PSN COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution Recognised by AICTE, New Delhi
and Affiliated to Anna University, Chennai)
Accredited with A+ Grade by NAAC. An ISO 9001:2015 Certified Institution
Melathediyoor, Tirunelveli – 627 152

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum approved by Board of Studies of
Mechanical Engineering for semester III to VI and Professional Electives
Under Regulation 2022

INSTITUTE VISION
To emerge as a pioneer institute inculcating engineering education, skills, research, values and ethics.
INSTITUTE MISSION
• To achieve greater heights of excellence in technical knowledge and skill development through innovative teaching and learning practices. • To develop the state of art infrastructure to meet the demands of technological revolution. • To improve and foster research in all dimensions for betterment of society. • To develop individual competencies to enhance innovation, employability and entrepreneurship among students. • To instill higher standards of discipline among students, inculcating ethical and moral values for societal harmony and peace.

DEPARTMENT VISION
To emerge as a preeminent department to produce quality Mechanical Engineering Graduates to meet national and global needs.
DEPARTMENT MISSION
• To educate students to be creative, inquisitive and innovation to become quality engineer and entrepreneurs. • To instil advanced knowledge with research capabilities for global careers and higher studies. • To inculcate moral and ethical standards in life and career.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
Sl. No.	**PEOs**
PEO1	The Graduates of Mechanical Engineering program will excel in technical knowledge, innovation and entrepreneurial skills.
PEO2	The Graduates will be able to design and develop various Mechanical Systems for interdisciplinary and multi-disciplinary applications.
PEO3	The Graduates will exhibit ethical attitude, human values, leadership quality and ability to solve engineering problems to a broader social context.

PROGRAM OUTCOMES			
PO'S No.	**KNOWLEDGE**	**STATEMENT**	**APPLIANCE**
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of Complex engineering problems.	Theory/ Practical / Project work
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.	Theory / Practical / Projects
3	Design / Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the needs with appropriate consideration for the public health and safety, and the cultural, Societal and environmental considerations.	Theory / Practical / Projects

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.	Theory / Practical
5	Modern Tool usage	Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	Theory / Practical / Project work
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.	Theory / Industrial visit / In plant training
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.	Theory / Industrial Visit/ In plant Training
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Theory / Industrial visit / In plant training
9	Individual and Team Work	Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.	Projects
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.	Projects/ Seminar/ Mini Project
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.	Projects
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.	Projects / Higher Studies

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Design, model and analyse mechanical systems and components using CAD tools and select suitable manufacturing processes.

PSO2: Formulate, analyze and provide the solution to thermal engineering related problems to meet industrial competitiveness.

SUMMARY SHEET

Semester wise Credits									**Credits Total**
Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	
Credits	**21**	**21**	**21.5**	**21.5**	**22**	**22**	**25**	**10**	**165**

Sl.No	Course code	Course Name	Classification		L	T	P	C
SEM - 01								
1	IC610001	Professional English I	IC	Theory	2	0	0	2
2	IC610002	Matrices and Calculus	IC	Theory	2	1	0	3
3	IC610003	Engineering Physics	IC	Theory	3	0	0	3
4	IC610004	Engineering Chemistry	IC	Theory	3	0	0	3
5	CS610005	Problem Solving and 'C' Programming	IC	Theory	3	0	0	3
6	ME610006	Engineering Graphics with CAD	IC	Theory with Practical Component	2	0	2	3
7	IP610101	Physics & Chemistry Laboratory	IC	Practical	0	0	3	1.5
8	IP610102	Programming in 'C' Laboratory	IC	Practical	0	0	3	1.5
9		NCC/NSS/NSO *	IM	Institute Mandatory	1	0	0	0
10	IC610007	tamilmarabu/Heritage of Tamil	IC	Theory	1	0	0	1
		Total			**17**	**1**	**8**	**21**
SEM - 02								
11	IC620008	Professional English II	IC	Theory with Practical Component	2	0	2	3
12	IC620009	Transforms & Partial Differential Equations	IC	Theory	2	1	0	3
13	IC620010	Engineering Materials (for Non Circuit Branches)	IC	Theory	3	0	0	3
	IC620011	Semiconductor Physics(for Circuit Branches)						
14	ME620012	Engineering Mechanics(for Non Circuit Branches)	PC	Theory with project	3	0	0	3
	CS620013	Fundamentals of Artificial Intelligence (for Circuit Branches)						
15	CS620014	Python Programming	IC	Theory	3	0	0	3
16	ME620015	Basic Engineering	IC	Theory	3	0	0	3
17	IP620103	Python Laboratory	IC	Practical	0	0	3	1.5
18	IP620104	Engineering practice laboratory	IC	Practical	0	0	3	1.5

19	IM610401	Environmental Studies	IM	Institute Mandatory	2	0	0	0
20	IC620016	Tamils and technology	IC	Theory	1	0	0	1
		Total			**25**	**1**	**8**	**22**
SEM – 03								
21	IC630017	Numerical Methods and Statistics (Common to MECH & MAE)	IC	Theory	3	0	0	3
22	ME630201	Engineering Thermodynamics (Common to MECH & MAE)	PC	Theory	3	0	0	3
23	ME630202	Fluid Mechanics and Machinery (Common to MECH, Aero and MAE)	PC	Theory	3	0	0	3
24	ME630203	Manufacturing Technology (Common to MECH & MAE)	PC	Theory with project	3	0	0	3
25	ME630204	Strength of materials(Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
26		Professional elective-1	PE	Theory	3	0	0	3
27	ME630301	Fluid Mechanics and Machinery (Common to MECH , MAE &AERO)	PC	Practical	0	0	3	1.5
28	ME630302	Manufacturing Technology Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
29	ME630501	Integrated Aptitude Skills - I (Lower)	EEC	skill based course	0	0	1	0.5
30	IM630402	Universal Human Values	IM	Theory	2	0	0	0
		Total			**19**	**0**	**9**	**21.5**
SEM – 04								
31	IC640018	Boundary value problems and probability distributions (Common to MECH & MAE)	IC	Theory	3	0	0	3
32	ME640205	Engineering Materials and Metallurgy (Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
33	ME640206	Thermal Engineering (Common to MECH & MAE)	PC	Theory with project	3	0	0	3
34	EE640901	Electrical Drives and Control (Common to MECH & MAE)	PC	Theory	3	0	0	3
35		Professional elective-2	PE	Theory	3	0	0	3
36		Institute elective -1	IE	Theory	3	0	0	3
37	ME640303	Thermal Engineering Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
38	EE640902	Electrical Drives and Control Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5

39	ME640502	Integrated Aptitude Skills - II (Lower)	EEC	skill based course	0	0	1	0.5
40		Inplant Training (2 Weeks)	IM					0
		Total			**17**	**0**	**9**	**21.5**
SEM – 05								
41	ME650207	Theory of Machines (Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
42	ME650208	Engineering Metrology and Measurements(Common to MECH & MAE)	PC	Theory with project	3	0	0	3
43	ME650209	Design of Machine Elements (Common to MECH & MAE)	PC	Theory	2	1	0	3
44		Institute elective -2	IE	Theory	3	0	0	3
45		Professional elective-3	PE	Theory	3	0	0	3
46		Professional elective-4	PE	Theory	3	0	0	3
47	ME650304	Dynamics of Machinary Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
48	ME650305	Computer Numerical Control Laboratary (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
49	ME650503	Integrated Aptitude Skills - I (Higher)	EEC	skill based course	0	0	2	1
50	ME650801	BIS	PM	Theory	2	0	0	0
		Total			**19**	**0**	**10**	**22**
SEM – 06								
51	ME660210	Heat and Mass Transfer (Common to MECH & MAE)	PC	Theory with project	2	1	0	3
52	ME660211	Design of Transmission Systems(Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
53	ME660212	CAD/CAM/CAE(Common to MECH & MAE)	PC	Theory	3	0	0	3
54		Institute elective -3	IE	Theory	3	0	0	3
55		Professional elective-5	PE	Theory	3	0	0	3
56		Professional elective-6	PE	Theory	3	0	0	3
57	ME660306	Heat Transfer Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
58	ME660307	CAD/CAM Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
59	ME660504	Training in Centre for excellence - BOSCH	EEC	skill based course	0	0	2	1
60	IM660403	Professional Ethics(Common to	IM	Theory	2	0	0	0

		MECH & MAE)						
61		Internship	IM					0
		Total			**19**	**0**	**10**	**22**
SEM – 07								
62	ME670213	Principles of Management	PC	Theory	3	0	0	3
63	ME670214	Finite Element Analysis (Common to MECH & MAE)	PC	Theory with project	3	0	0	3
64	ME670215	Mechatronics and Robotics	PC	Theory with Practical Component	2	0	2	3
65		Institute elective -4	IE	Theory	3	0	0	3
66		Professional elective-7	PE	Theory	3	0	0	3
67		Professional elective-8	PE	Theory	3	0	0	3
68	ME670308	3D Printing (Common to MAE)	PC	Practical	0	0	3	1.5
69	ME670309	Computer Aided Simulation and Analysis Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
70	MG670019	Innovation Entrepreneurship and Startups	IC	Theory	3	0	0	3
71	ME670505	Advanced career development	EEC	skill based course	0	0	2	1
		Total			**20**	**0**	**10**	**25**
SEM - 08								
72	ME680506	Project Work	EEC	Practical	0	0	20	10
		Total			**0**	**0**	**20**	**10**

VERTICAL 1: THERMAL SCIENCES (COMMON TO MAE & MECH)								
1	ME606101	Power Plant Engineering	PE	Theory	3	0	0	3
2	ME606102	Heating Ventilation and Air Conditioning	PE	Theory	3	0	0	3
3	ME606103	Thermal Management of Batteries and Fuel Cells	PE	Theory	3	0	0	3
4	ME606104	Refrigeration and Air Conditioning	PE	Theory	3	0	0	3
5	ME606105	Internal Combustion Engine	PE	Theory	3	0	0	3
6	ME606106	Air Breathing Engines	PE	Theory	3	0	0	3
7	ME606107	Design of thermal systems	PE	Theory	3	0	0	3
8	ME606108	Inverse Methods in Heat Transfer (NPTEL)	PE	Theory	3	0	0	3
9	ME606109	Fundamentals of combustion for propulsion (NPTEL)	PE	Theory	3	0	0	3
10	ME606110	Fundamentals of Gas Dynamics (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 2: ENERGY TECHNOLOGIES (COMMON TO MAE&MECH)								
1	ME606201	Fuel Cell and Hydrogen Technology	PE	Theory	3	0	0	3
2	ME606202	Alternate Energy Fuels	PE	Theory	3	0	0	3
3	ME606203	Bio Energy Conversion Technologies	PE	Theory	3	0	0	3
4	ME606204	Energy Storage Devices	PE	Theory	3	0	0	3
5	ME606205	Energy Conservation and Waste heat recovery	PE	Theory	3	0	0	3
6	ME606206	Solar energy technologies	PE	Theory	3	0	0	3
7	ME606207	Green energy sources	PE	Theory	3	0	0	3
8	ME606208	Micro and nano scale energy transport (NPTEL)	PE	Theory	3	0	0	3
9	ME606209	Design and Optimization of Energy systems (NPTEL)	PE	Theory	3	0	0	3
10	ME606210	Electric vehicles and Renewable energy (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 3: LOGISTICS AND SUPPLY CHAIN MANAGEMENT (COMMON TO MAE&MECH)								
1	ME606301	Warehousing Automation	PE	Theory	3	0	0	3
2	ME606302	Business Process Re-engineering	PE	Theory	3	0	0	3
3	ME606303	Total Quality Management	PE	Theory	3	0	0	3
4	ME606304	Project Management (Common to MAE,MECH,AERO)	PE	Theory	3	0	0	3
5	ME606305	Industrial psychology	PE	Theory	3	0	0	3
6	ME606306	Resource management techniques	PE	Theory	3	0	0	3
7	ME606307	Enterprise resource planning	PE	Theory	3	0	0	3
8	ME606308	Business Development: From Start to Scale (NPTEL)	PE	Theory	3	0	0	3
9	ME606309	Patent Law for Engineers and Scientists (NPTEL)	PE	Theory	3	0	0	3
10	ME606310	Business Analysis for Engineers (NPTEL)	PE	Theory	3	0	0	3

VERTICAL 4: COMPUTATIONAL ENGINEERING								
1	ME606401	Computational Solid Mechanics	PE	Theory	3	0	0	3
2	ME606402	Computational Fluid Dynamics and Heat transfer	PE	Theory	3	0	0	3
3	ME606403	Computational Bio Mechanics	PE	Theory	3	0	0	3
4	ME606404	Advanced Statistics and Data Analytics	PE	Theory	3	0	0	3
5	ME606405	Machine Learning for Intelligent Systems	PE	Theory	3	0	0	3
6	ME606406	Theory on Computation and Visualization	PE	Theory	3	0	0	3
7	ME606407	Foundations of Computational Materials Modelling (NPTEL)	PE	Theory	3	0	0	3
8	ME606408	Computational Fluid Dynamics using Finite Volume Method (NPTEL)	PE	Theory	3	0	0	3
9	ME606409	Foundation of Computational Fluid Dynamics (NPTEL)	PE	Theory	3	0	0	3
10	ME606410	Computational Fluid Dynamics for Turbo machinery(NPTEL)	PE	Theory	3	0	0	3
VERTICAL 5: DIVERSIFIED COURSES GROUP I								
1	ME606501	Design of Jigs, Fixtures and Press Tools	PE	Theory	3	0	0	3
2	MA606403	Mechanical Vibrations and Controls	PE	Theory	3	0	0	3
3	ME606502	Instrumentation for engineers	PE	Theory	3	0	0	3
4	ME606503	Automobile Engineering	PE	Theory	3	0	0	3
5	ME606504	Reverse Engineering	PE	Theory	3	0	0	3
6	ME606505	Nuclear Engineering	PE	Theory	3	0	0	3
7	ME606506	Production Planning and Control	PE	Theory	3	0	0	3
8	MA606408	Design for Quality, Manufacturing and Assembly (NPTEL)	PE	Theory	3	0	0	3
9	MA606409	Oil Hydraulics and Pneumatics (NPTEL)	PE	Theory	3	0	0	3
10	MA606410	Advanced Operations Research (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 6: MATERIALS SCIENCES(COMMON TO MAE&MECH)								
1	MA606101	Composite Materials	PE	Theory	3	0	0	3
2	MA606102	Tribology	PE	Theory	3	0	0	3
3	MA606103	Mechanical Behaviour of Materials	PE	Theory	3	0	0	3
4	MA606104	Polymer Technology	PE	Theory	3	0	0	3
5	MA606105	Smart Materials	PE	Theory	3	0	0	3
6	MA606106	Electrical, Electronic and Magnetic materials	PE	Theory	3	0	0	3
7	MA606107	Fracture mechanics	PE	Theory	3	0	0	3
8	MA606108	Basics of Materials Engineering (NPTEL)	PE	Theory	3	0	0	3
9	MA606109	Transport Phenomena in Materials (NPTEL)	PE	Theory	3	0	0	3
10	MA606110	Welding Processes (NPTEL)	PE	Theory	3	0	0	3

VERTICAL 7: MANUFACTURING ENGINEERING(COMMON TO MAE&MECH)								
1	MA606201	Computer Integrated Manufacturing	PE	Theory	3	0	0	3
2	MA606202	Industry 4.0	PE	Theory	3	0	0	3
3	MA606203	Flexible Manufacturing Systems(Common to MAE,MECH,AERO)	PE	Theory	3	0	0	3
4	MA606204	Additive Manufacturing Processes	PE	Theory	3	0	0	3
5	MA606205	Lean Manufacturing	PE	Theory	3	0	0	3
6	MA606206	Rapid Prototyping	PE	Theory	3	0	0	3
7	MA606207	Theory of metal cutting	PE	Theory	3	0	0	3
8	MA606208	Steel Quality : Role of Secondary Refining & Continuous Casting (NPTEL)	PE	Theory	3	0	0	3
9	MA606209	Laser Based Manufacturing (NPTEL)	PE	Theory	3	0	0	3
10	MA606210	Forming (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 8: DIVERSIFIED COURSES GROUP 2								
1	MA606501	Maintenance Engineering	PE	Theory	3	0	0	3
2	MA606502	Design of Pressure Vessels	PE	Theory	3	0	0	3
3	EE606604	Virtual Instrumentation (Common to MAE & EEE)	PE	Theory	3	0	0	3
4	MA606503	Computational Fluid Dynamics	PE	Theory	3	0	0	3
5	MA606504	Fluid Power Control System	PE	Theory	3	0	0	3
6	MA606505	Hydraulics and Pneumatics	PE	Theory	3	0	0	3
7	MA606506	Industrial Networking	PE	Theory	3	0	0	3
8	MA606507	Functional and Conceptual Design (NPTEL)	PE	Theory	3	0	0	3
9	MA606508	Vehicle Dynamics (NPTEL)	PE	Theory	3	0	0	3
10	MA606509	Micro fluidics (NPTEL)	PE	Theory	3	0	0	3

INSTITUTE ELECTIVE I									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	ME607118	Quality Control & Reliability Engineering	MECH	IE	Theory	3	0	0	3
2	ME607119	Industrial safety	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE II									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	ME607218	Space Technology	MECH	IE	Theory	3	0	0	3
2	ME607219	Renewable Energy Technologies	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE III									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**

1	ME607317	Nano Technology	MECH	IE	Theory	3	0	0	3
2	ME607318	Standards, Quality Control and Inspection	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE IV									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**S. No**
1	ME607417	Robotics and Mechanical Actuators	MECH	IE	Theory	3	0	0	1
2	ME607418	Failure Analysis and NDT Techniques	MECH	IE	Theory	3	0	0	2

SYLLABUS
SEMESTER III

IC630017 NUMERICAL METHODS AND STATISTICS (Common to MECH and MAE)					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The objective of this course is to computing a value and being aware of two or more comparable values.
- The data series are organized as columns, interpolation occasionally aims to predict the future values
- The representative of values in order for researchers to draw conclusions about the larger population and to approximate a bigger population on factors pertinent to the research subject.

