - Risk management

UNIT II	MOTIVATION & CONCEPTS OF ENTREPRENEURSHIP FAILURE	9

Major Motives Influencing an Entrepreneur – Achievement Motivation Training, Self-rating, Business Games, Thematic Apperception Test – Stress Management, Entrepreneurship Development Programs – Need, Objectives – Issues & Reasons of Entrepreneurship Failure – Issues & Reasons of Entrepreneurship Failure – Essentials to avoid failure

UNIT III	BUSINESS	9

Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies

UNIT IV	FINANCING AND ACCOUNTING	9

Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Taxation – Income Tax, Excise Duty – Sales Tax

UNIT V	SUPPORT TO ENTREPRENEURS	9

Sickness in small Business – Concept, Magnitude, Causes and Consequences, Corrective Measures –Business Incubators – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
CAT 1 10 Marks CAT 2 10 Marks Descriptive type Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Illustrate the skills for successful entrepreneurs **(Apply)**

CO2: Explain the concepts of entrepreneurship failure **(Understand)**

CO3: Discover market survey and techno economic feasibility assessment **(Apply)**

CO4: Identify the funds from financial source **(Understand)**

CO5: Identify and correct sickness in business **(Understand)**

Text Books

1. Khanka. S.S., "Entrepreneurial Development" S.Chand& Co. Ltd., Ram Nagar, New Delhi, (2020)
2. Donald F Kuratko, "Entreprenuership – Theory, Process and Practice", 9th Edition, Cengage Learning, (2014)

Reference Books

1. Hisrich R D, Peters M P, "Entrepreneurship" 8th Edition, Tata McGraw-Hill, (2016)
2. Mathew J Manimala, "Enterprenuership theory at cross roads: paradigms and praxis" 2nd Edition Dream tech, (2005)
3. Rajeev Roy, "Entrepreneurship" 2nd Edition, Oxford University Press, (2011)

Web Resources

1. https://nptel.ac.in/courses/110/106/110106141/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1						1		1	1	2	2	2		
CO2						1		1	1	2	2	2		
CO3						1		1	1	2	2	2		
CO4						1		1	1	2	2	2		
CO5						1		1	1	2	2	2		

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COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Illustrate the skills for successful entrepreneurs (Apply)

1. Discover the main functions performed by the entrepreneurs (Apply)
2. Explain the factors affecting growth of entrepreneurship (Understand)

COURSE OUTCOME 2: Explain the concepts of entrepreneurship failure (Understand)

1. Describe achievement motivation? Do you consider it an essential ingredient of entrepreneurship? (Remember)
2. Define the term stress? It is always bond for people? Explain. (Understand)

COURSE OUTCOME 3: Discover market survey and techno economic feasibility assessment (Apply)

1. List out the factors to be considered while preparing a feasibility report (Remember)
2. Illustrate the major steps in detailed project report? What are the precautions than an entrepreneur should take at the time of preparation of detailed project report? (Apply)

COURSE OUTCOME 4: Identify the funds from financial source (Understand)

1. Define the term Sales Tax? Elaborate the types of sales taxation in India (Understand)
2. Discuss the various causes and consequences of industrial sickness in India (Understand)

COURSE OUTCOME 5: Identify and correct sickness in business (Understand)

1. Discuss the need for policy support to small scale enterprises (Understand)
2. Describe Joint Venture. State the reasons behind creation of joint venture (Understand)

21ME6720	CORROSION AND SURFACE ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Chemistry, Engineering Materials and Metallurgy.

Objectives

- To impart knowledge on corrosion.
- To understand the corrosion control methods.
- To know the importance of surface modification and special modification techniques.

UNIT I	BASIC ASPECTS OF CORROSION	9

Introduction, classification, economics, emf series, Galvanic series. Corrosion. Theories : Derivation of potential – current relationships of activation controlled and diffusion controlled corrosion processes; Potential – pH diagrams Fe-H2O system, application and limitations; Passivation

UNIT II	FORMS OF CORROSION	9

Definition, factors and control methods of various forms of corrosion - Uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement.

UNIT III	CORROSION CONTROL METHODS	9

Atmospheric corrosion – classification, factors influencing atmospheric corrosion, temporary corrosion preventive methods; organic coating, corrosion inhibitors, cathodic protection, anodic protection

UNIT IV	SURFACE MODIFICATION AND SURFACE COATING TECHNIQUES	9

Conventional surface modification methods: shot peening, flame and induction hardening, carburizing, nitriding, diffusion aided surface alloying Surface coating techniques by chemical/electro-chemical routes: electro/electroless deposition, anodizing, galvanizing, etc. Surface coating by physical routes: thermal/plasma spray, physical/chemical vapor deposition, sputtering, etc.

UNIT V	ADVANCED SURFACE MODIFICATION TECHNIQUES	9

Advanced surface modification methods: laser, plasma, ion and electron beam assisted surface Engineering

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
2 Test Each 10 Marks Descriptive Questions	Multiple Choice Questions (MCQ)	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. Remember various basic aspects of corrosion. **(Remember)**
CO2. Enumerate the various forms of corrosion. **(Understand)**
CO3. Apply the corrosion control methods in the manufacturing of components **(Apply)**
CO4. Apply the surface modification and surface coating techniques in production of components **(Apply)**
CO5. Apply the advanced surface modification techniques in production of components **(Apply)**

Text Books

1. Surface Engineering for Wear Resistances (Introduction and classification of Wear), By: K.G. Budinski, Prentice Hall, Englewood Cliffs, 1988.
2. Corrosion Engineering (classification of Corrosion), By: M.G. Fontana, M.C. Graw Hill, N.York, 1987.

Reference Books

1. E.E. Stansbury, R.A. Buchanan , "Fundamentals of electrochemical corrosion", ASMInternational, 2000.
2. M.G.Fontana, N.D. Greene , "Corrosion Engineering", 3rd Edition, McGraw Hill, New York, 2005.
3. S.N.Banerjee , "An Introduction to Science of Corrosion and its Inhibition", Oxonian Press, New Delhi, 1985.
4. Zaki Ahmad , "Principles of Corrosion Engineering and Corrosion Control", Butterworth Heinemann, London, 2006.
5. Materials Science and Engineering by W. D. Callister
6.. Introduction to Surface Engineering and Functionally Engineered Materials, by Peter Martin, WILEY, 2011
7. Surface Engineering of Metals: Principles, Equipment, Technologies, by: Tadeusz Burakowski, Tadeusz Wierzchon, CRC Press, 1988
8. Surface Engineering for Corrosion and Wear Resistance, by JR Davis, ASM International, 2001

Web Resources

https://onlinecourses.nptel.ac.in/noc23_mm21/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	1	1		1	1						3	2
2	3	2		2									3	2
3	2	1		1		2	2	1					2	3
4	3		1			2	2						2	3
5	2	1	1			2	2						2	3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Remember various basic aspects of corrosion (Remember)

1. Explain the chemical treatment for stainless steel and other alloys that enhances the ability of the treated surfaces to resist corrosion. **(Remember)**
2. Draw the Pourbaix diagram for iron–water system and interpret. Bring out its advantage and limitations **(Remember)**

COURSE OUTCOME 2: Enumerate the various forms of corrosion. (Understand)

1. Deduce the construction and working of the autocatalytic mechanism of pitting corrosion. Mention the means of combating pitting corrosion (**Understand)**
2. Identify and explain which material can dezincification take place in and label its consequences. **(Understand)**

COURSE OUTCOME 3: Apply the corrosion control methods in the manufacturing of components (Apply)

4. Apply the suitable protection method to mitigate corrosion damage to active metal surfaces **(Apply)**
1. Select the widely used temporary corrosion preventive methods to avoid rusting and justify. **(Apply)**

COURSE OUTCOME 4: Apply the surface modification and surface coating techniques in the production of components (Apply)

1. Apply the best coating method of nickel also label its advantages and limitations compared to the PVD methods. **(Apply)**
2. Name the surface modification technique and illustrate the process based on the given applications like sand removal in foundries, decoding, descaling, and surface finishing for castings used in engine blocks and cylinder heads **(Apply)**

COURSE OUTCOME 5: Apply the advanced surface modification techniques in production of components (Apply)

1. Identify and illustrate the advanced surface modification technique which can able to heat treat localized areas without affecting the entire work piece. **(Apply)**
2. Apply the thermal high speed heat treatment processes in solid and or liquid state **(Apply)**

PROFESSIONAL ELECTIVE - IV

21ME7701	DESIGN FOR MANUFACTURING AND ASSEMBLY	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Manufacturing Technology
- Engineering Materials and Metallurgy

Objectives

- This course provides the essential concepts behind manufacturing and assembly orient design.
- It also provides design guidelines for machining, casting and injection molding to achieve cost effective design.

UNIT I	TOLERANCE ANALYSIS	9

Geometric Tolerances – Tolerance Analysis – Worst Case Method – Assembly Limits – Design and Manufacturing Datum – Conversion of Design Datum into Manufacturing Datum – Tolerance Stacks – True Position Theory – Zero True Position Tolerance – Process Capability.

UNIT II	MATERIALS SELECTION AND DESIGN FOR ASSEMBLY	9

Principal Materials – Selection of Materials and Processes –Design – Possible Solutions – Evaluation Method. General Design Principles for Manufacturability – General Design Guidelines for Manual Assembly – Assembly Efficiency – Effects of Part Symmetry – Part Thickness and Weight on Handling Time – Types of Manual Assembly Methods – Design for High Speed Automatic Assembly And Robot Assembly.

UNIT III	DESIGN FOR MACHINING	9

Design Features to Facilities Machining – Single Point and Multipoint Cutting Tools – Choice and Shape of Work Material – Accuracy and Surface Finish – Design Recommendations for Turning and Milling Operations: Process Description – Suitable Materials. Guidelines for Machining of Rotational and Non-Rotational Components – Reduction of Machined Area – Design for Clampability – Design for Accessibility.

UNIT IV	DESIGN FOR INJECTION MOLDING AND POWDER METAL PROCESSING	9

Injection Molding Materials – The Molding Cycle – Molding Systems and Molds – Cycle Time and Mold Cost Estimation – Estimation of Optimum Number of Cavities – Design Guidelines for Injection Molding. Design for Powder Metal Processing: Introduction to Powder Metal Processing – Materials and Manufacturing Cost – Design Guidelines for Powder Metal Parts.

UNIT V	DESIGN FOR SAND AND DIE CASTING	9

Sand Casting Alloys – Sand Cores – Design Rules for Sand Castings – Identification of Uneconomical Design – Modifying The Design. Die Casting Alloys – The Die Casting Cycle – Determination of Number of Cavities and Appropriate Machine Size in Die Casting – Design Principles for Die Casting.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive exam

Outcomes

Upon completion of the course, the students will be able to:

CO1: Show the dimensions of components and identify the suitable geometrical tolerances for manufacturing-oriented design **(Apply)**
CO2: Determine the suitable materials for components and demonstrate the design considerations for assembly in different applications **(Apply)**
CO3: Illustrate suitable design recommendations for various machining operations **(Apply)**
CO4: Demonstrate the design for injection molded components and apply the design recommendations for powder metal processing. **(Apply)**
CO5: Determine the uneconomical design for sand and die castings **(Apply)**

Text Books

1. Boothroyd G, Dewhurst P & Knight W. A., "Product Design for Manufacture and Assembly", 3rd Edition, CRC Press, USA, 2011.

Reference Books

1. Bralla J.G., "Design for Manufacturability Handbook", 2nd Edition, McGraw Hill Education, New York, 1999.
2. Design for Manufacturing and Assembly: Concepts, architectures and implementation 1998th Edition

Web Resources

1. https://archive.nptel.ac.in/courses/112/106/112106249/ **(Design for Manufacturing and Assembly)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1		1							3	
CO2	3	2	3	1		1							3	
CO3	3	2	3	1		1							3	
CO4	3	2	3	1		1							3	
CO5	3	2	3	1		1							3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Show the dimensions of components and identify the suitable geometrical tolerances for manufacturing-oriented design **(Apply)**

1. Illustrate about the assembly limits, Datum features and tolerance stack
2. explain about design principle which used in manufacturability

COURSE OUTCOME 2: Determine the suitable materials for components and demonstrate the design considerations for assembly in different applications **(Apply)**

1. Discuss in detail about the design for assembly
2. Show the steps involved in minimizing the material usage

COURSE OUTCOME 3: Illustrate suitable design recommendations for various machining operations. **(Apply)**

1. Write down difference between clamp ability and accessibility.
2. Explain in detail about reduction of machine area by simplification by separation with suitable sketch.

COURSE OUTCOME 4: Demonstrate the design for injection molded components and apply the design recommendations for powder metal processing. **(Apply)**

1. Briefly discuss the factors to be considered while selecting the injection molding
2. Describe in detail on design guidelines for Powder Metal Parts

COURSE OUTCOME 5: Determine the uneconomical design for sand and die castings. **(Apply)**

1. Show the factors involved in uneconomical design.
2. Discuss in detail about casting requiring special sand cores.

21ME7702	INDUSTRIAL ERGONOMICS IN DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- Introduce to industrial design based on ergonomics.
- Consider ergonomics concept in manufacturing.
- Apply ergonomics in design of controls and display.
- Apply environmental factors in ergonomics design.
- Develop aesthetics applicable to manufacturing and product.

UNIT I	INTRODUCTION	9

An approach to industrial design, Elements of design structure for industrial design in engineering application in modern manufacturing systems- Ergonomics and Industrial Design: Introduction to Ergonomics, Communication system, general approach to the man-machine relationship, Human component of work system, Machine component of work system, Local environment-light, Heat, Sound.

UNIT II	ERGONOMICS AND PRODUCTION	9

Introduction, Anthropometric data and its applications in ergonomic, working postures, Body Movements, Work Station Design, Chair Design. Visual Effects of Line and Form: The mechanics of seeing, Psychology of seeing, Figure on ground effect, Gestalt's perceptions - Simplicity, Regularity, Proximity, Wholeness. Optical illusions, Influences of line and form.

UNIT III	DESIGN PRINCIPLES FOR DISPLAY AND CONTROLS	9

Displays: Design Principles of visual Displays, Classification, Quantitative displays, Qualitative displays, check readings, Situational awareness, Representative displays, Design of pointers, Signal and warning lights, colour coding of displays, Design of multiple displays Controls: Design considerations, Controls with little efforts – Push button, Switches, rotating Knobs. Controls with muscular effort – Hand wheel, Crank, Heavy lever, Pedals. Design of controls in automobiles, Machine Tools.

UNIT IV	ENVIRONMENTAL FACTORS	9

Colour: Colour and light, Colour and objects, Colour and the eye – after Image, Colour blindness, Colour constancy, Colour terms – Colour circles, Munsel colour notation, reactions to colour and colour combination – colour on engineering equipments, Colour coding, Psychological effects, colour and machine form, colour and style

UNIT V	AESTHETIC CONCEPTS	9

Concept of unity, Concept of order with variety, Concept of purpose, Style and environment, Aesthetic expressions - Symmetry, Balance, Contrast, Continuity, Proportion. Style - The components of style, House style, Style in capital good. Introduction to Ergonomic and plant layout software's, total layout design.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY/	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret ergonomics need in the industrial design. **(Understand)**
CO2: Apply ergonomics in creation of manufacturing system. **(Apply)**
CO3: Discuss on design of controls and display. **(Apply)**
CO4: Interpret environmental factors in ergonomics design. **(Apply)**
CO5: Discuss the importance of aesthetics to manufacturing system and product. **(Apply)**

Text Books

1. Ergonomics in Design: Methods and Techniques (Human Factors and Ergonomics) by Marcelo M. Soares , Francisco Rebelo, (2017)
2. Ergonomics in Product Design by Sendpoints Publishing Co. Ltd (2018)

Reference Books

1. Benjamin W.Niebel, Motion and Time Study, Richard, D. Irwin Inc., 7thEdition, 2012
2. Brain Shakel,"Applied Ergonomics Hand Book", Butterworth Scientific London, 2020.
3. Bridger, R.C., Introduction to Ergonomics, 2ndEdition (reprinted), 2013, McGraw Hill Publications.
4. Martin Helander, A Guide to human factors and Ergonomics, Taylor and Francis, 2016

Web Resources

https://www.digimat.in/nptel/courses/video/107103004/L01.html (**Industrial Ergonomics in Design)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1		1	3			1			1	3	
CO2	1	1	1		1	3			1			1	3	
CO3	1	1	3		1	3			1			1	3	
CO4	1	1	1		1	3			1			1	3	
CO5	1	1	1		1	3			1			1	3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret ergonomics need in the industrial design (Remember, Understand)

1. What are the objectives in industrial ergonomics **(Remember)**
2. Draw the human – machine systems and its components **(Understand)**

COURSE OUTCOME 2: Apply ergonomics in creation of manufacturing system (Understand, Apply)

1. Explain Anthropometric data and its application in ergonomics. **(Understand)**
2. Describe about simplicity, regularity and proximity **(Apply)**

COURSE OUTCOME 3: Discuss on design of controls and display (Remember, Apply)

1. Name five types of display and one example each? **(Remember)**
2. Write the design controls in automobiles and machine tools with examples **(Apply)**

COURSE OUTCOME 4: Consider environmental factors in ergonomics design. (Understand, Apply)

1. Explain munsell colour system. **(Apply)**
2. What is colour circle? And its application **(Understand)**

COURSE OUTCOME 5: Report on importance of aesthetics to manufacturing system and product (Understand, Apply)

1. Describe aesthetic expressions in industrial ergonomics **(Apply)**
2. What are the ways of using industrial designers?**(Understand)**.

21ME7703	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Partial Differential Equations and application of Fourier series, Fluid Mechanics and Machinery, Heat and Mass Transfer

Objectives

- To understand the basic flow equations, characteristics of mathematical models for a given flow.
- To gain knowledge on the important aspects of grid generation for practical problems
- To Familiarize with Finite Volume techniques in Computational fluid analysis.
- To learn the concepts of time dependent and panel methods
- To acquire the knowledge in both structures and unstructured grid generation.

UNIT I	FUNDAMENTAL CONCEPTS	9

Introduction – Basic Equations of Fluid Dynamics – Mathematical properties of Fluid Dynamics Equations – Elliptic, Parabolic and Hyperbolic equations – Well posed problems – discretization of partial Differential Equations – Transformations and grids – Explicit finite difference methods of subsonic, supersonic and viscous flows..

UNIT II	GRID GENERATION	9

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries – Elliptic grid generation using Laplace's equations for geometries like aerofoil and CD nozzle

UNIT III	PANEL METHODS	9

Elements of two and three-dimensional panels, panel singularities – Application of panel methods to incompressible, compressible, subsonic and supersonic flows – Numerical solution of flow over a cylinder using 2D panel methods using both vertex and source panel methods for lifting and nonlifting cases respectively.

UNIT IV	TIME DEPENDENT METHODS	9

Stability of solution – Explicit methods – Time split methods – Approximate factorization scheme – Unsteady transonic flow around aerofoils – Sometime dependent solutions of gas dynamic problems – Numerical solution of unsteady 2D heat conduction problems using SLOR methods.

UNIT V	FINITE VOLUME TECHNIQUES	9

Finite Volume Techniques – Cell Centred Formulation – Lax-Vendoroff Time Stepping – RungeKutta Time Stepping – Multi-stage Time Stepping – Accuracy – Cell Vertex Formulation – Multistage Time Stepping – FDM-like Finite Volume Techniques – Central and Up-wind Type Discretization – Treatment of Derivatives

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO 1 Explain and calculate the governing equations for fluid flow. **(Understand)**
CO 2 Explain how grids are generated. **(Understand)**
CO 3 Describe the issues about two-phase flow modelling. **(Apply)**
CO 4 Apply the concept of discretization, upwind differencing and implicit, explicit solutions. **(Apply)**
CO 5 Apply finite difference and finite volume methods to fluid flow problems. **(Apply)**

Text Books

1. Blazek, J., "Computational Fluid Dynamics: Principles and Applications", 2nd Ed., Elsevier, 2006.
2. Chung. TJ, "Computational Fluid Dynamics", Cambridge University Press, 2010.

Reference Books

1. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017.
2. John F. Wendt (Editor), "Computational Fluid Dynamics - An Introduction", Springer - Verlag, Berlin, 2009
3. Klaus A Hoffmann and Steve T. Chiang. "Computational Fluid Dynamics for Engineers", Vols. I & II Engineering Education System, P.O. Box 20078, W. Wichita, K.S., 67208 - 1078 USA, 2000

Web Resources

1. **https://nptel.ac.in/courses/112105045 (Computational Fluid Dynamics)**
2. **https://nptel.ac.in/courses/112103289 (Computational Fluid Dynamics)**
3. **https://archive.nptel.ac.in/courses/112/106/112106294/ (Computational Fluid Dynamics)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3	1	1	3								3	
CO2	1	3	1	1	3								3	
CO3	1	3	1	1	3								3	
CO4	1	3	1	1	3								3	
CO5	1	3	1	1	3								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Explain and calculate the governing equations for fluid flow. (Remember, Understand)

1. How is Partial Differential Equation Classified? **(Remember)**
2. Derive an expression for the explicit method for supersonic flow . **(Understand)**

COURSE OUTCOME 2: Explain how grids are generated. (Remember, Understand)

1. Write an application of C-grid**(Remember)**
2. Explain the concept of grid generation using laplace's equation with examples. **(Understand)**

COURSE OUTCOME 3: Describe the issues about two-phase flow modelling. (Remember, Understand, Apply)

1. Write the types of Algorithms. **(Remember)**
2. Write down the application of panel methods to subsonic and supersonic flows **(Understand)**
3. Interpret the results of flow over a cylinder for lifting cases using Numerical simulation techniques. **(Apply)**

COURSE OUTCOME 4: Apply the concept of discretization, upwind differencing and implicit, explicit solutions. (Remember, Understand, Apply)

1. Compare the stability aspect of explicit and implicit equation solving approaches. **(Remember)**
2. Derive an expression for solving 2D unsteady heat transfer problem using implicit scheme and finite volume method. **(Understand)**
3. Demonstrate the concept of explicit methods in Unsteady transonic flow around aerofoils. **(Apply)**

COURSE OUTCOME 5: Apply finite difference and finite volume methods to fluid flow problems. (Remember, Understand, Apply)

1. State the cell vertex formulation.**(Remember)**
2. Explain the Runge-Kutta Time stepping method in detail with emphasis on stability and accuracy of the method. **(Understand)**
3. Illustrate with suitable example for the conservative upwind discretization of hyperbolic system. **(Apply)**

21ME7704	HVAC SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering, Heat and Mass Transfer

Objectives

- To calculate direct, diffuse and reflected radiation as well as to understand clearly about various
  incident radiation related parameters
- To calculate angle of incidence for horizontal, vertical and tilted surfaces such as walls
- To compare and contrast the conventional cooling and heating load calculations
- To understand the concept and application of various air heating systems as well as to make aware the various trouble shooting measures for common arising problems
- To classify and contrast the various water heating systems based on piping arrangement and water circulation

UNIT I	HEAT TRANSFER THROUGH BUILDING STRUCTURES	9

Building Survey, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs; Heat gain through glass, calculation of solar heat gain through ordinary glass tables, shading devices, effect of shading devices. Equivalent temperature difference method, Thermal resistance of various building materials, Infiltration, stack effect, wind effect.

UNIT II	HEAT LOAD DESIGNS	9

Winter heating load calculation, heat losses through structure, heat losses due to infiltration, Effects of solar radiation and internal heat sources on heating loads. Methods for estimating energy requirements for heating.

UNIT III	HVAC SYSTEM DESIGN	9

Principles of HVAC system design and analysis; component and system selection criteria including room air distribution, fans and air circulation, humidifying and dehumidifying processes, piping and ducting design. Air quality standards. Control systems and techniques; operational economics. The engineering principles and key factors influencing the thermal environments and quantification of these factors, functional requirements of utilities, and the design of systems to local codes.

UNIT IV	AIR CONDITIONING SYSTEMS	9

Ventilation Systems; Space Heating Systems; Automatic control; Commissioning, operation and maintenance; Introduction to HVAC & R analysis. Thermal equipment performance; Direct contact heat and mass transfer; Component modelling and simulation; Performance analysis and optimization of environmental plant systems. Part-load and year-round operation, system performance and operational problems; Ventilation systems: outdoor air control, ventilation effectiveness, ADPI, fan-duct network; filtration systems

UNIT V	AIR HEATING SYSTEMS	9

Primary and secondary water loops, constant and variable flow; System control: air side control, water side control; Energy requirement: cooling load profile, fan and pump power, system operation for energy effectiveness and heat recovery, chiller optimization. Thermal environment; Air quality; Energy
conservation measures; Energy codes; Noise and vibration control

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test 20 Marks)	End Semester Exams (50 Marks)

CAT 1 – 10MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1. List the factors that impact the heating & cooling loads in buildings **(Remember)**

CO2. Discuss the internal and external cooling loads on a building by separating sensible and latent Parts **(Apply)**

CO3. Analyze the heating & cooling loads and Design an HVAC system for a residential or commercial building **(Analyze)**

CO4. Analyze the various HVAC systems available and selecting the most appropriate one **(Analyze)**

CO5. Select appropriate air heating system for a particular location and application **(Analyze)**

Text Books

1. HVAC Fundamentals Volume-l / James E. Brumbou / Audel / 4th Edition

Reference Books

1. Fundamentals of HVAC Systems / Robert Mcdowall / Academic Press / 2007
2. Home Heating & Air Conditioning systems / James Kittle / MGH
3. HVAC Fundamentals / Samuel C. Sugarman / Fairmont Press / 2005.
4. Principles of Refrigeration – Dossat, Pearson
5. R&AC Hand Book by ISHRAE

Web Resources

1. https://nptel.ac.in/courses (**HVAC Systems**)

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	3	1			1							3
CO2	1	1	3	1			1							3
CO3	1	1	3	1	2		1							3
CO4	1	1	3	1	2		1							3
CO5	1	1	3	1			1							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 List the factors that impact the heating & cooling loads in buildings **(Remember)**

1. Apply insulation considerations: If there is insulation present in the walls or roofs, consider its thermal resistance (R-value) and its impact on reducing heat transfer. The R-value represents the resistance to heat flow and should be included in the calculations. **(Remember)**
2. Understand the heat transfer mechanisms: Heat transfer can occur through conduction, convection, and radiation. It's important to consider these mechanisms while calculating the heat transfer. **(Understand)**

COURSE OUTCOME 2: Discuss the internal and external cooling loads on a building by separating sensible and latent Parts **(Apply)**

1. Solar radiation impact: How does solar radiation affect heating loads? **(Remember)**
2. Internal heat sources: What role do internal heat sources play in heating loads? **(Apply)**

COURSE OUTCOME 3: Analyze the heating & cooling loads and Design an HVAC system for a residential or commercial building **(Analyze)**

1. Components and layout: What components are involved in HVAC system design, and how should they be laid out? **(Understand)**
2. Load calculations: How are load calculations performed in HVAC system design? **(Analyze)**

COURSE OUTCOME 4: Analyze the various HVAC systems available and selecting the most appropriate one **(Analyze)**

1. Types of air conditioning systems: What are the different types of air conditioning systems available? **(Understand)**
2. Cooling capacity: How is the cooling capacity of an air conditioning system determined? **(Analyze)**

COURSE OUTCOME 5: Select appropriate air heating system for a particular location and application **(Analyze)**

1. Cooling load profile: How is the cooling load profile determined in a building? **(Understand)**
2. Fan and pump power: Specify the factors affect the power consumption of fans and pumps in HVAC systems? **(Apply)**

21ME7705	PROCESS PLANNING AND COST ESTIMATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

- To introduce the process planning concepts
- To make cost estimation for various products after process planning

UNIT I	INTRODUCTION TO PROCESS PLANNING	9

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-. Production equipment and tooling selection

UNIT II	PROCESS PLANNING ACTIVITIES	9

Process parameters calculation for various production processes-Selection jigs and fixtures election of quality assurance methods - Set of documents for process planning-Economics of process planning-case studies

UNIT III	INTRODUCTION TO COST ESTIMATION	9

Importance of costing and estimation –methods of costing-elements of cost estimation –Types of estimates – Estimating procedure- Estimation labor cost, material cost- allocation of over head charges- Calculation of depreciation cost

UNIT IV	PRODUCTION COST ESTIMATION	9

Estimation of Different Types of Jobs - Estimation of Forging Shop, Estimation of Welding Shop, Estimation of Foundry Shop

UNIT V	MACHINING TIME CALCULATION	9

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of Machining Time for Different Lathe Operations ,Drilling and Boring - Machining Time Calculation for Milling, Shaping and Planning -Machining Time Calculation for Grinding.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Select the process, equipment and tools for various industrial products **(Understand)**
CO2 Prepare process planning activity chart. **(Understand)**
CO3 Explain the concept of cost estimation. **(Apply)**
CO4 Compute the job order cost for different type of shop floor. **(Apply)**
CO5 Calculate the machining time for various machining operations. **(Apply)**

Text Books

1. Peter scalon, “Process planning, Design/Manufacture Interface”, Elsevier science technology Books, Dec 2002.
2. Sinha B.P, “Mechanical Estimating and Costing”, Tata-McGraw Hill publishing co, 1995.

Reference Books

1. Chitale A.V. and Gupta R.C., "Product Design and Manufacturing", 2nd Edition, PHI, 2002
2. Ostwalal P.F. and Munez J., "Manufacturing Processes and systems", 9 th Edition, John Wiley, 1998.
3. Russell R.S and Tailor B.W, "Operations Management", 4th Edition, PHI, 2003

Web Resources

1. https://nptel.ac.in/courses/112107238 (Process Planning and Cost Estimation)
2. https://nptel.ac.in/courses/105103206 **(Process Planning and Cost Estimation)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		2	2	1							2		3	
CO2		2	2	1							2		3	
CO3		2	2	1							3		3	
CO4		2	2	1							3		3	
CO5		2	2	1							3		3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Select the process, equipment and tools for various industrial products (Remember, Understand)

1. What are parameters to determine the tool performance? **(Remember)**
2. Explain basic steps involve in process planning. **(Understand)**

COURSE OUTCOME 2: Prepare process planning activity chart. (Remember, Understand)

1. What are the functions of jig and fixture? **(Remember)**
2. Explain the various quality assurance methods in detail. **(Understand)**

COURSE OUTCOME 3: Explain the concept of cost estimation (Remember, Understand, Apply)

1. Distinguish cost estimation and cost accounting. **(Remember)**
2. From the following data provided by a mask machine manufacturer, find prime cost, factory cost, production cost, total coat and profit

Items	INR
Value of stock material as on 1-07-2021	52,000
Material purchased	5,48,000
Wages to workers	2,40,000
Depreciation of plant and machinery	16,000
Depreciation of office equipment	4,000
Rent, taxes and insurance	32,000
General administrative expenses	6,800
Water, power and telephone bill of factory	19,200
Water, power and telephone bill of office	5,000
Transportation in factory	4,000
Insurance and rent of office building	4,000
Direct expenses	1,00,000
Commission and pay of salesman	21,000

Repair and maintenance	2,000
Production Managers salary	60,000
Salary of office staff	1,20,000
Value of stock of material on 30-06-2021	72,000
Sale of products	12,72,000. **(Understand)**

3. Find out the production cost per gear for a transmission unit in automobile from the following data.

Charges for forging per kg	Rs. 22.5
Wrought iron used per month @ Rs. 90 per Kg	27 tonnes
Wages of operator	Rs. 450/day
No of operator employed	36
Cartage/day	Rs. 2,250
Deprecation of machines and tools	Rs. 4500 per month
Wages of helpers	Rs. 270 per day each
No of helpers employed	8
Salary of supervisor	Rs. 45,000 per month
Packing charges for 108 gears	Rs. 360
Electric charges	Rs. 11700 Per month
Salary of manager and maintenance staff	Rs. 1,26,000 per month

If 13,500 gears are to be produced per month and factory runs 26 days a month at 8 hour shift then what should be the selling price of each gears so as to earn profit of 20 percentage of factory cost? **(Apply)**

COURSE OUTCOME 4: Compute the job order cost for different type of shop floor (Remember, Understand, Apply)

1. What is shrinkage allowance? **(Remember)**
2. Calculate the cost of forging a crank shaft as show in figure 1 below using the following data available. The forging is to be made out of 50 mm dia.