UNIT 1 : SOLUTION OF EQUATION AND EIGNVALUE PROBLEM	**9**
Solution of linear system of equation, Bijection method, fixed point Iteration method, Newton Raphson Method , Ragula Falsi method ,Decomposition Method , Gauss Elimination Method ,Gauss Jordan Method Gauss Jacobi Method ,Finding largest eigen value, Inverse of matrix by Jordan Method.	
UNIT 2 : INTERPOLATION AND APPROXIMATING POLYNOMIALS	**9**
Lagrangian polynomials, Divided difference formulae for equal intervals and unequal intervals, Interpolating with a cubic spline ,Newton's forward and backward difference formulas, Stirlings formula.	
UNIT 3: NUMERICAL DIFFERENTIATION AND INTEGRATION	**9**
Differentiation using interpolation formulae , Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rule , Romberg's Method ,Double integrals using trapezoidal and Simpson's rules.	
UNIT 4: THEORY OF ESTIMATION	**9**
Estimation: Point and Interval estimates for population parameters of large sample and small samples, determining the sample size.	
UNIT 5: TESTING OF HYPOTHESIS	**9**
Sampling distributions ,Testing of hypothesis for mean , variance ,proportions and differences using Normal 't' ,Chi square and F distributions, Tests for independence of distributions of attributes and goodness of fit	
Total: 45 periods	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Compute the solutions of the variables using iterative methods.

CO2: Understand and apply methods to find interpolating and approximating polynomials.

CO3: Solve complicated differentiation and integration by numerical methods.

CO4: Identify the type of estimations for small samples and large samples

CO5: Solve the physical problems by small and large sampling theory

CO's PO's&PSO's MAPPING

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

low, 2 - medium, 3 - high, '-' no correlation
TEXT BOOKS:
1. M.K. JAIN, S.R.K. IYENGAR and R.K. JAIN "Numerical methods: for scientific and engineering computation" 2013. 6th ed.,
2. DEVORE, J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, 8th Edition, 2014.
3. S.C. GUPTA AND V.K. KAPOOR "Fundamentals of mathematical statistics" Elevanth thoroughly revised ed., Sultan Chand & Sons educational publishers, New Delhi (June 2003)
4. T. VEERARAJAN, "Probability, Statistics and Random Processes" Tata McGraw-Hill Publishing Company Limited, New Delhi(2006)
REFERENCE BOOKS:
1. SANKARARAO.K "Numerical Methods for Scientists and Engineers" -3rd edition Printice Hall of India Private Ltd. New Delhi-(2007).
2. WALPOLE, R.E., MYERS, R.H., MYERS, S.L. and YE. K., "Probability and Statistics For Engineers and Scientists", 9th Edition, Pearson Education, Asia, 2010
3. VEERARAJAN.T AND RAMACHANDRAN. T " Numerical Methods with Programming in C" second Ed., Tata Mc. Graw Hill Publishing. Co. Ltd (2007)

ME630201Engineering Thermodynamics (Common to MECH & MAE)						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE 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 the properties of pure substances, to enlighten the basic concepts of vapour power cycles
- Impart knowledge on the macroscopic properties of ideal and real gases.

Teach the various properties of steam through steam tables and Mollier chart

UNIT 1 : BASICS, ZEROTH AND FIRST LAW OF THERMODYNAMICS	**9**
Basics concepts, Thermodynamic systems, Properties and processes, equilibrium, modes of work, Zeroth law, Concept of temperature and Temperature Scales. First law application to closed and open systems, steady and unsteady flowprocesses.	
UNIT 2 : SECOND LAWOF THERMODYNAMICS AND ENTROPY	**9**
Heat Engine,Refrigerator , Heat pump. Statements of second law and their equivalence & corollaries. Carnot cycle, Reversed Carnot cycle ,Performance ,Clausius inequality. Concept of entropy, T-s diagram, Tds Equations, Entropy change for a pure substance.	
UNIT 3: PROPERTIES OF PURE SUBSTANCE	**9**
Steam - formation and its thermodynamic properties of pure substances, thermodynamic properties of pure substances in solid, liquid and vapour phases -p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.	
UNIT 4: IDEAL AND REAL GASES AND THERMODYNAMIC RELATIONS	**9**
Properties of ideal and real gases, equation of state, Avogadro's Law, Van der Waals equation of state, compressibility factor, Exact differentials. Thermodynamic relations, Maxwell relations, Clausius Clapeyron equations, relations for changes in Entropy, Enthalpy & Internal Energy, Joule,Thomson coefficient & inversion curve.	
UNIT 5: PROPERTIES OF MIXTURES	**9**
Ideal gas mixtures, Evaluation of properties, Dalton's law of partial pressure, properties of air,water vapour mixtures: DBT, WBT, RH, dew point temperature, degree of saturation, enthalpy of moist air, sensible heating and cooling, bypass factor, calculations using psychrometric table and chart. **Total: 45 periods**	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Apply the zeroth and first law of thermodynamics by formulating temperature scales and calculatingthe property changes in closed and open engineering systems.	
CO2: Apply the second law of thermodynamics in analysing the performance of thermal devices throughenergy and entropy calculations	
CO3: Apply the second law of thermodynamics in evaluating the various properties of steam throughsteam tables and Mollier chart	
CO4: Applythepropertiesofpuresubstanceincomputingthemacroscopicpropertiesofidealandreal gasesusing gaslaws andappropriatethermodynamic relations	
CO5: Apply the properties of gas mixtures in calculating the properties of gas mixtures and applying various thermodynamic relations to calculate property changes.	
CO's PO's&PSO's MAPPING	

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

low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Nag.P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 6th Edition. 2017.

2.Yunus Cengel, Michael Boles, 'Thermodynamics – An Engineering Approach' 8th Edition 2016 – Tata McGraw Hill, New Delhi.

REFERENCE BOOKS:

1. Holman.J.P, "Thermodynamics", 3rd Ed. McGraw-Hill, 1995.
2. Vanwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 4th Edition 1994.
3. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2008.
4. Merle C, Potter, Craig W, Somerton, "Thermodynamics for Engineers", Schaum Outline Series, Tata McGraw-Hill, New Delhi, 3rd Edition 2013.

WEB RESOURCES:

https://onlinecourses.nptel.ac.in/noc19_me57/preview

https://archive.nptel.ac.in/courses/112/106/112106310/#

ME630202 - Fluid Mechanics and Machinery (Common to MECH, AERO and MAE)						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To understand the characteristics of fluids and working of hydraulic machines

UNIT 1: BASIC CONCEPTS AND PROPERTIES	**9**
Units & Dimensions, Properties of fluids, Specific gravity, specific weight, viscosity, compressibility, capillarity and surface tension , Flow characteristics: concepts of system and control volume ,Application of control volume to continuity equation ,energy equation, momentum equation Pascal's law, measurement of pressure, manometers, Hydrostatic law.	
UNIT 2: FLOW THROUGH PIPES	**9**
Laminar flow though circular conduits and circular annuli, Boundary layer concepts, Boundary layer thickness,Hydraulic and energy gradient ,DarcyWeisbach equation, Friction factor and Moody diagram Minor losses,Flow through pipes in series and in parallel, loss of energy in pipes, Equivalent pipes, Buoyancy and stability of floating bodies	
UNIT 3: DIMENSIONAL ANALYSIS	**9**
Dimension and units – Buckingham's Π theorem, Discussion on dimensionless parameters – Models and similitude – Applications of dimensionless parameters	
UNIT 4: HYDRAULIC TURBINES	**9**
Force exerted on moving plate vanes ,Definition and classifications , Pelton, Francis, Propeller and Kaplan turbine: Working principles, Velocity triangle, Work done, specific speed, efficiencies, Performance curve for turbines	
UNIT 5: HYDRAULIC PUMPS	**9**
Definition and classifications, Centrifugal and Reciprocating Pumps: Working principles ,Indicator diagram, Specific speed, efficiency and performance curves, Cavitations in pumps	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: List the various fluid properties and to apply control volume analysis to fluid mechanics' problems.

CO2: Apply the concepts of mass and momentum conservation and the Bernoulli equation to solve problems&. Differentiate the various losses that occur in fluid flow through pipes and to estimate the head losses.

CO3: Manipulate dimensional analysis for various fluid parameters and complex problems

CO4: Describe the various types, principle and working of various turbines.

CO5: Demonstrate the various types pumps and its working principle.

CO's PO's&PSO's MAPPING

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

low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.BansalR.K.,**"ATextbookofFluidMechanicsandHydraulicsMachines",**LaxmiPublication,India, (2015)

2.RajputR.K.,**"FluidMechanicsandHydraulicMachines",**S.Chand&CompanyLtd.,NewDelhi, (2013)

3.Modi P.N., & Seth S.M., "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard book house, (2012)

REFERENCE BOOKS:
1. KumarK.L.,**"EngineeringFluidMechanics",**S.ChandPublishing(P)Ltd.,NewDelhi,(2014)
2. StreeterV. L.,and Wylie E.B., **"FluidMechanics",**McGrawHill,(2008)
3. WhiteF.M.,**"FluidMechanics",**TataMcGraw-Hill,NewDelhi,(2010)
WEB RESOURCES:
https://onlinecourses.nptel.ac.in/noc19_me57/preview
https://archive.nptel.ac.in/courses/112/106/112106310/#

ME630203 MANUFACTURING TECHNOLOGY(Common to MECH and MAE)						
Course Category: Program Core	**Course Type: Theory with project**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To make the student to understand the important concepts of basic manufacturing processes.
- To understand the principles of various fabrication and forming processes and bulk deformation processes, sheet metal
- To understand the concept and mechanics of metal cutting, working of standard machine tools such as lathe, shaping and allied machines, milling, drilling and allied machines, grinding and allied machines and broaching.

UNIT 1: METAL CASTING PROCESSES	**9**
Sand casting ,Sand moulds - Type of patterns, Pattern materials ,Pattern allowances, Types of Moulding sand ,Properties ,Core making, Methods of Sand testing, CO2 process ,Moulding machines ,Melting furnaces. Working principle of Special casting processes ,Shell, investment casting ,Ceramic mould , Pressure die casting ,Centrifugal casting ,Sand Casting defects ,Inspection methods	
UNIT 2: JOINING PROCESSES	**9**
Hot working and cold working of metals, Forging processes, Open, impression and closed die forging, forging operations. Rolling of metals, Types of Rolling ,Flat strip rolling , shape rolling operations ,Defects in rolled parts. Principle of rod and wire drawing, Tube drawing, Principles of Extrusion, Types, Hot and Cold extrusion.	
UNIT 3: METAL FORMING AND SHEET METAL PROCESSES	**9**
Hot working and cold working of metals ,Forging processes ,Types of Forging Machines ,Typical forging operations. Rolling of metals , Types of Rolling mills , Principle of rod and wire drawing ,Tube drawing , Principles of Extrusion Sheet metal characteristics ,Typical shearing operations, bending and drawing operations ,Stretch forming operations ,Hydro forming , Rubber pad forming , Metal spinning ,Explosive forming ,Magnetic pulse forming ,Peen forming ,Super plastic forming.	
UNIT 4: THEORY OF METAL CUTTING	**9**
Introduction: Material removal processes, Theory of metal cutting: Mechanics of metal cutting, chip formation, orthogonal cutting, cutting tool materials, tool wear, tool life, surface finish, cutting fluids ,Centre lathe, constructional features, cutting tool geometry, various operations, taper turning methods, thread cutting methods, special attachments, machining time and power estimation. Capstan and turret lathes, Automats ,Single spindle, Swiss type, multi spindle ,Turret Indexing mechanism, Bar feed mechanism	
UNIT 5: GEAR MANUFACTURING AND SURFACE FINISHING PROCESSES	**9**
Gear manufacturing processes: Extrusion, Stamping and Powder metallurgy. Gear machining: Forming, Gear generating process , Gear shaping, Gear hobbing. Surface finishing,Abrasive processes: Types of grinding process ,cylindrical grinding, surface grinding, centre less grinding, grinding wheel specifications and selection. Fine finishing processes,Honing, lapping, super finishing, polishing and buffing, power brushing,Tumbling ,Metal spraying , Metallization.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Explain different metal casting processes, associated defects, merits and demerits	
CO2: Compare different metal joining processes.	
CO3: Summarize various hot working and cold working methods of metals	
CO4: Gain an understanding and appreciation of breadth and depth of the field of manufacturing	
CO5: To become familiar with Surface Finishing Processes	
CO's PO's&PSO's MAPPING	

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

low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Hajra Choudhury, "Elements of Workshop Technology, Vol. I", Media PromotorsPvt Ltd., Mumbai, 2012.
2. Hajra Choudry, "Elements of Workshop Technology: Machine Tools (Volume - 2)", Media Promoters. 2010.

REFERENCE BOOKS:

1. B.S. NagendraParashar& R.K. Mittal, "Elements of Manufacturing Processes", Prentice Hall of India, 2004.
2. P.N. Rao, "Manufacturing Technology: Foundry, Forming and Welding - Volume 1", Tata McGraw-Hill Publishing Limited, 4th Edition, 2013
3. Rao, P.N. "Manufacturing Technology", Metal Cutting and Machine Tools, 3rd edition Tata McGraw–Hill, New Delhi, 2013
4. P.C. Sharma, "A text book of Production Technology (Manufacturing Processes) 7th Edition", S. Chand and Company, 2008.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/107/112107219

https://archive.nptel.ac.in/courses/112/105/112105126

ME630204- STRENGTH OF MATERIALS (Common to MECH & MAE)

Course Category: Program Core	Course Type: Theory with practical Component	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To understand the stresses developed in bars, compounds bars, beams, shafts, cylindersand spheres.
- To verify the principles studied in theory by conducting the experiments.

UNIT 1:STRESS, STRAIN AND DEFORMATION OF SOLIDS **6**

Rigid bodies and deformable solids ,Tension, Compression and Shear Stresses, Deformation of simple and compound bars, Thermal stresses ,Elastic constants.

UNIT 2: TRANSVERSELOADINGONBEAMSANDSTRESSESIN BEAM **6**

Beams,types transverse loading on beams, Shear force and bending moment in beams, Cantilevers, Simply supported beams.

UNIT 3: TORSION AND SPRINGS **6**

Torsion formulation stresses and deformation in circular and hollows shafts, Stresses in helical springs, Deflection of helical springs.

UNIT 4: DEFLECTION OF BEAMS **6**

Double Integration method, Area moment Theorems for computation of slopes anddeflections in beams.

UNIT 5: THIN CYLINDERS AND SPHERES **6**

Stresses in thin cylindrical shell due to internal pressure circumferential and longitudinal stresses and deformation in thin cylinders, spherical shells subjected to internal pressure, Deformation inspherical shells.

LIST OF EXPERIMENTS **15**

1. Tension test on a mild steel rod
2. Compression test on wooden piece
3. Torsion test on mild steel rod
4. Deflection test on beams
5. Compression test on helical springs **TOTAL : 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Visualize the concept of stress, strain in various sections.

CO2: Compute the shearing and bending of beams due to loading.

CO3: Calculate the torsion stress and deflections on the springs.

CO4: Recognize the deflection of beam when the stress is acted.

CO5: Analyse the stress on columns & thin cylinders and know the application of theories of failure problems.

CO's PO's&PSO's MAPPING

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

low, 2 - medium, 3 - high, '-' no correlation

TEXT 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)
3. Rajput. R. K, "Strength of Materials"6th Edition, S Chand PublishingCompany (2015).

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 Gere, “Mechanics of Materials”, D.Van Nostrand company , New York, (2009)
4. Don H. Morris, William F. Riley and Leroy D. Sturges, “Mechanics of Materials”, John Wiley and Sons Inc., (2008)

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc19_ce18/preview
2. https://www.youtube.com/watch?v=ufd-CJj8Jxs

ME630301 - FLUID MECHANICS AND MACHINERY LABORATORY
(Common to MECH, MAE &AERO)

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To impart knowledge of characteristics of fluids

LIST OF EXPERIMENTS

1. Determination of the Coefficient of discharge of given Orifice meter.
2. Determination of the Coefficient of discharge of given Venturi meter.
3. Calculation of the rate of flow using Rota meter.
4. Determination of friction factor for a given set of pipes.
5. Conducting experiments and drawing the characteristic curves of centrifugal pump/submersible pump.
6. Conducting experiments and drawing the characteristic curves of reciprocating pump.
7. Conducting experiments and drawing the characteristic curves of Gear pump.
8. Conducting experiments and drawing the characteristic curves of Pelton wheel.
9. Conducting experiments and drawing the characteristics curves of Francis turbine.