Material price	Rs.100 per kg
Direct labour charges	Rs. 43 per piece
Overhead charges	150% of material cost
Density	7.5 g/cc
Losses	28% of net weight

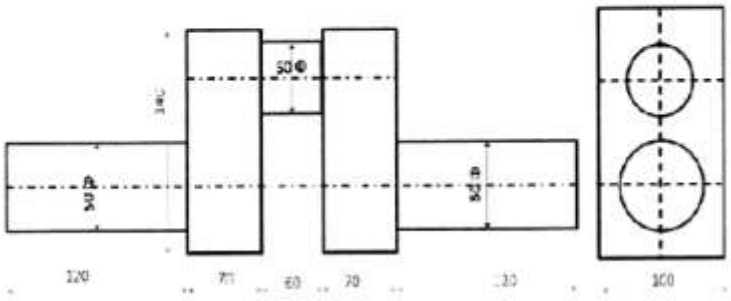


Figure 1

(Understand)

3. Calculate the cost of welding two pieces of mild steel sheets each 2 meters long and 7 mm thick. A 60° V is prepared by means of gas cutting before welding is to be commenced. The cost of oxygen is Rs. 7/cumeter and acetylene is Rs. 4/cu meter. The filler metal costs Rs. 20 per kg.
   The following data is also available :
   For gas cutting (10 mm thick plate)

Cutting speed	20 m/hr
Consumption of oxygen	2 cu m/hr
Consumption of acetylene	0.2 cu m/hr
Data for rightward welding	
Consumption of oxygen	0.8 cu m/hr
Consumption of acetylene	0.8 cu m/hr
Dia of filler rod used	3.5 mm
Filler rod used per meter of weld	3.4 m
Rate of welding	3 m/hr
Density of filler metal	8 g/cc **(Apply)**

COURSE OUTCOME 5: Calculate the machining time for various machining operations. (Remember, Understand, Apply)

1. What is tear down time? **(Remember)**
2. A 400 mm □ 60 mm rectangular cast iron piece is to be face milled with a carbide cutter. The cutting speed and feed are 60 m/min and 60 m/mm. If the cutter diais 80 mm with 12 cutting teeth. Find cutter r.p.m. feed per tooth, milling time. **(Understand)**
3. Calculate the machining time to drill eight 8 mm dia holes and one 40 mm dia central hole in the flange shown below (Figure 2). With cutting speed 10 m/min, feed for 8 mm drill 0.1 mm/rev, 40 mm drill is 0.4 mm/rev, 20 mm dia drill 0.2 mm/rev.

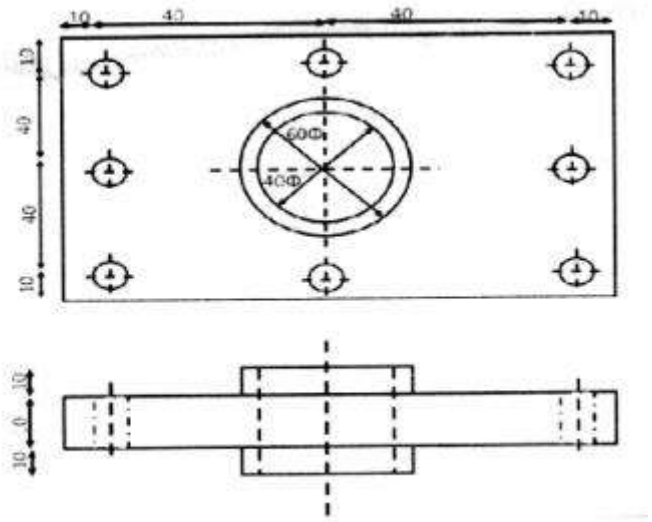


Figure 2

(Apply)

21ME7706	INDUSTRIAL INTERNET OF THINGS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- This course aims to focus on basics of industrial internet, get an idea about IIOT architectures and acquire the knowledge about various network protocols

UNIT I	INTRODUCTION TO INDUSTRIAL INTERNET	9

Innovation and IIoT – Intelligent Devices – Industrial Internet – Health care – Oil and Gas Industry – Smart Office – Logistics – IoT Innovations in Retail.

UNIT II	TECHNICAL AND BUSINESS INNOVATORS OF INDUSTRIAL INTERNET	9

Miniaturization – Cyber Physical Systems – Wireless technology – IP Mobility – Network Functionality Virtualization – Cloud and Fog - Big Data and Analytics – M2M Learning and Artificial Intelligence.

UNIT III	IIOT REFERENCE ARCHITECTURE	9

Industrial Internet Architecture Framework – Functional Viewpoint –Operational Domain, Information Domain, Application Domain, Business Domain – Implementation View point – Architectural Topology – Three Tier Topology – Data Management.

UNIT IV	INDUSTRIAL INTERNET SYSTEMS	9

Introduction-Proximity Network Protocols – WSN Edge Node – Legacy Industrial Protocols –RS232 Serial Communications, 40-20ma Current Loop, Field Bus Technologies – Modern Communication Protocols – Industrial Ethernet – Industrial Gateways.

UNIT V	MIIDDLEWARE TRANSPORT PROTOCOL	9

TCP/IP, UDP, RTP, CoAP –Middleware Software patterns –Software Design patterns – Application Programming Interface (API) – CAN Protocol-Web Services – Middleware IIoT – Securing the IIoT-Identity Access Management.

Total Periods **45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the company's performance using IoT **(Understand)**
CO2: Discuss the different styles of technical and business innovators **(Understand)**
CO3: Identify various IIoT Architectures related to data management system **(Apply)**
CO4: Organize the design of Industrial Internet Systems **(Apply)**
CO5: Construct a Middleware software system related to proximity edge networks **(Apply)**

Text Books

1. S. Misra, C. Roy, and A. Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0. CRC Press, 2020.
2. S. Misra, A. Mukherjee, and A. Roy, Introduction to IoT. Cambridge University Press, 2020

Reference Books

1. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights, 2014.
2. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015.

Web Resources

1. https://onlinecourses.nptel.ac.in/noc20_cs69/preview **(Industrial Internet of things)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	1	3									3
CO2	1	2	2	1	3									2
CO3	2	2	3	1	3									3
CO4	2	2	3	1	3									2
CO5	2	2	3	1	3									3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret the company's performance using IoT (Understand)

1. How IOT is working in oil & gas industry. Explain in detail (Remember)
2. Compare IOT and IIOT in terms of functionality, connectivity and usage (Understand)

COURSE OUTCOME 2: Discuss the different styles of technical and business innovators (Understand)

1. Compare artificial intelligence & machine learning (Understand)
2. Outline the domains where fog computing is used (Understand)

COURSE OUTCOME 3: Identify various IIoT Architectures related to data management system (Apply)

1. List out the viewpoints in industrial internet (Remember)
2. Build the framework of industrial internet architecture (Apply)

COURSE OUTCOME 4: Organize the design of Industrial Internet Systems (Apply)

1. Outline RS232 Serial Communication Protocol working and specifications (Understand)
2. Identify the modes of data transfer in serial communication (Apply)

COURSE OUTCOME 5: Construct a Middleware software system related to proximity edge networks (Apply)

1. Classify the seven software design patterns and explain with an example (Understand)
2. Construct the architecture of TCP/IP Protocol in IIOT (Apply)

21ME7707	MANUFACTURING AND INSPECTION OF GEARS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

- This course aims to focus the inspection process that led to better design of gears.
- Develop a broad understanding of the methods used to manufacture and inspect gears.

UNIT I	PRODUCTION OF CYLINDERICAL GEARS	9

Types of cylindrical gears - Gear production methods - Procedure for cutting gears - Cutter selection - Work holding methods - Rack type gear shaping machine - Internal gear cutting methods - CNC gear hobbing - Gear shaping machines - Gear skiving.

UNIT II	PRODUCTION OF CONICAL GEARS	9

Types of conical gears - Production methods for straight bevel gears - Bevel gear generator - Duplex rotary cutter method - Production methods for spiral bevel and hypoid bevel gears - Gleason spiral bevel generator.

UNIT III	GEAR MATERIALS SELECTION AND HARDENEING METHODS	9

Properties of gear materials - Non-metallic, non-ferrous and plastic gears - Selection of material for power transmission - Selection of materials for worm and wheel - Hardening methods - Case hardening – Carburizing - Induction hardening - Flame hardening.

UNIT IV	GEAR FINISHING AND INSPECTIONS	9

Gear finishing – Grinding – Shaving - Lapping - Honing - Gear inspection - Types of error in gears - Gear quality standards and allowable limits - Composite error measurement - Computerized gear inspection - Gear failure reasons and remedies.

UNIT V	MASS PRODUCTION METHODS AND PRODUCTION SYSTEMS	9

Mass production methods - Stamping - Die casting - Powder metallurgy process - Injection moulding - Compression moulding of plastic gears - Cold and hot rolling - Gear broaching - Gear production systems - Batch production - Gear production cells - Automobile gear and gear boxes -Production of heavy engineering gears.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the methods of manufacturing cylindrical gears **(Understand)**
CO2: Discuss the manufacturing methods of conical gears **(Understand)**
CO3: Illustrate the gear materials and hardening methods **(Apply)**
CO4: Examine the gear quality and standards **(Apply)**
CO5: Describe the mass production methods and systems of gears **(Apply)**

Text Books

1. H. J. Watson, "Modern Gear Production", 1st edition, Pergamon, 2013.
2. Sreeramulu Moinikunta, "Production Technology" Wiley, 2018.

Reference Books

1. Thomas Bergs and Christian Brecher, "Aachen Forum on Gear Production: Gear Finishing Technology and Quality Inspection" 9th edition, 2021,
2. Stephen and Radzevich, "Dudley's Handbook of Practical Gear Design and Manufacture", 4th edition, CRC Press, 2021.

Web Resources

1. https://nptel.ac.in/courses/112105234 **(Manufacturing and Inspection of Gears)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	2	1			1							3	
CO2	1	2	1			1							3	
CO3	1	2	1			1							3	
CO4	1	2	1			1							3	
CO5	1	2	1			1							3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret the methods of manufacturing cylindrical gears (Understand)

1. List out the different types of cylindrical gears. Explain in detail (Remember)
2. Describe the rack type gear shaping machine (Understand)

COURSE OUTCOME 2: Discuss the manufacturing methods of conical gears (Understand)

1. Describe the straight bevel gear & spiral bevel gear (Understand)
2. Outline the duplex rotary cutter method where it is used (Understand)

COURSE OUTCOME 3: Illustrate the gear materials and hardening methods (Apply)

1. List out the viewpoints in hardening process (Remember)
2. Illustrate the selection of gear materials for transmission system (Apply)

COURSE OUTCOME 4: Examine the gear quality and standards (Apply)

1. Discuss the various gear inspection methods (Understand)
2. Identify the gear failures and remedies (Apply)

COURSE OUTCOME 5: Describe the mass production methods and systems of gears (Apply)

1. Classify the mass production methods of gears (Understand)
2. Illustrate the die casting and powder metallurgy process (Apply)

21ME7708	PRECISION MANUFACTURING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- This course deals with precision manufacturing, micro machining and fundamental design requirements of precision machine tools. It also provides insights on machine surface characteristics and error detection methods.

UNIT I	INTRODUCTION	9

Need for Precision Manufacturing - Taniguchi Diagram - Four Classes of Achievable Machining Accuracy – Normal Precision - High-Precision - Ultra-Precision Processes and Nanotechnology.

UNIT II	PRECISION MACHINING AND UNCONVENTIONAL MICROMACHINING TECHNIQUES	9

Overview of Micro and Nano Machining - Conventional Micro Machining Techniques - Ultrasonic Micromachining - Photochemical Machining - Electro Chemical Micromachining - Laser Beam Micromachining - Electron Beam Micromachining

UNIT III	MACHINE DESIGN FOR PRECISION MANUFACTURING	9

Philosophy of Precision Machine Design - Ultra-Precision Machine Elements: Guide Ways - Drive Systems - Friction Drive - Linear Motor Drive - Spindle Drive. Bearings: Principle - Construction and Application of Rolling - Hydrodynamic and Hydrostatic Bearings

UNIT IV	MECHANICAL AND THERMAL ERRORS	9

Sources of Error - Principles of Measurement - Errors Due to Machine Elements – Bearings – Spindles - Kinematic Design - Structural Compliance – Vibration - Thermal Effects - Environmental Control of Precision Machinery. Error Mapping and Error Budgets.

UNIT V	DIMENSIONAL METROLOGY FOR MICRO MACHINING	9

Laser Tracking Systems - Laser Scanners, White Light Interference 3D Microscopes - Metrology: 3D Surface Topography – Non-Optical Scanning Microscopy – Scanning Electron Microscopes - Scanning Probe Microscopes - Parameters for Characterizing 3D Surface Topography.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Illustrate the precision engineering and machining accuracy. **(Understand)**
CO2: Explain the working principle of different precision machining process. **(Understand)**
CO3: Choose the basic design requirements for the construction of precision machine tools. **(Apply)**
CO4: Identify various errors affecting the accuracy of precision manufacturing **(Apply)**
CO5: Apply a suitable measurement technique to measure and characterize the features of precision machined components. **(Apply)**

Text Books

1. Richard Leach, Stuart T. Smith, “Basics of Precision Engineering”, CRC Press, 2018.
2. Wei Gao, “Metrology (Precision Manufacturing)” Springer, 2019.

Reference Books

1. Giovanni Lucchetta, "Advances in Micro and Nano Manufacturing: Process Modeling and Applications", Mdpi AG, 2022,
2. Jain V.K., "Introduction to Micromachining", 2nd Edition, Narosa Publishers, New Delhi, 2018.

Web Resources

1. https://nptel.ac.in/courses/112105231 **(Precision Manufacturing)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	1	2	3			1							3	
CO2	1	2	3			1							3	
CO3	2	2	3			1							3	
CO4	2	2	3			1							3	
CO5	2	2	3			1							3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Illustrate the concepts of precision engineering and machining accuracy (Understand)

1. List out the various types of precision process. Explain in detail **(Remember)**
2. Describe the ultra-precision process and nanotechnology **(Understand)**

COURSE OUTCOME 2: Explain the working principle of different precision machining process. (Understand)

1. Describe the working of electro chemical micro machining process **(Understand)**
2. Discuss the laser beam machining. where it is used **(Understand)**

COURSE OUTCOME 3: Choose the basic design requirements for the construction of precision machine tools. (Apply)

1. Describe the Construction and Application of Rolling **(Remember)**
2. Illustrate the working of hydrostatic and hydrodynamic bearings **(Apply)**

COURSE OUTCOME 4: Identify various errors affecting the accuracy of precision manufacturing (Apply)

1. Discuss the error mapping and error budgets **(Understand)**
2. Identify the various error affecting the precision manufacturing **(Apply)**

COURSE OUTCOME 5: Apply a suitable measurement technique to measure and characterize the features of precision machined components. (Apply)

1. Differentiate the scanning electron microscope and scanning probe microscope **(Understand)**
2. Illustrate the white Light Interference 3D Microscopes **(Apply)**

21ME7709	TRADITIONAL AND NON-TRADITIONAL OPTIMIZATION TOOLS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To know the introduction and classical optimization techniques.
- To understand the linear programming techniques to solve problems
- To understand the non-linear programming: one dimensional minimization method.
- To understand the non-linear programming: Unconstrained and Constrained Optimization Techniques
- To understand the evolutionary algorithms in optimization.

UNIT I	INTRODUCTION AND CLASSICAL OPTIMIZATION TECHNIQUES	9

Historical Development, Engineering applications of Optimization, Design vector and constraints, Constraint surface, Objective function, Classification of Optimization Problems. Single variable optimization, Constrained and unconstrained multi-variable optimization, Direct substitution method, Lagrange's method of multipliers, Karush-Kuhn-Tucker conditions

UNIT II	LINEAR AND NON LINEAR PROGRAMMING	9

Statement of an LP problem, Graphical Solution of an LP problem, Simplex method, Dual simplex method, Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Golden section method, Direct root methods

UNIT III	NON-LINEAR PROGRAMMING: UNCONSTRAINED AND CONSTRAINED OPTIMIZATION TECHNIQUES	9

UNCONSTRAINED: Types of Direct Search Methods - Random search methods, Grid search method, Univariate method. Types of Indirect Search Methods: Steepest descent method, Fletcher-Reeves method CONSTRAINED: Types of Direct Search Methods: Random search method, Sequential linear programming. Indirect methods: Transformation techniques, Exterior penalty function method, Interior penalty function method

UNIT IV	INTRODUCTION TO NON-TRADITIONAL TOOLS	9

Introduction - Genetic Algorithms: Representation of Design Variables - Representation of Objective Function and Constraints - Genetic Operators – Algorithm - Numerical Results. Simulated Annealing: Procedure – Algorithm - Features of the Method - Numerical Results. Particle Swarm Optimization: Computational Implementation of PSO - Improvement to the Particle Swarm Optimization Method - Solution of the Constrained Optimization Problem

UNIT V	ANT COLONY OPTIMIZATION AND OPTIMIZATION OF FUZZY SYSTEMS	9

Ant Colony Optimization: Ant Searching Behavior - Path Retracing and Pheromone Updating - Pheromone Trail Evaporation – Algorithm - Optimization of Fuzzy Systems: Fuzzy Set Theory - Optimization of Fuzzy Systems - Computational Procedure - Numerical Results – Neural Network Based Optimization

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:
CO1: Apply the classical optimization techniques to solve the problems. **(Apply)** **CO2:** Solve problems using linear and nonlinear programming techniques **(Apply)** **CO3:** Apply the constrained and unconstrained optimization techniques to solve problems **(Apply)** **CO4:** Use the evolutionary algorithms for the multivariable problems. **(Apply)** **CO5:** Solve multivariable problems using Ant colony and fuzzy system optimization methods **(Apply)**
Text Books
1. Singiresu S.Rao, "Engineering Optimization", Vth Edition, John Wiley&Sons, 2020.
Reference Books
1. David G Luenberger, Yinyu Ye, "Linear and Non-linear Programming", Springer 2015 2. Kalyanmoy Deb," Optimization for Engineering Design", PHI Publications 2012
Web Resources 1. https://nptel.ac.in/courses/112105235 **(Traditional and Non-Traditional Optimization Tools)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	3								3	
CO2	1	1	2	2	3								3	
CO3	1	1	2	2	3								3	
CO4	1	1	2	2	3								3	
CO5	1	1	2	2	3								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to Apply the classical optimization techniques to solve the problems. (Apply)

1. Ten jobs are to be performed in an automobile assembly line as noted in the following table:

Job number	Time required to complete the job (min)	Jobs that must be completed before starting this job
1	4	None
2	8	None
3	7	None
4	6	None
5	3	1, 3
6	5	2, 3, 4
7	1	5, 6
8	9	6
9	2	7, 8
10	8	9

It is required to set up a suitable number of workstations, with one worker assigned to each workstation, to perform certain jobs. Formulate the problem of determining the number of workstations and the particular jobs to be assigned to each workstation to minimize the idle time of the workers as an integer programming problem.

Hint: Define variables x_{ij} such that $x_{ij} = 1$ if job *i is assigned to station j, and* $x_{ij} = 0$ otherwise**.**

2. A pipe of length *l* and diameter *D* has at one end a nozzle of diameter *d* through which water is discharged from a reservoir. The level of water in the reservoir is maintained at a constant value h above the center of nozzle. Find the diameter of the nozzle so that the kinetic energy of the jet is a maximum. The kinetic energy of the jet can be expressed as

$$\frac{1}{4}\pi\rho d^2\left(\frac{2gD^5h}{D^5+4fld^4}\right)^{3/2}$$

Where ρ is the density of water, f the friction coefficient and g the gravitational constant.

COURSE OUTCOME 2: Solve problems using linear and nonlinear programming techniques (Apply)

State the following LP problem in standard form:

$$\text{Maximize } f = -2x_1 - x_2 + 5x_3$$

subject to

$$x_1 - 2x_2 + x_3 \le 8$$
$$3x_1 - 2x_2 \ge -18$$
$$2x_1 + x_2 - 2x_3 \le -4$$

Find the solution of the following LP problem graphically:

$$\text{Maximize } f = 2x_1 + 6x_2$$

subject to

$$-x_1 + x_2 \le 1$$
$$2x_1 + x_2 \le 2$$
$$x_1 \ge 0, \quad x_2 \ge 0$$

COURSE OUTCOME 3: Apply the constrained and unconstrained optimization techniques to solve problems (Apply)

1. Find the minimum of the function $f = \lambda^5 - 5\lambda^3 - 20\lambda + 5$ by the following methods:
   (Apply) Unrestricted search with a fixed step size of 0.1 starting from $\lambda = 0.0$
   (b) Unrestricted search with accelerated step size from the initial point 0.0 with a starting step length of 0.1
   (c) Exhaustive search in the interval (0,5)
   (d) Dichotomous search in the interval (0,5) with $\delta = 0.0001$
   (e) Interval halving method in the interval (0,5)
   (f) Fibonacci search in the interval (0,5)
   (g) Golden section method in the interval (0,5)

2.

A bar is subjected to an axial load, P_0, as shown in Figure 6.17. By using a one-finite-element model, the axial displacement, $u(x)$, can be expressed as [6.1]

$$u(x) = \{N_1(x) \quad N_2(x)\} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix}$$

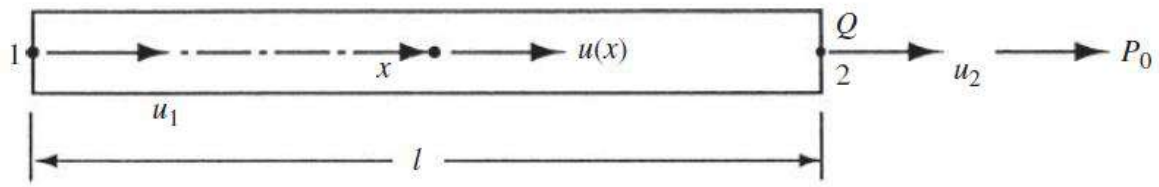
where $N_i(x)$ are called the shape functions:

$$N_1(x) = 1 - \frac{x}{l}, \qquad N_2(x) = \frac{x}{l}$$

and u_1 and u_2 are the end displacements of the bar. The deflection of the bar at point Q can be found by minimizing the potential energy of the bar (f), which can be expressed as

$$f = \frac{1}{2}\int_0^l EA\left(\frac{\partial u}{\partial x}\right)^2 dx - P_0 u_2$$

where E is Young's modulus and A is the cross-sectional area of the bar. Formulate the optimization problem in terms of the variables u_1 and u_2 for the case $P_0 l/EA = 1$.



COURSE OUTCOME 4: Use the evolutionary algorithms for the multivariable problems (Apply)

1.

Consider the following two strings denoting the vectors $\mathbf{X}_1$ and $\mathbf{X}_2$

$$\mathbf{X}_1 : \{1\,0\,0\,0\,1\,0\,1\,1\,0\,1\}$$
$$\mathbf{X}_2 : \{0\,1\,1\,1\,1\,1\,0\,1\,1\,0\}$$

Find the result of crossover at location 2. Also, determine the decimal values of the variables before and after crossover if each string denotes a vector of two variables.

2.

Find the maximum of the function $f = -x^5 + 5x^3 + 20x - 5$ in the range $-4 \le x \le 4$ using the PSO method. Use 4 particles with the initial positions $x_1 = -2$, $x_2 = 0$, $x_3 = 1$, and $x_4 = 3$. Show detailed calculations for 2 iterations.

COURSE OUTCOME 5: Solve multivariable problems using Ant colony and fuzzy system optimization methods. (Apply)

1. Find the minimum of the function f (x) = x2 − 2x − 11 in the range (0, 3) using the ant colony optimization method. **(Apply)**

2. Two discrete fuzzy sets, A and B are defined as follows:

$$A = \{(60, 0.1)\ \ (62, 0.5)\ \ (64, 0.7)\ \ (66, 0.9)\ \ (68, 1.0)\ \ (70, 0.8)\}$$

$$B = \{(60, 0.0)\ \ (62, 0.2)\ \ (64, 0.4)\ \ (66, 0.8)\ \ (68, 0.9)\ \ (70, 1.0)\}$$

Determine the union and intersection of these sets. **(Apply)**

21ME7710	VEHICLE STYLING AND DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- This course deals with vehicle styling, vehicle interior and exterior design of automotive parts. It also provides standards, tests and norms for an automotive parts/system.

UNIT I	VEHICLE STYLING	9

Vehicle styling process - Exterior sketching - Two-wheeler and Four-wheeler sketching - Exterior clay modelling - Interior sketching - Two-wheeler and Four-wheeler sketching - Interior clay modelling

UNIT II	SELECTION OF ENGINE AND TRANSMISSION FOR AN AUTOMOBILE	9

Vehicle layouts - Chassis frame design - Engine selection criteria - Transmission selection - over gearing and under gearing - Fuel economy - Engine life and pollution - Comparison of manual and automatic transmission characteristics - Power limited acceleration - Effect of inertia and equivalent vehicle weight.

UNIT III	FORCES ACTING IN CRANK MECHANISM	9

Instantaneous piston velocity and acceleration - Instantaneous connecting rod velocity and acceleration - Side thrust - Resultant force - Turning moment of single cylinder and multi-cylinder engines - Various forces acting in crank mechanism.

UNIT IV	ENGINE BALANCING	9

Balancing of single cylinder, two-cylinder, four cylinder and six-cylinder in- line engines. Comparison of balancing inline and v-type engines.

UNIT V	STANDARDS, TESTS AND NORMS FOR AN AUTOMOTIVE PART/SYSTEM	9

Materials & automotive standards for automobile industry - Working environment of vehicle in usage & handling by various stake holder tests - Test conditions to verify part against all failure modes - Emission norms.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Illustrate the concepts of vehicle interior and exterior parts design. **(Understand)**
CO2: Select engine and transmission of a vehicle for a particular application. **(Understand)**
CO3: Determine forces in engine crank mechanism. **(Apply)**
CO4: Suggest suitable firing order for engines by balancing forces and moments. **(Apply)**
CO5: Describe the test procedures, standards and norms for an automobile/sub system. **(Understand)**

Text Books

1. A.K. Babu, S.C. Sharma, T.R. Banga, "Automobile Mechanics" 1st Edition, Khanna Publishers, 2018.
2. Kirpal Singh, "Automobile Engineering" Volume-1&2, 13thEdition, Standard Publishers Distributers, Delhi, 2017.

Reference Books

1. Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, "Automotive Transmissions: Fundamentals, Selection, Design and Application", 2nd Edition, Springer, 2014.
2. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", 2021.

Web Resources

1. https://nptel.ac.in/courses/107106088 **(Vehicle Styling And Design)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	1	3										3	
CO2	1	2	3										3	
CO3	2	1	3		1								3	
CO4	2	1	3		2								3	
CO5	1	2	3		1								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Illustrate the concepts of vehicle interior and exterior parts design (Understand)

1. Discuss the interior and exterior design for two-wheeler vehicle. **(Understand)**
2. Enlist various types of sketches used for four-wheeler vehicle **(Remember)**

COURSE OUTCOME 2: Select engine and transmission of a vehicle for a particular application. (Understand)

1. How to design a transmission system for a passenger car? **(Remember)**
2. Discuss on the factors considered in selecting orientation of engine, fuel, method of cooling for given vehicle layout and requirement. **(Understand)**

COURSE OUTCOME 3: Determine forces in engine crank mechanism. (Apply)

1. Describe the expressions for instantaneous piston velocity, piston acceleration, connecting rod angular velocity and angular acceleration at any crank angle? **(Remember)**
2. Design a detailed procedure of engine crank mechanism **(Apply)**

COURSE OUTCOME 4: Suggest suitable firing order for engines by balancing forces and moments. (Apply)

1. Prove that 4-stroke, 6-cylinder engine with firing order of 1-5-3-6-2-4 is completely balanced. **(Apply)**
2. Choose a firing order for 4-stroke, 4 - cylinder engine, based on engine balancing. **(Understand)**

COURSE OUTCOME 5: Describe the test procedures, standards and norms for an automobile/sub system. (Understand)

1. Write down BS-IV norms for 2&3 wheelers powered by petrol. **(Understand)**
2. Discuss how rotation bending fatigue test and radial load durability test are done on alloy wheel rims of 2-wheelers. **(Understand)**

PROFESSIONAL ELECTIVE - V

21ME7711	PRODUCT DESIGN AND DEVELOPMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To provide the basic concepts of product design, product features and its architecture
- To incorporate them suitably in product.

UNIT I	INTRODUCTION	9

Need for IPPD – Strategic importance of Product development – integration of customer, designer, material supplier and process planner, Competitor and customer – Behaviour analysis. Understanding customer – prompting customer understanding – involve customer in development and managing requirements – Organization – process management and improvement – Plan and establish product specifications

UNIT II	CONCEPT GENERATION AND SELECTION	9

Task – Structured approaches – clarification – search – externally and internally – explore systematically – reflect on the solutions and processes – concept selection – methodology – benefits.

UNIT III	PRODUCT ARCHITECTURE	9

Implications – Product change – variety – component standardization – product performance – manufacturability – product development management – establishing the architecture – creation – clustering – geometric layout development – fundamental and incidental interactions – related system level design issues – secondary systems – architecture of the chunks – creating detailed interface specifications.

UNIT IV	INDUSTRIAL DESIGN	9

Integrate process design – Managing costs – Robust design – Integrating CAE, CAD, CAM tools – Simulating product performance and manufacturing processes electronically – Need for industrial design – impact – design process – investigation for industrial design – impact – design process – investigation of customer needs – conceptualization – refinement – management of the industrial design process – technology driven products – user – driven products – assessing the quality of industrial design.

UNIT V	DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT	9

Definition – Estimation of Manufacturing cost – reducing the component costs and assembly costs – Minimize system complexity – Prototype basics – principles of prototyping – planning for prototypes – Economic Analysis – Understanding and representing tasks – baseline project planning – accelerating the project – project execution.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline the need for Integrated Product and Process Design. **(Understand)**
CO2: Illustrate the structured approaches in concept generation. **(Apply)**
CO3: Apply the principles of product architecture in component standardization. **(Apply)**
CO4: Develop integrated environment for industrial design. **(Apply)**
CO5: Examine the economic aspects of product development. **(Apply)**

Text Books

3. Karl T., Ulrich and D. Steven, and Eppinger, Product Design and Development, McGraw Hill, (2011)
4. Dieter G. E., Engineering Design, McGraw – Hill International, (2019)

Reference Books

5. Chitale A. K., Gupta R. C., "Product Design and Manufacturing", 6th Edition, PHI Publication, (2014).
6. Stephen R. Rosenthal, "Effective Product Design and Development", Business & Economics (2002).
7. Kemnneth Crow, "Concurrent Engg./Integrated Product Development", DRM Associates, 26/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
8. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin, Homewood, 2012.

Web Resources

1. https://nptel.ac.in/courses/112104230/ **(Product Design and Development)**
2. http://meche.mit.edu/research/design **Product Design and Development)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2			1							3	
CO2	3	2	2			1							3	
CO3	3	2	2			1							3	
CO4	3	2	2		1	1							3	
CO5	3	2	2			1							3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Outline the need for Integrated Product and Process Design (Understand)

1. Explain the phases of generic product development process and point out the tasks and responsibilities of the organization **(Remember)**
2. Briefly explain the organizational policies for product planning, process management and improvement of product **(Understand)**

COURSE OUTCOME 2: Illustrate the structured approaches in concept generation. (Apply)

1. How can the concept selection methods be used to benchmark existing products. Perform such an evaluation for five automobile you might consider purchasing **(Understand)**
2. Prepare an external - search plan for the problem of permanently applying serial numbers to plastic products **(Apply)**

COURSE OUTCOME 3: Apply the principles of product architecture in component standardization (Apply)

1. Summarize the design issues that make an impact in related system of product architecture **(Remember)**
2. Describe the four-step method to structure the decision process, using the desk jet printer, with a geometric layout **(Apply)**

COURSE OUTCOME 4: Develop integrated environment for industrial design. (Apply)

1. Is Industrial Design Worth the Investment? Explain with respect to, singular architecture and integral architecture **(Apply)**
2. Explain the need for CAE/CAD/CAM in Industrial design, using suitable illustrations **(Understand)**

COURSE OUTCOME 5: Examine the economic aspects of product development (Apply)

1. Summarize the reasons why reducing the number of parts in a product might reduce production costs. Also explain some reasons why costs might increase **(Apply)**
2. What would you expect to be some of the characteristics of individuals who successfully lead project teams? Explain them in detail **(Apply)**.

21ME7712	PRODUCT LIFE CYCLE MANAGEMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

ıe objectives of product life cycle management (PLM) are to;

- Improve product quality and reduce time to market, prototyping costs reduce environmental impacts.
- Identify potential sales opportunities and revenue contributions

UNIT I	FUNDAMENTALS OF PLM	9

Introduction to PLM, Need for PLM, Product information, Product lifecycle management concept, Information models and product structures-Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems.

UNIT II	FUNCTIONS AND FEATURES	9

User Functions: Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions: Communication and Notification, data transport, data translation, image services, system administration and application integration

UNIT III	DIGITAL MANUFACTURING AND INTEGRATION OF PLM	9

Digital manufacturing, benefits manufacturing, manufacturing the first-one, Ramp up, virtual learning curve, manufacturing the rest, production planning. Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, Optimization of ERP for PLM and CAD.

UNIT IV	COLLABORATIVE PRODUCT DEVELOPMENT	9

Engineering vaulting, product reuse, smart parts, engineering change management, Bill of materials and process consistency, Digital mock-up and prototype development, design for environment, virtual testing and validation, marketing collateral.

UNIT V	PLM IN INDUSTRIES	9

Case studies on PLM selection and implementation (like auto, aero, electronic) and other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance- process compliance and process automation.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	DESCRIPTIVE QUESTIONS

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Identify product data, information, structures and PLM concepts. **(Understand)**
CO2: Develop the functions and features of PLM/PDM **(Apply)**
CO3: Recognize tools and standards for digital manufacturing and integration of PLM **(Understand)**
CO4: Apply PLM concepts through collaborative product development **(Apply)**
CO5: Interpret the implement PLM approaches for industrial applications. **(Understand)**

Text Books

1. Product Lifecycle Management for a Global Market, Springer; 29th September 2016, ISBN-10 : 3662516330
2. Jaya Krishna S, Product Lifecycle Management: Concepts and cases, ICFAI Publications 2011.

Reference Books

1. AnttiSaaksvuori and AnselmiImmonen, "Product Lifecycle Management", Springer Publisher, 2008 (3rd Edition)
2. IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.
3. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
4. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006
5. SOA approach to Enterprise Integration for Product Lifecycle, IBM Red books, 2011.

Web Resources

4. https://onlinecourses.nptel.ac.in/noc21_me83/preview **(Product Life Cycle Management)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			2	1		1		3				1	3	
CO2			2	1		1		3				1	3	
CO3			2	1	1	1		3				1	3	
CO4			2	1	1	1		3				1	3	
CO5			2	1		1		3				1	3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to Identify product data, information, structures and PLM concepts. (Understand)

1. Mention the need for PLM **(Remember)**
2. List the reasons for the deployment of PLM systems **(Understand)**

COURSE OUTCOME 2: Students will be able to develop the functions and features of PLM/PDM (Apply)

1. Discuss the relationship between version and revision with an illustration **(Apply)**
2. Elaborate the technologies related to document management with suitable illustration **(Apply)**

COURSE OUTCOME 3: Students will be able to Recognize tools and standards for digital manufacturing and integration of PLM (Understand)

1. Explain in detail digital manufacturing **(Understand)**
2. Explain the process of creation of 3DXML and CAD software tools **(Understand)**

COURSE OUTCOME 4: Students will be able to apply PLM concepts through collaborative product development (Apply)

1. Sketch the architecture of collaborative product commerce and explain its challenges **(Apply)**
2. Explain the steps involved in the prototype development through collaborative approach **(Apply)**

COURSE OUTCOME 5: Students will be able to Interpret the implement PLM approaches for industrial applications (Understand)

1. Explain the consequences of the ten step approach **(Understand)**
2. Develop a suitable case study for the selection of PLM **(Apply)**

21ME7713	CRYOGENIC ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course:

Engineering Thermodynamics, Thermal Engineering

Objectives

- To provide the knowledge of evolution of low temperature science.
- To provide knowledge on the properties of materials at low temperature
- To familiarize with various gas liquefaction and refrigeration systems and to provide design aspects of cryogenic storageand transfer lines.

UNIT I	INTRODUCTION TO CRYOGENIC SYSTEMS	9

Historical development - Applications of Cryogenics: Space, Food Processing, Super conductivity, Electrical Power, Biology, Medicine, Electronics and Cutting Tool Industry - Low Temperature Properties - Properties of Engineering Materials: Mechanical properties, Thermal properties, Electric and Magnetic properties, Properties of Cryogenic fluids.

UNIT II	LIQUEFACTION & CRYOGENIC REFRIGERATION SYSTEMS	9

Introduction to liquefaction Systems: Ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude & Cascaded System - Introduction to Cryogenic Refrigeration Systems: Magnetic Cooling, Stirling Cycle Cryo Coolers.

UNIT III	CRYOGENIC REFRIGERATION SYSTEMS	9

Ideal refrigeration systems - Refrigeration using liquids and gases as refrigerant - Refrigerators using solids as working media

UNIT IV	CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS	9

Cryogenic storage vessels and transportation - thermal insulation and their performance at cryogenic temperatures - Super insulations, Vacuum insulation, Powder insulation - Cryogenic fluid transfer systems.

UNIT V	CRYOGENIC INSTRUMENTATION	9

Pressure - flow-rate - liquid-level and temperature measurements - types of Heat Exchangers used in cryogenic systems (only description with figure) - Cryo Pumping Applications.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive Exam CAT 1 - 10 AND CAT2 - 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive Exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline the scope and history of cryogenics and to understand the properties of materials at low temperature applying fundamental knowledge. **(Understand)**

CO2: Apply the knowledge of low temperature production methods to understand and analyze different liquefaction systems. **(Apply)**

CO3: Apply the knowledge of ideal refrigeration techniques, to understand and analyse common cryogenic refrigeration systems. **(Apply)**

CO4: Summarize various cryogenic fluid storage and transport systems and to evaluate their performance applying fundamental concepts **(Understand)**

CO5: Discuss cryo pumping and cryogenic instrumentation. **(Understand)**

Text Books

1. J. H. Boll Jr, Cryogenic Engineering**,** 2019
2. Randal F.Barron, Cryogenic systems, McGraw Hill, 2017

Reference Books

4. Klaus D.Timmerhaus and Thomas M.Flynn, CryogenicProcess Engineering, Plenum Press, New York, 2021
5. R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 2013

Web Resources

1. NPTEL (**CRYOGENIC ENGINEERING)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1			1	1							3
CO2	3	1	1			1	1							3
CO3	3	1	1			1	1							3
CO4	3	1	1			1	1							3
CO5	3	1	1			1	1							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to outline the scope and history of cryogenics and to understand the properties of materials at low temperature applying fundamental knowledge. (Understand)

1. Explain the historical development of cryogenics. **(Remember)**
2. Explain how the ultimate and yield strengths of engineering materials change with cryogenic temperature? **(Understand)**

COURSE OUTCOME 2: Students will be able Apply the knowledge of low temperature production methods to understand and analyze different liquefaction systems. (Apply)

1. With a neat sketch, explain any one system for the liquefaction of Hydrogen. Derive expressions for liquid yield and work of liquefaction. **(Understand)**
2. Prove that COP of an ideal Stirling cycle refrigerator is same as that of Carnot refrigerator. **(Apply)**

COURSE OUTCOME 3: : Students will be able to apply the knowledge of ideal refrigeration techniques, to understand and analyse common cryogenic refrigeration systems. (Apply)

1. Illustrate the working of a simple cascade gas liquefaction system **(Apply)**
2. Explain the working of cryogenic refrigeration system with suitable example. **(Understand)**

COURSE OUTCOME 4: Students will be able to summarize various cryogenic fluid storage and transport systems and to evaluate their performance applying fundamental concepts (Understand)

1. Discuss the principles of storage and handling cryogenic fluid. **(Understand)**
2. Write short notes on insulations used in cryogenic applications. **(Understand)**

COURSE OUTCOME 5: Students will be able to discuss cryo pumping and cryogenic instrumentation. (Understand)

1. With neat sketch explain any three types of heat exchangers used in cryogenic systems. **(Understand)**
2. Explain any one pressure measurement system used in cryogenic applications. **(Understand)**

21ME7714	POWER PLANT ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Thermodynamics, Thermal Engineering

Objectives

- Providing an overview of Power Plants and detailing the role of Mechanical Engineers in their operation and maintenance

UNIT I	COAL BASED THERMAL POWER PLANTS	9

Rankine cycle - improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.

UNIT II	DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS	9

Otto, Diesel, Dual & Brayton Cycle - Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.

UNIT III	NUCLEAR POWER PLANTS	9

Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors : Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium-Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.

UNIT IV	POWER FROM RENEWABLE ENERGY	9

Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.

UNIT V	ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS	9

Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO.1 Illustrate the layout, construction and working of the components inside a thermal power plant.
CO.2 Illustrate the layout, construction and working of the components inside a Diesel, Gas and Combined cycle power plants.
CO.3 Illustrate the layout, construction and working of the components inside nuclear power plants.
CO.4 Illustrate the layout, construction and working of the components inside Renewable energy power plants.
CO.5 Estimate the costs of electrical energy production in different power plants and evaluate different pollution control measures in coal and nuclear power plants.

Text Books

1. Nag. P.K., "Power Plant Engineering", Third Edition, Tata McGraw – Hill Publishing Company Ltd., 2008

Reference Books

1. El-Wakil. M.M., "Power Plant Technology", Tata McGraw – Hill Publishing Company Ltd., 2010.
2. Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, "Power Plant Engineering", Second Edition, Standard Handbook of McGraw – Hill, 1998.

Web Resources

1. https://onlinecourses.nptel.ac.in/noc22_me73/preview (**POWER PLANT ENGINEERING)**
2. https://nptel.ac.in/courses/112101007 (**POWER PLANT ENGINEERING)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2			3	1							3
CO2	1	2	2			3	1							3
CO3	1	2	2			3	1							3
CO4	1	2	2			3	1							3
CO5	1	2	2			3	1							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Explain the layout, construction and working of the components inside a thermal power plant. (Understand)

1. Mention any four-equipment used for ash collection. **(Remember)**
2. Explain briefly on draught and its types and also discuss the different types of draught systems. **(Understand)**

COURSE OUTCOME 2: Illustrate the layout, construction and working of the components inside a Diesel, Gas and Combined cycle power plants. (Understand)

1. Define regenerator efficiency. **(Remember)**
2. Discuss briefly on integrated gasification combined cycle and its benefits. **(Understand)**

COURSE OUTCOME 3: Illustrate the layout, construction and working of the components inside nuclear power plants. (Understand)

1. Mention any four ways of Nuclear Power plant safety. **(Remember)**
2. Discuss the working principle and construction of Pressurized Water Reactor and Boiling Water Reactor. **(Understand)**

COURSE OUTCOME 4: Illustrate the layout, construction and working of the components inside Renewable energy power plants. (Understand)

1. Enlist the classification of fuel cell. **(Remember)**
2. Explain the principle of working and construction of solar power plant using suitable sketches. State their advantages, disadvantages and applications. **(Understand)**

COURSE OUTCOME 5: Estimate the costs of electrical energy production in different power plants and evaluate different pollution control measures in coal and nuclear power plants. (Apply)

1. A new factory having a minimum demand of 100 kW and a load factor of 25% is comparing two power supply agencies. i) Public supply tariff is Rs. 40 per kW of maximum demand plus 2 paise per kWh. Capital cost = Rs. 70,000; Interest and depreciation = 10% **(Understand)**
2. A hydro power plant is to be used as peak load plant at an annual load factor of 30%. The electrical energy obtained during the year is 750 × 105 kWh. Determine the maximum demand. If the plant capacity factor is 24% find reserve capacity of the plant. **(Apply)**

21ME7715	PRODUCTION PLANNING AND CONTROL	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

- To understand the various components and functions of production planning and control such as work study, product planning, process planning, production scheduling, Inventory Control.
- To know the recent trends like manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).

UNIT I	INTRODUCTION	9

Objectives and benefits of planning and control -Functions of production control-Types of production-job- batch and continuous-Product development and design-Marketing aspect - Functional aspects-Operational aspect-Durability and dependability aspect aesthetic aspect. Profit consideration-Standardization, Simplification & specialization- Break even analysis -Economics of a new design.

UNIT II	WORK STUDY	9

Method study, basic procedure-Selection-Recording of process - Critical analysis, Development - Implementation - Micro motion and memo motion study – work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

UNIT III	PRODUCT PLANNING AND PROCESS PLANNING	9

Product planning– Extending the original product information– Value analysis– Problems in lack of product planning– Process planning and routing– Pre requisite information needed for process planning– Steps in process planning– Quantity determination in batch production– Machine capacity, balancing– Analysis of process capabilities in a multiproduct system.

UNIT IV	PRODUCTION SCHEDULING	9

Production Control Systems– Loading and scheduling– Master Scheduling– Scheduling rules–Gantt charts– Perpetual loading– Basic scheduling problems – Line of balance – Flow production scheduling– Batch production scheduling– Product sequencing – Production Control systems – Periodic batch control– Material requirement planning kanban – Dispatching– Progress reporting and expediting– Manufacturing lead time– Techniques for aligning completion times and due dates.

UNIT V	INVENTORY CONTROL AND RECENT TRENDS IN PPC	9

Inventory control -Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system - Ordering cycle system-Determination of Economic order quantity and economic lot size- ABC analysis - Recorder procedure-Introduction to computer integrated production planning systems- elements of JUST IN TIME SYSTEMS-Fundamentals of MRP II.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive Exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline production planning and Control objectives, functions types and Economic analysis **(Understand)**
CO2: Conduct production planning and Control activities such as work study, Time study, Production study & Work sampling in industries. **(Apply)**
CO3: Summarize product planning and process planning concepts. **(Apply)**
CO4: Plan manufacturing requirements and scheduling in Production Control systems. **(Apply)**
CO5: Discuss about inventory control and the recent trends in PPC **(Understand)**

Text Books

1. James B.Dilworth, "Operations management – Design, Planning and Control for manufacturing and services" Mcgraw Hill International edition, 2019
2. Martand Telsang, "Industrial Engineering and Production Management", First edition, S.Chand and Company, 2000.

Reference Books

1. Jawad Akhtar , "Production Planning and Control with SAP Erp Hardcover", SAP Press; Second edition, 2016.
2. Ramachandran S, Devaraj R, Rasidhar L, "Production Planning And Control [Print Replica] Kindle Edition", AIRWALK PUBICATIONS; 1st edition, 2017.
3. Dr.V. Jayakumar, "Production Planning & Control", Lakshmi Publications 7th Edition 2016.
4. Mukhopadhyay, "Production Planning and Control: Text and Cases Paperback – 1", Prentice Hall India Learning Private Limited; 2nd edition, 2007.

Web Resources

1. https://nptel.ac.in/courses/112107143 (**PRODUCTION PLANNING AND CONTROL)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2				1					3		3	
CO2	2	2				1					3		3	
CO3	2	2	1			1					3		3	
CO4		2				1			2		3		3	
CO5		2			2	1			2		3		3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Outline production planning and Control objectives, functions types and Economic analysis (Understand)

1. Discuss in detail about the various functions of production planning and control. **(Understand)**
2. Enumerate the various aspects of Product design and development or Product analysis? **(Understand)**

COURSE OUTCOME 2: Conduct production planning and Control activities such as work study, Time study, Production study & Work sampling in industries. (Apply)

1. A work study was conducted in a machine shop. The data has been recorded as follows:

   Total number of observations = 160

   Hand controlled work = 14

   Machine controlled work = 106

   Machine idle time = 40

   Average performance rating = 80%

   No of parts produced = 36

   Allowance for personal needs and fatigue = 10%

   Duration of study = 3 days

   Available working hours/day =8 hrs

   Determine the standard time per piece **(Apply)**

2. Enumerate in detail the various charts in method study with illustration and neat sketch **(Understand)**

COURSE OUTCOME 3: Summarize product planning and process planning concepts. (Apply)

1. Enumerate various phases in the development of a new product **(Understand)**
2. As a product planning engineer, how do you analyze the process capacities in a multi-product system and how do you document the results. **(Apply)**

COURSE OUTCOME 4: Plan manufacturing requirements and scheduling in Production Control systems. (Apply)

1. The processing times (including setup time) and due dates for six jobs waiting to be processed at a work centre are given in the following table. Determine the sequence of jobs, the average flow time, average tardiness, and average number of jobs at work centre for each of these rules: **(Apply)**
   I. SPT
   II. EDD

Job	Processing time (days)	Due date (days from present time
A	2	7
B	8	16
C	4	4
D	10	17
E	5	15
F	12	18

2. Explain Gantt chart and Line of Balance. **(Understand)**

COURSE OUTCOME 5: Discuss about inventory control and the recent trends in PPC (Understand)

1. Explain with a block diagram, the basic elements of JIT manufacturing system **(Understand)**
2. What are the components of Material Requirement Planning (MRP)? **(Understand)**

21ME7716	LOW-COST AUTOMATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

CNC Machines and Automation

Objectives

- To give basic knowledge about automation
- To understand the basic hydraulics and pneumatics systems for automation
- To understand the assembly automation

UNIT I	AUTOMATION OF ASSEMBLY LINES	9

Concept of automation - mechanization and automation - Concept of automation in industry - mechanization and automation - classification, balancing of assembly line using available algorithms - Transfer line-monitoring system (TLMS) using Line Status - Line efficiency - Buffer stock Simulation in assembly line.

UNIT II	AUTOMATION USING HYDRAULIC SYSTEMS	9

Design aspects of various elements of hydraulic systems such as pumps, valves, filters, reservoirs, accumulators, actuators, intensifiers etc. - Selection of hydraulic fluid, practical case studied on hydraulic circuit design and performance analysis - Servo valves, electrohydraulic valves, proportional valves, and their applications.

UNIT III	AUTOMATION USING PNEUMATIC SYSTEMS	9

Pneumatic fundamentals - control elements, position and pressure sensing -logic circuits – switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods – step counter method. Pneumatic equipments - selection of components - design calculations -application - fault finding – hydro pneumatic circuits.

UNIT IV	AUTOMATION USING ELECTRONIC SYSTEMS	9

Introduction - various sensors – transducers - signal processing - servo systems - programming of microprocessors using 8085 instruction - programmable logic controllers.

UNIT V	ASSEMBLY AUTOMATION	9

Types and configurations - Parts delivery at workstations - Various vibratory and non-vibratory devices for feeding - hopper feeders, rotary disc feeder, centrifugal and orientation - Product design for automated assembly, Low-cost automation - Robotic circuits.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO.1 Summarize the concepts of automated assembly line in industries. **(Apply)**
CO.2 Design and performance analysis of low-cost automation using hydraulics system. **(Analyze)**
CO.3 Design and performance analysis of low-cost automation using pneumatic system. **(Analyze)**
CO.4 Design and performance analysis of low-cost automation using PLC system. **(Analyze)**
CO.5 Design and construct the Assembly system and part feeders. **(Analyze)**

Textbooks

1. Mikell P Groover, "Automation, Production System and Computer Integrated Manufacturing", Prentice Hall Publications, 4 th edition, 2016.
2. Kuo .B.C, "Automatic control systems", Prentice Hall India, New Delhi, 2016.

Reference Books

1. Anthony Esposito, "Fluid Power with applications", Prentice Hall international, 2013.
2. Peter Rohner, "Industrial hydraulic control", Wiley Edition, 2012.
3. Mujumdar.S.R, "Pneumatic System", Tata McGraw Hill 201.

Web Resources

1. https://nptel.ac.in/courses/108105063 (**Low-Cost Automation)**
2. https://nptel.ac.in/courses/112102011 (**Low-Cost Automation)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1								3	
CO2	3	2	2	1	1								3	
CO3	3	2	2	1	1								3	
CO4	3	2	2	1	1								3	
CO5	3	2	2	1	1								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Summarize the concepts of automated assembly line in industries (Apply)

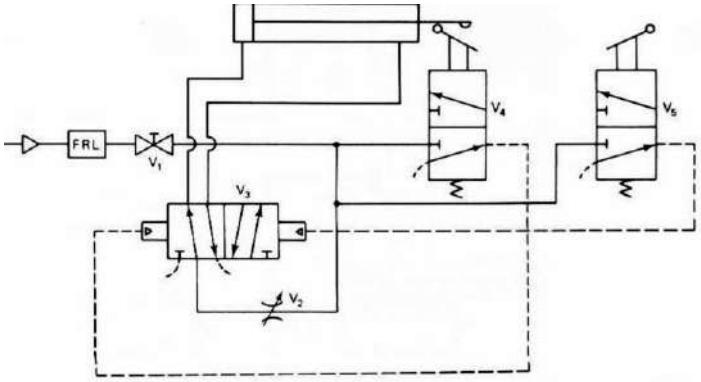
1. As the number of workstations on an automated production line increase, does line Efficiency (a) decrease, (b) increase, or (c) remain unaffected? **(Understand)**
2. An automated production line operates with an ideal cycle time of 35 sec. Line stops are characterized by a mean time between failures of 70 min and a mean time to repair of 8.0 min. What is the average hourly production rate? **(Apply)**

COURSE OUTCOME 2 Design and performance analysis of low-cost automation using hydraulics system. (Analyze)

1. Develop a hydraulic system to control the speed of speed of a hydraulic motor using flow control valve **(Apply)**
2. Compare the various performance factors of a gear, vane and piston pumps **(Analyze)**

COURSE OUTCOME 3 Design and performance analysis of low-cost automation using pneumatic system. (Analyze)

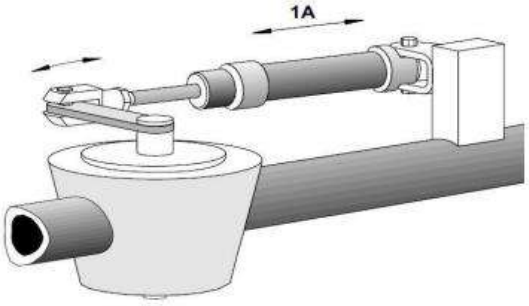
1. Consider the circuit, what happens to the cylinder when valve v_4 is depressed. **(Analyze)**



2. What undesirable consequence occurs when components of a pneumatics system such as pipes, and vales are undersized? **(Apply)**

COURSE OUTCOME 4 Design and performance analysis of low-cost automation using PLC system (Analyze)

1. Develop an electro pneumatic system for Opening/closing the flow in a pipeline. **(Analyze)**



2. Develop PLC programming for sequencing of cylinders to follow A+B+B-A- **(Apply)**

COURSE OUTCOME 5 Design and construct the Assembly system and part feeders. (Analyze)

1. Differentiate the part design features of automated assembly over manual assembly **(Analyze)**
2. Design a part feeder orientation system for Orienting a Cylindrical Parts whose Length is Greater than its Diameter. **(Apply)**

21ME7717	SUSTAINABILITY THROUGH GREEN MANUFACTURING SYSTEM	L	T	P	C
		3	0	0	3

Prerequisites for the course:

Nil

Objectives

- To provide an overview of the Sustainability through Green Manufacturing Systems; various methodologies and its application in improving the eco-efficiency.
- To learn about the commonly used Sustainable manufacturing tools such as Environmentally Conscious Quality Function Deployment (ECQFD) and Life Cycle Assessment (LCA).

UNIT I	INTRODUCTION	7

Concept of sustainability –– Definitions of sustainable - Environmental effects of design – Environmental damage – In efficient energy use – Design for recycling.

UNIT II	QUALITY FUNCTION DEPLOYMENT	11

Environmentally Conscious Quality Function Deployment (ECQFD), ECQFD Phase-I, ECQFD Phase-II, ECQFD Phase-III, ECQFD Phase-IV, Extended Producer Responsibility (EPR) policy

UNIT III	ENVIRONMENTAL LIFE CYCLE ASSESSMENT	9

Fundamentals of Life Cycle Assessment (LCA), LCA Phase-I, LCA Phase-II, LCA Phase-III, LCA Phase-IV, Life Cycle Cost Analysis- Material flow and cycles – Material recycling – Emission less manufacturing

UNIT IV	GREEN DESIGN METHOD	9

Environmental, Economic, Societal and Business indicators - Mass balance analysis – Green indicate – Design for disassembly design for recycle – Risk analysis – Material selection

UNIT V	SUSTAINABLE ECONOMIC ENVIRONMENT	9

Solar energy devices – wind energy resources – Full cost accounting methodology – Selection of natural friendly materials.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 10 MARKS CAT 2 10 MARKS	Descriptive type questions. Assignment	Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the basic Concepts & knowledge about sustainable manufacturing **(Understand)**

CO2: Identify and apply the QFD tools required for implementing sustainable manufacturing **(Apply)**

CO3: Conduct Life Cycle Assessment and cost analysis required for Green manufacturing **(Apply)**

CO4: Apply the design factors and considerations for sustainable manufacturing **(Apply)**

CO5: Conduct economic and environment analysis for sustainable green manufacturing systems **(Apply)**

Text Books

1. Rogers, P.P., Jalal, K.F. and Boyd, J.A., "An Introduction to Sustainable Development", Earth scan, London, 2018.

Reference Books

1. P. Lawn, "Sustainable Development Indicators in Ecological Economics", Edward Elgar Publishing Limited 2017.
2. S. Asefa, "The Economics of Sustainable Development", W.E. Upjohn Institute.2017.
3. G. Atkinson, S. Dietz, E. Neumayer, "Handbook of Sustainable Manufacturing". Edward Elgar Publishing Limited, 2017.

Web Resources

1. https://archive.nptel.ac.in/courses/112/104/112104225/# **(SUSTAINABILITY THROUGH GREEN MANUFACTURING SYSTEM)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1			1	3							3
CO2		2				1	3							3
CO3		2		2		1	3							3
CO4	2	2	1			1	3							3
CO5		2				1	3							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret the basic Concepts & knowledge about sustainable manufacturing (Understand)

1. Illustrate the sustainability in manufacturing system through green systems. **(Understand)**
2. Explain green manufacturing concepts in detail. **(Understand)**

COURSE OUTCOME 2: Identify and apply the QFD tools required for implementing sustainable manufacturing (Apply)

1. Explain the Extended Producer Responsibility (EPR) policy. **(Remember)**
2. Demonstrate the environmental impact of current manufacturing systems in detail with a case study. **(Apply)**

COURSE OUTCOME 3: Conduct Life Cycle Assessment and cost analysis required for Green manufacturing (Apply)

1. Examine how the life cycle assessment system should be in green manufacturing assessment. **(Apply)**
2. Enumerate the factors affecting the selection of material handling equipment in a production shop **(Apply)**

COURSE OUTCOME 4: Apply the design factors and considerations for sustainable manufacturing (Apply)

1. State the role of government, employer and workers for productivity improvement **(Understand)**
2. Apply the design factors in green manufacturing systems in detail with a case study. **(Apply)**

COURSE OUTCOME 5: Conduct economic and environment analysis for sustainable green manufacturing systems (Apply)

1. State the recycling techniques for different natural friendly materials **(Understand)**
2. Identify the practices, challenges and solutions of Full cost accounting methodology in developed countries. **(Apply)**

21ME7718	ADVANCED MANUFACTURING SYSTEM FOR MICROSYSTEM FABRICATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, Engineering Materials and Metallurgy

Objectives

- Learn about the precision machine tools
- Learn about the macro and micro components.
- Understand handling and operating of the precision machine tools.
- Learn to work with miniature models of existing machine tools/robots and other instruments.
- Learn metrology for micro system

UNIT I	INTRODUCTION TO MICROSYSTEMS	9

Design, and material selection, micro-actuators: hydraulic, pneumatic, electrostatic/ magnetic etc. for medical to general purpose applications. Micro-sensors based on Thermal, mechanical, electrical properties; micro-sensorsfor measurement of pressure, flow, temperature, inertia, force, acceleration, torque, vibration, and monitoring of manufacturing systems

UNIT II	FABRICATION PROCESSES FOR MICRO-SYSTEMS	9

Additive, subtractive, forming process, microsystems-Micro-pumps, micro- turbines, micro engines, micro-robot,and miniature biomedical devices.

UNIT III	INTRODUCTION TO PRECISION ENGINEERING	9

Machine tools, holding and handling devices, positioning fixtures for fabrication/ assembly of microsystems. Precision drives: inch worm motors, ultrasonic motors, stick- slip mechanism and other piezo-based devices.

UNIT IV	PRECISION MACHINING PROCESSES	9

Precision machining processes for macro components - Diamond turning, fixed and free abrasive processes, finishing processes.