TOTAL: 30 PERIODS

List of Requirements: (for a batch of 30 students)

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1.	Orifice meter Setup	1
2.	Venturi meter Setup	1
3.	Rotameter Setup	1
4.	Pipe flow analysis setup	1
5.	Centrifugal pump/ Submergible pump setup	1
6.	Reciprocating pump setup	1
7.	Gear pump set up	1
8.	Pelton wheel setup	1
9.	Francis turbine setup	1

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Measure the coefficient of discharge of orifice, venturi meter and rate of flow using Rota meter

CO2: Calculate the rate flow using rotameter

CO3: Predict the pressure loss due to friction and minor losses in pipe flow

CO4: Analyse the characteristics of various pumps

CO5: Determine the efficiency of the Pelton wheel and Francis Turbine

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

ME630302 - MANUFACTURING LABORATORY
(Common to MECH &MAE)

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To Study and practice the various operations that can be performed in lathe, shaper machines and welding machines and to equip with the practical knowledge required in the core industries

LIST OF EXPERIMENTS

1. Machining Operations for:
2. Taper Turning
3. External Thread cutting
4. Internal Thread Cutting
5. Eccentric Turning
6. Knurling
7. Contour milling using vertical milling machine
8. Drilling operation
9. Preparation of arc welding of butt joints, lap joints and Tee joints.
10. Cylindrical grinding
11. Measurement of cutting forces in Turning Process

TOTAL: 30 PERIODS

List of Requirements: (for a batch of 30 students)

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1.	Universal Milling Machine	1
2.	Vertical Milling Machine	1
3.	Surface Grinding Machine	1
4.	Cylindrical Grinding Machine	1
5.	Radial Drilling Machine	1
6.	Lathe Tool Dynamometer	1
7.	Tool Makers Microscope	1
8.	Arc Welding	1

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Use different machine tools to manufacturing process

CO2: Modify the shape of the given work piece

CO3: Ability to use different machine tools for finishing operations

CO4: Ability to manufacture tools using cutter grinder

CO5: Ability to calculate cutting forces

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	3	-	-	-	-	-	2	1	2	-	-
CO2	3	2	-	3	-	-	-	-	-	2	1	2	-	-
CO3	3	2	-	3	-	-	-	-	-	2	-	2	-	-
CO4	2	2	3	-	-	-	-	-	2	1	2	3	-	-
CO5	2	2	3	-	-	-	-	-	2	1	2	3	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

ME630501 INTEGRATED APTITUDE SKILLS-I (LOWER)					
Course Category: EEC	**Course Type: Skill Based Course**	**L**	**T**	**P**	**C**
		0	**0**	**1**	**0.5**

COURSE OBJECTIVES:

- To understand the basic concepts of quantitative ability
- To understand the basic concepts of logical reasoning Skills
- To acquire satisfactory competency in use of verbal reasoning

UNIT 1 : QUANTITATIVE APTITUDE **5**

1. Numbers in Number Systems, Types of Numbers, Series (Arithmetic Progression, Geometric Progression) 2. Problem on Ages 3. HCF & LCM 4. Profit & Loss 5. Problems on Trains, Boats & Stream 6. Calendar & Clocks 7. Time & Work 8. Speed & Distance (Or) Time & Distance 9. Decimal Fractions, Simplification (Including Expression & Evaluation) 10. Square Root, Cubic Root 11.Average 12. Surds & Indices 13. Odd Man Out & Series

UNIT 2 : LOGICAL REASONING **5**

1. Series completion 2. Analogy 3. Classification 4. Coding-Decoding 5. Blood Relation 6. Puzzle test 7. Sequential Output Tracing 8. Direction sense test 9. Logical Venn Diagram 10. Alphabet Test 11. Alpha-numeric sequence Puzzle 12. Number, Ranking and Time sequence Test 13. Mathematical Operations 14. Logical Sequence of words 15. Arithmetical Reasoning 16. Inserting the mission character 17. Data Sufficiency 18. Eligibility test 19. Assertions and Reasoning 20. Situation Reaction Test 21. Verification of truth of the statement

UNIT 3: VERBAL ABILITY **5**

1. Vocabulary Based - Synonyms 2. Vocabulary Based - Antonyms 3. Spotting Errors 4. Spelling 5. Jumbled words 6. One word substitution 7. Sentence Correction 8. Idioms & Phrases. 9. Commonly confusing words 10. Statement and Conclusion 11. Change of Voice 12. Facts/Inferences and Judgment

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Students at the end of the course will be able to solve aptitude, logical and verbal reasoning questions

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	-	-	-	-	-	2	-	1	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
Agarwal R.S, “Quantitative Aptitude,” S.Chand and Company Pvt. Ltd., New Delhi, First Edition 1989, Reprint, 2016
Agarwal R.S, “A Modern Approach to Verbal and Non-Verbal Reasoning,” S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1994, Reprint, 2016
Agarwal R.S, “Objective General English,” S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1997, Reprint, 2016
REFERENCE BOOKS:
Anand P A, “Quantitative Aptitude,” Wiley India Pvt. Ltd., New Delhi, Edition,2016
Arun Sharma, “How to Prepare for Logical Reasoning,” Tata-McGraw Hill Education Series. New Delhi, First Edition 2016
Sharon Weiner Green, Ira K Wolf, “Barron’s GRE,” Barron Publishers. First Edition 1995, Reprint, 2016
The Princeton Review, “Cracking the GRE”, Random House Publisher, Premium Edition 2016.
WEB RESOURCES:
www.indiabix.com - http://www.practiceaptitudetests.com

IM630402 UNIVERSAL HUMAN VALUES						
Course Category: IM	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		2	**0**	**0**	**0**	
COURSE OBJECTIVES:						

- To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education
- To help students initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
- To help students understand the meaning of happiness and prosperity for a human being.
- To facilitate the students to understand the role of community engagement in national development
- To facilitate the students to understand the responsibility of Indian citizens towards community development.

UNIT 1: COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION	**6**
Need for Value Education, basic guidelines, content and process for Value - Right Understanding, relationship and Physical Facility. Happiness and Prosperity correctly- understanding and living in harmony at various levels. Process of Value Education – Self-exploration	
UNIT 2: UNDERSTANDING HARMONY IN THE HUMAN BEING & NATURE	**6**
Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer). Understanding the characteristics and activities of 'I' and harmony in 'I'. Understanding the harmony in the Nature. Interconnectedness,	
UNIT 3: UNDERSTANDING HARMONY IN THE FAMILY & SOCIETY	**6**
Understanding harmony in the Family- the basic unit of human interaction. Understanding values in human-human relationship - the foundational values of relationship. Difference between intention and competence. . Understanding the harmony in the society - Human Goals. Health and self-regulation. Harmony from Family Order to World Family Order – Process of Development of a Child – In an environment of Relationship	
UNIT 4: COMMUNITY ENGAGEMENT	**6**
Concept, Ethics and Spectrum of Community engagement, Local community, Rural culture and Practice of community engagement, Stages, Components and Principles of community development, Utility of public resources. Contributions of self-help groups, Rural Development Programs and Rural institutions, Local Administration and Community Involvement	
UNIT 5: SOCIAL RESPONSIBILITY	**6**
Social contribution of community networking, Various government schemes. Programmes of community engagement and their evaluation. Community Engaged Research and Ethics in Community Engaged Research, Rural Distress, Rural Poverty, Impact of COVID-19 on Migrant Laborers, Mitigation of Disaster.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student 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: To implement the role of community engagement in national development.	
CO5: To identify the responsibility of Indian citizens towards community development	
CO's PO's&PSO's MAPPING	

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

low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

3. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics.
4. Principles of Community Engagement, Regina M Benjamin, MD, Vice Admiral, US Public Health Service Surgeon General 2nd Edition, NIH Publication No. 11-7782, Printed June 2011.

REFERENCE BOOKS:

5. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
6. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
7. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/107/112107219

https://archive.nptel.ac.in/courses/112/105/112105126

SYLLABUS
SEMESTER IV

IC640018 BOUNDARY VALUE PROBLEMS AND PROBABILITY DISTRIBUTION
(Common to MECH &MAE)

Course Category: Intuition Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Objective of the subject is to provide a venue for the promotion, encouragement, and interdisciplinary collaboration of various fields using the theory,
- Techniques and applications of boundary value problems and Make predictions about the likelihood of specific events using the probability distribution for discrete random variables.
- Students will use the normal distribution's fundamentals to calculate probability.
- Implement a normal distribution. Check out a normal distribution.

UNIT 1: INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS **9**

Single Step Methods: Taylor Series Method , Euler Method for First Order Equation ,Fourth Order Runge Kutta Method for Solving First and Second Order Equations ,Multistep Methods: Milne's and Adam's Predictor and Corrector Methods

UNIT 2: BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS **9**

Finite Difference Solution of Second Order Ordinary Differential Equation, Finite Difference Solution of One Dimensional Heat Equation by Explicit and Implicit Methods, One Dimensional Wave Equation and Two Dimensional Laplace and Poisson Equations

UNIT 3: PROBABILITY AND RANDOM VARIABLES **9**

Random experiment , sample space , concept of probability Axioms of Probability , ,conditional probability ,Total probability ,Baye's theorem ,Discrete and continuous type of random variables ,Moments , Moment generating functions and their properties

UNIT 4: STANDARD DISTRIBUTIONS **9**

Discrete distributions: Binomial, Poisson, Geometric, Negative Binomial ,Continuous distributions , Uniform, Normal, Exponential, Gamma, and Weibull distributions ,Mean and variance of distribution , Method of finding Mean and variance using MGF

UNIT 5: TWO DIMENSIONAL RANDOM VARIABLES **9**

Joint distributions - Marginal and conditional distributions -Independent random variables - Covariance - Correlation and Regression - Transformation of random variables - Central limit theorem with its applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the method of finding numerical solution for differential equation by initial value problems and terminal problem

CO2: Apply the method of finding numerical solution for differential equation by boundary value problems and with their application.

CO3: Gain knowledge about conditional probability and applications of Baye's theorem

CO4: Identify the different types of distribution and apply in real life

CO5: Apply the discrete data to analyse the correlation and regression

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	-	-	-	-	-	1	-	2	2
CO2	3	3	1	2	1	3	-	-	-	-	-	-	2	2

CO3	3	2	3	3	3	-	-	-	-	-	1	-	2	2
CO4	3	2	2	1	2	3	-	-	-	-	-	-	2	2
CO5	3	1	2	3	2	-	-	-	-	-	-	-	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

M.K. JAIN, S.R.K. IYENGAR and R.K. JAIN "Numerical methods: for scientific and engineering computation" 2013. 6th ed.,

M.K. JAIN "Numerical solutions to differential equation" Wiley Eastern New Delhi 2015.

DEVORE, J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning , New Delhi, 8th Edition, 2014.

S.C. GUPTA AND V.K. KAPOOR "Fundamentals of mathematical statistics" Elevanth thoroughly revised ed., Sultan Chand & Sons educational publishers, New Delhi (June 2003)

T. VEERARAJAN, "Probability, Statistics and Random Processes" Tata McGraw-Hill Publishing Company Limited, New Delhi(2006)

REFERENCE BOOKS:

VEERARAJAN.T AND RAMACHANDRAN. T " Numerical Methods with Programming in C" second Ed., Tata Mc. Graw Hill Publishing. Co. Ltd (2007)

SANKARARAO.K " Numerical Methods for Scientists and Engineers" -3rd edition Printice Hall of India Private Ltd. New Delhi-(2007).

WALPOLE, R.E., MYERS, R.H., MYERS, S.L. and YE. K., "Probability and Statistics For Engineers and Scientists", 9th Edition, Pearson Education, Asia, 2010.

ME640205– ENGINEERING MATERIALS AND METALLURGY (Common to MECH &MAE)					
Course Category: Program Core	**Course Type: Theory with practical component**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

This course provides students an understanding of basic structure and crystal arrangement of materials, the phase diagrams, mechanical properties of materials through mechanical testing, effects of alloying elements, and advantages of heat treatment and the method of heat treatment processes.

UNIT 1 : CRYSTALLOGRAPHY AND CRYSTAL DEFECTS **6**

Structure of metals and alloys ,Molecules and bonding ,Crystal structure-Miller indices of atomic planes , Bragg's law ,crystal defects ,points, line and plane defects ,allotropy grain and grain boundaries,Electron diffraction from a crystal: reciprocal lattice, structure factors,TEM instrumentation: electron sources; electromagnetic lenses; geometric and wave optics applied to TEM; lens aberrations and resolution.

UNIT 2 : CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS **6**

Constitution of alloys,Solid solutions, substitutional and interstitial ,phase diagrams, Isomorphous, eutectic, eutectoid, peritectic, and peritectoid reactions, Iron – Iron carbide equilibrium diagram. Classification of steel and cast-Iron microstructure, properties and application.

UNIT 3 : MECHANICAL TESTING, FATIGUE, CREEP AND FRACTURE **6**

Mechanisms of plastic deformation, slip and twinning ,Types of fracture ,fracture mechanics,Griffith's theory,Testing of materials under tension, compression and shear loads ,Hardness tests (Brinell, Vickers and Rockwell), Micro and nano-hardness tests, Impact test lzod and charpy, fatigue and creep failure mechanisms.

UNIT 4 : METALLURGY, FERROUS AND NON FERROUS ALLOYS **6**

Effect of alloying additions on steel (Mn, Si, Cr, Mo, Ni, V,Ti& W) ,stainless and tool steels ,HSLA, Maraging steels,Grey, white, malleable, spheroidal ,alloy cast irons, Copper and its alloys ,Brass, Bronze and Cupronickel ,Aluminium and its alloys; Al-Cu ,precipitation strengthening treatment, Titanium alloys, Mg-alloys, Ni-based super alloys – shape memory alloys- Properties and Applications- overview of materials standards

UNIT 5 :HEAT TREATMENT **6**

Critical temperature on heating , Annealing ,Spheroidizing ,Normalizing ,Hardening ,Isothermal Transformation diagram ,Martensitic transformation ,Tempering, austempering and martempering , continuous cooling Transformation (CCT) diagram, Flame and Induction hardening ,Vacuum and Plasma hardening.

LIST OF EXPERIMENTS: TOTAL: 30 +15 PERIODS

1. To study the microstructure of mild steel with the help of microscope.
2. To study the microstructure of aluminum with the use of suitable etchant.
3. To study the heat-treatment processes (annealing and tempering) applied to a steel sample.
4. To study the effects of heat treatment on the microstructure of steels.
5. To study the effects of heat treatment on the mechanical properties of steels (impact strength and hardness will be measured for heat treated specimen)

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Classify the structure of materials at different levels

CO2: Identify the mechanism of fracture and deformation of crystalline materials.

CO3: Apply material testing and metallography technique for testing industrial components.

CO4: Interpret the concept of phase, phase diagrams & basic terminologies associated with metallurgy.

CO5: Summarize & classify different heat treatment and surface treatment techniques.

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	1	-	-	-	-	1	-	2	-	-

CO2	3	2	-	2	2	-	-	-	-	1	-	2	-	-
CO3	3	3	-	2	1	-	-	-	-	1	-	2	-	-
CO4	3	2	-	2	2	-	-	-	-	1	-	2	-	-
CO5	3	2	-	2	1	-	-	-	-	1	-	2	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Smith, Foundations of Materials Science and Engineering, 4th Edition, McGraw Hill, 2017.
2.William D. Callister, Material science and Engineering and Introduction, Wiley, 2014.
3.S.H. Avner , introduction to Physical Metallurgy 2nd ed. , Tata McGraw hill 2017

REFERENCE BOOKS:

1.V.Raghavan, Materials Science and Engineering, , PHI, 2005
2.Donald R. Askland and Pradeep.P. Phule, The Science and Engineering of Materials,Cengage Learning, 4th Ed., 2017.
3.George Ellwood Dieter, Mechanical Metallurgy, McGraw-Hill.
4. ASM Handbooks, American Society of Metals.

WEB RESOURCES:

https://easyengineering.net/me6403-engineering-materials-and-metallurgy/

ME640206 THERMAL ENGINEERING (Common to MECH &MAE)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Tolearntheconceptsandlawsofthermodynamicstopredicttheoperationofthermodynamiccyclesandperformance ofInternalCombustion(IC)enginesand Gas Turbines
- Toanalyze theworking ofICenginesandvarious auxiliarysystemspresentinIC engines
- Toevaluate thevarious performanceparametersof ICengines
- To analyze the performance of steam nozzle, calculate critical pressure ratio and Evaluating the performance of steam turbines through velocity triangles, understand the needfor governing and compounding of turbines
- To apply the thermodynamic concepts intoRefrigerationandAirconditioningsystems

UNIT 1 : THERMODYNAMIC CYCLES **9**

Air Standard Cycles, Carnot, Otto, Diesel, Dual, Brayton ,Cycle Analysis, Performance and Comparison.

UNIT2: INTERNAL COMBUSTION ENGINES – FEATURES AND COMBUSTION **9**

IC engine, Classification, working, components and their functions. Ideal and actual : Valve and port timing diagrams, actual and theoretical p-v diagrams- two stroke & four stroke, and SI & CI engines ,comparison. Geometric, operating, and performance comparison of SI and CI engines. Desirable properties and qualities of fuels. Air-fuel ratio calculation, lean and rich mixtures. Combustion in SI & CI Engines, Knocking, phenomena and control.

UNIT 3: INTERNAL COMBUSTION ENGINE PERFORMANCE AND AUXILIARY SYSTEMS **9**

Performance and Emission Testing, Performance parameters and calculations. Morse and Heat Balance tests. Multipoint Fuel Injection system and Common rail direct injection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging –Emission Norms

UNIT 4: STEAM NOZZLES AND TURBINES **9**

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

UNIT 5: REFRIGERATION AND AIR CONDITIONING **9**

Air refrigeration system ,Vapour compression refrigeration cycle- super heat, sub cooling ,Performance calculations ,working principle of vapour absorption system, Ammonia ,Water, Lithium bromide ,water systems (Description only),Types& Properties of Refrigerants ,Comparison between vapour compression and absorption systems, Psychrometry process-Types of Air conditioning systems,Requirements for comfort and industrial air,conditioning

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Applythermodynamicconcepts todifferent air standardcycles andsolve problems.

CO2:ExplainthefunctioningandfeaturesofICengine, componentsandauxiliaries

CO3:Calculatethe variousperformance parameters ofIC engines

CO4:Explain the working of different types of steam nozzles and turbines, calculation of performanceparameters and methods of turbine compounding to reduce rotor speed of an impulse turbine

CO5:ToanalyzetheusageofRefrigerationandAirconditioning..

CO-PO MAPPING

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

CO4	3	2	1	1	-	-	-	-	-	-	-	1	2	1
CO5	3	2	1	1	-	-	-	-	-	-	-	1	2	1

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Rajput. R. K., "Thermal Engineering", Laxmi Publications, Ltd., 9th Edition, 2020.

2.Ganesan.V, "InternalCombustionEngines"4thEdition, TataMcGrawHill,2017

REFERENCE BOOKS:

1. Ballaney. P, "Thermal Engineering", 25th Edition, Khanna Publishers, 2017

2. Domkundwar, Kothandaraman, &Domkundwar, "A Course in Thermal Engineering", 6th Edition, DhanpatRai& Sons, 2011.

3. Mathur M.L and Mehta F.S., "Thermal Science and Engineering", 3rd Edition, Jain Brothers Pvt. Ltd, 2017.

4. B. K. Sarkar., "Thermal Engineering" Tata McGraw Hill Education, 1st Edition, 2001

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/103/112103316/

https://onlinecourses.nptel.ac.in/noc23_me31/preview

EE640901	ELECTRICAL DRIVES AND CONTROL (For IV Semester Mechanical Engineering and Mechanical and Automation Engineering)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts of different types of electrical machines and their performance.
- To study the different methods of starting D.C motors and induction motors.
- To study about the performance of conventional and solid-state drives

CO-PO MAPPING:

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

UNIT I INTRODUCTION 9

Basic Elements – Types of Electric Drives – factors influencing the choice of electrical drives – heating and cooling curves – Loading conditions and classes of duty – Selection of power rating for drive motors with regard to thermal overloading and Load variation factors

UNIT II DC MOTOR DRIVES 9

DC motor drives – DC motors & their performance - shunt, series, compound - permanent magnet motor- universal motor - DC servomotor – braking – regenerative - dynamic braking - plugging.

UNIT III INDUCTION MOTOR DRIVES 9

Induction motor drives – stator voltage control of induction motor – torque-slip characteristics – operation with different types of loads - effect of harmonics and control of harmonics.

UNIT IV STARTING METHODS 9

Types of D.C Motor starters – Typical control circuits for shunt and series motors – Three phase induction motors starters: Stator resistance starter, rotor resistance starter, auto transformer starter- Single phase induction motors: Split phase - capacitor start - capacitor start and capacitor run – Shaded pole induction motor.

UNIT V SPEED CONTROL OF D.C. AND AC DRIVES 9

Speed control of DC series and shunt motors – Armature and field control, Ward-Leonard control system – overview of SCR and chopper – speed control using controlled rectifiers and DC choppers Speed control of three-phase induction motor – Voltage control, voltage/frequency control, slip power recovery scheme – Speed control using AC voltage regulators – applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this Course, the students will able to

CO1: Express the concepts of Electrical drives

CO2: Discuss about the characteristics of DC Motors

CO3: Express the starting methods of DC and AC motors.

CO4: Explain about the speed control of DC Motors

CO5: Explain about the speed control of AC Motors

TEXT BOOKS:

1. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, 2013.
2. B.L. Theraja and A.K.Theraja, “A Text book of Electrical Technology- Vol. II, S.C Chand and Co., New Delhi, Reprint 2011.

REFERENCES:

1. Vedam Subrahmaniam, “Electric Drives (Concepts and Applications)”, Tata McGraw-Hill, 2010
2. Partab. H., “Art and Science and Utilization of Electrical Energy”, Dhanpat Rai and Sons, 2017
3. Pillai.S.K “A First Course on Electric Drives”, Wiley Eastern Limited, 2012
4. Singh. M.D., K.B.Khanchandani, “Power Electronics”, Tata McGraw-Hill, 2nd edition, 2017.

ME640303 – THERMAL ENGINEERING Laboratory (Common to MECH &MAE)					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To impart knowledge of characteristics of Engine fuels, Performance of Engine and air conditioning

LIST OF EXPERIMENTS

1. Valve Timing Diagrams
2. Port Timing Diagrams
3. Performance Test on 4-stroke Diesel Engine
4. Determination of Viscosity – Red Wood Viscometer
5. Determination of Flash Point and Fire Point
6. Determination of COP of a refrigeration system
7. Experiments on Air-Conditioning system
8. Performance test on two stage reciprocating air compressor.
9. Thermal conductivity measurement on metal bar.
10. Study of Steam Generators and Turbines.**TOTAL: 30 PERIODS**

List of Requirements: (for a batch of 30 students)

S.NO.	DESCRIPTION OF EQUIPMENT	QUANTITY
1.	I.C Engine – 2 stroke and 4 stroke model	1
2.	Red Wood Viscometer	1
3.	Apparatus for Flash and Fire Point	1
4.	4-stroke Diesel Engine with mechanical	1
5.	Steam Boiler with turbine setup	1
6.	Natural convection-vertical cylinder	1
7.	Forced convection inside tube apparatus	1
8.	Thermal conductivity measurement	1
9.	Emissivity measurement apparatus	1
10.	Parallel/counter flow heat exchanger	1
11.	Two stage reciprocating air compressor	1
12.	Refrigeration test rig	1

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Sketch the valve timing diagram and port timing diagram IC Engines.

CO2: Measure the flash and fire point of various fuel/lubricants

CO3: Evaluate the performance of four stroke single cylinder CI engine

CO4: Conduct a test to find thermal conductivity of various engineering materials.

CO5: Determine the COP of the refrigeration and Air conditioning

CO's PO's & PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	3	-	-	-	-	-	2	1	2	-	-
CO2	3	2	-	3	-	-	-	-	-	2	1	2	-	-
CO3	3	2	-	3	-	-	-	-	-	2	-	2	-	-
CO4	2	2	3	-	-	-	-	-	2	1	2	3	-	-
CO5	2	2	3	-	-	-	-	-	2	1	2	3	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

ME630502INTEGRATED APTITUDE SKILLS-II (LOWER)

Course Category: EEC	Course Type: Skill Based Course	L	T	P	C
		0	0	1	0.5

COURSE OBJECTIVES:

- To impart knowledge on
- To understand the basic concepts of quantitative ability
- To understand the basic concepts of logical reasoning Skills
- To acquire satisfactory competency in use of verbal reasoning

UNIT 1 : QUANTITATIVE APTITUDE — **5**

1. Percentage 2. Ratio & Proportions 3. Pipes & Cisterns 4. Permutations & Combinations 5. Partnership 6. Alligation (Or) Mixture 7. Races & Games 8. Stocks & Shares 9. Height & Distance 10. True Discount & Banker's Discount 11. Probability 12. Mensuration (Area, Volume & Surface Area) 13. Interest (Simple Interest, Compound Interest) 14. Logarithm 15. Chain Rule16. Data Interpretation (Tabulation, Bar Chart, Pie Chart, Line Graphs)

UNIT 2 : LOGICAL REASONING — **5**

VERBAL REASONING: 1. Logic 2. Statement – Argument 3. Statement – Assumptions 4. Statement – Courses of action 5. Statement –Conclusion 6. Deriving Conclusion from passages 7. Theme Detection 8. Cause and Effect reasoning

NON-VERBAL REASONING 1. Series 2. Analogy 3. Classification 4. Analytical Reasoning 5. Mirror – Images 6. Water – Images 7. Spotting out the embedded figures 8. Completion of incomplete patterns 9. Figure Matrix 10. Paper Folding 11. Paper Cutting 12. Rule Detection 13. Grouping of identical figures 14. Cubes and Dice 15. Dot Situation 16. Construction of squares and triangles 17. Figure formation and analysis 18. Eligibility test 19. Assertions and Reasoning 20. Situation Reaction Test 21. Verification of truth of the statement

UNIT 3: VERBAL ABILITY — **5**

1. Concord 2. Cloze Passage 3. Analogies or Reverse Analogies4.Jumbled Sentences. 5. Error Deduction. 6. Reading Comprehension 7. Paragraph Formation 8. Completing Statements 9. Usage of Prepositions 10. Inference(Theme Detection) 11. Verification of Truth from the Statements 12. Change of Speech

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Students at the end of the course will be able to solve aptitude, logical and verbal reasoning questions.

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	-	-	-	-	-	2	-	1	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
1. Agarwal R.S, "Quantitative Aptitude," S.Chand and Company Pvt. Ltd., New Delhi, First Edition 1989, Reprint, 2016
2. Agarwal R.S, "A Modern Approach to Verbal and Non-Verbal Reasoning," S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1994, Reprint, 2016
3. Agarwal R.S, "Objective General English," S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1997, Reprint, 2016
REFERENCE BOOKS:
1. Anand P A, "Quantitative Aptitude," Wiley India Pvt. Ltd., New Delhi, Edition,2016
2. Arun Sharma, "How to Prepare for Logical Reasoning," Tata-McGraw Hill Education Series.New Delhi, First Edition 2016
3. Sharon Weiner Green, Ira K Wolf, "Barron's GRE," Barron Publishers. First Edition 1995, Reprint, 2016
4. The Princeton Review, "Cracking the GRE", Random House Publisher, Premium Edition 2016.
WEB RESOURCES:
www.indiabix.com
http://www.practiceaptitudetests.com

ELECTRICAL DRIVES AND CONTROL LABORATORY

EE640902

L	T	P	C
0	0	3	1.5

COURSE OBJECTIVE:

To expose the students to the operation and control of electrical drives and develop their practical skill.

CO-PO MAPPING:

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

LIST OF EXPERIMENTS

1. Brake test on DC Shunt motor
2. Brake test on DC Series motor
3. Brake test on DC Compound Motor
4. Speed control of DC shunt motor (Armature / Field control)
5. Swinburne's test.
6. Load test on three phase squirrel cage Induction motor
7. Load test on Single - phase Induction Motor.
8. Speed control of three phase squirrel cage Induction Motor
9. Speed control of Single - phase Induction Motor.
10. Speed control of DC Motor using rectifier.
11. Speed control of DC Motor using chopper.
12. Study of Starters for AC& DC Machine.

Additional Experiments:

1. Using MATLAB, simulate the following tests
2. Load characteristics of DC shunt motor.

3. Speed control of DC Motor using rectifier.
4. Speed control of DC Motor using chopper.
5. Speed control of Single-phase induction motor using inverter.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Use characteristics of various electrical drives depending on their type excitation.
CO2: Develop knowledge helpful for application of DC and AC machines.
CO3: Conduct speed control of different types of electrical drives.
CO4: Understand the concept of different types of testing in electrical dives.
CO5: Know the procedure to conduct speed control tests on electrical drives.

TEXT BOOKS:

1. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.
2. Theraja B. L., A Textbook of Electrical Technology, S. Chand & Company, New Delhi, 2008.

REFERENCES:

1. Kothari D. P. Laboratory Manual for Electrical Machines, I K International Publishing House Pvt. Ltd.
2. Nagrath I J and D P Kothari - Electric Machines – Tata McGraw Hill, 4th edition, 2010.

SYLLABUS

SEMESTER V

ME650207-Theory of Machines (Common to MECH & MAE))					
Course Category: Program Core	**Course Type: Theory with practical component**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To understand the concept of machines, mechanisms and related terminologies, to analyze a mechanism for displacement, velocity and acceleration at any point in a moving link.
- To acquire the knowledge in force analysis, energy stored in flywheel, balancing of machines, vibration and control mechanisms.

UNIT 1: MECHANISMS AND VELOCITY & ACCLERATION ANALYSIS | **6**

Definitions:Link, Kinematic pair, Kinematic chain, Mechanism, and Machine. Analysis of simple mechanisms (Single slider crank mechanism and four bar mechanism),Graphical Methods for displacement, velocity and acceleration: Shaping machine mechanism , Instantaneous Centre & Kennedy's theorem (Problems).

UNIT 2: UNIT II KINEMATICS OF CAMS | **6**

Classifications,Cam Nomenclature ,Types of follower,Displacement diagrams , Parabolic, Simple harmonic and cycloidal motions ,Graphical construction of displacement diagrams and layout of plate Cam profiles, Circular arc with Flat faced follower.

UNIT 3: FLYWHEELS AND BALANCING OF MASSES | **6**

Static force analysis of mechanisms ,Turning moment diagrams ,Fluctuation of energy, speed ,Flywheels of engines and punching press. Static and dynamic balancing ,Balancing of rotating masses ,Balancing of reciprocating masses in a single cylinder engine,Primary and secondary unbalanced forces.

UNIT 4: FREE AND FORCED VIBRATIONS | **6**

Free vibration , Equations of motion , Natural frequency ,Whirling of shafts and critical speed , Torsional vibration of two and three rotor systems, torsionally equivalent shaft.

UNIT 5: MECHANISMS FOR CONTROL

Governors, Types, Centrifugal governors, Porter &Proell governor, Hartnell & Hartung governor, Characteristics, Effect of friction, Controlling Force Gyroscopes, Gyroscopic couple Gyroscopic stabilization.

LIST OF EXPERIMENTS: TOTAL: 30+15 = 45 PERIODS

Study of Ackerman's Steering Gear Mechanism.

1. To study various types of gears.
2. To study various types of gear trains.
3. To draw velocity diagram of slider crank mechanism.
4. To draw acceleration diagram of four bar mechanism.
5. To draw displacement diagram, velocity diagram & acceleration diagram of cam follower

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the basic concepts of Mechanisms, Machines and their relative motions.

CO2: Construct & Design different CAM profiles for given conditions using graphical-Analytical.

CO3: Analyze the static and dynamic force in mechanical systems in flywheels and rotating masses.

CO4: Apply the fundamental concepts of vibration to determine the natural frequency bodies.

CO5: Calculate the speed range of governors and determine the gyroscopic couple.

CO's PO's&PSO's MAPPING

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

CO4	3	3	2	2	2						2	3	1	2
CO5	3	3	3	2	3						2	3	2	

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. 1. Khurmi R.S & Gupta J.K, "Theory of Machines", S. Chand Publications, 2015.
2. S.S Rattan, "Theory of Machines", Edition: 4, Tata McGraw-Hill Publishing Company Ltd 2017
3. Thomas Bevan, "Theory of Machines", Edition: 3, CBS Publishers &Distributors , 2005.

REFERENCE BOOKS:

1 Uicker J.J., Pennock G.R., Shigley J.E., "Theory of Machines and Mechanisms" (Indian Edition), Oxford University Press, 3rd Edition, 2009.
2.Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 3rd Edition, 2005.
3.Ghosh A and A.K.Mallick, "Theory of Mechanisms and Machines", East West Press, New Delhi, 3rd Edition, 2006.
4.Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", New Age InternationalPublishers, 2006.
5. A. Ghosh and A.K Mallick, "Theory of Mechanisms and Machines", Edition: 1, AffiliatedEast- West Pvt. Ltd , 2008.

WEB RESOURCES:https://nptel.ac.in/courses/112/106/112106270/

ME650208–ENGINEERING METROLOGY AND MEASUREMENTS
(Common to MECH & MAE)

Course Category: Program Core	Course Type: Theory with project	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on basic principles of instrumentation and metrology.
- To become an expert in the field of measurements and instrumentation.

UNIT 1: BASICS OF METROLOGY **9**

Introduction to Metrology ,Need ,Elements, Work piece, Generalized measurement system, Units and standards, measuring instruments: sensitivity, stability, range, accuracy and precision, static and dynamic response repeatability, systematic and random errors, correction, calibration, Introduction to Dimensional and Geometric Tolerance, interchangeability.

UNIT 2: LINEAR AND ANGULAR MEASUREMENT **9**

Linear measuring instruments: Vernier, micrometer, Slip gauges and classification, Tool Makers Microscope, limit gauges: Mechanical, Pneumatic and electrical comparators, applications. Angular measurements: bevel protractor clinometers angle gauges, sine bar, Autocollimator, Applications.

UNIT 3: FORM MEASUREMENT **9**

Measurement of screw threads: Thread gauges, floating carriage micrometer, measurement of gear tooth thickness: constant chord and base tangent method, Gleason gear testing machine, radius measurements surface finish: equipment and parameters, straightness, flatness and roundness measurements, Machine tool alignment Tests: principles of machine tool alignment testing on lathe, drilling and milling machine.

UNIT 4: ADVANCES IN METROLOGY & MEASUREMENTS **9**

Basic concept of lasers Advantages of lasers ,laser Interferometers ,types ,DC and AC Lasers interferometer ,Applications ,Straightness ,Alignment. Basic concept of CMM ,Types of CMM, Constructional features ,Probes ,Accessories , Software ,Applications ,Basic concepts of Machine Vision System ,Element ,Applications.

UNIT 5: MEASUREMENT OF MECHANICAL PARAMETERS **9**

Force, torque, power: mechanical, pneumatic, hydraulic and electrical type, Pressure measurement, Flow: Venturi, orifice, rotameter, pitot tube, Temperature: bimetallic strip, thermocouples, pyrometer, electrical resistance thermistor.

TOTAL: 45PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1:Apply the knowledge of measuring instruments in industry for selecting appropriate instruments.

CO2:Suggest the linear measuring instruments for measuring dimension with high accuracy.

CO3: Design tolerances and fits for selected product quality.

CO4:Evaluate the quality of the machine tool with alignment test.

CO5: Utilize the mechanical measuring instruments in industries for sequence applications.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. AlanS.Morris,"TheEssenceofMeasurement",PrenticeHallofIndia,1996.

2. JainR.K.,"EngineeringMetrology",KhannaPublishers,2018.

3.R.S.figlio land D.E.Beasley,Theory andDesignforMechanicalMeasurements,3rded.JohnWiley & Sons,

2008.
REFERENCE BOOKS:
1.GuptaI.C,“EngineeringMetrology”,DhanpatraiPublications,2018.
2.JayalA.K,“Instrumentation and Mechanical Measurements”, Galgotia Publications2005.
3.Beckwith,Marangoni, Lienhard,“MechanicalMeasurements”,PearsonEducation,2013.
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/104/112104250/

ME650209 – DESIGN OF MACHINE ELEMENTS(Common to MECH & MAE)

Course Category: Program Core	Course Type: Theory	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

- To synergize forces, moments, torques, stress and strength information to develop ability to analyze, design and/or select machine elements.**(Use of PSG Design Data Book permitted)**

UNIT 1: SIMPLE STRESSES **9**

Introduction to the design process, factors influencing machine design, selection of materials based on mechanical properties,preferred numbers, fits and tolerances ,Types of simple stresses ,static and varying loading , combined loading ,theories of failures, application , allowable stress, factor of safety ,stress concentration factor, fluctuating stress, design for fatigue loading Soderberg, Goodman and Gerber relations.