UNIT V	METROLOGY FOR MICRO SYSTEMS	9

Metrology for micro systems - Surface integrity and its characterization.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive Exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive Exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline the concepts and applications of micro systems for advanced manufacturing **(Understand)**
CO2: Interpret the various fabrication processes of micro systems. **(Understand)**
CO3: Enumerate the machines, handling tools and fixtures for the assembly of microsystems. **(Understand)**
CO4: Summarize the precision manufacturing processes for macro components. **(Understand)**
CO5: Apply metrology for micro system **(Apply)**

Text Books

1. Davim, J. Paulo, ed. Micro fabrication and Precision Engineering: Research and Development. Woodhead Publishing, 2017
2. Gupta K, editor. Micro and Precision Manufacturing. Springer; 2017

Reference Books

1. Dornfeld, D., and Lee, D. E., Precision Manufacturing, 2008, Springer.
2. H. Nakazawa, Principles of Precision Engineering, 1994, Oxford University Press.
3. Whitehouse, D. J., Handbook of Surface Metrology, Institute of Physics Publishing, Philadelphia PA, 1994.
4. Murthy.R.L, —Precision Engineering in Manufacturing||, New Age International, New Delhi, 2005

Web Resources

5. https://archive.nptel.ac.in/courses/112/104/112104162/ (**Advanced Manufacturing System for Microsystem fabrication)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1		1	1							3	
CO2	3	1	1		1	1							3	
CO3	3	1	1		1	1							3	
CO4	3	1	1		1	1							3	
CO5	3	1	1		1	1							3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to outline the concepts and applications of micro systems for advanced manufacturing (Understand)

1. List out the application of MEMS in industries. **(Remember)**
2. Design a pressure sensor with a mems microsensors suitable for an engineering application. **(Understand)**

COURSE OUTCOME 2: Students will be able to Interpret the various fabrication processes of micro systems. (Understand)

1. Why electrostatic forces used to run micro motors rather than conventional electromagnetic forces. **(Understand)**
2. Explain the concept miniaturization of MEMS. Distinguish between micro actuator and micro accelerometer. **(Understand)**

COURSE OUTCOME 3: Students will be able to enumerate the machines, handling tools and fixtures for the assembly of microsystems. (Understand)

1. Interpret suitable MEMS fixtures for handling and assembly of microparts. **(Understand)**
2. Compare piezo motors and ultrasonic motors **(Understand)**

COURSE OUTCOME 4: Students will be able to summarize the precision manufacturing processes for macro components. (Understand)

1. What is the most accurate machining process? Why? **(Understand)**
2. Explain the working of diamond turning process? **(Understand)**

COURSE OUTCOME 5: Students will be able to apply metrology for micro system (Apply)

1. Select the gauge which is used to check the perfect threading in hole and explain the process and machine tool with neat sketch. **(Apply)**
2. Which parameter influence the surface integrity during rolling process and explain with neat sketch. **(Understand)**

21ME7719	ELECTRO AND ELECTROLESS PLATING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Chemistry

Objectives

- To give an overview of various methods of electro and electroless plating
- To study the various inspection methods in Coating process

UNIT I	FUNDAMENTALS OF ELECTROPLATING AND ELECTROLESS PLATING	9

Fundamental Principles – Electro Deposition of Copper, Nickel, Chromium, Zinc, T in and precious metals such as Gold and Silver – Surface Preparation for Electro Deposition – Electrolytic cleaning. Measurement of pH, Surface Tension, Conductivity, Throwing Power and Current Efficiency of Electro plating electrolytes**.**

UNIT II	TYPES OF PLATING	9

Brush Plating – Barrel Plating – Pulse Plating – Electro Forming – Electro Winning – Electro Refining and their applications.

UNIT III	COMPOSITE COATING	9

Need for composite coating – Principles of Alloy Deposition – Mechanism of Co-Deposition – Composite coating by Electrode position and Electroless Deposition for Nickel – Chromium, Nickel – Silicon Carbide, Nickel – PTFE – Alloys. Engineering applications of composite coating for Wear resistance and Tribological applications.

UNIT IV	INSPECTION AND TESTING OF ELECTRO/ELECTROLESS DEPOSITION	9

Testing of Electrodeposit for Thickness, Adhesion, Stress, Porosity, Hardness, Ductility and Solderability – Use of Hull Cell in Plating – Determination of Corrosion Rate by Polarization method.

UNIT V	EFFECT OF VARIOUS PARAMETERS AND DEFECTS IN ELECTRO /ELECTROLESS PLATING	9

Effect of current density, Particle size, Volume Fraction of Particle in the bath, Agitation, temperature, PH on deposition rate and volume fraction of Co-deposited particles. Defects in electro plating and electroless plating – Porosity, Poor adhesion, Hydrogen embrittlement etc –Causes and Remedies.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Summarize the fundamentals of Electro and Electroless plating **(Understand)**
CO2: Categorize different types of plating process **(Apply)**
CO3: Familiarize composite coating and its application in various fields **(Understand)**
CO4: Conduct different testing and inspection methods for electro and electroless deposition. **(Apply)**
CO5: Interpret the effects of various parameters and defects in electro and electroless plating **(Understand)**

Text Books

1. Lowenkeeim, F A – Model Electroplating – John Wiley & Sons, Inc., USA
2. N.Kanani, Electroplating and Electroless plating of copper and its alloys, ASM International, 2003

Reference Books

1. Metal Finishing Guide Book and Directory, USA
2. Electro Platers Process control Hand Book, Foulke and Grane
3. Glenn O. Mallory, Juan B. Hajdu, Electroless Plating, Fundamentals and Applications, American Electroplaters and Surface Finishers Society, 2010

Web Resources

1. NPTEL :: Mechanical Engineering - Technology of Surface Coating (**Electro and Electroless plating)**
2. https://nptel.ac.in/courses/112107248 (**Electro and Electroless plating)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2				1	2					1		3
CO2	3	2				1	2					1		3
CO3	3	2				1	2					1		3
CO4	3	2				1	2					1		3
CO5	3	2				1	2					1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to Understand the fundamentals of Electro and Electroless plating (Understand)

1. Explain briefly the principle and process of electrodeposition in Silver. **(Understand)**
2. Discuss in detail the electrolytic cleaning process. **(Understand)**

COURSE OUTCOME 2: Students will be able to Categorize different types of plating process. (Apply)

1. Distinguish between Barrel plating and blush plating. **(Understand)**
2. Demonstrate the application of electroforming in electroplating process with suitable example? **(Apply)**

COURSE OUTCOME 3: Students will be able to Familiarize composite coating and its application in various fields (Understand)

1. Explain the process of Electrodeposition of Nickel and Chromium by composite coating. **(Understand)**
2. Briefly explain the applications of composite coating in wear and tribological applications. **(Understand)**

COURSE OUTCOME 4: Students will be able to Utilize different testing and inspection methods for predicting various parameters of electrodeposit (Apply)

1. Determine the corrosion rate of pure aluminium metal by polarization method. **(Apply)**
2. Write a note on the testing of mechanical properties of electrodeposit. **(Understand)**

COURSE OUTCOME 5: Students will be able to Interpret the effects of various parameters in electro and electroless plating (Understand)

1. Explain the defects in electroplating and electroless plating along with its causes and remedies **(Understand)**
2. Write a short note on Hydrogen Embrittlement. **(Understand)**

21ME7720	ENERGY CONVERSION IN INDUSTRIES	L	T	P	C
		3	0	0	3

Prerequisites for the course:

Nil

Objectives

- Comprehend the techniques available for energy conservation in Industries utilities
- Know the techniques adopted for performance evaluation of thermal utilities
- Learn and appreciate the working principle employed in VCRS and VAM systems
- List the parameters considered in electricity billing and the losses associated with a motor

UNIT I	BOILERS	11

Types-Performances evaluation via direct and indirect method–energy conservation avenues. Properties of steam – Assessment of steam distribution losses – Steam trapping –Condensate and flash steam recovery system – Opportunities for energy saving in steam consumption systems

UNIT II	FURNACES AND THERMIC FLUID HEATERS	7

Furnaces and Thermic Fluid Heaters: method-Energy conservation avenues-Refractory & insulation-Types & its application

UNIT III	HVAC AND WASTE HEAT RECOVERY	9

VCRS – performance assessment – energy savings opportunities – VAM: working, types, benefits, comparison with vapor compression system. WHR systems: Classification–Benefits- Commercial waste heat recovery devices: recuperator, regenerator, heat pipe, heat exchangers (Plate, Shell & Tube), heat pumps, thermo compressor. CHP– Poly generation

UNIT IV	ELECTRICAL SYSTEMS AND INDUCTION MOTORS	9

Electricity billing – Demand side management – Power factor improvement transformer losses – Harmonics induction Motors: Types – Losses – performance assessment adopting direct and indirect method-Factors affecting motor performance-energy efficient motors

UNIT V	ENERGY CONSERVATION IN ELECTRICAL UTILITIES	9

Performance assessment and energy conservation avenues in: fans-blowers–pumps–air compressors-illumination systems –cooling towers

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the methods for energy saving in steam consumption systems. **(Understand)**
CO2: Discuss about furnaces and Thermal fluid heaters, its type and application. **(Understand)**
CO3: Enumerate the working principle employed in VCRS and VAM systems **(Understand)**
CO4: Identify the parameters considered in electricity billing and the losses associated with a motor **(Apply)**
CO5: Comprehend the techniques available for energy conservation in electrical utilities **(Apply)**

Text Books

1. L.C.Witte, P.S.Schmidt, D.R.Brown, "Industrial Energy Management and Utilisation" Hemisphere Publication, Washington, 2016

Reference Books

1. S.C . Bhattia "Industrial energy conservation" Woodhead publishing India 2018.
2. W.R. Murphy and G. McKay "Energy Management" Butter worths, London 2017

Web Resources

1. https://onlinecourses.nptel.ac.in/noc20_mm20/preview **(Energy Conversion in Industries)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3		2	1			2							3
CO2	3		2	1			2							3
CO3	3		3	1			2							3
CO4	3	1	2	1			2							3
CO5	3	1	3	1			3							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Interpret the methods for energy saving in steam consumption systems. (Understand)

1. Explain the Assessment of steam distribution losses **(Understand)**
2. Enumerate Types & Performances evaluation via direct and indirect method energy conservation **(Remember)**

COURSE OUTCOME 2: Discuss about furnaces and Thermal fluid heaters, its type and application. (Understand)

1. Explain the Furnaces and Thermic Fluid Heaters. **(Remember)**
2. Describe the Insulation and Refractory method with its types and application to new module of industries **(Understand)**

COURSE OUTCOME 3: Enumerate the working principle employed in VCRS and VAM systems (Understand)

1. Explain the Commercial waste heat recovery devices to process in industries **(Understand)**
2. Outline the classifications of WHR systems with suitable diagrams **(Understand)**

COURSE OUTCOME 4: Identify the parameters considered in electricity billing and the losses associated with a motor (Apply)

1. Obtain the Factors affecting motor performance & energy efficient motors **(Understand)**
2. Identify the Harmonics induction Motors with its Types, Losses, & performance assessment adopting direct and indirect method **(Apply)**

COURSE OUTCOME 5: Comprehend the techniques available for energy conservation in electrical utilities (Apply)

1. Case study the cooling towers in industries which can be alternate to use in any other places **(Apply)**
2. Identify the practices, challenges and solutions of performance assessment Industries methodology in developed countries. **(Apply)**

PROFESSIONAL ELECTIVE - VI

21ME7721	Design of Jigs and Fixtures	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, Design of Machine Elements, Design of Transmission Systems

Objectives

- Understand the importance of tool design for productive manufacturing and the basic procedure of tool design, drafting of tool drawing etc.,
- Bring in the required properties in the tool material by proper selection and heat treatment appropriate to the cutting process adopted

UNIT I	FUNDAMENTALS OF JIGS AND FIXTURES	9

Introduction – Difference between Jigs and Fixtures – Advantages of jigs and Fixtures – Economy and cost - Elements of Jigs and Fixtures – Fool Proofing – Materials used in Jigs and Fixtures - Degrees of Freedom – 12 degrees of freedom – 6 point location principle – 3-2-1 principle of location – Essential features of Jigs and Fixtures – General Design Principles – Design steps – Common defects in Jigs design.

UNIT II	PRINCIPLES OF LOCATION AND CLAMPING	9

Principles of location – location point – types of locators – pins and studs – V block – cup and cone location points – adjustable locating points – special adjustable stops – location from finished holes in the work – Diamond pin locator – Cam operated 'V' locator – Quick action 'V ' locator - Six point location of a three legged object – Location of a cylinder on a v-block.

Principles of clamping – types of clamping – lever clamp – hinged clamp – two way clamp – swinging clamp – wedge clamp – eccentric clamping arrangement – quick action clamp – Cam operated clamp – quarter turn screw – Toggle clamp – Pneumatic and hydraulic clamps – Washers - 'C' washer – spherical and flat washers.

UNIT III	JIGS BUSHINGS	9

Materials for jig bushing - press fit bushing – Fixed renewable bushing – slip renewable bushing – liner bushing – screw bushing – miscellaneous type of drill bushings – bushing specifications.

UNIT IV	DRILL JIGS	9

Open drill jig – plate drill jig – template drill jig – channel drill jig – turn over drill jig – angle plate drill jig – closed box drill jig – leaf drill jig – post jig – indexing drill jig – universal drill jig - design of template and leaf jig.

UNIT V	PRINCIPLE OF FIXTURE DESIGN	9

Introduction - principles of fixture design – element of fixtures – design consideration of locators and clamps for fixtures – types of fixtures – design of turning fixtures – mandrels – type of mandrels – boring fixtures – milling fixtures – essentials of milling fixtures – method of locating milling fixtures with respect to cutter position – grinding fixtures – surface grinding and cylindrical grinding fixtures – broaching fixtures – internal and external broaching fixtures – welding fixtures.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	**1. Descriptive Questions**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the fundamentals of Jigs and fixtures **(Understand)**
CO2: Discuss the locating and clamping of Jigs and fixtures **(Understand)**
CO3: Recognize the mounting of Jigs and Fixtures on machine tool through Jigs Bushings **(Understand)**
CO4: Recognize the mounting of Jigs and Fixtures on machine tool through drill jigs **(Understand)**
CO5: Apply the design procedure for fixtures. **(Apply)**

Text Books

5. P. H Josh, Jigs and Fixtures, 3rd edition, TMH, Newdelhi, July 2017
6. Kempster M. H. A. - 'An Introduction to Jig and Tool Design' - Viva Books Pvt. Ltd. – 2002

Reference Books

6. John G. Nee - 'Fundamentals of Tool Design' - Society of Manufacturing - 1998 - 4th Edition
7. Production Techno1ogy Hand Book' - HMT - Tata McGraw Hill
8. E. K. Henriksen – 'Jig and Fixture Design Manual' - Industrial Press, New York - 1973
9. Donaldson, Lecain and Goold – 'Tool Design' - McGraw Hill, New York - 1976

Web Resources

1. https://archive.nptel.ac.in/courses/112/105/112105127/ /**Design of Jigs and Fixtures**
2. http://www.dragonworks.info/Metalworking/Milling%20Fixtures/Milling%20fixtures.htm / **Design of Jigs and Fixtures**
3. https://www.tvsts.com/jigsandfixtures / **Design of Jigs and Fixtures**

CO Vs PO Mapping and CO Vs PSO Mapping

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CO4	3	1	2	1									3	
CO5	3	1	2	1									3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to interpret the fundamentals of Jigs and fixtures (Understand)

1. Identify the differences between jig and fixtures **(Understand)**
2. Explain possible freedom of movement o job in a jig, fixture **(Understand)**

COURSE OUTCOME 2: Students will be able to discuss locating and clamping of Jigs and fixtures (Understand)

1. Identify locating of work piece in a jig, fixture **(Understand)**
2. list the different types of fixtures **(Understand)**

COURSE OUTCOME 3: Students will be able to recognize the mounting of Jigs and Fixtures on machine tool through Jigs Bushings (Understand)

1. Explain mounting of jig on a machine tool **(Understand)**
2. Describe the specifications of bushing **(Understand)**

COURSE OUTCOME 4: Students will be able to recognize the mounting of Jigs and Fixtures on machine tool through drill jigs (Understand)

1. Explain the indexing of drill jigs **(Understand)**
2. Describe the mounting of fixtures on the machine tool **(Understand)**

COURSE OUTCOME 5: Students will be able to apply the design procedure for fixtures (Apply)

1. Develop the milling, welding, fixtures and grinding fixtures **(Apply)**
2. Design procedure of jigs and fixtures **(Apply)**

21ME7722	FAILURE ANALYSIS AND NDT TECHNIQUES	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology, Engineering materials and Metallurgy

Objectives

- To introduce need and scope of failure analysis and fundamental sources of failures.
- To learn about non-destructive testing and basic principles of visual inspection.
- To study about magnetic testing and principles, techniques.
- To learn the principle of radiography testing and its inspection techniques and methods.
- To study the acoustic testing principle and technique and instrumentation

UNIT I	INTRODUCTION	9

Introduction and need and scope of failure analysis. Engineering Disasters and understanding failure analysis. Fundamental sources of failures. Deficient design. Improper Manufacturing & Assembly. Tree diagram and FMEA.

UNIT II	VISUAL INSPECTION	9

Introduction to Non-Destructive Testing: An Introduction, Visual examination, Basic Principle, The Eye, Optical aids used for visual inspection, Applications. Liquid Penetrant Testing: Physical principles, Procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods, Sensitivity, Applications, Limitations and Standards

UNIT III	MAGNETIC TESTING	9

Magnetic Particle Testing, Eddy Current Testing: Magnetism-basic definitions and principle of. magnetic particle testing, Magnetizing techniques, induced current flow, Procedure used for testing a component, Equipment Used for magnetic particle testing, Sensitivity, Limitations. Eddy Current Testing: Principles, Instrumentation for eddy current testing Techniques. Sensitivity Advanced Eddy Current Test Methods, Applications, Limitations.

UNIT IV	RADIOGRAPHY TESTING	9

Radiography, Ultrasonic Testing: Basic principle, Electromagnetic radiation, Sources, Radiation attenuation in the specimen. Effect of radiation in film, Radiographic imaging, Inspection techniques, Applications of radiographic inspection, Limitations, Safety in Industrial Radiography, Standards, Neutron radiography. Ultrasonic Testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for Normal Beam Inspection, Techniques for Angle Beam Inspection, Flaw characterization techniques, Ultrasonic flaw detection equipment, Modes of Display, Immersion Testing, Applications of Ultrasonic Testing, Advantages, Limitations

UNIT V	ACOUSTIC TESTING	9

Acoustic Emission Testing: Principle of Acoustic Emission Testing, Technique, Instrumentation, Sensitivity, Applications, Standards. Thermograph: Basic Principles, Detectors and Equipment, Techniques, Applications, Codes and Standards. In Situ Metallographic Examination: Approach to the Selection of Site for Metallographic examination, Replication process, Significance of Microstructure observation, Decision making, Applications, Codes and Standards.(digital signal process)

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	**1. Descriptive Questions**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Discuss the need and scope of failure analysis and fundamental sources of failures. **(Understand)**
CO2: Interpret about non-destructive testing and basic principles of visual inspection. **(Understand)**
CO3: Conduct magnetic particle testing and eddy current testing with different procedures. **(Apply)**
CO4: Conduct radiography testing and ultrasonic testing with different procedures. **(Apply)**
CO5: Characterize the acoustic testing, techniques and instrumentation. **(Apply)**

Text Books

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu Practical Non-Destructive Testing, Narosa Publishing House, 2014
2. Ravi Prakash, Non-Destructive Testing Techniques, 1st revised edition, New Age InternationalPublishers, 2012

Reference Books

1. ASM Metals Handbook,Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 2021, Volume-17.
2. Paul E Mix, Introduction to Non-destructive testing: a training guide, Wiley, 2nd Edition NewJersey, 2005
3. 5. J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-HillEducation, 2nd edition (2011).

Web Resources

1. https://archive.nptel.ac.in/courses/112/107/112107241/ **FAILURE ANALYSIS AND NDT TECHNIQUES**
2. https://onlinecourses.nptel.ac.in/noc21_me14/preview / **FAILURE ANALYSIS AND NDT TECHNIQUES**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	3	1	1	1						1	3	
CO2	1	2	3	1	1	1						1	3	
CO3	1	2	3	1	1	1						1	3	
CO4	1	2	3	1	1	1						1	3	
CO5	1	2	3	1	1	1						1	3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to discuss the need and scope of failure analysis and fundamental sources of failures (Understand)

1. Illustrate about discontinuities. Explain various types of discontinuities with examples **(Understand)**
2. Compare and contrast the fundamental sources of failures with examples **(Understand)**

COURSE OUTCOME 2: Students will be able to interpret about non-destructive testing and basic principles of visual inspection. (Understand)

1. Illustrate the methodologies used to inspect the gear tooth profile and explain details of visual or optical inspection procedure. **(Understand)**
2. Compare and contrast the principles, characteristics detected, advantages, limitations and applications of visual inspection, liquid penetrant testing methods. **(Understand)**

COURSE OUTCOME 3: Students will be able to conduct magnetic particle testing and eddy current testing with different procedures (Apply)

1. Elucidate the procedure used for testing a component through Magnetic Particle Testing method and briefly explain its applications. **(Understand)**
2. Construct the block diagram of Eddy current testing method and explain its working principle. **(Apply)**

COURSE OUTCOME 4: Students will be able to conduct radiography testing and ultrasonic testing with different procedures. (Apply)

1. Construct the black diagram of X-ray Radiography with a neat sketch and state its advantages, limitations and applications. **(Apply)**
2. Describe in details about the working principle of Pulse echo, Transmission and Phased Array techniques with a neat sketch. **(Understand)**

COURSE OUTCOME 5: Students will be able to characterize the acoustic testing, techniques and instrumentation. (Apply)

1. Illustrate the working principle of Acoustic Emission testing method with a neat sketch. **(Understand)**
2. Demonstrate and explain the simple experimental test setup for Acoustic Emission testing. **(Apply)**

21ME7723	ENERGY CONSERVATION AND WASTE HEAT RECOVERY	L	T	P	C
		3	0	0	3

Prerequisites for the course

Thermal Engineering, Heat and Mass Transfer

Objectives

- To impart knowledge on the various methods of Energy Conservation, Energy policies and Waste heat recovery from thermal systems.

UNIT I	INTRODUCTION	9

Energy Scenario – world and India. Energy Resources availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries – an overview. Energy conservation and energy efficiency – needs and advantages, Energy strategy for the future, Energy Conservation Act.

UNIT II	ENERGY POLICIES	9

National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programs, Basic concept of Input – Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy – Carbon Trading – Renewable Energy Certification – CDM

UNIT III	WASTE HEAT RECOVERY IN THERMAL UTILITIES AND SYSTEMS	9

Election criteria for waste heat recovery technologies – recuperators – Regenerators – Economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems, identifying opportunities for energy savings – steam systems, Cogeneration and HVAC systems.

UNIT IV	ENERGY CONSERVATION AND AUDITING	9

Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel & energy substitution. Energy auditing – types, methodologies, barriers. Energy audit instruments; Duties and responsibilities of energy managers and auditors – Energy audit questionnaire.

UNIT V	ENERGY MANAGEMENT	9

Organizational background desired for energy management persuasion, motivation, publicity role, industrial energy management systems. Energy monitoring and targeting – Elements, data, information analysis and techniques – Energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS). Economics of various energy conservation schemes – Energy policy and energy labeling

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	**1. Descriptive Questions**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1. Summarize the present energy scenario and interpret the need for energy conservation measures. **(Understand)**

CO2. Familiarize with various energy policies (National and International) & standards. **(Understand)**

CO3. Comprehend the concepts of waste heat recovery system and perform energy analysis. **(Apply)**

CO4. Conduct energy audit and optimize energy requirements. **(Apply)**

CO5. Interpret the economics of energy conservation schemes in industrial energy management systems. **(Understand)**

Text Books

1. Chirla Chandra Sekhara Reddy, Gade Pandu Rangaiah, Waste Heat Recovery: Principles and Industrial Applications, World Scientific Publishing Co Pte Ltd, 2022.
2. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press

Reference Books

1. Steve Doty, Wayne C. Turner "Energy Management Handbook", 7th Edition, the Fairmont Press, Inc., (2013)
2. F Kreith, D.Y.Goswami, "Energy management and conservation handbook", CRC Press, (2017)
3. Industrial Energy Conservation Manuals, MIT Press, Mass, (2007)
4. YP Abbi and Shashank Jain. "Handbook on Energy Audit and Environment Management", TERI Publications, (2006)
5. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press

Web Resources

1. www.energymanagertraining.com/ **ENERGY CONSERVATION AND WASTE HEAT RECOVERY**
2. www.classcentral.com/ **ENERGY CONSERVATION AND WASTE HEAT RECOVERY**
3. https://nptel.ac.in/courses/ **ENERGY CONSERVATION AND WASTE HEAT RECOVERY**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1				2	3					1		3
CO2	1	1				2	3					1		3
CO3	2	1				2	3					1		3
CO4	1	2		2	1	2						1		3
CO5	1	2		2	1	2						1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to summarize the present energy scenario and interpret the need for energy conservation measures (Understand)

1. What are the energy-saving options available for office buildings? **(Understand)**
2. How can the construction industry promote energy conservation? **(Understand)**

COURSE OUTCOME 2: Students will be able to familiarize with various energy policies (National and International) & standards. (Understand)

1. How are thermic fluid heaters utilized in waste heat recovery? **(Understand)**
2. How can opportunities for energy savings be identified in waste heat recovery systems? **(Understand)**

COURSE OUTCOME 3: Students will be able to comprehend the concepts of waste heat recovery system and perform energy analysis (Apply)

1. Develop the design considerations which are important for waste heat recovery systems? **(Apply)**
2. How do fluidized bed heat exchangers contribute to waste heat recovery? **(Understand)**

COURSE OUTCOME 4: Students will be able to conduct energy audit and optimize energy requirements. (Apply)

1. What is the importance of matching energy use to requirement in energy audits? **(Understand)**
2. Optimize input energy requirements in energy audits? **(Apply)**

COURSE OUTCOME 5: Students will be able to interpret the economics of energy conservation schemes in industrial energy management systems. (Understand)

1. What organizational background is desirable for energy management persuasion and motivation? **(Understand)**
2. What techniques are used in analyzing energy consumption, production, and cumulative sum of differences (CUSUM)? **(Understand)**

21ME7724	SIMULATION OF IC ENGINES	L	T	P	C
		3	0	0	3

Prerequisites for the course

Engineering Thermodynamics, Thermal Engineering

Objectives

- The basic engine parameters of significance for the operation of an engine and the effect of varying them on performance and fuel economy.
- Simulate engine operation through the use of ideal air cycle models, ideal air exchange models, fuel air processes with chemical equilibrium and time dependent models that include heat transfer and time dependent combustion.
- Use simple models to describe the combustion processes in spark ignition and diesel engines

UNIT I	First and second laws of thermodynamics	9

First and second laws of thermodynamics – Estimation of properties of gas mixtures - Structure of engine models – Open and closed cycle models - Cycle studies

UNIT II	Chemical Reactions and Heat Transfer in IC Engine	9

Chemical Reactions, First law application to combustion, Heat of combustion – Adiabatic flame temperature, Chemical Equilibrium and calculation of equilibrium composition - Heat transfer in engines – Heat transfer models for engines.

UNIT III	Combustion in SI engines	9

Combustion in SI engines, Flame propagation and velocity, Single zone models – Multi zone models – Mass burning rate, Turbulence models – One dimensional models – Chemical kinetics modeling – Multidimensional models.

UNIT IV	Combustion in CI engines	9

Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model – Whitehouse way model, Two zone models - Multizone models- Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model – Introduction to Multidimensional and spray modelling

UNIT V	Thermodynamics of the gas exchange process	9

Thermodynamics of the gas exchange process - Flows in engine manifolds – One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines – Isothermal and non-isothermal models.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive Exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret about the first and second law of thermodynamics and properties of gas mixtures. **(Understand)**
CO2: Summarize the chemical reactions and heat transfer in IC Engine. **(Understand)**
CO3: Demonstrate the models to describe the combustion of SI Engine. **(Apply)**
CO4: Demonstrate the models to describe the combustion of CI Engine. **(Apply)**
CO5: Discuss about the thermodynamics of gas exchange process **(Understand)**

Text Books

1. Simulation and Optimization of Internal Combustion Engines", SAE International, 2021
2. 1D and Multi-D Modeling Techniques for IC Engine Simulation", SAE International, 2020

Reference Books

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002.
4. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.
5. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

Web Resources

1. https://archive.nptel.ac.in/courses/112/107/112107214/ **SIMULATION OF IC ENGINE**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1												2
CO2	2	1	1	1	3	1								2
CO3	2	1	1	1	3	1								3
CO4	2	1	1	1	3	1								3
CO5	2	1	1	1	3	1								3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to interpret about the first and second law of thermodynamics and properties of gas mixtures. (Understand)

1. Sate first and second law of thermodynamics **(Understand)**

2. Difference between open loop and closed loop systems **(Understand)**

COURSE OUTCOME 2: Students will be able to summarize the chemical reactions and heat transfer in IC Engine. (Understand)

1. Describe how equilibrium constant can be used to calculate the composition of an equilibrium mixture. **(Understand)**

2. What are the different types of heat transfer in an engine? **(Understand)**

COURSE OUTCOME 3: Students will be able to demonstrate the models to describe the combustion of SI Engine. (Apply)

1. Develop the practice turbulence model for SI engine **(Apply)**
2. Interpret the chemical kinetics modelling and its principles **(Understand)**

COURSE OUTCOME 4: Students will be able to demonstrate the models to describe the combustion of CI Engine (Apply)

1. Discuss the single zone and multizone model of combustion in SI engine **(Understand)**
2. Develop the practice model for Watson's theory of caring **(Apply)**

COURSE OUTCOME 5: Students will be able to discuss about the thermodynamics of gas exchange process (Understand)

1. Distinguish between isothermal and non-isothermal models **(Understand)**
2. Interpret the process of gas exchange in IC engine **(Understand)**

21ME7725	Supply chain Management and Logistics	L	T	P	C
		3	0	0	3

Prerequisites for the course

NIL

Objectives

The course provides insight on the fundamentals, tools and techniques of supply chain and logistic networks

UNIT I	Introduction	9

Role of Logistics and Supply Chain Management: Scope and Importance- Evolution of Supply Chain - Decision Phases in Supply Chain - Competitive and Supply Chain Strategies – Drivers of Supply Chain Performance and Obstacles.

UNIT II	Supply Chain Network Design	9

Role of Distribution in Supply Chain – Factors Influencing Distribution Network Design – Design Options for Distribution Network Distribution Network in Practice-Role of Network Design in Supply Chain – Framework for Network Decisions.

UNIT III	Logistics In Supply Chain	9

Role of transportation in supply chain – factors affecting transportations decision – Design option for transportation network – Tailored transportation – Routing and scheduling in transportation.

UNIT IV	Sourcing and Coordination In Supply Chain	9

Role of sourcing supply chain supplier selection assessment and contracts- Design collaboration - sourcing planning and analysis - supply chain co-ordination - Bull whip effect – Effect of lack of co-ordination in supply chain and obstacles – Building strategic partnerships and trust within a supply chain.