UNIT 2: DESIGN OF KEY, SHAFTS AND COUPLINGS **9**

Design of solid and hollow shafts based on strength, rigidity and critical speed. Design of keys. keyways and splines- Design of couplings- flange couplings –pushed pin type flexible coupling

UNIT 3: DESIGN OF TEMPERORARY JOINTS AND PERMANENT JOINTS **9**

Threaded joints: I.S.O. Metric screw threads,treaded joints in tension- torque requirement for tightening and eccentrically loaded bolted joints.
Welded joints: Types of welded joints,weld symbols, strength of welds,centrally loaded joints,axially loaded joints,eccentrically loaded joints,riveted joints for structures.

UNIT 4: DESIGN OF SPRINGS AND ENGINE COMPONENTS **9**

Helical springs and leaf springs: Stresses and deflection in helical springs ,Design of leaf springs,stress and deflection, pre stressing, Connecting Rods and crank shafts.

UNIT 5: DESIGN OF BEARINGS **9**

Sliding contact bearings: Theory of lubrication,hydrodynamic bearings,Sommer field number,design of hydrodynamic bearings. Rolling contact bearings: Static and dynamic load capacity,cubic mean load, variable load,probability of survival,selection of deep groove and angular contact ball bearings.

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Describe the fundamental scientific principles of mechanical design (stress, strain,material properties, failure theories, fatigue phenomena, etc.) and their importance and use indesign.

CO2: Calculate the diameter based on strength, rigidity and design various types of coupling based on application.

CO3: Calculate the design parameter of permanent and temporary joint on various loading application.

CO4: Select and design a mechanical springbaseduponthe applicationand requirements.

CO5: Calculate the design parameter of various types of bearing

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Bhandari V.B,"Design of Machine Elements",4th Edition,Tata Mc Graw-Hill Education,NewDelhi,2017.
2. Richard G.Budynas and J.Keith Nisbett., "Shigley's Mechanical Engineering Design",10th Edition

(SIE),Tata McGraw-Hill Education,NewDelhi,2017
3. JosephShigley,CharlesMischke,RichardBudynasandKeithNisbett,“MechanicalEngineeringDesign”, Edition: 9, TataMcGraw-Hill , 2011.
REFERENCE BOOKS:
1. “Design Data book”, Edition: 5, PSG College of Technology, Coimbatore, 2016.
2. T.V.Sundararajamoorthy,N.Shanmugam,“Machine Design”,Edition:1,Anuradha Publications, 2012.
3. C.Robert Juvinall and M.Kurt Marshek,“Fundamentals of Machine Design”,Edition:4,Wiley, 2005.
4. Ugural A.C, “Mechanical Design – An Integral Approach”, McGraw-Hill Book Co,2009.
5. PSG College of Technology,“Design Data”,Kalaikathir Achchagam,2016.
6. R.S.Khurmi,”Atext book of MachineDesign”,S.Chand&Co,NewDelhi,2015.
WEB RESOURCES: https://archive.nptel.ac.in/courses/112/105/112105125/

ME650304 – Dynamics of Machinery Laboratory(Common to MECH & MAE)						
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**	
		0	**0**	**3**	**1.5**	

COURSE OBJECTIVES:

- To supplement the principles of learning kinematics and Dynamics of Machinery
- To understand the measuring devices are used for dynamic testing.

LIST OF EXPERIMENTS

1. Determination of Mass moment of inertia of flywheel and axle system.
2. Motorized gyroscope–Study of gyroscopic effect and couple.
3. Governor-Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and Hartnell Governors.
4. Cams–Cam profile drawing.
5. Cams-Motion curves and study of jump phenomenon.
6. Single degree of freedom Spring Mass System –determination of naturalFrequency and verification of Laws of springs–Damping coefficient determination.
7. Vibration of Equivalent Spring mass system–Un damped and damped vibration.
8. Whirling of shafts–Determination of critical speeds of shafts with concentrated loads.
9. Balancing of rotating masses and reciprocating masses.
10. Determination of transmissibility ratio using vibrating table.

TOTAL: 30 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: To make the students understand the moment of inertia of flywheel.

CO2: To make the students understand the concept of gyroscopic effect.

CO3: Demonstrate the working principle of governors.

CO4: Analyze various types of transmissions, apply balancing in machine systems.

CO5: Analyze various types of CAM Sand gears.

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	3	-	-	-	-	-	-	2	-	-
CO2	2	2	-	-	3	-	-	-	-	-	-	-	-	-
CO3	2	1	-	-	3	-	-	-	-	-	-	-	-	-
CO4	2	1	-	1	3	-		-	-	-	-	-	-	-
CO5	2	1	-	2	3	-		-	-	-	-	-	-	-
CO6	2	1	-	2	3	-		-	-	-	-	-	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

ME650305 – Computer Numerical Control Laboratory (Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To introduce the evolution, types and principles of CNC machine tools

LIST OF EXPERIMENTS

1. Program for Turning, Facing operation and Machining.
2. Program for circular interpolation, taper turning operation and Machining.
3. Program for thread cutting operation and Machining.
4. Program using Do-Loop and Sub-routine and Machining.
5. Program for profile milling operation, circular interpolation and Machining.
6. Program for Circular, rectangular pocket milling and Machining.
7. CAM Programming and CNC milling.
8. CAM Programming and CNC Turning. **TOTAL: 30 PERIODS**

Course Outcomes: At the end of the course, the student will be able to

CO1:To recognize the evolution, types and principle of CNC machine tools

CO2:To acquire knowledge on constructional features of CNC machine tools

CO3:To display competency in manual CNC part programming for milling and turning machines

CO4: To exhibit generation of part programs using CNC programming CNC Lathe.

CO5: To demonstrate machining the parts on actual machines CNC Lathe, CNC Milling Machine and

Course Outcomes: At the end of the course, the student will be able to

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

ME630501 INTEGRATED APTITUDE SKILLS (HIGHER)						
Course Category: EEC	**Course Type: Skill Based Course**	**L**	**T**	**P**	**C**	
		0	**0**	**2**	**1**	

COURSE OBJECTIVES:

- To understand the basic concepts of quantitative ability
- To understand the basic concepts of logical reasoning Skills
- To acquire satisfactory competency in use of verbal reasoning

UNIT 1 : QUANTITATIVE APTITUDE	**10**
Distance, Time, and Work Geometry, Mensuration Percentage, Profit, and Loss Set Theory Number System Data Interpretation Time, Speed	
UNIT 2 : LOGICAL REASONING	**5**
Number Series, verbal classifications,analogies,Logical games	
UNIT 3: VERBAL ABILITY	**5**
Paragraph Completion Word Usage Para Jumble Reading Comprehension Fill in the Blanks and Grammar	
TOTAL: 20 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Students at the end of the course will be able to solve aptitude, logical and verbal reasoning questions

CO's PO's & PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	-	-	-	-	-	2	-	1	2	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

Agarwal R.S, "Quantitative Aptitude," S.Chand and Company Pvt. Ltd., New Delhi, First Edition 1989, Reprint, 2016

Agarwal R.S, "A Modern Approach to Verbal and Non-Verbal Reasoning," S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1994, Reprint, 2016

Agarwal R.S, "Objective General English," S.Chand and Company Pvt. Ltd.,New Delhi, First Edition 1997, Reprint, 2016

REFERENCE BOOKS:

Anand P A, "Quantitative Aptitude," Wiley India Pvt. Ltd., New Delhi, Edition,2016

Arun Sharma, "How to Prepare for Logical Reasoning," Tata-McGraw Hill Education Series. New Delhi, First Edition 2016

Sharon Weiner Green, Ira K Wolf, "Barron's GRE," Barron Publishers. First Edition 1995, Reprint, 2016

The Princeton Review, "Cracking the GRE", Random House Publisher, Premium Edition 2016.

WEB RESOURCES:

www.indiabix.com - http://www.practiceaptitudetests.com

SYLLABUS
SEMESTER VI

ME660210-HEAT AND MASS TRANSFER (Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Theory with Project**	**L**	**T**	**P**	**C**
		2	**1**	**0**	**3**

COURSE OBJECTIVES:

- To gather adequate knowledge of various modes of heat and mass transfer that occurs in any physical systems.

UNIT 1:CONDUCTION	**6**

General Differential equation of Heat Conduction, Cartesian and Polar Coordinates, One Dimensional Steady State Heat Conduction , plane and Composite Systems,Conduction with Internal Heat Generation Extended Surfaces ,Unsteady Heat Conduction, Lumped Analysis ,Semi Infinite and Infinite Solids ,Use of Heislers charts.

UNIT 2:CONVECTION	**6**

Free and Forced Convection ,Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes. laminar flow, turbulent flow, Reynolds analogy.

UNIT 3:CONVECTIVE PHASE CHANGE HEAT TRANSFER AND HEATEXCHANGERS	**6**

Nusselt's theory of condensation ,Regimes of Pool boiling and Flow boiling. Correlations in boiling and condensation. Heat Exchanger Types , Overall Heat Transfer Coefficient ,Fouling Factors , Analysis ,LMTD method ,NTU method-Fouling factor-effectiveness.

UNIT 4:RADIATION	**6**

Black Body Radiation ,Grey body radiation ,Shape Factor ,Electrical Analogy, Radiation Shields,Radiation through gases. Radiation exchange between gray surfaces, radiosity, and irradiation.

UNIT 5:MASSTRANSFER	**6**

Introduction about mass transfer ,Diffusion Mass Transfer ,Fick's Law of Diffusion, Steady state Molecular Diffusion ,Convective Mass Transfer ,Momentum, Heat and Mass Transfer Analogy,Convective Mass Transfer Correlations.

TOTAL: 30+15 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Understanding the physics involved in various heat transfer mechanisms.

CO2: Applyingtheknowledgeofmathematicsandanalyzethedifferentsituationsinheat condition.

CO3: To analyze the effect of different boiling regimes and condensation and also through the proper use of modelling can able to choose different heat exchangers for specific applications.

CO4: Tobeabletocalculateheattransferrateobtaining temperature distribution in different situations.

CO5: Apply the knowledge of mass transfer to determine the diffusion coefficient

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	3	2	2	2	-	-	-	2	-	-	-	2	-	-
CO2	3	2	2	2	-	-	-	2	-	-	-	2	-	-
CO3	3	2	2	2	-	-	-	2	-	-	-	2	-	-
CO4	3	2	2	2	-	-	-	2	-	-	-	2	-	-
CO5	3	2	2	2	-	-	-	2	-	-	-	2	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Sachdeva, R.C., Fundamentals of Engineering Heat and Mass Transfer, New AgeInternational,4th edition Paperback, 2017.
2. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, NewDelhi,MulticolourEdition 2012.

REFERENCE BOOKS:

1. Yadav,R.,Heatand MassTransfer,CentralPublishingHouse,1995.
2. Ozisik,M.N.,HeatTransfer,McGraw-HillBookCo.,1994.
3. Nag.P.K.HeatTransfer,TataMcGraw-Hill,New Delhi,3rdedition,2011.
4. Holman,J.P.,HeatandMass Transfer,TataMcGraw-Hill,10thedition, 2011.

WEB RESOURCES:

https://nptel.ac.in/courses/112/106/112106270/

ME660211 – DESIGN OF TRANSMISSION SYSTEMS(Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Theory With Practical Component**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To help the learners understand the procedural design and selection of power transmission elements such as gears, belt, rope and chain drives.
- To learn how to use the standard data and manufacturing catalogs

(Use of PSG Design Data Book permitted)

UNIT 1: BELT AND CHAIN DRIVES	**6**
Design of belt drives using basic equations, Design of V- belt drive based on manufacturer's data, Design of chain drives, Introduction to timing belt and silent chain. Continuously variable transmission (CVT).	
UNIT 2:SPUR AND HELICAL GEAR	**6**
Review of gear fundamentals Design of spur gear pair. Design of helical gears -parallel axis helical gear, normal and transverse planes, helix angles, determining dimensions of helical gear pair. Equivalent number of teeth-forces for helical gears	
UNIT 3: BEVEL, WORM GEARS AND POWER SCREWS	**6**
Introduction to design of bevel gears, Design of worm gear drive ,efficiency, thermal consideration. Forms of threads, square and trapezoidal threads, collar friction, force analysis, design of power screws.	
UNIT 4: SPEED REDUCER AND GEAR BOX	**6**
Geometric progression ,Design of single stage speed reducer ,gear tooth forces, shaft design and bearing selection. Design of gear box for machine tools,kinematic arrangement, ray diagram and number of gear teeth-Fluid couplings.	
UNIT –V DESIGN OF CAMS, CLUTCHES AND BRAKES	**6**
Cam Design: Types, pressure angle and under cutting base circle determination, forces and surface stresses. 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.	
LIST OF EXPERIMENTS	**15**

1. Design of rigid coupling
2. Design of brake
3. Design of clutches
4. Design of Journal Bearing
5. Design of Spur Gear
6. Design of Bevel Gear

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Make proper assumptions and perform correct analyses and selection of belt drives and chain drives.

CO2: Find suitable dimensions of spur and helical gear drive for given application.

CO3: Design of bevel gear, worm gear to suit given loading conditions.

CO4: Select the number of speeds and design the gears in the gear box.

CO5: Estimate the dimensions to design clutches and brakes.

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	3	3	3	3	-	-	-	-	-	1	1	2	3	3
CO2	3	3	3	3	-	-	-	-	-	1	1	2	3	3
CO3	3	3	3	3	-	-	-	-	-	1	1	2	3	3
CO4	3	3	3	3	-	-	-	-	-	1	1	2	3	3
CO5	3	3	3	3	-	-	-	-	-	1	1	2	3	3

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Bhandari V.B,"Design of Machine Elements",4th Edition,Tata Mc Graw-Hill Education,NewDelhi,2017.
2. Richard G.Budynas and J.Keith Nisbett., "Shigley's Mechanical Engineering Design",10th Edition (SIE),Tata McGraw-Hill Education,NewDelhi,2017

REFERENCE BOOKS:

1. Maitra G.M.,Prasad L.V.,"Handbook of Mechanical Design",
2. 2nd Edition,TataMcGraw-Hill Education,New Delhi, 2001.
3. StevenR.Schmid,BernardJ.Hamrock,Bo.O.Jacobson,"Fundamentals of MachineElements",3rd edition, CRC Press,2014.
4. Sundararaja moorthy T.V, Shanmugam .N, "Machine Design", Anuradha Publications,Chennai,2018.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/105/112105234/

ME660212-CAD/CAM/CAE (Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understand the basic fundamentals of computer aided design and manufacturing.
- To provide an overview of how computers are being used in mechanical component design
- To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.

UNIT– I COMPUTERGRAPHICS 9

Raster scan graphics coordinate system, database structure for graphics modelling, transformation of geometry,2D and 3D transformations, mathematics of projections, clipping ,hidden surface removal

UNIT– II GEOMETRIC MODELING 9

Requirements, geometric models, geometric construction models, and curve representation methods, parametric representation of various curves: cubic spline, bezier curves. Surface representation methods, Solid modelling..

UNIT– III PART PROGRAMMING FOR NCMACHINES **9**

NC, NC modes, NC elements, CNC machine tools, structure of CNC machine tools, features of Machining center, turning center, CNC Part Programming: fundamentals, manual part programming methods, Computer Aided Part Programming. Direct Numerical Control, Adaptive Control.

UNIT– IVGROUPTECHNOLOGY **9**

History of group technology- Role of G.T. in CAD/CAM integration ,Part families ,Classification and coding ,DCLASS and MICLASS and OPITZ coding systems-Facility design using G.T.benefits of G.T. Cellular manufacturing. Process planning ,role of process planning in CAD/CAM integration , Approaches to computer aided process planning,Variant approach and generative approaches ,CAPP and CMPP process planning systems.

UNIT-VSHOPFLOORCONTROL AND INTRODUCTIONOFFMS 9

Shop floor control-phases ,Factory data collection system ,Automatic identification methods Bar code technology,Automated data collection system. FMS, components of FMS ,types ,FMS workstation Material handling and storage systems,FMS layout ,Computer control systems,Application and benefits.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the various graphical representation system and mathematical modeling.

CO2: Describe the mathematical basis in the technique of representation of geometric entities including points, lines, and parametric curves, surfaces and solid, and the technique of transformation of geometric entities using transformation matrix.

CO3: To formulate different type of part programming for Machine element

CO4: To learn and understand about Group Technology concepts and its significance towards Cellular manufacturing and CAPP.

CO5:To analyze, design, and learn about shop floor control, factory data collection and FMS.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation
TEXT BOOKS:
1. Ibrahim Zeid"Mastering CADCAM"TataMcGraw-Hill PublishingCo.2009
2. Mikell.P.Groover"Automation,Production Systems and Computer Integrated Manufacturing",PrenticeHall ofIndia,2008.
3. RadhakrishnanP,SubramanyanS.andRajuV.,"CAD/CAM/CIM",2ndEdition,NewAgeInternational (P)Ltd, NewDelhi,2010.
REFERENCE BOOKS:
1. Chris McMahon and JimmieBrowne"CAD/CAM Principles","Practice and Manufacturing management "Second Edition,Pearson Education,1999.
2. Donald Hearn and M.P auline Baker"Computer Graphics "'.Prentice Hall,Inc,2014.
3. Foley,Wan Dam, Feinerand Hughes-"Computer graphics principles & practice"Pearson Education -2003
4. William MN eumannand Robert F.Sproul"Principles of Computer Graphics",McGraw Hill Book Co. Singapore,1989.
5. Mikell. P. Groover and Emory Zimmers Jr., "CAD/CAM", prentice hall of India Pvt.Ltd.,2003.
6. JamesA.ReghandHenry W.Kreabber,"Computer Integrated Manufacturing",3rd Edition,Pearson Education, 2004.
WEB RESOURCES: https://archive.nptel.ac.in/courses/112/102/112102101/

ME660306 – HEAT TRANSFER LABORATORY
(Common to MECH & MAE)

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To identify the parameters that characterizes these problems and the methods to solveitinvariouspracticalsystemsandtoanalyzecomplexheatandmasstransferproblemsinany engineering systems.
- To gather adequate knowledge of various modes of heat transfer that occurs in any physical systems.