UNIT V	Supply chain and Information Technology (IT)	9

The role IT in supply chain- The supply chain IT frame work - Customer Relationship Management – Internal supply chain management – supplier relationship management – future of IT in supply chain – E-Business in supply chain.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Discuss the building blocks, functions and drivers of supply chain management **(Understand)**
CO2: Summarize the factors involved in network design **(Understand)**
CO3: Illustrate the role of logistics in industrial supply chain **(Apply)**
CO4: Interpret the role of coordination in supply chain **(Understand)**
CO5: Discuss the necessity of IT in different cases of supply chain **(Understand)**

Text Books

1. Sunil Chopra, Peter Meindl and Kalra, "Supply Chain Management, Strategy, Planning, and Operation", Pearson Education, 7 th edition 2018.

Reference Books

1. Simchi – Levi Davi, "Designing and Managing the Supply Chain", Tata McGraw Hill Publishing Company Ltd, New Delhi, 3rd edition 2019.
2. Srinivasan, G, "Quantitative Models in Operations and Supply Chain Management", Prentice Hall India Pvt Limited, India, 2018.

Web Resources

1. https://archive.nptel.ac.in/courses/112/106/112106249/ **Supply chain management and logistics**
2. https://archive.nptel.ac.in/courses/110/106/110106045/ **Supply chain management and logistics**
3. https://archive.nptel.ac.in/courses/110/108/110108056/ **Supply chain management and logistics**
4. https://archive.nptel.ac.in/courses/110/107/110107074/ **Supply chain management and logistics**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3	2		1					1			3	
CO2	1	3	2		1					1			3	
CO3	1	3	2		1					1			3	
CO4	1	3	2		1					1			3	
CO5	1	3	2		1					1			3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Discuss the building blocks, functions and drivers of supply chain management (Understand)

1. Discuss in detail about decision phases in supply chain. **(Understand)**
2. Interpret the drivers of supply chain performance. **(Understand)**

COURSE OUTCOME 2: Summarize the factors involved in network design (Understand)

1. Summarize the framework of structuring drivers. **(Understand)**
2. Discuss in detail about factors influencing distribution network design **(Understand)**

COURSE OUTCOME 3: Illustrate the role of logistics in industrial supply chain (Apply)

1. Show in detail about factors affecting transportations decision. **(Understand)**
2. Determine in detail about tailored transportation. **(Apply)**

COURSE OUTCOME 4: Interpret the role of coordination in supply chain. (Understand)

1. Show in detail about supplier selection assessment and contracts. **(Understand)**
2. Discuss in detail about sourcing planning and analysis **(Understand)**

COURSE OUTCOME 5: Discuss the necessity of IT in different cases of supply chain. (Understand)

1. Summarize the supply chain IT frame work. **(Understand)**
2. Discuss in detail about E-Business in supply chain. **(Understand)**

21ME7726	OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

Prerequisites for the course

Matrices and Advanced Calculus, Partial Differential Equation and Application of Fourier Series, Probability and Statistical Analysis

Objectives

- To learn Selecting the constraints on the availability of resources and developing a model and rendering an optimal solution for the given circumstances.
- To study Appraising the challenges in the transportation and production problems and furnishing a rational solution to maximize the benefits.
- To learn the network models and project management problems and rendering an optimal solution for the given circumstances.
- To learn Planning the purchase/ manufacturing policies, managing the spares/ stocks and meeting the customer demands.
- To Analysing the queue discipline and exploring the avenues for better customer service.

UNIT I	Linear Models	9

Introduction - Phases of OR Study – Formation of Linear Programming Problem (LPP) - Canonical form of LPP - Solutions to LPP - Graphical Solution - Simplex Algorithm - Artificial Variables Technique - Big M Method.

UNIT II	Transportation Problems, Assignment Problems and Sequencing Problems	9

Transportation Problems: Mathematical Formulation-Basic Feasible Solutions – North-West Corner (NWC) – Least Cost Method (LCM) – Vogels Approximation Method (VAM). Assignment Problems: Mathematical Formulation –Hungarian Algorithm. Sequencing Problems:1 Jobs N Machine, N Jobs 1 Machine, N Jobs 2 Machine, N Jobs 3 Machine, N Jobs M Machine and 2 Jobs N Machine Problems.

UNIT III	Network Models and Project Management	9

Network Models: Shortest Route - Minimal Spanning Tree - Maximum Flow Models. Project Management: Construction of Networks-Activity and Event Based Diagrams –Program Evaluation and Review Technique (PERT) & Critical Path Method (CPM) Problems – Cost Analysis.

UNIT IV	Inventory Models	9

Types of Inventory – Economic Order Quantity (EOQ) - Deterministic Inventory Models - Price Break Problems - Stochastic Inventory Models - Multi Item Deterministic Models - Selective Inventory Control Techniques.

UNIT V	Queuing Models and Replacement Models	9

Queuing Models: Queuing Systems and Structures - Notations - Parameter - Single Server and Multiserver Models. Replacement Models: Replacement of Items Due to Deterioration with and Without Time Value of Money - Individual and Group Replacement Policy

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO.1 Formulate and solve linear programming problems. **(Apply)**
CO.2 Develop solutions to transportation, assignment, and sequencing problems. **(Apply)**
CO.3 Construct networks and analyse optimality for various applications. **(Analyse)**
CO.4 Identify inventory models and solve for optimality. **(Apply)**
CO.5 Analyse queuing characteristics and compute the optimum replacement period for capital equipment and items that fail suddenly **(Analyse)**

Text Books

1. Gupta P.K. & Hira D.S., "Operations Research", 7th Edition, S. Chand Publishing, New Delhi, 2014.

Reference Books

1. Taha & Hamdy A., "Operation Research: An Introduction", 10th Edition, Pearson Education, Chennai, 2017.
2. Hiller Frederick S. , Lieberman Gerald J., Bodhibrata Nag & Preetam Basu, "Introduction to Operations Research", 10th Edition, McGraw-Hill Education, Bengaluru, 2017.
3. Vohra N.D., "Quantitative Techniques in Management", 5th Edition, McGraw Hill Education, Noida, 2017.

Web Resources

1. https://archive.nptel.ac.in/courses/112/106/112106134 /**Operations Research**
2. https://onlinecourses.nptel.ac.in/noc22_ma48/preview / **Operations Research**
3. https://archive.nptel.ac.in/courses/112/106/112106131 / **Operations Research**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2											3	
CO 2	3	2	1										3	
CO 3	1	1	1	1							3		3	
CO 4	1	1	3	1									3	
CO 5	1	1	3	2									3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Formulate and solve linear programming problems. (Apply)

1. How does the formation of a Linear Programming Problem (LPP) differ from other optimization problems? **(Understand)**
2. Minimize Z=3x1+2x2 solve by graphically.
   Subject to 5x1+x2≥10
   $x_1+x_2\geq 6$
   $x_1+4x_2\geq 12$
   $X_1,X_2,\geq 0$ **(Apply)**

COURSE OUTCOME 2: Develop solutions to transportation, assignment, and sequencing problems. (Apply)

1. Obtain an initial basic feasible solution to the following transportation problem using the North-West Corner Rule. **(Apply)**

	D_1	D_2	D_3	D_4	Supplies
S_1	20	25	28	31	200
S_2	32	28	32	41	180
S_3	18	35	24	32	110
Demands	150	40	180	170	

2. Use the Hungarian method to solve the following assignment problem: **(Apply)**

	J_1	J_2	J_3	J_4
M_1	10	9	7	8
M_2	5	8	7	7
M_3	5	4	6	5
M_4	2	3	4	5

COURSE OUTCOME 3: Construct networks and analyse optimality for various applications. (Analyze)

1. Draw the A project consists of seven activities for which the relevant data are given below:

Activity	Preceding activities	Duration (days)
A	---	4
B	---	7
C	---	6
D	A, B	5
E	A, B	7
F	C, D, E	6
G	C, D, E	5

i. Draw the network. ii. Identify the critical path and find the project completion time. **(Analyze)**

2. Construct the project network for project summarized in Table Q12b. Calculate the expected duration and variance of each activity and determine the critical path and expected project completion time. **(Analyze)**

Table – Q 12b

Activity	Predecessor (s)	Duration (week)		
		a	m	b
A	–	6	7	8
B	–	1	2	9
C	–	1	4	7
D	A	1	2	3
E	A,B	1	2	9
F	C	1	5	9
G	C	2	2	8
H	E,F	4	4	4
I	E, F	4	4	10
J	D, H	2	5	14
K	I, G	2	2	8

COURSE OUTCOME 4: Identify inventory models and solve for optimality. (Apply)

1. An industry produces a particular product with a demand rate r =14000 units/year, Production rate k = 35,000 units/year, set up cost Co = Rs. 500 per setup and carrying cost Cc = Rs. 15/unit/year. Determine the EBQ ad cycle time. **(Apply)**

2. A newspaper boy buys papers for 30 paise each and sells them for 70 paise. He cannot return unsold newspapers. Daily demand has the following distribution. **(Apply)**

No. of customers	23	24	25	26	27	28	29	30	31	32
Probability	0.01	0.03	0.06	0.10	0.20	0.25	0.15	0.10	0.05	0.05

COURSE OUTCOME 5: Analyse queuing characteristics and compute the optimum replacement period for capital equipment and items that fail suddenly. (Analyze)

1. A machine owner finds from his past records that the costs per year of maintaining a machine, whose purchase price is Rs.6000, are as given below, Determine at what age a replacement is due. **(Analyze)**

Yr.	1	2	3	4	5	6	7	8
Maintenance cost	1000	1200	1400	1800	2300	2800	3400	4000
Resale price	3000	1500	750	375	200	200	200	200

2. The following mortality rates have been observed for a certain type of light bulbs.

Week	1	2	3	4	5
Percent failing by the end of week	10	25	50	80	100

There are 1000 bulbs in use and it costs Rs.2 to replace an individual bulb, which has burnt out. If all the bulbs were replaced simultaneously, it would cost 50 paise per bulb. Find the average cost of group replacement policy. **(Analyze)**

21ME7727	Introduction to NANO Technology	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- Make the students to understand about the nanomaterials, synthesis and its characterization.

UNIT I	BASICS AND SCALE OF NANOTECHNOLOGY	9

Introduction –Scientific revolutions –Time and length scale in structures –Definition of a nanosystem –Dimensionality and size dependent phenomena –Surface to volume ratio – Fraction of surface atoms –Surface energy and surface stress – surface defects – Properties at nanoscale (optical, mechanical, electronic and magnetic).

UNIT II	DIFFERENT CLASSES OF NANOMATERIALS	9

Classification based on dimensionality – Quantum Dots, Wells and Wires – Carbon – based nano materials (buckyballs, nanotubes, graphene)–Metal based nano materials (nanogold, nanosilver and metal oxides) – Nanocomposites – Nanopolymers –Nanoglasses –Nano ceramics – Biological nanomaterials.

UNIT III	SYNTHESIS OF NANOMATERIALS	9

Classification of synthesis: Top down and bottom up nanofabrication. Chemical Methods: Metal Nanocrystals by Reduction – Solvothermal Synthesis – Photochemical Synthesis – Sonochemical Routes – Chemical Vapor Deposition (CVD) –Metal Oxide – Chemical Vapor Deposition (MOCVD).Physical Methods:Ball Milling –Electro deposition – Spray Pyrolysis – Flame Pyrolysis – DC/RF Magnetron Sputtering – Molecular Beam Epitaxy (MBE)

UNIT IV	FABRICATION AND CHARACTERIZATION OF NANOSTRUCTURES	9

Nanofabrication: Photolithography and its limitation – Electron-beam lithography (EBL) – Nanoimprint –Softlithography patterning. Characterization: Field Emission Scanning Electron Microscopy (FESEM) –Environmental Scanning Electron Microscopy (ESEM) High Resolution Transmission Electron Microscope (HRTEM) –Scanning Tunneling Microscope (STM) – Surface enhanced Raman spectroscopy (SERS) – X-ray Photoelectron Spectroscopy (XPS) – Auger electron spectroscopy (AES) –Rutherford backscattering spectroscopy (RBS).

UNIT V	APPLICATIONS OF NANO TECHNOLOGY	9

Solar energy conversion and catalysis – Molecular electronics and printed electronics – Nanoelectronics – Polymers with aspecial architecture – Liquid crystalline systems – Linear and nonlinear optical and electro-optical properties, Applications in displays and other devices – Nanomaterials for data storage – Photonics, Plasmonics – Chemical and biosensors – Nanomedicine and Nanobiotechnology –Nanotoxicology challenges.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the basics in nano sciences and scales using in this technology. **(Understand)**
CO2: Summarize the classification of nano materials. **(Understand)**
CO3: Outline the various synthesizing methods for nanomaterials. **(Understand)**
CO4: Discuss the fabricating methodologies and characterization techniques for nano materials. **(Understand)**
CO5: Demonstrate the applications of nanotechnologies in various fields. **(Apply)**

Text Books

1. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, (2012)
2. Pradeep T., "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., (2016)

Reference Books

1. Charles P. Poole Jr., Frank J. Ownes, 'Introduction to Nanotechnology", Wiley Interscience, (2003)
2. Dupas C., Houdy P., Lahmani M., "Nanoscience: Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, (2007)
3. Mark Ratner and Daniel Ratner, "Nano Technology", Pearson Education, New Delhi, (2003)
4. Nabok A., "Organic and Inorganic Nanostructures", Artech House, (2005)
5. Bhusan, Bharat (Ed), "Springer Handbook of Nanotechnology", 2ndEdition, (2007)

Web Resources

1. https://nptel.ac.in/courses/118/104/118104008/ **Introduction to NANO technology**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		1	1								3	3	
CO2	2		1	1								3	3	
CO3	2		1	1								3	3	
CO4	2		1	1								3	3	
CO5	2		1	1								3	3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to interpret the basics in nano sciences and scales using in this technology. (Understand)

1. Discuss about the implications of Nano Technology. **(Understand)**
2. Write a technical note on "Time and length scale in structures ". **(Understand)**

COURSE OUTCOME 2: Students will be able to summarize the classification of nano materials. (Understand)

1. Make short note on Metal based Nano materials. **(Understand)**
2. Explain Synthesis of Nanoparticles through Homogenous and Heterogeneous Nucleation. **(Understand)**

COURSE OUTCOME 3: Students will be able to outline the various synthesizing methods for nanomaterials. **(Understand)**

1. Discuss in detail different types of ball-milling and their advantages. **(Understand)**
2. Write in detail the special magnetic properties of nanomaterials with special reference to Super para magnetism. **(Understand)**

COURSE OUTCOME 4: Students will be able to discuss the fabricating methodologies and characterization techniques for nano materials. (Understand)

1. Explain in detail how XRD analysis is important in nanomaterial characterization. **(Understand)**
2. Explain in detail size and surface, morphological analysis of nanostructures using SEM. **(Understand)**

COURSE OUTCOME 5: Students will be able to demonstrate the applications of nanotechnologies in various fields. (Apply)

1. Discuss the advantages and basic principles of Nano sensors. **(Understand)**
2. Explain in detail about the case study using Plasmonics. **(Apply)**

21ME7728	Smart and New Materials	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To provide Knowledge of smart materials and structures in designing mechanical systems for advanced engineering applications.

UNIT I	INTRODUCTION AND HISTORICAL PERSPECTIVE	9

Classes of materials and their usage – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Poly functional materials – Generation of smart materials – Diverse areas of intelligent materials –Primitive functions of intelligent materials – Intelligent inherent in materials –Examples of intelligent materials, structural materials, Electrical materials, biocompatible materials etc. – Intelligent biological materials – Biomimetics – Wolff's law– Technological applications of Intelligent materials.

UNIT II	SMART MATERIALS AND STRUCTURAL SYSTEMS	9

The principal ingredients of smart materials – Thermal materials – Sensing technologies – Micro sensors – Intelligent systems – Hybrid smart materials – An algorithm for synthesizing a smart material – Passive sensory smart structures–Reactive actuator based smart structures – Active sensing and reactive smart structures – Smart skins – Aero elastic tailoring of airfoils – Synthesis of future smart systems.

UNIT III	ELECTRO-RHEOLOGICAL (FLUIDS) SMART MATERIALS	9

Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response Post-Yield flow applications in Clatches, Dampers and Others.

UNIT IV	PIEZOELECTRIC SMART MATERIALS	9

Background – Electrostriction – Pyroelectricity – Piezoelectricity – Industrial piezoelectric materials – PZT – PVDF – PVDF film – Properties of commercial piezoelectric materials – Properties of Piezoelectric film (explanation) – Smart materials featuring piezoelectric elements.

UNIT V	SHAPE – MEMORY (ALLOYS) SMART MATERIALS	9

Background on shape – memory alloys (SMA) Nickel – Titanium alloy (Nitinol) –Materials characteristics of Nitinol – Martensitic transformations – Austenitictrans formations – Thermoelastic martensitic transformations – Cu based SMA, chiral materials – Applications of SMA – Continuum applications of SMA.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline the behaviour and applicability of various smart materials. **(Understand)**
CO2: Discuss the behavior of smart materials and structural systems. **(Understand)**
CO3: Summarize the properties and behavior of Electro-Rheological material. **(Understand)**
CO4: Interpret the properties and applications of Piezoelectric smart materials. **(Understand)**
CO5: Infer knowledge on the characteristics and applications of SMA material. **(Understand)**

Text Books

1. M.V.Gandhi and B.S. Thompson, Smart Materials and Structures Chapman and Hall, London, First Edition, 2013
2. T.W. Deurig, K.N.Melton, D.Stockel and C.M.Wayman, Engineering aspects of Shape Memory alloys, Butterworth –Heinemann, 2015

Reference Books

1. Martin, J.W., Engineering Materials, Their properties and Applications, Wykedham Publications (London) Ltd., 1987.
2. C.A.Rogers, Smart Materials, Structures and Mathematical issues, Technomic Publising Co., USA, 2017.
3. Van Vlack.L.H., Elements of Materials Science and Engineering Prentice Hall; Publishers, Sixth edition, 1989.

Web Resources

1. https://archive.nptel.ac.in/courses/112/104/112104251/ **(Smart and New Materials)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		3	1		1	1					1	3	
CO2	2		3	1		1	1					1	3	
CO3	2		3	1		1	1					1	3	
CO4	2		3	1		1	1					1	3	
CO5	2		3	1		1	1					1	3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to outline the behavior and applicability of various smart materials. (Understand)

1. Explain the diverse areas of intelligent materials. **(Understand)**
2. Write short notes on Biomimetics. **(Understand)**

COURSE OUTCOME 2: Students will be able to discuss the behavior of smart materials and structural systems. (Understand)

1. List the properties of Micro sensors and its applications. **(Understand)**
2. Explain in detail about the Reactive actuator based smart structures **(Understand)**

COURSE OUTCOME 3: Students will be able to summarize the properties and behavior of Electro-Rheological material. (Understand)

1. Explain the Working Principle and application of ER Fluids. **(Remember)**
2. Compare ER Fluids with Other Smart Materials. **(Understand)**

COURSE OUTCOME 4: Students will be able to interpret the properties and applications of Piezoelectric smart materials. (Understand)

1. List and explain the Industrial piezoelectric materials. **(Understand)**
2. Distinguish the difference between Pyroelectricity and Piezoelectricity. **(Understand)**

COURSE OUTCOME 5: Students will be able to infer knowledge on the characteristics and applications of SMA material. (Understand)

1. Explain in detail about characteristics of Nitinol. **(Understand)**
2. Describe the application of SMA in nuclear reactors. **(Understand)**

21ME7729	DRONE TECHNOLOGIES	L	T	P	C
		3	0	0	3

Prerequisites for the course
Nil

Objectives

- To understand the basics of drone concepts
- To learn and understand the fundaments of design, fabrication and programming of drone
- To impart the knowledge of drone flying and operation
- To know about the various applications of drone
- To understand the safety risks and guidelines of fly safely

UNIT I	INTRODUCTION TO DRONE TECHNOLOGY	9

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability

UNIT II	DRONE DESIGN, FABRICATION AND PROGRAMMING	9

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts - Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.

UNIT III	DRONE FLYING AND OPERATION	9

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment Drone controls Flight operations –management tool –Sensors-Onboard storage capacity - Removable storage devices- Linked mobile devices and applications

UNIT IV	DRONE COMMERCIAL APPLICATIONS	9

Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing

UNIT V	FUTURE DRONES AND SAFETY	9

The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	**1. Descriptive Questions**

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Discuss the various types and concepts of drone technology. **(Understand)**
CO2: Summarize the fundamentals of drone fabrication and programming. **(Understand)**
CO3: Interpret the knowledge of drone flying and operations. **(Understand)**
CO4: Develop a drone mechanism for specific applications. **(Apply)**
CO5: Discuss the guidelines for safety flying of a drone. **(Understand)**

Text Books

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby, "Make:Getting Started with Drones ",Maker Media, Inc, 2016

Reference Books

1. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016

2 . Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.

Web Resources

1. https://nptel.ac.in/courses/101104083 /**Drone Technologies**
2. https://onlinecourses.nptel.ac.in/noc20_ae04/preview / **Drone Technologies**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	1		1						3		3
CO2	1	2	1	1		1						3		3
CO3	1	2	1	1		1						3		3
CO4	1	2	1	1		1						3		3
CO5	1	2	1	1		1						3		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Discuss the various types and concepts of drone technology (Understand)

1. Describe in details about types of current generation of drones based on their method of propulsion **(Understand)**
2. Explain briefly about the Opportunities/applications for entrepreneurship and employability **(Understand)**

COURSE OUTCOME 2: Summarize the fundamentals of drone fabrication and programming. (Understand)

1 Explain the technical characteristics of the parts of Drone and Functions of the component parts of drone. **(Understand)**

2 Describe the methods of programming which are stored inside the drone. **(Understand)**

COURSE OUTCOME 3: Interpret the knowledge of drone flying and operations (Understand)

1. Describe the operations of a small drone in a controlled environment **(Understand)**
2. Interpret the classifications of Removable storage devices and linked mobile devices and briefly explain the applications of this storage devices **(Understand)**

COURSE OUTCOME 4: Develop a drone mechanism for specific applications. (Apply)

1 Demonstrate the applications of drones in agriculture. **(Apply)**

2 Illustrate the applications of drones in inspection of transmission lines and power distribution and also Drones in filming and panoramic picturing. **(Apply)**

COURSE OUTCOME 5: Discuss the guidelines for safety flying of a drone. (Understand)

1. Explain the guidelines to fly safely and Specific aviation regulation and standardization and in Drone license. **(Understand)**
2. Describe the methods of miniaturization of drones for Increasing autonomy of drones and also describe the use of drones in swarms. **(Understand)**

21ME7730	INDUSTRIAL SAFETY ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- This course aims to acquaint with the idea of Safety Rules followed in Industries and recognize the safety legislation, OHS, safety management and Human factors Issues

UNIT I	INTRODUCTION	9

Evolution of modern safety concepts – Fire prevention – Mechanical hazards – Boilers, Pressure vessels, Electrical Exposure – First Aid.

UNIT II	CHEMICAL HAZARDS	9

Chemical exposure – Toxic materials – Radiation Ionizing and Non-ionizing Radiation – Industrial Hygiene – Industrial Toxicology – Toxic Chemicals and its harmful effects on humans - Factors influencing the effects of toxic materials

UNIT III	ENVIRONMENTAL CONTROL	9

Industrial Health Hazards – Environmental Control – Environmental Protection Act – Industrial Noise – Noise measuring instruments, Control of Noise, Vibration – Personal Protection

UNIT IV	HAZARD ANALYSIS	9

System Safety Analysis –Techniques – Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), HAZOP analysis and Risk Assessment.

UNIT V	SAFETY REGULATIONS	9

Explosions – Disaster management – catastrophe control, hazard control, Factories Act, Safety regulations Product safety – case studies.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	1. Descriptive Questions

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Illustrate the representation of various safety concepts and principles followed in real time Industries **(Understand)**

CO2: Outline the chemical exposures in industries and industrial toxicology **(Understand)**

CO3: Classify the various types of environmental hazards in workplace, effects and its control measures **(Understand)**

CO4: Apply various hazard analysis and risk assessment techniques in industries **(Apply)**

CO5: Demonstrate the various safety standards in industries with the help of case studies **(Apply)**

Text Books

1. R.K. Jain & Sunil S. Rao, "Industrial Safety, Health and Environment Management Systems", 3rd Edition, Khanna Publishers, New Delhi, 2022.
2. C. Ray Asfahl & David W.Rieske "Industrial Safety & Health Management", Prentice Hall Publishers, 2018.

Reference Books

1. David L.Goetsch, "Occupational Safety and Health for Technologists", Engineers and Managers, Pearson Education Ltd. 8th Edition, (2014)
2. Basudev Panda, "Industrial Safety, Health Environment and Security", 2013.
3. Yang Miang Goh , "Introduction To Workplace Safety And Health Management", World Scientific Publishing Company, 2020

Web Resources

1. https://onlinecourses.nptel.ac.in/noc20_mg43/preview **/Industrial Safety Engineering**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2				3						1		3
CO2	1	2				3						1		3
CO3	1	2				3						1		3
CO4	1	2				3						1		3
CO5	1	2				3						1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Illustrate the representation of various safety concepts and principles followed in Real Time Industries (Understand)

1. Illustrate the various media available and used for extinguishing fire. **(Understand)**
2. Enlist various safety measures while working on plants **(Remember)**

COURSE OUTCOME 2: Outline the chemical exposures in industries and industrial toxicology (Understand)

1. How hazards are monitored and can be controlled at the workplace in chemical industry? **(Remember)**
2. Discuss Industrial Toxicology and how toxic chemicals will effect on humans? **(Understand)**

COURSE OUTCOME 3: Classify the various types of environmental hazards in workplace, effects and its control measures (Understand)

1. List out the various kinds of PPE and how it will protect against humans? **(Remember)**
2. Discuss in detailed procedure to eliminate noise in working environment using hierarchy of controls technique **(Understand)**

COURSE OUTCOME 4: Apply various hazard analysis and risk assessment techniques in industries (Apply)

1. Construct fault tree for cotton disease involved in textile industry and evaluate using gate by gate method **(Apply)**
2. Outline the FMEA Procedures and develop the FMEA check sheet with suitable example. **(Understand)**

COURSE OUTCOME 5: Demonstrate the various safety standards in industries with the help of case studies (Apply)

1. Illustrate the Bhopal Gas Tragedy Disaster 1984 **(Apply)**
2. Outline the Chapter III under Factories Act 1948 **(Understand)**

OPEN ELECTIVE - I

21ME5801	NUCLEAR ENGINEERING	L	T	P	C
		3	0	0	3

Prerequisites for the course:

Engineering Physics

Objectives

To gain some fundamental knowledge about nuclear physics, nuclear reactor, nuclear fuels, reactors and safe disposal of nuclear wastes

UNIT I	NUCLEAR PHYSICS	7

Nuclear model of an atom–Equivalence of mass and energy–binding–radioactivity–half life–neutron interactions–cross sections

UNIT II	NUCLEAR REACTIONS AND REACTION MATERIALS	9

Mechanism of nuclear fission and fusion – radio activity – chain reactions – critical mass and composition – nuclear fuel cycles and its characteristics – uranium production and purification –Zirconium ,thorium,beryllium.

UNIT III	NUCLEAR SAFETY SYSTEMS	11

Safety objectives, Shutdown systems in PWR,BWR,PHWR, Reactivity Worth of shutdown system, Operating Environment, Grouping of safety systems, Heat Removal systems, Emergency Core Cooling, Containment and subsystem, Site selection and Rejection criterion.

UNIT IV	NUCLEAR POWER PLANTS	9

Introduction, Fermi pile Experiment, Major Components of nuclear power plants. Classifications of Nuclear reactors, Nuclear Breeding, Breeder reactors, Nuclear Materials.

UNIT V	SAFETY AND DISPOSAL	9

Safety and disposal: Nuclear plant safety–safety systems–changes and consequences of accident–criteria for safety – nuclear waste – types of waste and its disposal – radiation hazards and their prevention–weapons proliferation

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 & CAT 2 EACH 10 MARKS	DESCRIPTIVE TYPE QUESTIONS. ASSIGNMENT	DESCRIPTIVE QUESTIONS

Outcomes

Upon completion of the course, the students will be able to:

CO1: List the basic concepts of atoms, equivalence mass and energy **(Understand)**
CO2: Interpret the nuclear reactions and reaction materials **(Apply)**
CO3: Describe the nuclear fuel cycle and its characteristics **(Understand)**
CO4: Demonstrate about the functions of different nuclear reactor **(Apply)**
CO5: Discuss about the safety and disposal methods of nuclear waste **(Understand)**

Text Books

1. Nuclear reactor Safety- principles and concept by G. Vaidyanathan, Yes Dee Publishing, (2017).
2. Power Plant Engineering: by Arora&Domkundwar, Dhanpatrai Publication (2016).
3. Power Plant Engineering by P.K.Nag, Tata McGraw Hill Publishing Company Ltd. (2017).

Reference Books

1. Nuclear Reactor Engineering by Samuel Glass tone, CBS Publishers & Distributors (2016).
2. Introduction to Nuclear Engineering by John R. Lamarsh, Pearson Education India (2017).

Web Resources

1. https://nptel.ac.in/courses/112101007/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3					1	3							3
2	3					1	3							3
3	3					2	3							3
4	3		3		1	2	3	2				1		3
5	3				1	2	3	2				1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: List the basic concepts of atoms ,equivalence mass and energy (Understand)

1. Derive mass energy equivalence equation and explain the term mass defect and its significance. (U)

2. Write short notes on Ruther ford model of an atom .(U)

COURSE OUTCOME 2: Interpret the nuclear reactions and reaction materials (Apply)

1. Explain the nuclear fuel. What is chain reaction? How it is measured? What is the difference between controlled and uncontrolled chain reaction? (U)
2. Draw and explain the solvent extraction equipment in following cases. (A)
   (i) Explain in brief how uranium material is produced and purified.
   (ii) Write short notes on the purification of thorium and beryllium materials
3. Explain the process of uranium production and purification. (U)

COURSE OUTCOME 3: Describe the nuclear fuel cycle and its characteristics (Understand)

1. Explain about the nuclear safety inspections. (U)

2. How the nuclear plant safety system works in Shutdown to cooling the fuel. (U)

COURSE OUTCOME 4: Demonstrate about the functions of different nuclear reactor (Apply)

1. Describe the boiling water reactor with the help of neat sketch and explain its chief characteristics(U)
2. Illustarte the boiling water reactor power plant. (A)

3. Write short notes on the following(U)
   [i] Boiling water reactor
   [ii] Fast breeder reactor.

COURSE OUTCOME 5: Discuss about the safety and disposal methods of nuclear waste (Understand)

1. Explain about the nature of wastes generated from each stage of nuclear fuel cycle. (A)
2. Explain about the disposal of gaseous nuclear wastes with a diagram. (U)

21ME5802	RENEWABLE SOURCES OF ENERGY	L	T	P	C
		3	0	0	3

Prerequisites for the course

NIL

Objectives

- To identify the new methodologies /technologies for effective utilization of renewable energy sources

UNIT I	INTRODUCTION	9

World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy Utilisation – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials – Achievements / Applications – Economics of renewable energy systems.

UNIT II	SOLAR ENERGY	9

Solar Radiation – Measurements of Solar Radiation – Flat Plate and Concentrating Collectors – Solar direct Thermal Applications – Solar thermal Power Generation – Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications.

UNIT III	WIND ENERGY	9

Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects

UNIT IV	BIO - ENERGY	9

Biomass direct combustion – Biomass gasifiers – Biogas plants – Digesters – Ethanol production – Bio diesel – Cogeneration – Biomass Applications

UNIT V	OTHER RENEWABLE ENERGY SOURCES	9

Tidal energy – Wave Energy – Open and Closed OTEC Cycles – Small Hydro-Geothermal Energy – Hydrogen and Storage – Fuel Cell Systems – Hybrid Systems

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Describe the renewable energy scenario all over the world. **(Understand)**

CO2: Interpret the basics of solar energy and its applications. **(Understand)**

CO3: Apply the principles of energy estimation in wind energy. **(Apply)**

CO4: Explain about biogas digesters and cogeneration plant**. (Understand)**

CO5: Compare different renewable energy sources and construct a hybrid system. **(Understand)**

Text Books

1. Rai G.D., "Non-Conventional Energy Sources", Khanna Publisher, New Delhi, (2011)
2. Twidell, J.W. & Weir A, " Renewable Energy Sources", EFN Spon Ltd. UK, (2022)

Reference Books

1. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., (2012)
2. Chetan Singh Solanki, Solar Photovoltaics, "Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, (2015)
3. David M. Mousdale "Introduction to Biofuels", CRC Press, Taylor & Francis Group, USA (2017)
4. Tiwari G.N., "Solar Energy – Fundamentals Design, Modelling and applications", Narosa Publishing House, New Delhi, (2002)
5. Freris L.L., "Wind Energy Conversion systems", Prentice Hall, UK, (2002)

Web Resources

1. https://nptel.ac.in/courses/121106014/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2					2	2	2						3
2	2					2	2	2						3
3	2					2	2	2						3
4	2					2	2	2						3
5	2					2	2	2						3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Describe the renewable energy scenario all over the world (Understand)

1. Describe the types of Solar power plant. What are the limitations of solar power plant? (U)
2. Illustrate the conventional and unconventional energy sources. Describe briefly. (U)

COURSE OUTCOME 2: Explain the basics of solar energy and its applications. (Understand)

1. Classify the methods of solar energy storage. Describe thermal energy storage system. (U)
2. Discuss the main components of a flat-plate collector. Explain the functions of each and write its advantage and disadvantage of flat plate collector. (U)

COURSE OUTCOME 3: Apply the principles of energy estimation in wind energy. (Apply)

1. Determine the operation and control of wind turbine. (A)
2. Describe the main applications of wind energy. Giving neat sketches. (U)

COURSE OUTCOME 4: Explain about biogas digesters and cogeneration plant. (Understand)

1. Explain the process of photo synthesis. What are the necessary conditions of it? (U)
2. Discuss the factors affecting Bio digestion (U).

COURSE OUTCOME 5: Compare different renewable energy sources and construct a hybrid system. (Understand)

1. Differentiate open cycle OTEC system and Closed OTEC cycle. (U)
2. Explain briefly how prime movers for geothermal energy conversion are classified and elaborate it. (U).

21ME5803	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Manufacturing Technology

Objectives

1. To know the principal methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies
2. To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.

UNIT I	INTRODUCTION	10

Overview – History – Need– Classification – Additive Manufacturing Technology in productdevelopment– Materials for Additive Manufacturing Technology – Tooling – Applications

UNIT II	CAD & REVERSE ENGINEERING	10

Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for AdditiveManufacturing Technology: CAD model preparation – Part Orientation and support generation –Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology: MIMICS, MAGICS.

UNIT III	LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS	10

Classification – Liquid based system – Stereolithography Apparatus (SLA) – Principle, process,advantages and applications – Solid based system –Fused Deposition Modeling – Principle, process,advantages and applications, Laminated Object Manufacturing

UNIT IV	POWDER BASED ADDITIVE MANUFACTURING SYSTEMS	10

Selective Laser Sintering – Principles of SLS process – Process, advantages and applications, ThreeDimensional Printing – Principle, process, advantages and applications– Laser Engineered NetShaping (LENS), Electron Beam Melting.

UNIT V	MEDICAL AND BIO-ADDITIVE MANUFACTURING	5

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) – Case studies

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS Descriptive Questions	MCQ Assignment Slip Test	Descriptive type

Outcomes

Upon completion of the course, the students will be able to:

CO1: Distinguish the basic concepts of additive manufacturing and its applications. **(Understand)**
CO2: Demonstrate the software's for additive manufacturing technology. **(Apply)**
CO3: Construct liquid and solid based additive manufacturing and its applications. **(Apply)**
CO4: Illustrate power based additive manufacturing and its applications. **(Apply)**
CO5: Apply the possibilities and limitations in medical and bio additive manufacturing. **(Apply)**

Text Books

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", World Scientific Publishers, (2010)
2. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, (2003)

Reference Books

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, (2007)
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, (2006)
3. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, (2000)
4. Ian Gibson, David Rosen and Brent Stucker, "Additive Manufacturing Technologies: 3D printing, Rapid prototyping and Direct Digital Manufacturing", Springer, (2014)
5. Andreas Gebhardt "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing"Hanser Gardner Publication (2011)
6. Tom Page "Design for Additive Manufacturing"LAP Lambert Academic Publishing, (2012)

Web Resources

1. https://nptel.ac.in/courses/112104265/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
1	3										2	3	3	
2			3		3							3	3	
3	3				3						2	3	2	1
4	3				3						2	3	2	1
5					3						2	3	2	1

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Distinguish the basic concepts of additive manufacturing and its applications (Understand)

1. Write a note on the impact of AM on product development. (U)
2. Describe a) Virtual prototyping b) Rapid Tooling. (U)

COURSE OUTCOME 2: Demonstrate the software's for additive manufacturing technology. (Apply)

1. Explain the geometric modeling techniques? (U)
2. Demonstrate the techniques used in Tool path generation? (A)

COURSE OUTCOME 3: Construct liquid and solid based additive manufacturing and its applications.(Apply)

1. Illustrate about strength, Weakness and applications of SGC? (A)
2. What are the steps in pre build and post-build process for LOM? (U)

COURSE OUTCOME 4: Illustrate power based additive manufacturing and its applications. (Apply)

1. Discover the effect of surface deviation in LENS? (A)
2. What is indirect SLS and direct SLS. Explain the same. (U)

COURSE OUTCOME 5: Apply the possibilities and limitations in medical and bio additive manufacturing. (Apply)

1. Prepare the design and production of customized implants and prosthesis. (A)
2. Discuss in detail about Computer Aided Tissue Engineering. (U)

21ME5804	FUNDAMENTALS OF RESEARCH	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

This course aims to introduce students to the important aspects of research. The intent of the course is to make students aware of the details associated with formal research and to help students overcome common mis conceptions that may be present in their minds. By going through this course, students are likely to be ableto take up research activities in a more systematic and
formal manner right from the beginning

UNIT I	INTRODUCTION TO RESEARCH	9

Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords – Ethics in Research

UNIT II	LITERATURE REVIEW	9

Literature Collection – Methods – Analysis – Citation Study – Gap Analysis – Problem Formulation Techniques.

UNIT III	RESEARCH METHODOLOGY	9

Appropriate Choice of Algorithms/Methodologies/Methods – Measurement and Result Analysis – Investigation of Solutions for Research Problem – Interpretation – Research Limitations. Data analysis, Design of Experiments, Experimental skills,Safety in Laboratory

UNIT IV	JOURANALS AND PAPERS	9

Journals in Science/Engineering - Indexing and Impact factor of Journals. Plagiarism and Research Ethics. Intellectual property. Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study – Systematic Approach to Prepare Review / Research papers.

UNIT V	REPORTS AND PRESENTATIONS	9

How to Write a Report - Language and Style - Format of Project Report - Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs. Research Tools.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 and CAT 2 Each 10 Marks DESCRIPTIVE TYPE OF QUESTIONS	MCQ, CASE STUDY, PRESENATIONS	DESCRIPTIVE TYPE

Outcomes

Upon completion of the course, the students will be able to:

CO1: List the various stages in research and categorize the quality of research problem. **(Apply)**
CO2: Formulate a research problem from published literature/journal papers**. (Apply)**
CO3: Select appropriate research method for a defined problem **(Apply)**
CO4: Prepare review/ research paper, select suitable journal and submit a paper **(Apply)**
CO5: Prepare research report and presentation **(Apply)**

Text Books

1.Wailliman, Nicholas. "Research Methods: The basics". 3rd Edition Routledge, 2021.
2.David V.Thiel," Research Methods For Engineers", Cambridge University Press 2014
3.Habbeb Adewale Ajimotokan, "Research Techniques Qualitative, Quantitative and Mixed Methods Approaches for Engineers" Springer 2022

Reference Books

1. Melville S, Goddard W. " Research Methodology: An Introduction For Science and Engineering Students". Kenwyn Co Ltd. 1996
2. Kumar, Ranjit. " Research Methodology: A step-by-step guide for beginners". SAGE Publications Limited, 2019

Web Resources

1.https://nptel.ac.in/courses/121106007

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	2	1		1			2		3		1	2	2
2	2	2	1		1			2		3		1	2	2
3	2	2	1		1			2		3		1	2	2
4	2	2	1		1			2		3		1	2	2
5	2	2	1		1			2		3		1	2	2

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: List the various stages in research and categorize the quality of research problem. **(Apply)**

1. Discuss the applications of research from the view point of

   (i) The service provider
   (ii) The administrator, manager and/or planer
   (iii) The Consumer
   (iv) The Professional (Apply)
2. Discuss the types of research on different perspectives say application perspective, objective perspective and mode of enquiry perspective. (Apply)
3. Identify two research questions, related to your professional area, that could be answered by undertaking each of the following types of research.

a. Descriptive Research b. Correlational research
c. Explanatory Research d. Exploratory research (Analyze)

4. Draw the research process "onion' (Understand)

COURSE OUTCOME 2: Formulate a research problem from published literature/journal papers. **(Apply)**

1. Undertake a keyword search for a theme or issue that interests you using (a) an Internet search engine, such as Google Scholar, and (b) a library search facility. Compare the results (analyze)
2. Discuss about the source of information for literature review. (Understanding)
3. Write a short notes on "Note Taking" (Understand)

COURSE OUTCOME 3: Select appropriate research method for a defined problem **(Apply)**

1. List the sources of research problems (Understand)
2. Elaborate the considerations in selecting a research problem (Understand)
3. Discuss in details about steps in formulating a research problem (Understand)
4. Select a broad subject area of interest to you and 'dissect' it. (Apply)

COURSE OUTCOME 4: Prepare review/ research paper, select suitable journal and submit a paper **(Apply)**

1. What is meant by indexing? Why it is needed? (Understand)
2. Discuss in detail about the "Intellectual Property Rights" (Understand)
3. Explain the systematic approach to prepare and review papers. (Apply)

COURSE OUTCOME 5: Prepare research report and presentation **(Apply)**

1. Discuss any two software tools in preparing thesis in required format. (Apply)
2. Design two-minute paper presentations. Prepare one slide showing a plot of the major results from a research project. Deliver two-minute presentations on the topic showing only one slide of results. (Analyze)

OPEN ELECTIVE - II

21ME6801	SOLAR CELLS AND FUNDAMENTALS	L	T	P	C
		3	0	0	3

Prerequisites for the course

NIL

Objectives

- To identify the new methodologies /technologies for effective utilization of solar cells.

UNIT I	SOLAR SYSTEM	8

Solar system: Energy from the sun, solar window, atmospheric effects, diffused radiations, Air mass, effect of Air Mass, seasonal effects, environmental effects on standard test conditions

UNIT II	SOLAR PHOTOVOLTAIC SYSTEMS	10

solar power generation systems a) off-grid systems b) grid connected systems c) power control and management systems, economics of solar photovoltaic systems, World Energy Requirement, Energy and Role of Photovoltaic, Types of PV Installation, Common Systems type, GRID-TIED System, Hybrid Systems, Photovoltaic in Energy Supply.

UNIT III	DESIGN OF SOLAR CELL	11

Solar Cell technologies Crystalline Cells: Mono- crystalline and poly – crystalline cells- Commercial Si solar cells, process flow of commercial Si cell technology, process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact- Semiconductors as basic solar cell material, materials and properties, P – N junction and solar cell.

UNIT IV	SELECTION AND MAINTENANCE OF SOLAR PLANT	9

Introduction, Solar energy system site considerations, components of typical SPV system, Types of Roof, overview of the planning stage, Selection of systems design and objective for grid connected system.

UNIT V	FUNDAMENTALS OF PV CELLS	7

– Fundamentals of Solar Photo Voltaic Conversion – Solar PV Power Generation – Solar PV Applications.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Enumerate the fundamentals of solar system in atmospheric and environment effects. **(Understand)**
CO2 Describe the solar photovoltaic system in a various field in world energy requirement. **(Understand)**
CO3 Design solar cell in various techniques for suitable infrastructure with required enhanced Properties. **(Apply)**
CO4 Demonstrate the site area of selection using the fundamentals of roof, grid with the components of solar PV system. **(Apply)**
CO5 Examine the fundamentals of PV cells in an energy conversion with the help of PV applications. **(Apply)**

Textbooks

1. Solar Power Hand Book, Dr. H. Naganagouda(2017).
2. Solar Photovoltaic; Chetansinghsolanki; PHI, Learning private ltd., New dehli- 2018.

Reference Books

1. Solar Electricity Handbook; MichaleBoxwell; 2017 edition.
2. Renewable energy systems; Devid M, Buchla, Thomas E kissell, Thomas, L Floyd; Pearson India Education Services Pvt. Ltd. 2017

Web Resources

https:nptel.ac.in/courses/1211060114/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2					2	2	2						3
CO2	2					2	2	2						3
CO3	2					2	2	2						3
CO4	2					2	2	2						3
CO5	2					2	2	2						3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Enumerate the fundamentals of solar system in atmospheric and environment effects. (Understand)

1. How Do We Generate Electricity From The Sun?**(U)**
2. What Happens With A Solar Pv System At Night And On Cloudy Days? **(U)**
3. How Do I Get Started With Solar? **(U)**

COURSE OUTCOME 2 Describe the solar photovoltaic system in a various field in world energy requirement. (Understand)

1. Explain the Stand alone PV system. **(U)**
2. Explain the Grid connected PV system (**U)**

COURSE OUTCOME 3 Design solar cell in various techniques for suitable infrastructure with required enhanced Properties. (Apply)

1. Explain the Working principle of solar cell. **(U)**
2. Demonstrate about solar cell technologies in crystalline & poly crystalline cells.**(A)**

COURSE OUTCOME 4 Demonstrate the site area of selection using the fundamentals of roof, grid with the components of solar PV system. (Apply)

1. Predict the criteria level for site selection of solar photovoltaic (PV)**(A)**
2. Examine the Site Selection for a Solar Power Plant in SPV System**.(A)**

COURSE OUTCOME 5 Examine the fundamentals of PV cells in an energy conversion with the help of PV applications. (Apply)

1.Explain about the solar PV generation **(U)**

2. Interpret the energy conversion in solar photovoltaic cell & its applications **(A)**

21ME6802	ENERGY ENGINEERING AND MANAGEMENT	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To create awareness on the energy scenario of India with respect to world
- To Comprehend the impact of energy on environment

UNIT I	INTRODUCTION	9

Comparison of energy scenario – India and World (energy sources, generation mix, consumption pattern, T&D losses, energy demand, per capita energy consumption) – energy pricing –energy security-energy conservation and its importance –EnergyConservationAct2001

UNIT II	ELECTRICAL SYSTEMS	9

HT and LT supply, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Electric Motors - Motor Efficiency Computation, Energy Efficient Motors, Illumination – Lux, Lumens, Types of lighting, Efficacy, LED Lighting and scope of Encon in Illumination.

UNIT III	THERMAL SYSTEMS	9

Stoichiometry, Boilers, Furnaces and Thermic Fluid Heaters – Efficiency computation and encon measures. Steam: Distribution & Usage: Steam Traps, Condensate Recovery, Flash Steam Utilization, Insulators & Refractories

UNIT IV	ENERGY AND ENVIRONMENT	9

Greenhouse effect and the carbon cycle - current evidence and future effects of climate change - Global Environmental Concerns-United Nations Frame work Convention on Climate Change(UNFCC), Kyoto Protocol, Conference of Parties(COP), Emissions trading(ET), Joint implementation(JI), Clean Development Mechanism (CDM), Proto type Carbon Fund(PCF), Sustainable Development

UNIT V	ENERGY MANAGEMENT	9

Energy audit - need – types – methodology – barriers - analysis on energy costing and sharing - bench marking - fuel and energy substitution – billing parameters in TANGEDCO – demand side management - instruments for energy audit – energy monitoring and targeting – CUSUM – energy labeling

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Recognize the importance of energy engineering and suggest measures for improving per capita energy consumption **(Understand)**
CO2 Identify theworking of electrical systems **(Understand)**
CO3 Predict the methodologies for energy recovery using boilers. **(Apply)**
CO4 Apply the sources of additional revenue generation for energy conservation projects Adopting UNFCC **(Apply)**
CO5 Examine the energy sharing and cost sharing pattern of fuels used in industries **(Apply)**

Text Books

1. Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, 2004

Reference Books

1. Witte. L.C., P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilisation" Hemisphere Publ, Washington, 1988.
2. Callaghn, P.W. "Design and Management for Energy Conservation", Pergamon Press, Oxford, 1981.
3. Dryden. I.G.C., "The Efficient Use of Energy" Butterworths, London, 1982
4. Turner. W.C., "Energy Management Hand book", Wiley, New York, 1982.
5. Murphy. W.R. and G. Mc KAY, "Energy Management", Butterworths, London 1987.

Web Resources

1. **https://nptel.ac.in/courses/112105221**
2. **https://nptel.ac.in/courses/108106022**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		2	2			2								3
CO2		2	2		1	2								3
CO3		2	2		1	2								3
CO4		2	2		1	2								3
CO5		2	2		1	2								3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Recognize the importance of energy engineering and suggest measures for improving per capita energy consumption (Understand)

1. Describe the concept of energy planning. (R)
2. Write short notes on Energy conservation Act. (U)

COURSE OUTCOME 2: Identify the working of electrical systems (Understand)

1. Examine the power loss for motors and improvement of motor efficiency. (R)
2. Explain the electrical load management andmaximum demand control. (U)

COURSE OUTCOME 3: Suggest methodologies for energy recovery using boilers (Apply)

1. Explain the performance evaluation of boilers. (R)
2. Examine the process of condensate recovery and flash steam utilization. (A)
3. An oil-fired boiler is generating 30 T/hr steam andoperates for 8000 hrs/ year. The TDS in boiler feedwater was reduced from 500 ppm to 200 ppm. Themaximum permissible limit of TDS in the boiler is3000 ppm and make up water is 10%. Temperature of the blow down water is 170 C and boiler feedwater temperature is 40 C .GCV of fuel is 10000kcal/kg and efficiency of the boiler is 80%.Calculate the saving in fuel oil per annum due toreduction in the blow down. (A)

COURSE OUTCOME 4: Assess the sources of additional revenue generation for energy conservation projectsAdopting UNFCC (Apply)

1. Explain Green house concept. (R)
2. Describe the United Nations Frame work Convention on Climate Change (U)
3. Compose the case study of Clean Development Mechanism (CDM) (A)

COURSE OUTCOME 5: Analyse the energy sharing and cost sharing pattern of fuels used in industries (Apply)

1. Integrate the need for energy audit and composethe types of energy audit. (R)
2. Illustrate the various instruments used forenergy auditing. (U)
3. The contract demand of plant is 1000 kVA. The minimum billing demand is 75% of the contract demand. The basic tariff structure is as follows: Demand charges: Rs. 180 per kVA / month Unit charges: Rs. 3.75 for the first one lakh units / month Rs. 3.50 above one lakh units / month Fuel surcharge: Rs. 0.20 per unit / month Service Tax: Rs. 0.25 per unit / month Meter rent: Rs 500 / month The energy consumption is 3, 15,000 units and the maximum demand recorded is 600 kVA. Calculate the cost of monthly electricity. (A)

21ME6803	DESIGN OF EXPERIMENTS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Probability and Statistics

Objectives

- To impart knowledge on concepts in design and principles of implementing quality in a product or service through tools such as control charts, statistical process control method, and various strategies of designing experiments, methods to improve the reliability of a product.

UNIT I	INTRODUCTION	9

Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level.

UNIT II	METHODS OF DESIGN	9

Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. – Demonstration using Minitab/ SPSS software

UNIT III	QUALITY BY EXPERIMENTAL DESIGN	9

Quality, Western and Taguchi's quality philosophy, elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function. Robust Design: Steps in Robust Design: Parameter design. Reliability Improvement through experiments, Illustration through Numerical examples. Demonstration using Minitab/ SPSS software

UNIT IV	SIGNAL TO NOISE RATIO AND TOLERANCE DESIGN	9

Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Larger-the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples. Parameter and tolerance design concepts, Taguchi's inner and outer arrays, parameter design strategy, tolerance design strategy. Design using Orthogonal Array. Demonstration using Minitab/ SPSS software

UNIT V	STATISTICAL CONSIDERATION AND RELIABILITY	9

Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams –Multivariable charts –Matrix plots and 3-D plots.-Reliability-Survival and Failure-Series and parallel systems-Mean time between failure-Weibull distribution. Demonstration using Minitab/ SPSS software

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)

CAT 1 – 10 MARKS CAT 2 – 10 MARKS DESCRIPTIVE QUESTIONS	1.Assignment 2. Online Quizzes 3.Problem-Solving Activities	1. Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Recite the basic concepts of probability distribution **(Understand)**

CO2 Describe the fundamental principles of Design of Experiment process for optimization **(Understand)**

CO3 Examine Taguchi's approach to experimental design for robust design **(Apply)**

CO4 Calculate Taguchi's approach to tolerance design process for S-N ratio **(Apply)**

CO5 Illustrate the concepts in reliability principles in the design of an engineering product **(Apply)**

Text Books

1. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley and sons, 2012.
2. Box, G. E., Hunter,W.G., Hunter, J.S., Hunter,W.G., Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition, Wiley, 2005.

Reference Books

1. Krishnaiah K, and Shahabudeen P, Applied Design of Experiments and Taguchi Methods, PHI, India, 2011.
2. Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 1996.
3. Product Design And Development, Karl t. Ulrich, Steven D. Eppinger,TataMcgraw-Hill- 3 rd Edition, 2003.
4. Product Design Techniques in Reverse Engineering and New Product Development, Kevin Otto & Kristin Wood, Pearson Education (LPE), 2001.

Web Resources

1. **https://onlinecourses.nptel.ac.in/noc21_mg48/preview**
2. **https://nptel.ac.in/courses/111104075**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2			2								3	
2	2	2			2								3	
3	2	2			2								3	
4	2	2			2								3	
5	2	2			2								3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Understand the basic concepts of probability distribution (Understand)

1. Write down the guidelines for Design of Experiments. (R)

2. Explain the concept of probability and its functions. (U)

COURSE OUTCOME 2: Apply fundamental principles of Design of Experiment process for Optimization (Understand)

1. Write down the procedure for two-level experimental designs for two factors. (R)
2. Explain the types of design methods with arrays. (U)

COURSE OUTCOME 3: Describe the Taguchi's approach to experimental design for robust design (Apply)

1. Write short notes on Quadratic loss function.(R)
2. Explain the concept of Taguchi's quality philosophy. (U)
3. Illustrate the steps in Robust design process. (A)

COURSE OUTCOME 4: Describe the Taguchi's approach to tolerance design process for S-N ratio (Apply)

1. Write short notes on Signal to Noise ratio (S-N).(R)
2. Explain the concepts of design strategy. (U)
3. Examine the procedure for Design using Orthogonal Array with suitable examples. (A)

COURSE OUTCOME 5: Familiarized with concepts in reliability principles in the design of an engineering product (Apply)

1. Write short notes on Cause and Effect diagrams. (R)
2. Briefly explain the survival and failure.(U)
3. Elaborate the concept of Reliability, MTBF, MTTF in detail. (A)

21ME6804	ENGINEERING ECONOMICS AND COST ANALYSIS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To enable students to understand the fundamental economic concepts applicable to engineering and to learn the techniques of incorporating inflation factor in economic decisionmaking.

UNIT I	INTRODUCTION TO ECONOMICS	8

Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of EngineeringEconomics – Engineering efficiency, Economic efficiency, Scope of engineering economics – Elementof costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis - V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning.

UNIT II	VALUE ENGINEERING	10

Make or buy decision, Value engineering – Function, aims, Value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment seriespayment Present worth factor- equal payment series capital recovery factor - Uniform gradient seriesannual equivalent factor, Effective interest rate, Examples in all the methods.

UNIT III	CASH FLOW	9

Methods of comparison of alternatives – present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the methods.

UNIT IV	REPLACEMENT AND MAINTENANCE ANALYSIS	9

Replacement and Maintenance analysis – Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset – capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.

UNIT V	DEPRECIATION AND INFLATION	9

Depreciation- Introduction, Straight line method of depreciation, declining balance method of depreciation-Sum of the year's digits method of depreciation, sinking fund method of depreciation/ Annuity method of depreciation, service output method of depreciation-Evaluation of public alternatives- introduction, Examples, Inflation adjusted decisions – procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
CAT 1 – 10 MARKS CAT 2 – 10 MARKS	1. Assignment 2. Online Quizzes 3. Problem-Solving Activities	1. Descriptive Questions

Outcomes
Upon completion of the course, the students will be able to:
CO1 Apply the principles of engineering economics in estimating the economic efficiency. **(Apply)** CO2 Choose either to make or buy a product based on economic specialized concepts. **(Apply)** CO3 Compare the various methods in cash flow to find the optimal method. **(Analyze)** CO4 Categorize the replacement and maintenance analysis based on economic life of an asset. **(Analyze)** CO5 Apply the concepts of depreciation and inflation in evaluation of public alternatives. **(Apply)**
Textbooks
1. Panneer Selvam, R, "Engineering Economics", 2nd Edition, Prentice Hall of India Ltd, New Delhi, 2013.
Reference Books
1. Chan S.Park, "Contemporary Engineering Economics", 6th Edition, Prentice Hall of India, 2015. 2. Donald.G. Newman, Jerome.P.Lavelle, "Engineering Economics and analysis" 12th Edition, Engg. Press,Texas, 2013. 3. Degarmo, E.P., Sullivan, W.G and Canada, J.R, "Engineering Economy", 10th Edition, Macmillan, NewYork, 2011.
Web Resources 1. https://nptel.ac.in/courses/112107209

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		1	1						2		3			3
CO2		2							2		3			3
CO3		2							2		3			3
CO4		2							2		3			3
CO5		2							2		3			3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1 Apply the principles of engineering economics in estimating the economic efficiency. **(Apply)**

1. Trace out the flow of goods, services, resources and money payments in an economy with suitable sketch. **(Understand)**
2. Enumerate briefly the various cost concepts. Establish the cost-output relationship in the short-run with suitable diagram. **(Apply)**
3. From the following figures extracted from the book of Beta associates, find the following. i. Break-even sales quantity, ii. Break-even sales, iii. If the actual production quantity is 60,000, find a. contribution, b.Margin of safety. Data:- Fixed cost = Rs.10,00,000 Variable cost per unit = Rs.50 and Selling price per unit = Rs.100 **(Apply)**

COURSE OUTCOME 2 Choose either to make or buy a product based on economic specialized concepts. (Apply)

1. As an engineer how will you calculate single payment compound amount factor?

   Illustrate your answer with examples. **(Understand)**

2. Explain value engineering procedure. **(Understand)**

3. A company has extra capacity that can be used to produce a sophisticated fixture which it has been buying for Rs.900 each. If the company makes the fixtures, it will incur material cost of Rs 300 per unit, labour cost of Rs.250 per unit and variable overhead cost of Rs.100 per unit. The annual fixed cost associated with the unused capacity is Rs.10,00,000. Demand over the next year is estimated at 5,000 units. Would it be profitable for the company to make the fixtures?**(Apply)**

COURSE OUTCOME 3 Compare the various methods in cash flow to find the optimal method. (Analyze)

1. Summarize the different types of rate of return methods in engineering decision making. **(Understand)**
2. A firm is diversifying into new business. The life of the business is 10 years without any salvage value at the end of its life. The initial outlay required is Rs.20,00,000/- and the annual net profit estimated is Rs.3,50,000/- Find rate of return for the new business. Check whether the business is worth for a cost of capital of 12%.**(Apply)**
3. Arova industry is planning to expand its production operation. It has identified two different technologies for meeting the goal. The initial outlay and annual revenues with respect to each of the technologies are summerised in the below given table. Suggest the best technology which is to be implemented based on the present worth method of comparison assuming 20% interest rate compounded annually. **(Analyze)**

	Initial outlay	Annual revenue	Life (years)
Technology 1	6,00,000	2,00,000	10
Technology 2	10,00,000	3,00,000	10

COURSE OUTCOME 4 Categorize the replacement and maintenance analysis based on economic life of an asset. (Analyze)

1. Illustrate annual equivalent total cost with suitable examples and state its limitations **(Understand)**
2. Three years earlier Coimbatore corporation purchased a 10HP motor for pumping drinking water and its useful life was estimated as 10 years. But due to rapid development, it is unable to meet demand per water. The options available are either to augment the capacity with an additional 5 HP motor or to replace the existing 10 HP motor with a new 15HP motor. The data on the two options are follows. **(Apply)**

Details of motors	**Old 10HP motor**	**New 10HP motor**	**New 15HP motor**
Purchase cost(P) in Rs.	25,000	12,000	32,000
Life in years(n)	10	7	7

Salvage value at the end of the machine life(Rs.)	1,500	800	5,000
Annual O&M cost(Rs.)	1,600	1,000	500

3. A firm is considering replacement of an equipment, whose first cost is Rs.1,750 and the scrap value is negligible at any year. Based on experience, it was found that the maintenance cost is zero during the first year and it increases by Rs.100 every year thereafter.
   When should the equipment be replaced if i = 0%
   When should the equipment be replaced if i = 12% **(Analyze)**

COURSE OUTCOME 5 Apply the concepts of depreciation and inflation in evaluation ofpublic alternatives. (Apply)

1. Elucidate the different methods of calculating depreciation. **(Understand)**
2. Two equipments are purchased each for Rs.12,000. The estimated useful life is 5 years for both; the estimated scarp value for each equipment is Rs.2000. For one equipment the straight line method is used to calculate the annual depreciation and for the other equipment, the reducing balance method is adopted. Compare the depreciation charges for both for all the 5 years.**(Apply)**
3. Two mutually exclusive projects are being considered for investment. Project A1 requires an initial outlay of Rs. 50,00,000 with net receipts estimated to be Rs. 11,00,000 per year for the next eight years. The initial outlay for the project A2 is Rs. 80,00,000, and net receipts have been estimated at Rs. 20,00,000 per year for the next eight years. There is no salvage value associated with either of the projects. Using the BC ratio, which project would you select? Assume an interest rate of 15%. **(Apply)**

OPEN ELECTIVE - III

21ME7801	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To impart the basics concept of economics and factors that influence demand and supply.
- To familiarize with economies of scale and cost concepts.
- To understand the market competitions and various pricing methods.
- To make the students understand the determination of GDP.
- To introduce the students with international trade and trade policies.