LIST OF EXPERIMENTS

1. Studying the heat transfer across a wall made of multiple materials to understand how each layer contributes to thermal resistance.
2. Measuring how well a surface emits thermal radiation compared to an ideal black body.
3. Investigating heat transfer that occurs when a fluid moves naturally due to temperature differences, without external forces.
4. Studying heat transfer when a fluid is forced to flow over a surface, improving heat dissipation.
5. Measuring heat loss from a pipe with insulation (lagging) to assess the effectiveness of thermal insulation.
6. Investigating the enhancement of heat transfer through the use of pin-fin structures, which increase the surface area for cooling.
7. Verifying the Stefan-Boltzmann law by measuring radiative heat transfer from a surface and comparing it to theoretical values.
8. Studying the heat transfer efficiency of a counterflow heat exchanger, where fluids flow in opposite directions to maximize temperature difference.
9. Analyzing the performance of a parallel flow heat exchanger, where fluids flow in the same direction, to understand its heat transfer limitations.
10. Measuring the thermal conductivity of materials to determine how well they conduct heat.

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understanding the physics involved in various heat transfer mechanisms.

CO2: Applying the knowledge of mathematics, and analyze the different situations in which heat transfer is involved.

CO3: To analyze the effect of different boiling regimes and condensation and also through the proper use of modelling can able to choose different heat exchangers for specific applications.

CO4: To be able to calculate heat transfer rate, time required for heating and cooling and obtaining the temperature distribution with respect to the domain of analysis under different situations.

CO5: Apply diffusive and convective mass transfer equations and correlations to solve problems for different applications and CNC Wire EDM.

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	3	-	-	-	-	-	-	2	-	-
CO2	2	2	-	-	3	-	-	-	-	-	-	-	-	-
CO3	2	1	-	-	3	-	-	-	-	-	-	-	-	-
CO4	2	1	-	1	3	-		-	-	-	-	-	-	-
CO5	2	1	-	2	3	-		-	-	-	-	-	-	-
1- low, 2 - medium, 3 - high, '-' no correlation														

ME660307 – CAD&CAM LABORATORY
(Common to MECH & MAE)

Course Category: Program Core	Course Type: Skill Based Course	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To gain practical experience in handling 2D drafting and 3D modeling software systems.
- To gain practical knowledge on assembly of 3D components in a modeling software
- To know the application of various CNC machines like CNC lathe, CNC Vertical
- To study the features of CNC Machine Tool and modern control systems
- To understand the post process steps using CAM packages

PRACTICAL EXPERIMENTS

1. Introduction of 3D Modeling software
2. Exercises in basic part modeling of components in 3D modeling software. Modeling and assembly of following machine elements using 3D Modeling software.
3. Shaft Coupling
4. Plummer Block
5. Screw Jack
6. Universal Joint
7. Machine Vice
8. Stuffing box
9. Connecting rod
10. Piston
11. Crankshaft
12. Preparation of Bill of materials and tolerance data sheet

LIST OF SOFTWARE :Solid Works 2019 -60 users. (FOR A BATCH OF 30 STUDENTS)

1. CAM
2. CNC lathe introduction to basic programming & operations.
3. Part Programming facing, turning, thread cutting (Internal/External).
4. Part Programming for Grooving, Drilling and Boring operation (Internal/External).
5. Part programming using Canned Cycle operations.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Qty
HARDWARE		
1	Computer Server	1
2	Computer nodes or systems (High end CPU with 32 GB main memory) networked to the server	30
3	Laser Printer	1
4	CNC Lathe	1
SOFTWARE		
1	Any High end integrated modeling and manufacturing CAD/ CAM software	30 licenses
2	Licensed operating system	Adequate
TOTAL: 30 PERIODS		

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Create 3D geometric modeling of industrial components with the use of CAD packages CO3: Generate part programming using CAM software

CO2: Applying the knowledge of mathematics, and analyze the different situations in which heat transfer is involved.

CO3: Generate part programming using CAM software

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	-	-	-	-	2	2	2	3	3
CO2	3	3	3	3	3	-	-	-	-	2	2	2	3	3
CO3	3	3	3	3	3	-	-	-	-	2	2	2	3	3

1- low, 2 - medium, 3 - high, '-' no correlation

ME660504-TRAINING IN CENTRE FOR EXCELLENCE (Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Theory & Practical**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**

COURSE OBJECTIVES:

- Understand the basic fundamentals of Mechatronics.
- To provide an overview of fundamentals of automation.
- To understand the application in engineering mechanisms.

ROBOTICS **10**

Basic Concepts: Definition and origin of robotics, different types of robotics , various generations of robots ,degrees of freedom ,Asimov's laws of robotics ,dynamic stabilization of robots. Manipulators, Actuators and Grippers: Construction of manipulators, manipulator dynamics and force control, electronic and pneumatic manipulator control circuits ,end effectors , U various types of grippers ,design considerations.

SENSORS FUNDAMENTALS AND ITS APPLICATIONS **10**

Sensors Fundamentals: Basic sensor technology, Sensor Systems, Sensor Characteristics, System Characteristics, Instrument Selection, Data acquisition, Installation. Process of developing sensors, sensor arrays smart sensors, Industrial sensor networking basic Elements. Smart sensors, sensor networks in R & D, sensors and networks, industrial network and automation.

PROGRAMMABLE LOGIC CONTROLLER **10**

what is A PLC, Technical Definition of PLC, What are its advantages, characteristics functions of A PLC, Chronological Evolution of PLC, Types of PLC, Unitary PLC, Modular PLC, Small PLC, Medium PLC, Large PLC, Block Diagram of PLC: Input/output (I/O) section, Processor Section, Power supply, Memory central Processing Unit: Processor Software / Executive Software, Multi asking, Languages, Ladder Language.

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the various graphical representation system in Robotics

CO2: To understand the principle working in mechatronics.

CO3: To learn the fundamentals of sensors.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

IM660403 – PROFESSIONAL ETHICS (Common to MECH & MAE)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

COURSE OBJECTIVES:

- StudentswillunderstandtheimportanceofValuesandEthicsintheirPersonallivesand professionalcareers
- Thestudents will learntherightsandresponsibilities
- Responsibilitiesofemployee, teammemberandaglobalcitizen.

UNIT I: INTRODUCTION TO PROFESSIONAL ETHICS	**6**

Basic Concepts, Governing Ethics, Personal &Professional Ethics, Ethical Dilemmas, Life Skills, Emotional Intelligence, Thoughts of Ethics, Value Education, Dimensions of Ethics.

UNIT II: BASIC THEORIES	**6**

Basic Ethical Principles, Moral Developments, Deontology, Utilitarianism, Virtue Theory, Rights Theory, Casuist Theory, Moral Absolution, Moral Rationalism, Moral Pluralism, Ethical Egoism, Feminist Consequentialism, Moral Issues, Moral Dilemmas, Moral Autonomy.

UNIT III: PROFESSIONAL PRACTICES IN ENGINEERING	**6**

Professions and Norms of Professional Conduct, Norms of Professional Conduct vs. Profession; Responsibilities, Obligations and Moral Values in Professional Ethics, Professional codes of ethics, the limits of predictability and responsibilities of the engineering profession, Central Responsibilities of Engineers .

UNIT IV: WORK PLACE RIGHTS & RESPONSIBILITIES	6

Ethics in changing domains of Research, Engineers and Managers; Organizational Complaint Procedure, difference of Professional Judgment with in the Nuclear Regulatory Commission (NRC), the Hanford Nuclear Reservation. Ethics in changing domains of research.

UNIT V: GLOBAL ISSUES IN PROFESSIONAL ETHICS	6

Introduction–Current Scenario, Technology Globalization of MNCs, International Trade, World Summits, Issues, Business Ethics and Corporate Governance, Sustainable Development Ecosystem, Energy Concerns, Ozone Deflection, Pollution, Ethics in Manufacturing and Marketing, Media Ethics; War Ethics; Bio Ethics, Intellectual Property Rights

TOTAL: 30 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1:Understanding basic purpose of profession, professional ethics and various moral and social issues

CO2:Awareness of professional rights and responsibilities of a Engineer, safety and risk benefit analysis of a engineer

CO3:Acquiring knowledge of various roles of Engineer In applying ethical principles at various professional levels

CO4: Professional ethical values and contemporize issues

CO5: Excelling in competitive and challenging environment to contribute to industrial growth

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Professional Ethics:R.Subramanian, Oxford University Press,2015.
2. Ethics in Engineering Practice & Research,Caroline Whitbeck, 2e,Cambridge University Press 2015

REFERENCE BOOKS:
1. Engineering Ethics, Concepts Cases:Charles EHarris Jr.,MichaelS Pritchard, Michae lJ Rabins,4e,Cengage learning,2015.
2. Business Ethics concepts & Cases: Manuel G Velasquez, 6e, PHI, 2008.
WEB RESOURCES:https://online courses.nptel.ac.in/noc22_mg54/preview

VERTICAL 1
THERMAL SCIENCES

ME606101 -POWER PLANT ENGINEERING						
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
To understand the various components, operations and applications of different types of power plants.						
UNIT 1: INTRODUCTION TO POWER PLANTS AND BOILERS						**9**
Layout of Steam, Hydel, Diesel, MHD, Nuclear and Gas turbine Power Plants Combined Power cycles , comparison and selection, Load duration Curves Steam boilers and cycles ,High pressure and Super Critical Boilers – Fluidized Bed Boilers.						
UNIT 2: STEAMPOWERPLANTANDGASTURBINEPOWERPLANTS						**9**
Fuel and ash handling, Combustion Equipment for burning coal, Mechanical Stokers ,Pulveriser, Electrostatic Precipitator, Draught ,Different Types, Surface condenser types, cooling towers – Gas turbine power plant ,Fuels,Gas turbine material ,open and closed cycles ,reheating ,Regeneration andintercooling , combined cycle.						
UNIT 3: NUCLEAR AND HYDEL POWER PLANTS						**9**
Nuclear Energy ,Fission, Fusion Reaction, Types of Reactors, Pressurized water reactor, Boiling water reactor, Waste disposal and safety hydel Power plant ,Essential elements, Selection of turbines, governing of Turbines – Micro hydel developments.						
UNIT 4: DIESEL AND OTHER POWER PLANTS						**9**
Types of diesel plants, components, Selection of Engine type, applications ,Geo thermal ,OTEC ,Tidel , Pumped storage, Solar central receiver system, Principle of working, Wind energy , types ,HAWT, VAWT, Tidal Energy, Solar energy.						
UNIT 5: POWER PLANT ECONOMICS AND ENVIRONMENTAL CONSIDERATIONS						**9**
Fixed and operating costs , Energy rates ,Types tariffs ,Economics of load sharing, Effluents from power plants and impact on Environment ,pollutants and pollution standards,Method of pollution control.						
						TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to						
CO1: Express the layout of the various power plants and boilers.						
CO2: Identify the handling equipment, condensers and applications in gas turbine power plants.						
CO3: Discuss the various types of reactors and explain the hydel power plant.						
CO4: Select the correct type of engine for diesel power plant and interpret different power plants.						
CO5: Compute the operating cost and tariffs using the various power plants.						

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	1	2	1				2		
CO2	3	3	2	2	-	1	1	2	-	-	-	2	-	-
CO3	2	2	2	3	2	2	2	2	2	1	-	2	-	-
CO4	3	2	2	2	2	3	2	2	-	-	2	2	-	-
CO5	2	3	2	2	2	2	2	2	2	1	2	2	-	-

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Rajput R.K., "A Text Book of Power Plant Engineering", Laxmi Publication, (2016)
2. Nag P.K., "Power Plant Engineering", Tata McGraw- Hill, (2014)
3. RamalingamK.K.,"PowerPlantEngineering",SciTechPublications, (2002)

REFERENCE BOOKS:

1. EI-Wakil M.M., "Power Plant Technology", Tata McGraw-Hill, (2003)
2. Nagpal G.R., "Power Plant Engineering", Khanna Publishers, (2010)
3. Rai G.D., "Introduction to Power Plant Technology", Khanna Publishers, (2009)

WEB RESOURCES: https://www.classcentral.com/course/swayam-power-plant-engineering-17735

ME606102-HEATING VENTILATION AND AIR CONDITIONING

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn building material characteristics and their influence on building heatingcooling load for all weather conditions.
- To study various conversion techniques related to build environment and codesfor the same.

UNIT 1: INTRODUCTION TO AIR CONDITIONING AND REFRIGERATION | **9**

Basic thermodynamics of HVAC, types of refrigeration systems, the refrigeration cycle,Refrigerants and their properties

UNIT 2: TESTING | **9**

Fuel and ash handling, Combustion Equipment for burning coal, Mechanical Stokers ,Pulveriser, Electrostatic Precipitator, Draught , Different Types, Surface condenser types, cooling towers ,Gas turbine power plant , Fuels, Gas turbine material ,open and closed cycles ,reheating ,Regeneration andintercooling combined cycle.

UNIT 3: HEATING SYSTEMS | **9**

Gas Furnaces, Gas Furnace Controls, Gas Furnace Installation, Troubleshooting GasFurnaces, Oil Fired Heating Systems, Oil Furnace and Boiler Service, Residential OilHeating Installation, Trouble shooting of oil heating systems, Electric Heat, Electric HeatInstallation, Heat Pump System Fundamentals, Heat PumpsApplications, Geothermal Heat Pumps, Heat Pump Installation, Troubleshooting of HeatPump Systems

UNIT 4: COMFORT AND PSYCHOMETRICS | **9**

Fundamentals: Psychometrics & Airflow, Air Filters, Ventilation and Dehumidification, Heattransmission in building structures ,Solar radiation ,Infiltration and ventilation-Cooling/heating load calculations, Residential Load Calculations, Indoor Air Quality (IAQ), Building energy calculations.

UNIT 5: DUCT AND COOLING TOWERS | **9**

Duct Installation, Duct Design, Zone Control Systems, Testing and Balancing Air Systems.
Chilled Water Systems. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Estimate heating loads, space heat gains and space cooling loads throughEngineering methods.

CO2: Determine the coil loads for cooling and heating systems.

CO3: Select equipment and design systems to provide comfort conditions within the building.

CO4: Understand the psychometrics

CO5: To gain knowledge about duct and cooling tower

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Faye.C.McQuiston, Jerald.D.Parker, Jeffrey.D.Spitler,"Heating, Ventilating, and Air Conditioning – Analysis and Design", Wiley India (P) Ltd, 7th edition, 2011.
2. N.C.Gupta, "Comprehensive HVAC system design", Viva books private limited,2016.

REFERENCE BOOKS:

1. Hand book of heating, ventilation and Air-conditioning, Jan. F. Kreider, CRC press.
2. Automotive heating and Air-conditioning, Mike Stubblefield and John H Haynes
3. Heating ventilation and air conditioning – Jan F. Kreider
4. Control systems for Heating, ventilating And air conditioning, Roger W. Haines, Springer.
5. HVAC Equations, Data, and Rules of Thumb - Arthur A. Bell Jr., PE, McGraw-Hill

WEB RESOURCES: https://www.rsi.edu/blog/hvacr/7-free-online-learning-resources-for-hvac-students/

https://researchguides.austincc.edu/c.php?g=434739&p=5832566

ME606103-THERMAL MANAGEMENT OF BATTERIES AND FUEL CELLS

Course Category: Professional Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the working principle of Li-ion Batteries and Battery Packs.
- To learn the thermal management system in Battery modules.
- To develop the different case studies in Battery Thermal Management System.
- To learn the working principle of Fuel Cells cooling methods.
- To learn the inside components of Thermal Management Systems in various famous Electric and Fuel Cell Electric Vehicles.

UNIT 1: ADVANCED BATTERIES | **9**

Li-ion Batteries- chemistry, different formats, operating areas, efficiency, aging. Battery Management System- Configuration, Characteristics. Tesla Model S- 18650 Cell specifications, P85 Battery Pack mechanical structure, Texas Instruments BMS. Supercapacitors Vs batteries. Diamond battery concepts.

UNIT 2: THERMAL MANAGEMENT IN BATTERIES | **9**

Thermal Management Systems- impact, Types- Air, Liquid, Direct refrigerant, Heat pipe, Thermo Electric, Phase Change Material Cooling methods. Solid-liquid PCM Types- Organic, Inorganic, Eutectics. PCM Thermal properties and applications. Tesla Model-S Battery Module- bonding techniques, thermal management.

UNIT 3: BATTERY THERMAL MANAGEMENT CASE STUDIES | **9**

EV Battery Cooling- challenges and solutions. Heat Exchanger Design and Optimization Model for EV Batteries using PCMs- system set up, selection of PCMs. Chevrolet Volt Model Battery Thermal Management System- Case study. Modelling Liquid Cooling of a Li-Ion Battery Pack with COMSOL Multiphysics- simulation concepts.

UNIT 4: THERMAL MANAGEMENT IN FUEL CELLS | **9**

Fuel Cells- operating principle, hydrogen-air fuel cell system characteristics, other fuel cell technologies,

polarization curves, applications. Fuel cell thermal management- basic model, energy balance, governing equations, characteristic curve, sizing, cooling methods, advantages, restrictions.

UNIT 5: FUEL CELL THERMAL MANAGEMENT CASE STUDIES | **9**

Fuel cell system, balance of plant,components required. Fuel cell power plant sizing problems,Fuel Cell Electric Vehicle Fuel economy calculations-Battery EVs Vs Fuel Cell EVs. Toyota Mirai FCV,Operating principle, High pressure hydrogen tank, Boost convertor, NiMH Battery, Internal circulation system, Hydrogen refuelling,Case studies. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Discuss the different Li-ion Batteries and Fuel Cell performances.

CO2: Design a Battery Pack with appropriate PCM.

CO3: Apply Cooling Models using Simulation

CO4: Estimate fuel economy.

CO5: Utilize different Thermal Management System approaches during real world usage.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Ibrahim Dinçer, Halil S. Hamut, and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems'', Wiley, 2017.
2. Jiuchun Jiang and Caiping Zhang, "Fundamentals and applications of Lithium-Ion batteriesin Electric Drive Vehicles'', Wiley, 2015.
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, 2005.
4. John G. Hayes and G. Abas Goodarzi, "Electric Powertrain", Wiley, 2018
5. Davide Andrea, "Battery Management Systems for Large Lithium-Ion Battery Packs" ARTECH House, 2010.

REFERENCE BOOKS:

1. Nag.P.K, "Engineering Thermodynamics", 5th Edition, Tata McGraw Hill Education, New Delhi, 2013.
2. "Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
3. Younes Shabany," Heat Transfer: Thermal Management of Electronics Hardcover" 2010, CRC Press.
4. T. Yomi Obidi, "Thermal Management in Automotive applications", 2015, SAE International.
5. Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw- Hill.

WEB RESOURCES:

https://www.rsi.edu/blog/hvacr/7-free-online-learning-resources-for-hvac-students/

https://researchguides.austincc.edu/c.php?g=434739&p=5832566

ME606104– REFRIGERATION AND AIR CONDITIONING

Course Category: Professional Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge on various refrigeration cycles, system components and refrigerants.
- To provide knowledge on design aspects of Refrigeration & Air conditioning Systems.

UNIT 1: FUNDAMENTALS OF REFRIGERATION AND AIR – REFRIGERATION CYCLES **9**

Introduction to Refrigeration - Necessity and applications ,Unit of refrigeration and C.O.P. ,Mechanical Refrigeration ,Types of Ideal cycle of refrigeration. Bell Coleman cycle and Brayton Cycle, Open and Dense air systems,Actual air refrigeration system,Refrigeration needs of Air crafts,Air systems , Application of Air Refrigeration, Justification ,Types of systems ,Problems.

UNIT 2: SIMPLE VAPOUR COMPRESSION REFRIGERATION SYSTEM **9**

Vapour compression refrigeration, working principle and essential components of the plant ,Simple Vapour compression refrigeration cycle ,COP , Representation of cycle on T-S and p-h charts , effect of sub cooling and super heating ,cycle analysis , Actual cycle Influence of various parameters on system performance , Use of p-h charts , Problems.

UNIT 3: VAPOUR ABSORPTION REFRIGERATION SYSTEM **9**

Simple vapour absorption system ,properties of ideal refrigerant, absorbent and refrigerant ,absorbent combination ,advantages of vapour absorption system over vapour compression system ,comparison between vapour absorption system and vapour compression system ,COP of ideal vapour absorption system domestic Electrolux refrigerator , Lithium Bromide absorption refrigeration system.

UNIT 4: REFRIGERATION COMPONENTS **9**

Compressors , types ,construction and working of various types of compressor ,condensers ,selection of condensers ,factors affecting the condenser capacity ,types ,construction and working of various types of condensers , evaporators , capacity of an evaporator ,heat transfer in evaporator ,classification of evaporators.

UNIT 5: PSYCHROMETRICS AND AIRCONDITIONING SYSTEM **9**

Concept of psychrometry and psychrometric,psychrometric relations ,adiabatic saturation ,psychrometers , psychrometric processes.Introduction to air conditioning system ,classification of air conditioning system , central system and unitary system.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the basic concepts of Refrigeration and its cycle.

CO2: Solve problems in vapor compression refrigeration systems for various conditions.

CO3: Demonstrate the vapour absorption system

CO4: Describe the various of components of refrigeration system

CO5: Understand the Psychrometric properties and its use in psychrometric processes

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

Khurmi R.S. & Gupta J.K., “Refrigeration and Air Conditioning”, S.Chand Publication, (2009)
Arora C.P., “Refrigeration and Air Conditioning”, Tata McGraw Hill, New Delhi, (2008)

REFERENCE BOOKS:

Roy J. Dossat, “Principles of Refrigeration”, Pearson Education, (2007)
Jordon and Priester, “Refrigeration and Air Conditioning”, Prentice Hall of India Pvt. Ltd., New Delhi, (2015)
Stoecker N.F. and Jones, “Refrigeration and Air Conditioning”, TMH, New Delhi, (2011)
Jones, “Air Conditioning Engineering”,Edward Amold Publication (2010))

WEB RESOURCES:

https://www.rsi.edu/blog/hvacr/7-free-online-learning-resources-for-hvac-students/

https://researchguides.austincc.edu/c.php?g=434739&p=5832566

ME606105 – INTERNAL COMBUSTION ENGINE					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To make the students familiar with the engine fuel and air supply systems, electronic injection systems used in modern automotive engines.
- To make the students understand about the combustion phenomenon of SI and CI engines, engine pollutants
- To teach the students on production and utilization of alternative solid, liquid and gaseous fuels.
- To teach modern trends in IC engines

UNIT 1: FUEL SUPPLY SYSTEMS IN CI AND SI ENGINES	**9**

Introduction-carburetion- mixture requirements-simple carburettor, compensation devices, high altitude fuel supply device-, Electronic injection system, CI engine- Injection systems- Mechanical and electronic-Combustion in CI engines

UNIT 2: COMBUSTION IN SI AND CI ENGINES	**9**

Introduction , Ignition - Stages of combustion-Normal and abnormal combustion- Factors affecting knock Combustion chambers- Fuel spray behaviour , spray structure, spray penetration-and evaporation , air motion,stages of combustion,Factors affecting combustion,Direct and indirect injection systems Combustion chambers.

UNIT 3: ENGINE LUBRICATION AND COOLING	**9**

Lubrication of engine components,Lubrication system,wet sump and dry sump, crankcase ventilation, Types ofcooling systems, liquid and air cooled, comparison of liquid and air cooledsystems.

UNIT 4: TURBO CHARGING, SUPER CHARGING AND ENGINE EMISSIONS	**9**

Introduction to Turbo charging and supercharging, Engine emissions , Emission control methods in SI and CI engines, catalytic converters,EGR, Modern evaporative emission control system Lean Burn Engines, homogeneous charge compression ignition engines.

UNIT 5: ALTERNATE FULES	**9**

Introduction to alternate fuels-biofuels, thermochemical and biochemical conversion, Vegetable oils and Biodiesel, Ethanol, LPG, Natural gas, Hydrogen-Production and Utilization perspective.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Analyze fuel supply systems and ignition of IC Engines.

CO2: Understand combustion process of SI and CI Engines.

CO3: Demonstrate the lubrication and cooling systems of IC Engine.

CO4: Describe the concept of turbo and super charging.

CO5: Apply concepts of different alternate fuels used for SI and CI engines

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

1. J.B Heywood, Internal Combustion Engine Fundamentals, McGraw Hill
2. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.

REFERENCE BOOKS:

1. M.L. Mathur and R.P.Sharma, A course in internal Combustion Engines, Dhanapat Rai Publications, New Delhi.
2. R.B.Mathur and R.P. Sharma, Internal combustion Engines.
3. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications,
4. S. N. Murugesan, Engineering Thermodynamics, RBA Publishers
5. G. D. Rai, Non-conventional energy sources, Khanna Publishers, New Delhi

WEB RESOURCES:

https://www.udemy.com/course/internal-combustion-engines/

https://alison.com/course/mechanical-engineering-internal-combustion-engine-basics

ME606106 – AIR BREATHING ENGINES						
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- To make the students familiar with the engine fuel and air supply systems, electronic injection systems used in modern automotive engines.
- To make the students understand about the combustion phenomenon of SI and CI engines, engine pollutants
- To teach the students on production and utilization of alternative solid, liquid and gaseous fuels.
- To teach modern trends in IC engines

UNIT 1: AIR-BREATHING ENGINES CLASSES	**9**
Classification, operational envelopes; Description and function of gasgenerator, turbojet, turbofan, turboprop, turbo shaft, ramjet, scramjet, turbojet/ramjet combined cycleengine; Engine thrust, take-off thrust, installed thrust, thrust equation; Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency,engine overall efficiency and its impact on aircraft range and endurance; Enginecycle analysis andperformance analysis for turbojet, turbojet with afterburner, turbofan engine, turboprop engine.	
UNIT 2:INLETS AND COMBUSTION CHAMBERS	**9**
Internal flow and stall in subsonic inlets, relation betweenminimum area ratio and eternal deceleration ratio, diffuser performance, supersonic inlets, startingproblem on supersonic inlets, shock swallowing by area variation; Classification of combustionchambers, combustion chamber performance, effect of operating variables on performance, flamestabilization.	
UNIT 3: NOZZLES	**9**
Theory of flow in isentropic nozzles, nozzles and choking, nozzle throat conditions, nozzleefficiency, losses in nozzles. Over expanded and under expanded nozzles, ejector and variable areanozzles, interaction of nozzle flow with adjacent surfaces, thrust reversal.	
UNIT 4: COMPRESSORS	**9**
Principle of operation of centrifugal compressor and axial flow compressor, work doneand pressure rise, velocity triangles, degree of reaction, free vortex and constant reaction designs ofaxial flow compressor, performance characteristics of centrifugal and axial flow compressors, stageefficiency calculations, cascade testing.	
UNIT 5: TURBINES	**9**
Principle of operation of axial flow turbines, limitations of radial flow turbines, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant angle designs,performance characteristics, sample ramjet design calculations, flame stability problems in ramjetcombustors, integral ram rockets.	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: know the basics and classifications of air breathing engines and determine performance of propulsion systems including turbojet, turbofan and turboprop configurations.

CO2: Understand thedesign and performance of subsonic and supersonic inlets, types of combustionchambers and factors affecting the combustors.

CO3: Discuss the types of nozzles, flow conditions in nozzles, interaction of nozzle flow with adjacent surfaces and thrust reversal

CO4: Describe different types of compressors, work done, velocity diagrams and stageefficiency calculations.

CO5: Explain various types turbines, work done, pressure rise, velocity triangles, degree of reaction.

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	1	2	2	-	-	-	2	2	-	-
CO2	3	2	2	1	1	2	2	-	-	-	2	2	-	-
CO3	3	2	1	3	1	2	2	-	-	-	2	2	-	-
CO4	3	2	3	2	1	2	2	-	-	-	2	2	-	-
CO5	3	2	3	2	1	2	2	-	-	-	2	2	-	-

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

1. Hill, P.G. & Peterson, C.R. ―Mechanics & Thermodynamics of Propulsion‖ Addison WesleyLongman INC, 1999.
2. Mattingly J.D., ―Elements of Propulsion: Gas Turbines and Rocket‖, AIAA, 1991.

REFERENCE BOOKS:

1. Cohen, H. Rogers, G. F.C. and Saravanamuttoo, H.I.H. ―Gas Turbine Theory‖, Longman,1989.
2. Oates, G.C. - Aero thermodynamics of Aircraft Engine Components‖, AIAA Education Series,New York, 1985.

WEB RESOURCES:

https://www.academia.edu/37275696/Air_Breathing_Engines

ME606107 – DESIGN OF THERMAL SYSTEM					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To build up necessary background for the design of various types of thermal systems.
- To learn the sizing of heat exchangers, thermal and mechanical stress analysis for various heat exchangeapplications.

UNIT 1: INTRODUCTION **9**

Engineering design, design as part of engineering undertaking; Basic considerations in design: formulation of thedesign problem, conceptual design, steps in the design process, computer aided design, Economic analysis.

UNIT 2:MODELING OF THERMAL SYSTEMS **9**

Types of models, mathematical modelling, curve fitting, linear algebraic systems, numerical model for a system,system simulation, methods for numerical simulation. Acceptable design of thermal systems Initial design, designstrategies, design of systems from different application areas, additional considerations for large practical systems.

UNIT 3: MECHANICAL DESIGN OF SHELL AND TUBE TYPE HEAT EXCHANGERS **9**

Thickness calculations, Tube sheet design using TEMA formula, Concept of equivalent plate for carrying outperforated analysis, General design of evaporator and condenser, flow induced vibration risks including acousticissue and remedies, tube to tube sheet joint design, buckling of tubes, thermal stresses.

UNIT 4: COMPACT AND PLATE HEAT EXCHANGERS **9**

Types - Merits and Demerits – Design of Compact heat exchangers, plate heat exchangers, Radiative heatexchangers, performance influencing parameters, limitations. Performance enhancement of heat exchanger.

UNIT 5: CONDENSERS AND COOLING TOWERS **9**

Design of surface and evaporative condensers, cooling tower ,performance characteristics, process hazards,Safety measures in equipment design.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Have a fundamental understanding of engineering design.

CO2: Be able to get the necessary background for the modelling thermal systems.

CO3:Understand the design of shell and tube type heat exchangers.

CO4: Familiarize the performance influencing parameters and the methods to enhance the performance for various heat exchange applications.

CO5: Acquire knowledge about the principles of condensers and cooling towers and recognize the significance ofsafety measures in equipment design.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

1. W. F. Stoecker, design of thermal systems, McGraw-Hill Education, 2011.
2. Walkers, "Industrial Heat Exchangers – A Basic Guide", Mc Graw Hill Book Co, 1982

REFERENCE BOOKS:

1. Nicholas Cheremistoff, "Cooling Tower", Ann Arbor Science Pub, 1981.
2. Arthur, P. Frass, "Heat Exchanger Design", John Wiley and Sons 2nd Edition, 1989.
3. 3. J.P.Gupta, "Fundamentals of Heat exchanger and pressure vessels technology", Hemisphere publishingcorporation, springer –Verlag (outside NA), 1986.
4. Donald Q. Kern and Alban D. Karus, "Extended surface heat transfer", Mc Graw Hill Book Co, 1972.
5. E.A.D.Sanders, "Heat Exchangers, Selection Design and Construction", Layman Scientific and Technical coPublished with John Wiley & Sons, 1988.
6. T.Taborek, G.F.Hewitt and N.Afgan, "Heat Exchangers, Theory and practice", McGraw-Hill Book Co,1983.Education Series,New York, 1985.

WEB RESOURCES: https://www.academia.edu/37275696/Air_Breathing_Engines

ME606108 – INVERSE METHODS IN HEAT TRANSFER (NPTEL)						
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- The principal objective of the course is to give the students an overview of inverse problems in heat transfer and ways of formulating and solving them through examples.

UNIT 1INTRODUCTION **9**

Introduction to inverse, Statistical description of errors, Inverse problems as optimization problems.

UNIT 2Classical Techniques **9**

Classical Techniques, Calculation of sensitivity coefficients, Parameter and Function estimation. Introduction to Nonlinear Techniques.

UNIT 3LEVENBERG **9**

The Levenberg-Marquardt method, Tikhonov regularization, Probability Theory, Bayesian Framework Markov Chain Monte Carlo Methods (MCMC) - Metropolis-Hastings algorithm (MH), Computational Implementation.

UNIT 4MACHINE LEARNING **9**

Introduction to Machine Learning - Deep Learning – ANNs, CNNs, RNNs.

UNIT 5GENETIC ALGORITHMS **9**

Surrogate Models for Inverse problems, Genetic Algorithms - Physics Informed Neural Networks for forward and inverse problems.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Determine the boundary heat flux and temperature field in the body using optimization problem.

CO2: Calculate the sensitivity coefficients using classical techniques.

CO3: Solve inverse heat conduction problem using The Levenberg-Marquardt method

CO4: Determine the heat transfer coefficient using Computational Implementation

CO5: Estimate the thermal boundary using machine learning and deep learning methods.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

REFERENCE BOOKS:

1. Beck, J. V., Blackwell, B., & St Clair Jr, C. R. Inverse Heat Conduction: Ill-Posed Problems. 1985. A WileyInterscience, New York.
2. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B., Bayesian data analysis. Chapman and Hall/CRC, 2004
3. Balaji, C. Essentials of thermal system design and optimization. Ane Books Pvt., New Delhi, 2011.

WEB RESOURCES: https://archive.nptel.ac.in/courses/112/106/112106316/

ME606109 – FUNDAMENTALS OF COMBUSTION FOR PROPULSION (NPTEL)					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

Practicing engineers in the area of development of combustion and propulsion systems for space and defence applications

UNIT 1INTRODUCTION **9**

Equilibrium: physical, thermodynamic and chemical ,Equilibrium controlled and rate-controlled processes in gaseous, liquid and solid fuels , Calculation of equilibrium states. Laminar premixed and diffusion flames: principal features and differences, Quenching, flammability and other limit phenomena,Discussion of burning behaviour of gaseous, liquid and solid fuels.

UNIT 2BASICS OF COMPOSITE SOLID PROPELLANT DEFLAGRATION **9**

Basics of composite solid propellant deflagration - Why model deflagration of composite propellants? - Statistical representation of composite propellants in HeQu1D – geometry and thermochemistry.Idea of lateral diffusion - Overview of the HeQu1D software and demonstration - Effect of aluminum.