UNIT I	BASIC CONCEPTS & DEMAND AND SUPPLY ANALYSIS	9

Scarcity and choice - Basic economic problems- Utility — Law of diminishing marginal utility — Demand and its determinants — law of demand —elasticity of demand — measurement of elasticity and its applications — Supply, law of supply and determinants of supply — Equilibrium — Changes in demand and supply and its effects —Consumer surplus and producer surplus (Concepts).

UNIT II	PRODUCTION AND COST	9

Production function — law of variable proportion — economies of scale — internal and external economies - Cost concepts — Social cost: private cost and external cost — Explicit and implicit cost — sunk cost - short run cost curves -long run cost curves — Revenue (concepts) — Shutdown point — Break-even analysis.

UNIT III	MARKET STRUCTURE	9

Perfect and imperfect competition — monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) — oligopoly — Kinked demand curve — Collusive oligopoly (meaning) — non-price competition — Product pricing — Cost plus pricing — Target return pricing—Penetration pricing — Predatory pricing — Going rate pricing — Price skimming.

UNIT IV	MACROECONOMIC CONCEPTS	9

Circular flow of economic activities — Stock and flow — Final goods and intermediate goods -Gross Domestic Product - National Income — Three sectors of an economy-Methods of measuring national income — Inflation- causes and effects — Measures to control inflation-Monetary and fiscal policies — Business financing — Stock market — Demat account and Trading account - SENSEX and NIFTY.

UNIT V	INTERNATIONAL TRADE	9

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments — Components — Balance of Payments deficit and devaluation — Trade policy — Free trade versus protection — Tariff and non-tariff barriers.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60Marks)**
CAT 1 - 10 Marks CAT 2 - 10 Marks	1.Descriptive type questions, and 2.Multiple choice questions,	1. Descriptive type questions.

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Interpret the impact of government policies on the general economic welfare. **(Understand)**
CO2: Choose appropriate decisions regarding volume of output and to evaluate the social cost of production. **(Apply)**
CO3: Determine the functional requirement of a firm under various competitive conditions. **(Apply)**
CO4: Identify the overall performance of the economy, and the regulation of economic fluctuations and its impact on various sections in the society. **(Apply)**
CO5: Determine the impact of changes in global economic policies on the business opportunities of a firm. **(Apply)**

Text Books

1. Gregory N Mankiw, 'Principles of Micro Economics', 8th Edition, 2016, Cengage Publications

Reference Books

1. Gregory N Mankiw, 'Principles of Macro Economics', 2nd Edition, 2017, Cengage Publications
2. Dwivedi D N, 'Macro Economics', 5th Edition, 2018, Tata McGraw Hill, New Delhi.

Web Resources

1. https://archive.nptel.ac.in/courses/107/103/107103085/ - (**Ergonomics Workplace Analysis.)**
2. https://youtu.be/3kVnUqvRJV0 - (**Lecture Series on Ergonomics by Dr Peter Crane)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1										3			3
CO2	1	2				1					3			3
CO3		2	1								3			3
CO4		2	1			1					3			3
CO5		2	1								3			3

COURSE LEVEL ASSESSMENT QUESTIONS

CO1: Students will be able to Interpret the impact of government policies on the general economic welfare. **(Understand)**

1. Why does the problem of choice arise? **(Remember)**
2. How do we solve the basic economic problems? **(Understand)**

CO2: Students will be able to Choose appropriate decisions regarding volume of output and to evaluate the social cost of production. (Apply)

1. Explain the term producer equilibrium. **(Understand)**
2. Suppose a chemical factory is functioning in a residential area. What are the external costs? **(Apply)**

CO3: Students will be able to determine the functional requirement of a firm under various competitive conditions. (Apply)

1. Explain the equilibrium of a firm under monopolistic competition. **(Remember)**
2. Apply any one method of non-price competition under oligopoly for retail shop. **(Apply)**

CO4: Students will be able to Identify the overall performance of the economy, and the regulation of economic fluctuations and its impact on various sections in the society. (Apply)

1. Enumerate the measures to control inflation. **(Remember)**
2. Determine the GDP of our country. **(Apply)**

CO5: Students will be able to Determine the impact of changes in global economic policies on the business opportunities of a firm. (Apply)

1. Enumerate the arguments in favor of protection. **(Understand)**
2. Suppose a foreign country imposes a tariff on Indian goods. How does it affect India's exports? **(Apply)**

21ME7802	FUNDAMENTALS OF ERGONOMICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

The fundamentals of ergonomics as well as numerous tools and approaches for creating a comfortable and secure workplace are covered in this course.

Objectives

- To introduce the principles of Ergonomics and its evaluation procedure.
- To impart basic knowledge on the movements of hand, leg etc. and its measurement techniques.
- To convey the different posture of hand and arm and motion assessment methods.
- To impart the environmental issues and perception on men machine interaction.
- To familiarize with the work system evaluation and safety methods.

UNIT I	INTRODUCTION TO ERGONOMICS	9

Fundamentals of Ergonomics / Human Factors - Disciplines - Physical - Cognitive and Organizational - Needs of Ergonomics in Workplace - Ergonomic Principles - Applications - Ergonomic Evaluation - Questionnaire Survey.

UNIT II	ANTHROPOMETRY	9

Human Body - Structure and Function - Types of Anthropometric Data - Application of Anthropometry in Design – Anthropometric Measuring Techniques - Statistical Treatment of Data and Percentile Calculations

UNIT III	POSTURE AND MOVEMENT	9

Posture : Biomechanical Background - Physiological Background - Sitting - Standing Change of Posture - Hand and Arm Postures

Movement: Lifting - Carrying - Pulling - Pushing - Repetitive Motions - Rapid Upper Limb Assessment (RULA) – Rapid Entire Body Assessment (REBA) and Ovako Working Posture Assessment (OWAS) Method.

UNIT IV	WORK COUNTER BEHAVIOR AND PERCEPTION	9

Work Counter: Environmental Issues - Physical Work Capacity - Factors Affecting work Capacity - Communication and Cognitive Issues - Information Processing and

Perception: Interaction with Machines - Mental Workload

UNIT V	WORK SYSTEM EVALUATION AND SAFETY	9

Work system Evaluation: Contribution of Ergonomics to Workstation Design - Analysis of Workplace Design - Work Envelopes - Workplace Evaluation Tools - Case Studies

Safety: Occupational / Ergonomic Safety and Stress at Various Workplace - Health Management Rules - Scope of Ergonomics in India-Case Studies.

	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60Marks)**
CAT 1 - 10 Marks CAT 2 - 10 Marks	1.Descriptive type questions, and 2.Multiple choice questions,	1. Descriptive type questions.

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Define ergonomics and its components. **(Understand)**
CO2: Apply statistical treatment of data in anthropometry design. **(Apply)**
CO3: Identify the various assessment methods for ergonomic improvement. **(Apply)**
CO4: Utilize the ergonomic principles in assigning task to the workers. **(Apply)**
CO5: Apply ergonomics to propose an effective work place design with safety. **(Apply)**

Text Books

1. Bridger, Robert. "Introduction to Human Factors and Ergonomics", United Kingdom, CRC Press, 2017.

Reference Books

1. Dul, Jan, and Weerdmeester, Bernard. "Ergonomics for Beginners: A Quick Reference Guide", 3rd Edition. United Kingdom, Taylor & Francis, 2017.
2. Pamela McCauley-Bush, "Ergonomics: Foundational Principles, Applications, and Technologies", 1st Edition, Taylor & Francis, CRC Press, New York, 2015.

Web Resources

1. https://archive.nptel.ac.in/courses/107/103/107103085/ - **Ergonomics Workplace Analysis.**
2. https://youtu.be/3kVnUqvRJV0 - **Lecture Series on Ergonomics by Dr Peter Crane**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	1	1		1							1		3
CO2	3	1	2		1							1		3
CO3	3	1			1	1						1		3
CO4	3	1	2		1	1						1		3
CO5	3	1			1	1	2					1		3

COURSE LEVEL ASSESSMENT QUESTIONS

CO1: Students will be able to define ergonomics and its components – (Understand)

1. What are the fundamentals of ergonomics and human factors? **(Remember)**
2. What is the role of questionnaire surveys in ergonomic evaluation? **(Understand)**

CO2: Students will be able to apply statistical treatment of data in anthropometry design. (Apply)

1. How is statistical treatment of data used in anthropometry? **(Understand)**

2. Apply a suitable anthropometric measuring techniques for generating data for shop floor. **(Apply)**

CO3: Students will be able to identify the various assessment methods for ergonomic improvement. (Apply)

1. Mention the biomechanical and physiological implications of frequently changing posture from sitting to standing? **(Understand)**
2. Compare and contrast the Rapid Upper Limb Assessment (RULA) method and Rapid Entire Body Assessment (REBA) **(Apply)**

CO4: Students will be able to utilize the ergonomic principles in assigning task to the workers. – (Apply)

1. What strategies can be employed to enhance an individual's physical work capacity? **(Understand)**
2. With a help of any technique assess the mental workload in an automobile assembly section of an industry. **(Apply)**

CO5: Students will be able to apply ergonomics to propose an effective work place design with safety – (Apply)

1. Explain the process of analyzing workplace design from an ergonomics perspective? **(Understand)**
2. Apply any one technique in identifying the essential elements available in an oil refinery industry for an effective ergonomic planning **(Apply)**

21ME7803	POLLUTION CONTROL AND ITS EQUIPMENTS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To study the pollution control regulation and standards, water and wastewater.
- To study the equipment for various water pollution.
- To study the equipment for air pollution control.
- To study the equipment for solid waste processing
- To study the pollution monitoring equipment

UNIT I	POLLUTION CONTROL REGULATIONS AND STANDARDS	9

Pollutants in water and wastewater – sources and impacts- Characteristics and impacts of solid and hazardous wastes - Indian Constitution and Environmental Protection Legislations – Environmental Standards under different Environmental legislations - Water Act (1974), Air Act (1981), Environmental Protection Act (1986) and major Notifications, Municipal solid Wastes (Management and Handling) Rules -Bio Medical Wastes (Management and Handling) Rules - Hazardous Wastes (Management and Handling Rules),Environment Impact Assessment Notifications - Unit operations and unit processes in Pollution Control- - Selection criteria for Pollution Control Equipment.

UNIT II	EQUIPMENTS FOR WATER POLLUTION CONTROL	9

Operational principles and Design criteria of Flash mixers, Flocculators, Clarifiers, Sand Filters, Adsorption Columns, Aerators, Air blowers, Distillation units, Centrifugal and Reciprocating Pumps, Chemical dosing systems, Motors, Pipes, valves and Fittings.

UNIT III	EQUIPMENTS FOR AIR POLLUTION CONTROL	9

Operational principles and Design criteria of Cyclone separators, gravity settlers, Wet Scrubbers, Air strippers, Bag Filters, Electrostatic precipitators, Biofilters

UNIT IV	EQUIPMENTS FOR SOLID WASTE PROCESSING	9

Operational principles and Design criteria of Dewatering equipment – centrifuge, Vacuum Filter, Filter Press- Size Reduction equipment – shredders, grinders – Trommel and Disc Screens – Air Classifiers - bailing and briquetting – incinerators –Pyrolysis

UNIT V	POLLUTIONS MONITORING EQUIPMENT	9

Equipment's for sampling of water, solids and air- Sample preservation Equipment – incubators – Cold Storage systems- equipment for analysis of water and air samples- Ambient air and flue gas sampling and monitoring equipment

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY/	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Outline the different types of pollution, their sources and effects. **(Understand)**
CO2: Interpret the pollution control regulations and standards **(Understand)**
CO3: Summarize the equipments for air pollution control **(Understand)**
CO4: Discuss different methods of pollution control from various sources in air, water and soil **(Understand)**

CO5: Identify and use the suitable pollution monitoring equipments for air and water samples **(Apply)**

Text Books

3. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
4. Rao. C.S ., "Environmental Pollution and Control Engineering", 2nd Edition, Revised, Wiley Eastern Limited, India, 2006

Reference Books

4. Shyam Diwan and Armin Rosencranz, Enviromental Law and Policy in India, Oxford, 2001
5. Metcalf & Eddy, INC, „Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2014.
6. Noel de Nevers, "Air Pollution Control Engg", Mc Graw Hill, New York, 2016.
7. CPCB (2021), "Pollution Control Acts, Rules and Notifications issued thereunder, PCL Series-Central Pollution Control Board, Delhi

Web Resources

2. https://archive.nptel.ac.in/courses/105/107/105107213/ **- Air Pollution and Control**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		1			2	3					1		3
CO2	1		2			2	3					1		3
CO3	1		2			2	3					1		3
CO4	1		2			2	3					1		3
CO5	1		2			2	3					1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to outline the different types of pollution, their sources and effects. (Understand)

3. Write a brief note on Governmental rules related to bio medical wastes. **(Understand)**
4. Discuss the criteria followed in selecting the pollution control equipment. **(Understand)**

COURSE OUTCOME 2: Students will be able to interpret the pollution control regulations and standards (Understand)

3. Discuss about the design considerations in selecting flocculators and aerators in water pollution control. **(Understand)**
4. What is the role of pumps in water pollution control. Explain the significance of reciprocating pump in pollution control. **(Understand)**

COURSE OUTCOME 3: Students will be able to summarize the equipments for air pollution control (Understand)

3. Explain the criteria for selection of air pollution control equipment. **(Understand)**
4. Explain with neat sketch the working principle, advantages and disadvantages of Electrostatic Precipitator **(Understand)**

COURSE OUTCOME 4: Students will be able to Discuss different methods of pollution control from various sources in air, water and soil (Understand)

3. Explain the types of vacuum filters used in solid processing. **(Understand)**
4. Mention the factors considered in selecting dewatering equipment. **(Understand)**

COURSE OUTCOME 5: Students will be able to Identify and use the suitable pollution monitoring equipments for air and water samples (Apply)

3. How water sample can be analysed for pollutants. Briefly discuss its methods **(understand)**
4. Explain how cold storage systems are predominant in pollution control. Justify your answers **(Apply)**

21ME7804	Energy Storage Devices	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To study the various types of energy storage devices and technologies and them comparison.
- To learn the techniques of various energy storage devices and their performances.
- To learn the basics of batteries and hybrid systems for EVs and other mobile applications.
- To learn about the renewable energy storage systems and management systems.
- To have an insight into other energy storage devices, hydrogen, and fuel cells.

UNIT I	INTRODUCTION TO ENERGY STORAGE	9

Need for Energy Storage – Types of Energy Storage – Various forms of Energy Storage – Mechanical– Thermal - Chemical– Electrochemical – Electrical - Other alternative energy storage technologies – Efficiency and Comparison.

UNIT II	ENERGY STORAGE SYSTEMS	9

Pumped Air Energy Storage – Compressed Air Energy Storage – Flywheel – Sensible and Latent Heat Storage – Storage Materials – Performance Evaluation - Thermochemical systems – Batteries – Types Charging and Discharging – Battery testing and performance.

UNIT III	MOBILE AND HYBRID ENERGY STORAGE SYSTEMS	9

Batteries for electric vehicles - Battery specifications for cars, heart pacemakers, computer standby supplies – V2G and G2V technologies – HESS

UNIT IV	RENEWABLE ENERGY STORAGE AND ENERGY MANAGEMENT	9

Storage of Renewable Energy Systems –Solar Energy – Wind Energy – Energy Storage in Micro grid– Smart Grid – Energy Conversion Efficiency - Battery Management Systems – EVBMS – Energy Audit and Management

UNIT V	OTHER ENERGY DEVICES	9

Superconducting Magnetic Energy Storage (SMES), Supercapacitors – MHD Power generation – Hydrogen Storage - Fuel Cells – Basic principle and classifications – PEMFC, AMFC, DMFC, SOFC, MCFC and Biofuel Cells – Biogas Storage.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive exam

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Discuss the need and identify the suitable energy storage devices for applications. **(Understand)**

CO2. Illustrate the working of various energy storage devices and their importance. **(Understand)**

CO3. Select the specification of batteries for mobile and hybrid storage systems. **(Apply)**

CO4. Discuss the storage of renewable energies and conduct energy audit. **(Apply)**

CO5. Outline the need for other energy devices and their scope for applications. **(Understand)**

Text Books

1. Rober Huggins, "Energy Storage: Fundamentals, Materials and Applications", 2 nd Edition, Springer, 2015.
2. Dell, Ronald M Rand, David A J, "Understanding Batteries", Royal Society of Chemistry, 2001

Reference Books

1. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, 2016.
2. Lindon David, "Handbook of Batteries", McGraw Hill, 2002.
3. Aulice Scibioh M. and Viswanathan B, "Fuel Cells – principles and applications', University Press(India), 2006
4. Ru-Shiliu, Leizhang, Sueliang Sun, "Electrochemical Technologies for Energy Storage and Conversion", Wiley Publications, 2012.

Web Resources

1. https://archive.nptel.ac.in/courses/113/105/113105102/ - (**Electrochemical energy storage)**
2. https://nptel.ac.in/courses/108105058 - **Fundamentals of energy - Energy resources and technology**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2					2	3							3
CO 2	2		1			2	3							3
CO 3	2		1			2	3							3
CO 4	2	1	1			2	3							3
CO 5	2		1			2	3							3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to discuss the need and identify the suitable energy storage devices for applications. (Understand)

1. Outline the various forms of energy storage methodologies **(Understand)**
2. Compare and contrast thermal and electrochemical methods of energy storage in commercial applications. **(Understand)**

COURSE OUTCOME 2: Students will be able to illustrate the working of various energy storage devices and their importance. (Understand)

1. Differentiate pumped air storage and compressed air storage. **(Understand)**
2. Explain the various methods involved in evaluating the performance of storage systems **(Understand)**

COURSE OUTCOME 3: Students will be able to select the specification of batteries for mobile and hybrid storage systems. (Apply)

1. What are the parameters you will consider in selecting the storage device for heart pacemaker. Justify them **(Apply)**
2. Identify the factors need to be considered in selecting the storage device for electric vehicles. **(Apply)**

COURSE OUTCOME 4: Students will be able to discuss the storage of renewable energies and conduct energy audit. (Apply)

1. Explain the methods involved in storing energy from wind. **(Understand)**
2. With a case study, conduct an energy audit in Air Conditioning System and provide a solution for energy efficiency**. (Apply)**

COURSE OUTCOME 5: Students will be able to explain the need for other energy devices and their scope for applications. (Understand)

1. Explain the various methods available for storing biogas at onsite conditions **(Understand)**
2. What is SMES? Mention its significance **(Understand)**

OPEN ELECTIVE - IV

21ME7805	DIGITAL MANUFACTURING	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To study the various aspects of digital manufacturing.
- To inculcate the importance of DM in Product Lifecycle Management and Supply chain Management.
- To formulate smart manufacturing systems in the digital work environment.
- To interpret IoT to support the digital manufacturing.
- To elaborate the significance of digital twin.

UNIT I	INTRODUCTION	9

Introduction – Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

UNIT II	DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT	9

Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM

UNIT III	SMART FACTORY	9

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cybersecurity

UNIT IV	INDUSTRY 4.0	9

Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine to Machine communication – Case Studies.

UNIT V	STUDY OF DIGITAL TWIN	9

Basic Concepts – Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT 2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Summarize the various elements in digital manufacturing. **(Understand)**
CO2: Illustrate the concepts involved in digital product development life cycle process and supply chain management in digital environment. **(Understand)**
CO3: Select the proper procedure of validating practical work through digital validation in Factories. **(Apply)**
CO4: Interpret the concepts of IoT and its role in digital manufacturing. **(Understand)**
CO5: Outline various practical manufacturing process through digital twin. **(Understand)**

Text Books

7. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.
8. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", A press, 2016

Reference Books

4. Lihui Wang and Andrew YehChing Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009.
5. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019.
6. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017
7. Ronald R. Yager and Jordan Pascual Espada, "New Advances in the Internet of Things", Springer., Switzerland, 2018

Web Resources

6. The Future of Manufacturing Business: Role of Digital Technologies - Course (nptel.ac.in) - **(The Future of Manufacturing Business: Role of Digital Technology)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	2	1	1	1	2						2		3	
CO 2	1	1	1	1	3						2		3	
CO 3	1	1	1	1	3						2		3	
CO 4	1	1	1	1	3						2		3	
CO 5	1	1	1	1	3						2		3	

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to summarize the various elements in digital manufacturing. (Understand)

1. Discuss the various key aspects of Digital manufacturing. **(Understand)**
2. List the practical benefits of Digital Manufacturing. **(Remember)**

COURSE OUTCOME 2: Students will be able to illustrate the concepts involved in digital product development life cycle process and supply chain management in digital environment. (Understand)

1. Briefly discuss the scope and challenges available in digital supply chain management. **(Understand)**
2. Write a brief note on Digital mockup and prototype development. (**Understand)**

COURSE OUTCOME 3: Students will be able to select the proper procedure of validating practical work through digital validation in Factories. (Apply)

1. What are the various levels of smart factories. Explain each with its salient features **(Understand)**
2. How can digital validation be effectively utilized to validate practical work in automotive industries. **(Apply)**

COURSE OUTCOME 4: Students will be able interpret the concepts of IoT and its role in digital manufacturing. (Understand)

1. Write short notes on Cloud computing. **(Understand)**
2. Differentiate IoT and IIoT. **(Understand)**

COURSE OUTCOME 5: Students will be able to outline various practical manufacturing process through digital twin. (Understand)

1. Outline the characteristics of a good digital twin atmosphere. **(Understand)**
2. With suitable block diagram, explain the various components of digital twin. **(Understand)**

21ME7806	MARINE VEHICLES	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To provide the students a basic knowledge about various types of marine vehicles
- To provide the students basic theory behind the design and development of marine vehicles

UNIT I	MARINE VEHICLES	9

Types – general – by function – commercial marine vehicles- passenger ship, cargo ships, oil and chemical tankers, cattle carriers, harbor crafts, off shore platform, container ships

UNIT II	REEFERS AND GAS CARRIERS	9

Introduction – Types, design considerations, safety – operation and controls, precaution during bunkering

UNIT III	REMOTELY OPERABLE VEHICLE (ROV), UMS SHIPS	9

Remotely Operable Vehicles (ROV) – The ROV business – Design theory and standards – control and simulation – design and stability – components of ROV – applications, UMS operation, and controls

UNIT IV	SUBMERSIBLES AND AUTONOMOUS UNDERWATER VEHICLE (AUV)	9

submersibles types – applications, AUV – Design and construction considerations – components – sensors – Navigation -control strategies – applications

UNIT V	MANNED AND UNMANNED SUBMERSIBLE	9

Introduction – Design and operational consideration – pressure hull exo-structure – ballasting and trim – maneuvering and control – Life support and habitability – emergency devices and equipment's – certification and classification, towed vehicles – gliders – crawler – Design and construction

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Classify the types of marine vehicles **(Understand)**
CO2: Illustrate the design and safety considerations in reefers and gas carriers **(Understand)**
CO3: Distinguish between Remotely Operable Vehicle (ROV), Unmanned Machinery Space (UMS) ships **(Apply)**
CO4: Classify the various submersible vehicles with its applications **(Understand)**
CO5: Outline the various components of manned and unmanned submersibles. **(Understand)**

Text Books

1. Jonathan M. Ross, human factors for naval marine vehicle design and operation, CRC press, 2009
2. Sabiha A. Wadoo, Pushkin Kachroo, Autonomous underwater vehicles, modelling control design and Simulation, CRC press, 2011

Reference Books

1. Ferial L hawry, The ocean engineering handbook, CRC press, 2000
2. Robert D. Christ,Robert L. Wernli, Sr. "The ROV Manual A User Guide for Remotely Operated Vehicles", Elsevier, second edition, 2014

Web Resources

1. NPTEL :: Ocean Engineering - Performance of Marine Vehicles at Sea (**Marine Vehicles**)

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1		1	1		1						3		3
CO 2	1		2	1		1						3		3
CO 3	1		2	1		1						3		3
CO 4	1		2	1		1						3		3
CO 5	1		2	1		1						3		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to understand the types of marine vehicles (Understand)

1. Explain the general classifications of marine vehicles. **(Understand)**
2. Write short notes on oil and chemical tankers. **(Understand)**

COURSE OUTCOME 2: Students will be able to describe the design and safety considerations in reefers and gas carriers (Understand)

1. Explain briefly the safety considerations in reefers and gas carriers. **(Understand)**
2. Describe the precautionary steps involved in bunkering of marine vehicles. **(Understand)**

COURSE OUTCOME 3: Students will be able to distinguish between Remotely Operable Vehicle (ROV), Unmanned Machinery Space (UMS) ships (Apply)

1. With a case study, discuss the components to be employed in ROV for underwater pipeline applications. **(Apply)**
2. Discuss the controls and operations of UMS ships **(Understand)**

COURSE OUTCOME 4: Students will be able to classify the various submersible vehicles with its applications (Understand)

1. Explain the components of AUV with neat sketches. **(Understand)**
2. Discuss the navigation and control strategies followed in AUV. **(Understand)**

COURSE OUTCOME 5: Students will be able to describe the various components of manned and unmanned submersibles. (Understand)

1. Distinguish the design consideration to be followed between manned and unmanned vehicles. **(Understand)**
2. Discuss in detail the components used in unmanned marine vehicles. **(Understand)**

21ME7807	SAFETY MEASURES FOR ENGINEERS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To provide the students a basic knowledge about safety in different fields
- To provide the students basic knowledge about personnel protection and risk control techniques

UNIT I	SAFETY MANAGEMENT AND ACCIDENT PREVENTION	9

Introduction: Need for Safety - Safety and Productivity - Safety Management Techniques - Job Safety Analysis - Safety Sampling Technique - Incident Recall Technique - Plant Safety Inspection - Accident: Nature and Causes of Accidents - Accident Proneness - Cost of Accident - Accident Prevention Methods - Accident Reporting and Investigation - Safety Education and Training

UNIT II	ELECTRICAL SAFETY EQUIPMENTS	9

Voltage Measuring Instruments: Safety Voltage Measurement - Contact and Non-Contact Type Testers. Rubber Insulating Equipment: Rubber Mats - Rubber Blankets - Rubber Covers - Line Hoses and Sleeves -Inspection Techniques – Standards. Insulated Tools: Hot Sticks - Cherry Picker - Standards for Tools - Safety Barriers and Signs - Safety Tags - Lock and Locking devices. Fire Extinguishers: Fire Safety Against Electrical fire - Types of Extinguishers.

UNIT III	SAFETY IN CHEMICAL INDUSTRY	9

Types of Chemical Industry - Statutory Provisions - Indian Standards – Types of Chemical Hazards & Controls – Material (Property) Hazards and Controls – Storage Hazards & Controls - Process Hazards & Controls - Utility Hazards & Controls - Pollution Hazards & Controls - Instrumentation for Safe Plant Operations - Safe Transfer of Chemicals - Inspection, Testing & Maintenance - Work Permits of Hazardous Work

UNIT IV	PERSONNEL PROTECTION EQUIPMENT (PPE)	9

Flash and Thermal protection: Glossary of Terminologies - Flame Resistant - Arc Thermal Performance Value (ATPV) - Energy Breakthrough (EBT) - ASTM Standard for Clothing Materials - Choice of Clothing - Flame and Non-Flame-Resistant Materials - Guidelines for Selection - Flash Suit Head Protection: Hard Hats – ANSI Z 89.1 Standard - Eye Protection - Requirements of Safety Glasses - Goggles - Selection - Face shield. Hearing Protection – Requirement - Ear plugs and Ear muffs - Noise Reduction Ratio

UNIT V	RISK ASSESSMENT AND CONTROL TECHNIQUES:	9

Risk Assessment: Basic Concepts of Risk - Safety Appraisal, Analysis and Control Techniques - Accident Investigation, Analysis and Reporting - Hazard and Risk Assessment Techniques - Reliability Engineering - Major Accident Hazard (MAH) Control - Onsite and Off-site Emergency Plans

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	Formative Assessment Test (20 Marks)	End Semester Exams (60 Marks)
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Perceive the safety management concepts and accident prevention methods. **(Understand)**
CO2: Apply appropriate insulating equipment, use of fire extinguishers **(Apply)**
CO3: List the hazards in chemical industries during transporting, storing and processing to ensure safe plant operations **(Understand)**

CO4: Infer suitable PPE based on the type of industry and standards. **(Understand)**
CO5: Implement the techniques like risk assessment disaster management and emergency preparedness with the proper knowledge on accident prevention. **(Apply)**

Text Books

1. Mistry K.U., "Fundamentals of Industrial Safety and Health", 2nd Edition, Siddharth Prakashan, Ahmedabad, 2008.

Reference Books

1. John Cadick, Mary Capelli Schellpfeffer & Dennis Neitzell, "Electrical Safety Handbook", 4th Edition, McGraw-Hill Education, 2012.
2. Rao S, Jain R.K. & Saluja H.L., "Electrical Safety, Fire Safety Engineering and Safety Management", 2nd Edition, Khanna Publishers, 2012.

Web Resources

1. https://archive.nptel.ac.in/courses/110/105/110105094/ - **(Industrial Safety Engineering)**
2. https://archive.nptel.ac.in/courses/103/107/103107156/ - **(Chemical Process Safety)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1			1		3					1	1		3
CO 2	1			1		3					1	1		3
CO 3	1			1		3					1	1		3
CO 4	1			1		3					1	1		3
CO 5	1			1		3					1	1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to perceive the safety management concepts and accident prevention methods. (Understand)

1. Discuss about the safety education and training in accident prevention. **(Understand)**
2. Explain the various accident prevention methods in detail. **(Understand)**

COURSE OUTCOME 2: Students will be able to apply appropriate measuring and /or insulating equipment, use of fire extinguishers and safe earthing practices (Apply)

1. What are the safety considerations to be followed in earthing systems? Brief them. **(Understand)**
2. How safety can be ensured in fire extinguishers. Explain them with a case study. **(Apply)**

COURSE OUTCOME 3: Students will be able to list the hazards in chemical industries during transporting, storing and processing to ensure safe plant operations (Understand)

1. Discuss the various types of chemical hazards and explain its control measures. **(Understand)**
2. What are the guidelines to be followed in the safe transfer of chemicals? Explain in brief. **(Understand)**

COURSE OUTCOME 4: Infer suitable PPE based on the type of industry and standards. (Understand)

1. Types and characteristics of head protectors **(Understand)**
2. When canister or cartridge type respirator should not be used? Explain your answers with justification **(Understand)**

COURSE OUTCOME 5: Implement the techniques like risk assessment disaster management and emergency preparedness with the proper knowledge on accident prevention. (Apply)

1. What is Total Loss Control? What are the four steps involved in managing the loss control **(Understand)**
2. In a factory rough casting of 15 Kg. are fettled by hand on a pedestal grinder (dia 12"). The castings are picked up from nearby store, fettled on the grinder and replaced on the floor on the other side of the machine. Carry out job safety analysis and prepare the job breakdown sheet. **(Apply)**

21ME7808	INTRODUCTION TO ROBOTICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

- To understand the functions of the basic components of a Robot.
- To study the use of various types of end Effectors and Sensors
- To impart knowledge in Robot Kinematics and Programming
- To learn Robot safety issues and economics.

UNIT I	FUNDAMENTALS OF ROBOT	9

Robot - Definition - Robot Anatomy - Coordinate Systems, Work Envelope Types and Classification-Specifications-Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load-Robot Parts and their Functions-Need for Robots-Different Applications

UNIT II	ROBOT DRIVE SYSTEMS AND END EFFECTORS	9

Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, Applications and Comparison of all these Drives, End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

UNIT III	SENSORS	9

Requirements of a sensor, Principles and Applications of the following types of sensors- Position sensors - Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, pneumatic Position Sensors, Range Sensors Triangulations Principles, Structured, Lighting Approach, Time of Flight, Range Finders, Laser Range Meters, Touch Sensors, binary Sensors, Analog Sensors, Wrist Sensors, Compliance Sensors, Slip Sensors,

UNIT IV	ROBOT KINEMATICS AND ROBOT PROGRAMMING	9

Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Lead through Programming, Robot programming Languages-VAL Programming-Motion Commands, Sensor Commands, End Effector commands and simple Programs.

UNIT V	FIELD APPLICATIONS OF ROBOTICS	9

Material transfer, Machine loading, Assembly, inspection, processing operations and service robots, Delivery Robots – Intelligent vehicles – Survey and inspection robots – Space Robots – Autonomous aircrafts – Underwater Inspection – Agriculture and Forestry – Military robots

Total Periods	45

Suggestive Assessment Methods		
Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
Descriptive exam CAT 1 10 AND CAT2 10 MARKS	MCQ QUIZ / SEMINAR/ ASSIGNMENT/SLIPTEST/CASE STUDY	Descriptive type

Course Outcomes

Upon completion of the course, the students will be able to:

CO1: Express the basic concepts, laws, components and parameters of robots **(Understand)**
CO2: Discuss about drive system and the types of grippers and its functions. **(Understand)**
CO3: Summarize the various types of sensors involved in controlling the robots **(Understand)**
CO4: Interpret the various programming techniques used in industrial robots **(Understand)**
CO5: Identify the use of robots in various field of applications **(Apply)**

Text Books

1. M.P.Groover, M.Weiss ,R.N. Nagal, N.G.Odrey, "Industrial Robotics - Technology, programming and Applications" Tata , McGraw-Hill Education Pvt Limited 2nd Edition, 2012
2. Roland Seigwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, “Introduction to autonomous mobile robots”, 2nd edition, MIT Press, 2011.

Reference Books

1. John.J.Craig, " Introduction to Robotics: Mechanics & control"Pearson Publication, Fourth edition, 2018.
2. Klafter R.D., Chmielewski T.A and Negin M., “Robotic Engineering - An Integrated Approach”, Prentice Hall, 2003.
3. Saeed B Niku, ‘Introduction to Robotics, Analysis, Control, Applications, Wiley India Pvt Ltd publication, 2nd Edition, 2011.

Web Resources

1. https://onlinecourses.nptel.ac.in/noc21_me76/preview **(Robotics)**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	1				2						1		3
CO 2	3	1				2						1		3
CO 3	3	1				2						1		3
CO 4	3	1	1	2		2						1		3
CO 5	3	1		2		2						1		3

COURSE LEVEL ASSESSMENT QUESTIONS

COURSE OUTCOME 1: Students will be able to express the basic concepts, laws, components and parameters of robots (Understand)

1. Sketch and explain the four basic robot configurations classified according to the coordinate system. **(Understand)**
2. Write short notes on Joint notation scheme. **(Understand)**

COURSE OUTCOME 2: Students will be able to Discuss about drive system and the types of grippers and its functions. (Understand)

1. Explain various types of Gripper mechanisms in robot. **(Understand)**
2. Explain how grippers are selected for high temperature applications? Justify your answers with gripper selection factors and considerations. **(Understand)**

COURSE OUTCOME 3: Students will be able to summarize and determine various types of sensors involved in controlling the robots (Understand)

1. Briefly explain the working principle of position sensors with neat sketch. **(Understand)**
2. Explain the working principle of Proximity sensors with neat sketch. **(Understand)**

COURSE OUTCOME 4: Students will be able to describe the various programming techniques used in industrial robots (Understand)

1. List the commands used in VAL II programming and describe its functions. **(Understand)**
2. Write down the capabilities and limitations of Lead through methods. **(Understand)**

COURSE OUTCOME 5: Students will be able to Identify the use of robots in various field of applications (Apply)

1. With necessary outline, discuss the application of robots in packaging industries **(Apply)**
2. With a case study, explain the applications of robot in underwater inspection. **(Apply)**

VALUE ADDED COURSES

21ME3V01	DIGITAL PROTOTYPING USING SOLIDWORKS	L	T	P	C
		0	0	4	2

Prerequisites for the course

Engineering Graphics, Basics of AutoCAD

Objectives

The objective of this skill training is to teach users the basic commands and tools necessary for professional 2D drawing, 3D drawing, Assembly of mechanical components design and drafting using Solidworks.

MODULE 1	Introduction to Solidworks and its User Interface	10

Introduction-Basic Commands, Interacting with Solidworks UI, Drawing tools, Editing tools, Drawing setup-Command Manager- Feature manager design tree, Callouts, Handles, Confirmation corner, mouse buttons, keyboard shortcuts, Command Manager,Hardware and Software requirements.

MODULE 2	Sketching	10

Sketching: 2D Sketching, Sketch entities, rules that govern sketches, sketch relations, dimensioning guidelines, – Inference line, Centerline line, Line, Circle, Arc, Ellipse, Rectangle, Slots, Polygon, Ellipse, Partial Ellipse, Spline, Points, Text, Construction geometry-Practice drawing

MODULE 3	Basic Part Modeling	10

Basic modeling terminologies, part details – Boss feature – sketching on a planar face - cut feature – view selector – hole wizard – filleting – editing tools – detailing – drawing views – changing parameters – dimensioning - Practice drawing

MODULE 4	Part Modeling Features	10

Boss feature with draft, symmetry in sketch, sketching inside the model – view options – model edges in sketch – trimmed sketch geometry - linear patterns – circular patterns – mirror patterns – revolved features- shells and ribs – thin features - Practice drawing

MODULE 5	Assembly	10

New assembly – positioning of component – Design tree – adding components – mating components – sub assemblies – assembly analysis – assembly explode – bill of materials - Practice drawing

MODULE 6	Generating views	10

Generating Model View, Projected Views, Inserting Standard 3 View - View creation relative to model, Inserting predefined views, Auxiliary Views, Detailed Views, Crop view, Broken –Out Section, Broken Views, Section View, Alternate Position View

Total Periods	**60**
Suggestive Assessment Methods	
Online Assessment	
4 Online assessment tests each carrying 25 marks (Total 100 marks)	
Course Outcomes	
Upon completion of the course, the students will be able to:	
CO1: Interpret the basics of Solidworks **(Understand)** CO2: Discuss the sketching tools and guidelines in sketching. **(Understand)** CO3: Interpret part modeling and its features **(Apply)** CO4: Assemble the modeled components using solidworks. **(Apply)** CO5: Generate predefined views using various tools using solidworks **(Apply)**	
Text Books	
1. Alejandro Reyes 2021 Beginner's guide to Solidworks 2021 2. David C Planchard, "Engineering Design with solidworks" 2019	
Reference Books	
1. Gaurav vera, matt weber, "Solidworks flow simulation 2020 Black book" 2019 2. CADArtife, John Willis, Sandeep Dogra"solidworks 2019 A Power guide for beginners and intermediate User (2019) 3. Arsath Natheem "Solidworks for Beginners" 2018	
Web Resources 1. Best SOLIDWORKS Online Courses - Updated [August 2023] (udemy.com)	

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	1	3				1			1	3	
CO2	3	2	2	1	3				1			1	3	
CO3	3	2	2	1	3				1			1	3	
CO4	3	2	2	1	3				1			1	3	
CO5	3	2	2	1	3				1			1	3	

21ME5V03	Numerical Simulation using Ansys Fluent	L	T	P	C
		0	0	4	2

Prerequisites for the course

Basic knowledge in Engineering Drawing, Basic Knowledge in Fluid Mechanics and Heat Transfer

Objectives

- To acquire knowledge on the basic concepts involved in grid generation in Fluent.
- To gain basic ideas on numerical fluid dynamics.
- To arrive at the solution of fluid flow equations and to apply those concepts for industrial needs.

MODULE 1	Introduction	10

CFD-Definition, Applications, CFD Methodology, Ansys Fluent, Menu bar & Toolbars, Navigation pane – Task pages – Boundry conditions – fluent in workbench.

MODULE 2	Solid modeling fundamentals	10

An Overview of Solid Modeling Operations, Working with Boolean operations, Working Plane, Importing of 3D models – practice problems

MODULE 3	Meshing	10

Free meshing, setting element attributes, selecting element type, defining element types, section properties, assigning element attributes before meshing, mesh controls, smart sizing, hybrid meshing, mesh extrusion – practice problems

MODULE 4	Material properties in fluent	10

Material library, specifying properties – boundary conditions – types of loads – types of solvers, solver setup, load step options, post processing – practice problems

MODULE 5	2D flow analysis	10

Flow inside square cavity & channel – steady flow past a cylinder – compressible flow in a nozzle – supersonic flow over a wedge – flow over an air foil - 2D Steady State Conduction

MODULE 6	3D analysis using Fluent	10

Flow over a circular pipe, flow over a sphere– flow analysis of Elbow - flow analysis of venturi – Flow analysis of Spiral Coil Heat Exchanger

Total Periods	**60**
Suggestive Assessment Methods	
Online Assessment	
4 Online assessment tests each carrying 25 marks (Total 100 marks)	
Course Outcomes	
Upon completion of the course, the students will be able to:	
CO1: Acquire knowledge on the mathematical nature of fluid dynamic equations and to specify boundary conditions **(Understand)** CO2: Generate grid by using numerical methods. **(Understand)** CO3: mesh the modelled part using various features **(Apply)** CO4: Apply time dependant methods for 2-D flow problems. **(Apply)** CO5: Apply time dependant methods for 3-D flow problems. **(Apply)**	
Text Books	
1. Divya zindani, Apurba Kumar Roy, "Working with ANSYS: A Tutorial Approach", 2017	
Reference Books	
1. John E Matsson "An Introduction to Ansys Fluent 2022", 2022 2. Huei-Huang Lee "Finite element simulations with Ansys workbench 2023". 2023	

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	1	3				1			1	3	
CO2	3	2	2	1	3				1			1	3	
CO3	3	2	2	1	3				1			1	3	
CO4	3	2	2	1	3				1			1	3	
CO5	3	2	2	1	3				1			1	3	

SWAYAM NPTEL ONLINE COURSES

Department: Mechanical Engineering

S.No	Course ID	Course Name	Start Date	End Date	Duration	Recommended for open elective	Recommended for professional elective
1	noc23_cs82	Introduction to Industry 4.0 and Industrial Internet of Things	24.07.2023	13.10.2023	12 Weeks	-	PE
2	noc23_de12	Introduction to Robotics	24.07.2023	13.10.2023	12 Weeks	-	PE
3	noc23_mg74	Entrepreneurship	24.07.2023	13.10.2023	12 Weeks	-	PE
4	noc23_me105	Automation in Manufacturing	24.07.2023	13.10.2023	12 Weeks	-	PE
5	noc23_mg71	Operations and Supply chain Management	24.07.2023	13.10.2023	12 Weeks	-	PE
6	noc23_mg98	Industrial Safety Engineering	24.07.2023	13.10.2023	12 Weeks	-	PE
7	noc23_me119	Computational Fluid Dynamics	24.07.2023	13.10.2023	12 Weeks	-	PE

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Vannarpettai, Tirunelveli - 627003, Tamil Nadu

MINOR/SPECIALIZATION COURSE ON ADDITIVE MANUFACTURING

B.E.Mechanical Engineering

Regulations 2021

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Department of Mechanical Engineering

B.E. Mechanical Engineering

MINOR/SPECIALIZATION COURSE ON ADDITIVE MANUFACTURING

REGULATIONS 2021

(CBCS)

Specialization Course on Additive Manufacturing

CURRICULUM AND SYLLABI

Offered one course per semester starting from 4th semester							
Course code	Course	Category	L	T	P	C	H
21ME4S01	Additive Manufacturing Technologies and Applications	S	3	0	0	3	3
21ME5S02	CAD for Additive Manufacturing	S	3	0	2	4	5
21ME6S03	Design for Additive Manufacturing	S	3	0	0	3	3
21ME7S04	3D Printing and Prototyping	S	3	0	2	4	5
21ME8S05	Prototyping project	S	0	0	8	4	8

ADDITIVE MANUFACTURING SYLLABI

21ME4S01	ADDITIVE MANUFACTURING TECHNOLOGIES AND APPLICATIONS	L	T	P	C
		3	0	0	3

Prerequisites for the course

Nil

Objectives

Students undergoing this course are expected to

1. Know the principles, methods, areas of usage, possibilities and limitations of the additive manufacturing technologies
2. Be familiar with the characteristics of various materials that are used in additive manufacturing.

UNIT I	ADDITIVE MANUFACTURING FUNDAMENTALS	9

Need for time compression in product development, Need for Additive Manufacturing (AM), Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Classification of AM process, Comparison of AM with CNC and other technologies.

UNIT II	LIQUID-BASED AM SYSTEMS	9

Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, Laser scanning, Applications, Advantages and Limitations, Case studies. Solid Ground Curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Polyjet: Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to microfabrication.

UNIT III	SOLID-BASED AM SYSTEMS	9

Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Fused Deposition Modelling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Multi-Jet Modelling (MJM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition and Directed Energy Deposition Processes.

UNIT IV	POWDER-BASED AM SYSTEMS	9

Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Three-dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Laser Engineered Net Shaping (LENS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Electron Beam Melting (EBM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies.

UNIT V	AM APPLICATIONS	9

Applications of AM- Prototyping- Tooling- Production- Customization and Personalization- Spare Parts, Maintenance and Repair- Art, Design, and Architecture- Evaluating the Adoption of AM- Applications in Aerospace Industry, Automotive Industry, Jewellery Industryapplication. AM inMedical and

Bioengineering Applications: Planning and simulation of complex surgery, Customised Implants & Prosthesis, Design and Production of Medical Devices.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	**Formative Assessment Test (20 Marks)**	**End Semester Exams (60 Marks)**
2 Test EACH 10 marks **MCQ/Descriptive Questions**	**MCQ,ASSIGNMENT**	**Descriptive Questions**

Outcomes

Upon completion of the course, the students will be able to:

CO.1 Explain the fundamentals of various Additive Manufacturing (AM)techniques.

CO.2 Describe the working principle, capability, limitation and applications of liquid, solid and powder based additive manufacturing techniques.

CO.3 Choose a suitable AM technique for the specified application.

CO.4 Compare different AM process and materials based on application.

CO.5 Explore the range of 3D printing and Prototyping technologies and their application for industrial, design, and creative field.

CO.6 Explain current and emerging 3D printing applications for various industrial environment.

Text Books

1. Olaf Diegel, "A Practical Guide to Design for Additive Manufacturing", Springer, 2019
2. Martin Leary, "Design for Additive Manufacturing", Elsevier, 2019.

Reference Books

1. Ben Redwood, "The 3D Printing Handbook: Technologies, Design and Applications",3D Hubs, 2017.
2. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific publications, Third Edition, 2010.
3. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer , 2001
4. Wholers Report 2000 – Terry Wohlers, Wohlers Associates, 2000
5. Rapid Prototyping & Engineering Applications – Frank W.Liou, CRC Press, Taylor & Francis Group, 2011.
6. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing,Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015

Web Resources

Nil

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	1	1	1								
2	3	1	1	2	1							
3	3	2	3	2	2							
4	3	2	2	2	2							
5	3	2	2	2	2							
6	3	3	3	2	2	2						3

21ME5S02	CAD FOR ADDITIVE MANUFACTURING	L	T	P	C
		3	0	2	4

Prerequisites for the course

Nil

Objectives

The course is aimed at giving exposure to and enhancing the knowledge and skills of fresh graduate engineers and engineers involved in the operation use of 3D Scanners and 3D printing / additive manufacturing with the aid of CAD packages and for those who want to provide training to others in this area. It gives exposure and on hand experience in the field of CAD packages, 3D Scanner and AM format.

UNIT-I	DESIGN OF SOLIDS	6

Introduction to modelling, Types of modelling, 3D modelling: Solid entities, Boolean operations, Types of solid model – Boundary representation (B-rep) technique and Construction Solid Modelling (CSG) approach, Advanced modelling methods-CAD Data exchange formats. AMF files, 3MF, XML, Meta Data, PLY, STEP for AM Application Protocols (AP).

UNIT-II	3D DATA CAPTURE AND SCANNING TECHNOLOGIES	6

Introduction to imaging, Portable CMM - Structured light, portable arm-based laser scanning - time-of-flight and phase shift (long range) scanners-X-Ray technology, -3D CT (X-Ray) scanners- Computed Tomography (CT), Basic Components of CT, Different Types of CT Scanners, Magnetic Resonance Imaging (MRI), Ultrasound imaging, 3-D laser scanners, Industrial CT Scanners.

UNIT-III	REVERSE ENGINEERING AND OBJECT DIGITIZATION	6

Reverse Engineering Methodology – Reverse Engineering Steps - The generic process-Three phases of reverse engineering-Phase I: Scanning, Phase II: Point processing, Phase III: Geometric model development, Case studies. Applications and selection of reverse engineering systems. Hardware and software involved. Point clouds, meshes (.stl), NURBS surface models and parametric CAD models.

UNIT-IV	3D RECONSTRUCTION	6

3D reconstruction, Image Reconstruction Procedure, Digital Communication Post processing the Captured Data - Handling Data Points - Curve and Surface and solid Creation. Layer-based Model Generation – Adaptive Slicing Approach for Cloud Data Modelling – Planar Polygon Curve Construction – Determination of Adaptive Layer Thickness – Application Examples.CAD Model Construction from Point Clouds, Data handling & Reduction Methods, AM Software (Magics, Mimics, 3Matic, Rhino)

UNIT-V	AM DATA FORMATS AND MESHING	6

Tessellated Models, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, and Newly Proposed Formats. STL File Manipulation and Repair Algorithms - Mesh Refining by Sub division Techniques.

S.No	List of Experiments	CO
1	2D sketching of product design ideas.	CO1
2	3D modelling and assembling.	CO1
3	Use of 3D digitalization scanners.	CO2
4	Use of point clouds/meshes editing software.	CO2
5	Preparation of 3D CAD models and stl file generation	CO3
6	File manipulations and repair using AMsoftware	CO5
Total Periods		**30 Theory +30 Lab**

Laboratory Requirements

Stratasys FDM Machine
3-D Scanner
Reverse Engineering Software

Suggestive Assessment Methods

Continuous Assessment Test (30Marks)	Lab Components Assessments (20 Marks)	End Semester Exams (50 Marks)
2 Test EACH 15marks MCQ/Descriptive Questions	Experiments and record of work (10) & Model practical (10)	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1 Develop 3D solid model using B-rep and CSG techniques.
CO2 Explain the different CAD data exchange formats.
CO3 Describe the working principle of different solid component scanning techniques
CO4 Explain the different stages of reverse engineering and object digitization
C05 Construct curve, surface and solid models using AM editing software (Practical)
CO6 Convert the different AM data formats (Practical)

Text Books

1. Michael E. Mortenson, "Geometric Modeling", Wiley, NY, 1997.
2. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
3. Ian Gibson, "Software Solutions for Rapid Prototyping", Professional Engineering Publishing Limited, UK, 2002.
4. Ali K. Kamrani and Emad Abouel Nasr, "Engineering Design and Rapid Prototyping", Springer, 2010.
5. Ibrahim Zeid, "CAD/CAM: Theory and Practice" TMH, 2009.

Reference Books
Nil
Web Resources
Nil

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	2	3	1	3							
2	3	1	1	1	3							
3	3	1	1	1	3							
4	3	2	1	1	3							
5	3	3	3	3	3							
6	3	3	3	3	3							

21ME6S03	DESIGN FOR ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Additive Manufacturing Technologies and Applications
- CAD for Additive manufacturing
- 3D Printing and Prototyping

Objectives

Students undergoing this course are expected to

- To impart knowledge on
- To introduce the basics of design for additive manufacturing.
- To demonstrate comprehensive knowledge of part consolidation and tooling design
- To know the design requirements for Metal AM and Polymer AM technique.
- To illustrate the implication of part design on build time and material strength
- To realize the concept of the post processing treatments in AM

UNIT I	STRATEGIC DESIGN IN ADDITVE MANUFACTURING	9

Design for additive manufacturing (DfAM) – Value addition with AM – General Guidelines for Designing AM parts – Design to Avoid Anisotropy – Design to Minimize Print Time – Design to Minimize Post–processing – Topology Optimisation. Design Analysis for AM – Considerations for Analysis of AM Parts – role of mesh, topology and size optimization – Build process simulation - Comparing Process and Material Performance.

UNIT II	PART CONSOLIDATION AND TOOLING DESIGN	9

Part Consolidation – Design for Function – Material Considerations – Number of Fasteners - Conventional DFM/DFA principles to DfAM – Assembly Considerations – Design of Moving Parts, AM Tooling Design – Mounting Fixtures and Guides – Conformal Cooling – Coolant Flow Strategies – Coolant Channel Shape and Spacing – Steps to minimise Print Time in Tooling.

UNIT III	DESIGN CONSIDERATIONS FOR METAL AM	9

Designing for Metal Powder Bed Fusion – Metal Powder Production – Powder Morphology – Powder Size Distribution – Other Powder Considerations – Potential Defects in AM Materials – Topology Optimisation – Lattice Structures – Overhangs and Support Material Designing to Reduce Residual stress and Stress Concentrations – General Part Positioning Guidelines - Design for Laser Powder Bed Fusion, Electron Beam Melting and Metal Binder Jetting.

UNIT IV	DESIGN FOR POLYMER AM PROCESS AND OTHER AM CONSIDERATIONS	9

Design considerations due to Anisotropy, Wall Thickness, Overhangs and Support Material, Holes, Ribs, fonts and intricate details – Design guidelines for Material Extrusion, Vat Photopolymerisation and Polymer Powder Bed Fusion. Designer Machine Operator Cooperation – Health and Safety – prevention of explosion – AM Part Certification

UNIT V	COST &VALUE OF AMAND FUTURE OF AM	9
A Cost Model of Conventional Manufacturing- Modelling the Cost of AM- Assessing the Value of AM- Cost and Value Scenarios. Future of AM: Functionally Graded Materials – Bio printing - Printed Electronics - Nano Printing - Food Printers.		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	LAB COMPONENT (30 Marks)	End Semester Exams (60 Marks)
2 Test EACH 10 marks MCQ/Descriptive Questions	Experiment – 20 Marks Model lab with project – 10 Marks	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO.1 Describe the design aspects for additive manufacturing.
CO.2 Convert the DFM/DFA into Design for Additive Manufacturing.
CO.3 Explain the design consideration of metal powder for AM process.
CO.4 Perform design of AM to reduce residual stresses.
CO.5 Describe the design aspects for polymer AM process.
CO.6 Compute the costing for AM products.

Text Books

1. Olaf Diegel, "A Practical Guide to Design for Additive Manufacturing", Springer, 2019.
2. Martin Leary, "Design for Additive Manufacturing", Elsevier, 2019.

Reference Books

1. Ben Redwood, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs, 2017.

Web Resourses

Nil

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	2	1	1	1								
2	3	3	3	3	1							
3	2	2	3	2	1							
4	3	3	3	3	1							
5	1	1	1	1	1							
6	2	2	2	2	2						2	

21ME7S04	3D PRINTING AND PROTOTYPING	L	T	P	C
		3	0	2	4

Prerequisites for the course

- Additive Manufacturing Technologies and Applications
- CAD for Additive manufacturing

Objectives

Students undergoing this course are expected to

- To explain pre-processing and model preparation in AM
- To Understand and operate on tessellated/meshed model
- To import knowledge on slicing process and software
- To explain AM data process like support generation
- To explain post processing techniques of AM

UNIT-I	PREPROCESSING IN ADDITIVE MANUFACTURING	6

Preparation of 3D-CAD model, Reverse engineering and Reconstruction of 3D-CAD model, Par orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generatio of codes for tool path, Surface preparation of materials. Introduction, Process, CAD Data formats Data translation, Data loss, STL format. Pre-Processing -Preparation of 3D-CAD model, Par orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generatio of codes for tool path, Surface preparation of materials - post processing.

UNIT II	AM SOFTWARE	6

Need for AM software, Build Preparation-Features of various AM software's like Magics, Mimics Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor SurgiGuide, 3-matic, Simplant, MeshLab.

UNIT III	AM Data Processing	6

AM Data Processing: Part Orientation and Support Structure Generation, Model Slicing and Contou Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Pat Generation.Modelling of AM Process: Surface Roughness due to Staircase Effect, Part Build-time Fabrication Cost, Optimal Orientation, Quantification of Building Inaccuracy and Part Stability.

UNIT IV	POST PROCESSING OF AM PARTS	6

Support Material Removal, Surface Texture Improvement- Polymer Surface Treatments - Accurac Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancement using Non-thermal and Thermal Techniques- Gluing and Welding AM Parts – Heat Treatment an Aging. Product Quality - sanding, Acetone treatment, polishing- -Inspection and testing - Defect and their causes.

UNIT V	PROCESS SELECTION AND MATERIAL SCIENCE	6

Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.Materials

science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship.

S.No	List of Experiments	CO
1	Slicing of an engineering component	CO1
2	Fabrication of the component through 3D printer and dimensional analysis	CO2
3	Use of FDM, SLA, DLP and SLS machines to produce 3D physical models.	CO2
4	Simulation of additive manufacturing	CO2
Total Periods		**30 Theory +30 Lab**

Laboratory Requirements:

Suggestive Assessment Methods

Continuous Assessment Test (20 Marks)	LAB COMPONENT (30 Marks)	End Semester Exams (60 Marks)
2 Test EACH 10 marks MCQ/Descriptive Questions	Experiment – 20 Marks Model lab with project – 10 Marks	Descriptive Questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Explain the concept of preprocessing and slicing for additive manufacturing.
CO2: Compare the different features of AM packages
CO3: Explain the data processing techniques for additive manufacturing
CO4: Discuss the different post processing methods
CO5: Select a process parameter for different AM techniques
CO6: Perform AM simulation and fabricate 3D physical product using appropriate RP machines (Practical)

Text Books

1. Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2015

Reference Books

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014.
2. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.

3. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.
4. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.
5. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006 6. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018.
6. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004.
V. Raja and K. Fernandes, Reverse Engineering: An Industrial Perspective, Springer- Verlag, 2008.

Web Resources

Nil

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	2	2	1	3							
2	3	2	2	1	3							
3	3	2	3	1	3							
4	3	2	3	1	3							
5	3	3	3	1	3							
6	3	3	3	3	3					2		

21ME8S05	PROTOTYPING PROJECT	L	T	P	C
		0	0	8	4

Prerequisites for the course

- Additive Manufacturing Technologies and Applications
- CAD for Additive manufacturing
- 3D Printing and Prototyping
- Design for additive Manufacturing

Objectives

- To prepare students to work in teams to solve open-end designing and manufacturing problemsand to develop the necessary skills for using modern AM technology.
- To make the students work in small groups following the typical stages of product development -designing, prototyping and manufacturing - in one continuous project.
- To teach use of new tools and techniques required to carry out the projects.
- To give guidance on the various procedures for validation of the product and analyze the costeffectiveness.
- To provide guidelines to prepare technical report of the project.

SUGGESTED PROBLEM APPROACH

- Analyze the situation and come up with more than one possible technical solution. Choose one andjustify why it is the best.
- For the selected design, produce complete technical documentation going from the hand sketchesto the fully dimensioned CAD files.
- Make physical, fully functioning prototypes to verify form, fit, and function. - Analyze the
  prototype for design and functional flaws. Prepare the final model and report to turn in, and give apublic presentation.

PROJECT ASSUMPTIONS

- Designing, prototyping and manufacturing facilities are at different locations and a system of communication has to be used to set up the working links between these locations.
- Work-in-progress should be accessible by all the participating team members. A proper file management system has to be developed and used.
- Project evaluation is based on quality and completion of listed “things to do”. Students’ statementsare required to say what the involvement of each member of the group was.
- Each project should begin with work scheduling; Microsoft Project software is recommended to accomplish this. Meetings with faculty are scheduled bi-weekly (or by appointment) to analyze work-in-progress.

PROJECT ASSESSMENT

The project is structured to ensure that each team makes steady progress on the project throughout the semester, with adequate time at the end of the semester to allow for a variety of printing methods.

1	Team Project Idea Submission	5
2	First Project Part file	5

3	First Project Printed Part	10
4	Final Project CAD files	15
5	Final Project Printed Parts	10
6	Final product assembly – functional test and quality	25
7	Final Printed Project & Presentation	30

The project is structured to ensure that each team makes steady progress on the project throughout the semester, with adequate time at the end of the semester to allow for a variety of printing methods,

SAMPLE PROJECT DETAILS

The team started the project with a hand sketch to show the idea of the mechanism and its location in the machinery. An Internet search of results for similar objects was required for this part ofthe project. Documentation - project documentation required use of a CAD package. The required documentation format was an assembly drawing as a solid model, and a detailed 3-D drawing file as the necessary technical documentation for prototyping, manufacturing, inspection, and production preparation.

Prototyping - the next step was prototyping, or making physical models. Using additive method plastic objects were built on the FDM. This machine builds precision objects layer by layer. This method is useful for shape and fit evaluation. There were two important issues in this stage of the project. AutoCAD (Mechanical Desktop) and Reverse engineering, AM software from the courses. A third file format, stereolithography (STL files), was created for use by the 3D printer. When conversions were done, the new formats were inspected for possible errors before proceeding with prototyping. Analysisat this stage of the project concentrated on two elements: design flaws: fitting parts together and possibilities of design improvements by reducing the weight and material selection, as well asdeveloping a concept of manufacturing and adapting the design to the process requirements.

Outcomes

Upon completion of the course, the students will be able to:

CO.1 Apply tools and techniques acquired in AM courses for development of new product.
CO.2 Adapt an efficient problem-solving method in analysing industrial product needs.
CO.3 Formulate a real world problem, identify the requirement and develop the design solutions.
CO.4 Identify technical ideas, strategies and methodologies for prototyping
CO.5 Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
CO.6 Prepare technical report and oral presentations.

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1			3	3	3						2	2
2			3	3	3						2	2
3			3	3	3						2	2
4			3	3	3						2	2
5			3	3	3						2	2
6									3	3		2

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Department of Mechanical Engineering

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