UNIT 3SOLID ROCKETS **9**

Erosive burning - Instability in solid rockets – 1 - Instability in solid rockets – 2

UNIT 4LIQUID PROPELLANT ROCKETS **9**

Principal ideas of combustion in liquid propellant rockets - Principal ideas of combustion in gas turbine afterburners - Combustion in boundary layers and hybrid rockets – essential ideas and emerging trends

UNIT 5 MECHANISM - STRATEGIES **9**

Instability in liquid propellant rockets and gas turbine after burners,modes and mechanism ,Strategies for evolving instability free designs , global and local considerations , Connection between instability in LPP gas turbine primary combustors and rockets/afterburners.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Describe the thermodynamic equilibrium of various types fuel.

CO2: Demonstrate the burning behaviour of gaseous, liquid and solid fuels.

CO3: Evaluate the Burning Characteristics of Solid Propellant Fuel.

CO4: Study composite solid-propellant deflagration mechanism.

CO5: Solve the problem of internal combustion and multi-stage operation by applying BLTE.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

REFERENCE BOOKS:

1. Understanding Combustion. H S Mukunda
2. Understanding Aerospace Chemical Propulsion. H S Mukunda.
3. Beckstead, Merrill W., R. L. Derr, and C. F. Price. "A model of composite solid-propellant combustion based on multiple flames." AiAA Journal 8.12 (1970): 2200-2207.
4. Varunkumar, S., M. Zaved, and H. S. Mukunda. "A novel approach to composite propellant combustion modeling with a new Heterogeneous Quasi One-dimensional (HeQu1-D) framework." Combustion and Flame 173 (2016): 411-424.
5. Varunkumar, S., and H. S. Mukunda. "Aluminized composite propellant combustion modeling

with Heterogeneous Quasi-Onedimensional (HeQu1-D) approach." Combustion and Flame 192 (2018): 59-70

WEB RESOURCES: https://nptel.ac.in/courses/112106290

ME606110 –FUNDAMENTALS OF GAS DYNAMICS (NPTEL)					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

Introduces compressible flow and its constitutive equations.

- The physical concepts behind isentropic flows, area-Mach number relation etc will be discussed with practical problems in mind.
- Properties of shocks and expansions are important parts of this course. All the numerical examples will be in SI units.

UNIT 1 INTRODUCTION	**9**
Fluids, compressible flow I & II laws of TD Clausius inequality - Control volume analysis Conservation of mass Conservation of momentum ,Conservation of energy,Tutorial	
UNIT 2STAGNATION RELATIONS	**9**
Sonic velocity,Wave propagation, Pressure-energy relation - Stagnation concept,Isentropic flows,Stagnation relations,	
UNIT 3CONSTANT AREA DUCTS	**9**
Varying area flow Mass, momentum, energy equations , Converging nozzle - M* concept, Gas tables,C-D nozzle.	
UNIT 4 FLOW ACROSS SHOCK	**9**
Standing normal shocks,Prandtl'srelation,Normal shocks in CD nozzle , Rankine-Hugoniot equation,Moving shocks.	
UNIT 5 SHOCK WAVE	**9**
Oblique Shocks,Theta-Beta-M relation,Shock polar curves , Expansion fans,Prandtl-Meyer flow.	
	TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Outline governing equations of compressible fluid flow

CO2: Analyze one dimensional Isentropic flow.

CO3: Examine one dimensional compressible flow through variable area duct.

CO4: Analyze compressible flow having normal shock.

CO5:Investigate compressible flow having normal shock.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation.

TEXT BOOKS:

1. Gas Dynamics, Zucker & Biblarz, 2nd ed. Wiley India.

REFERENCE BOOKS:

1. Gas Dynamics, Zucker & Biblarz, 2nd ed. Wiley India. 2. Gas Dynamics , Liepmann & Roshko, Dover Publications. 3. Dynamics and Thermodynamics of compressible flow, A. Shapiro.
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/106/112106196/

VERTICAL 2
ENERGY TECHNOLOGIES

ME606201 FUEL CELL AND HYDROGEN TECHNOLOGY						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
- To study in detail on the hydrogen production methodologies, possible applications and various storage options

UNIT 1: INTRODUCTION TO FUEL CELLS **9**

Basic Principles , Classification , Alkaline, Proton Exchange Membrane, Direct Methanol, Phosphoric Acid & Molten Carbonate, solid oxide, polymer electrolyte fuel cells , Parts ,Fuel cell poisoning, application,Micro fuel cells & portable power

UNIT 2 :THERMODYNAMICS **9**

Basic Reactions, Heat of reaction, Enthalpy of formation of substances , Enthalpy change of a reacting. system,Gibbs free energy of substances - Gibbs free energy change of a reacting system , Efficiency - Power, heat due to entropy change, and internal ohmic heating.

UNIT 3: ELECTROCHEMISTRY **9**

Nernst equation and open circuit potential, pressure effect, temperature effect ,Stoichiometric coefficients and reactants utilization , Mass flow rate calculation ,voltage and current in parallel and serial connection , Overpotentials and polarizations ,Activation polarization , Tafel equation and exchange current density - Ionic conductivity, catalysts, Temperature and humidification effect, electro-osmotic drag effect.

UNIT 4: DESIGN AND OPTIMISATION **9**

Geometries of fuel cells and fuel cell stacks-planar &tubular ,Rate of Diffusion of reactants . Water flooding and water management , Gas delivery and current collection ,Bipolar plate configuration Optimization of gas delivery and current collection, Heat Removal methods.

UNIT 5: HYDROGEN ENERGY **9**

Hydrogen: as a fuel; Properties, Applications, Hydrogen production methods , Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods. Hydrogen storage methods ,Metal hydrides, metallic alloy hydrides, carbon nano-tubes , Storage Safety

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the basic concepts and application of fuel cells.

CO2: Know the thermodynamics of fuel cells

CO3: Acquire knowledge on Electrochemistry of fuel cells.

CO4:Familiar with the concepts of design and optimization of fuel cells

CO5:Understand the basics of utilizing hydrogen for fuel cell application

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Shripad T. Revankar,PradipMajumdar, "Fuel Cells: Principles, Design, and Analysis (Mechanical and Aerospace Engineering Series)", CRC Press, May 2014.

REFERENCE BOOKS:
1 .James Larminie and Andrew Dicks, “Fuel Cell Systems Explained”, John Wiley & Sons Inc., 2nd Edition,2013.
2. B.Viswanathan and Aulice M. Scibioh, “Fuel Cells: Principles and Applications”,Universities Press, 1st Edition 2008
3. Matthew M. Mench, “Fuel Cell Engines”, Wiley; 1st Edition, March 2008.
4. FranoBarbir, “PEM Fuel Cells Theory and Practice”, Elsevier Academic Press, 2nd edition, 2012
WEB RESOURCES:
https://archive.nptel.ac.in/courses/103/101/103101215/
https://archive.nptel.ac.in/courses/103/101/103101215/

ME606202-ALTERNATE ENERGY FUELS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on
- To know about different types of alternate fuel
- To understand the suitability of various alternate fuels in IC engines

UNIT I INTRODUCTION **9**

Effects of constituents of Exhaust gas emission on environmental condition of earth (N2, CO2, CO, NOx, SO2, O2)- Pollution created by Exhaust gas emission in atmosphere-Greenhouse effect, Factors affecting greenhouse effect. Study of Global Carbon Budget, Carbon foot print and Carbon credit calculations-Emission norms as per Bharat Standard up to BS – VI and procedures for confirmation on production.

UNIT 2 ALCOHOL **9**

Sources of Methanol and Ethanol, methods of its production-Properties of methanol & ethanol as engine fuels, Use of alcohols in S.I. and C.I. engines, performance of blending methanol with gasoline-Emulsification of alcohol and diesel. Dual fuel systems-Improvement / Change in emission characteristics with respect to percentage blending of Alcohol.

UNIT 3 BIO DIESEL AND SYNTHETIC FUELS **9**

Base materials used for production of Bio Diesel (Karanji oil, Neem oil, Sunflower oil, Soyabean oil, Mustard oil, Palm oil, Jatropha seeds)-Process of separation of Bio Diesel. Properties-Diesel blended with vegetable oil, Various Vegetable oils for Engines – Esterification, performance and emission characteristics of Engine. Algae Biodiesel, DiMethyl Ether (DME), P-Series, and Eco Friendly Plastic fuels (EPF).

UNIT 4: HYDROGEN **9**

Hydrogen as a substitute fuel. Properties, sources and methods of production of Hydrogen, Storage and Transportation of hydrogen. Economics of Application and Advantages of hydrogen (Liquid hydrogen) as fuel for IC engine/ hydrogen car. Layout of a hydrogen car.

UNIT 5: GASEOUS FUELS FOR IC ENGINES **9**

Introduction to Bio gas system-Process during gas formation-Factors affecting bio gas formation-Usage of Bio gas in SI engine & CI engine-LPG &CNG : Properties of LPG & CNG as engine fuels-fuel metering systems-combustion characteristics-effect on performance, emission, cost and safety. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the Need for Alternative Fuels

CO2:Understand about alcohol fuels

CO3:Apply the usage of bio diesel and synthetic fuels

CO4:Understand the usage of Hydrogen as a substitute fuel

CO5:Use Gaseous fuels in Internal Combustion engines

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.S. S. Thipse, "Alternative Fuels", Jaico Publications, 1st Edition, 2010

2.Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005

REFERENCE BOOKS:

1.Sunggyu Lee James G. Speight Sudarshan K. Loyalka-Handbook of Alternative Fuel 2.Technologies by Taylor & Francis Group, LLC 2007
3.Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996
4.Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002
5.Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009
WEB RESOURCES:
https://archive.nptel.ac.in/courses/121/106/121106014/
https://afdc.energy.gov/fuels/

ME606203 BIO ENERGY CONVERSION TECHNOLOGIES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on Bio energy and its thermodynamic behaviour.
- Understanding the different conversion technologies for bio energy

UNIT 1 INTRODUCTION TO BIO ENERGY — **9**

Introduction to Bio Energy – Energy and Heat – Henry Law – Sources and Classification – Mass Balance – Enthalpy – Energy Balance – Properties of Biomass – Thermodynamics and Kinetics of basic chemical reaction, Reaction thermodynamics and Reaction Kinetics Size.

UNIT 2 BIO ENERGY FEEDS — **9**

Growing Condition, Yield for the Production of Biofuel Production – Plantation Harvesting and Storage of Feedstock Like Corn – Sweet Potato – Cassava – Soybean – Jatropha. Biomass Size Reduction, Briquetting, Drying, Storage And Handling of Biomass.

UNIT 3 BIOLOGICAL CONVERSION TECHNOLOGIES — **9**

Pre-treatment – physical , Thermochemical – Enzymatic hydrolysis of carbohydrates – Butanol fermentation, Substrate and factors affecting – anaerobic digestion, organic conversion and Methane production – Biogas cleaning, upgrading, utilization and digestate – Microbial fuel cell , Electron transfer process, Electrical power and energy generation, Design and Operation.

UNIT 4: THERMAL CONVERSION TECHNOLOGIES — **9**

Biomass Furnaces, Power Generation, Biomass Co-Firing with Coal – Bio Refinery – Sugar Based – Stoichiometry – Sugarcane, Sweet Sorghum, Sugar Beet Ethanol Production – Starch Based Ethanol – Pyrolysis Reactions and Mechanism – Bio-Oil – Bio-Oil Refining.

UNIT 5: BIO ENERGY SYSTEM ANALYSIS — **9**

Bio-hydrogen production – Techno-Economic Analysis, Steps, Tools, Software and Data sources – Life Cycle Assessment, Procedure, Tools – Bio Energy Market – Government Policy**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamentals of bio energy and thermodynamic functions

CO2: Understand the different feeds of bio fuel production and its processing

CO3: Apply the fundamentals and understand different biological conversion technologies.

CO4: Apply the fundamentals and understand different thermal conversion technologies

CO5: Understand the bio energy system analysis using TEA and LCA.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Yebo Li and Samir Kumar "Bioenergy: Principles and Applications" Wiley-Blackwell, 1st Edition, 2016

2.Ru-shi Liu, Lei Zhang and Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2nd Volume set, 2012.

REFERENCE BOOKS:

1.Venkata Ramana P and Srinivas S.N, "Biomass Energy Systems", Tata Energy Research Institute, 1997

2.Khandelwal. K. C. and Mahdi S. S, "Bio-Gas Technology", Tata McGraw-Hill Pub. Co. Ltd, 1986

3.Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd.,

1996
4. Bioenergy and Biofuel from Bio wastes and Biomass edited by Samir Kumar Khana, ASCE Publications, 2010.
WEB RESOURCES:
https://nptel.ac.in/courses/103103207
Prof. PK Das, Energy conservation and waste heat recovery, NPTEL Course, https://nptel.ac.in/courses/112105221.

ME606204 ENERGY STORAGE DEVICES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Basic concepts on different energy storage systems
- Hydrogen storage methods
- Energy storage using batteries
- Power Production using fuel-cell

UNIT IENERGY STORAGE METHODS | **9**

Need for Energy storage-Different energy storage Methods- Mechanical energy storage: Pumped storage, Compressed air storage - Electromagnetic storage-Electrostatic storage-Thermal energy storage: Sensible heat storage, Latent heat storage-Different methods of chemical Energy storage-Reversible Chemical Storage

UNIT 2 HYDROGEN ENERGY STORAGE SYSTEMS | **9**

Block diagram of Hydrogen energy systems - Properties of Hydrogen - Extraction methods of Hydrogen: Thermochemical methods - Electrolysis of water-Thermolysis of water- Bio photolysis - Hydrogen storage techniquesDelivery of Hydrogen-Conversion of Hydrogen - Applications-Safety Issues

UNIT 3 ENERGY STORAGE USING BATTERIES | **9**

Batteries - Construction and working - Elements of Electrochemical cell-operation of Electrochemical cell-Theoretical cell voltage and capacity-Losses in a cell-Battery classification-Constructions and working principle of Lead Acid battery-Nickel Cadmium batteries-Lithium-ion batteries-Battery parameters: Battery capacity, Battery Voltage, Depth of discharge-Battery life cycle-Discharge/charge rate, Self discharge-Ragone Plots

UNIT 4: BATTERY CHARGING AND CHARGE CONTROLLERS | **9**

Factors affecting battery performance: Battery voltage level, Battery Discharge current, Battery Temperature during discharge-Factors affecting Choice of a battery-Battery charging and discharging methods-Charge controllers for stand-alone PV system-Types of charge controllers for stand-alone PV system: Shunt type, Series type, DC-DC converter type, MPPT charge controller –Power stage and control scheme for battery charging using DC-DC converter-Flow chart for battery charging

UNIT 5: FUEL CELL | **9**

Introduction-Advantages-Applications-Classification of fuel cells- Construction and working of Phosphoric Acid fuel cell-Alkaline Fuel cell-Polymer Electrolyte Membrane Fuel cell-Fuels for Fuel Cells-Efficiency of Fuel cell-VI characteristics of Fuel Cell-MPPT controller for fuel cell

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate the concepts of different energy storage systems.

CO2:Comprehend different Hydrogen extraction schemes

CO3:Describe about different battery technologies

CO4:Analyze the performance of battery charge controllers and their application

CO5:Conceptualize the operation of different Fuel cell

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
1. Khan B.H.,"Non-Conventional Energy Resources", Tata McGraw Hill Publication, 2nd Edition, 2009.
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Elsevier Science,2001
3. Thomas B. Reddy,"Linden's Handbook of Batteries", Fourth Edition,McGrawHill,2011
4. EG&G Technical Services, Inc. "Fuel Cell Handbook", Seventh Edition, 2004
REFERENCE BOOKS:
1.Robert A. Huggins, "Energy Storage", Springer Science & Business Media, 2010.
2.Vladimir S. Bagotsky, "Fuel Cells- Problems and Solutions", Second Edition, Wiley, 2012
WEB RESOURCES:
Prof. SubhasishBasuMajumder, Electrochemical Energy Storage, NPTEL Course, https://nptel.ac.in/courses/113105102.
Prof. PK Das, Energy conservation and waste heat recovery, NPTEL Course, https://nptel.ac.in/courses/112105221.

ME606205 ENERGY CONSERVATION AND WASTE HEAT RECOVERY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Energy conservation techniques.
- Deliver the impact of energy conservation on current energy scenario

UNIT I THERMODYNAMICS — **9**

Availability, energy and energy-energy, energy, entropy relationship- Degradation of energy – energy analysis- exergy conservation- combustion, thermal efficiency, thermal losses; thermal balance sheets.

UNIT 2 ENERGY CONSERVATION — **9**

Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management.

UNIT 3 WASTE HEAT RECOVERY SYSTEMS — **9**

Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchangers – Thermal wheel – heat pipe heat exchanger – Heat pump – waste heat boilers – Incinerators

UNIT 4: HEAT EXCHANGER THEORY — **9**

Types Of heat exchangers - overall heat transfer coefficient – fouling factor - Design of heat Exchangers, L.M.T.D. and N.T.U. methods.

UNIT 5: HEAT RECOVERY SYSTEMS — **9**

Liquid to liquid heat exchangers – regenerators, recuperaters, rotating regenerators – selection of materials for heat exchangers, U- tube heat exchanger, fluidized bed heat exchanger –economizer.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate the concepts of different energy systems.

CO2:Know about energy conservation techniques.

CO3:Describe waste heat recovery systems technologies

CO4:Analyze the performance of heat exchanger theory

CO5:Conceptualize the operationheat recovery systems

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Khan B.H.,"Non-Conventional Energy Resources", Tata McGraw Hill Publication, 2nd Edition, 2009.

2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Elsevier Science,2001

3. Thomas B. Reddy,"Linden's Handbook of Batteries", Fourth Edition,McGrawHill,2011

4. EG&G Technical Services, Inc. "Fuel Cell Handbook", Seventh Edition, 2004

REFERENCE BOOKS:

1.Robert A. Huggins, "Energy Storage", Springer Science & Business Media, 2010.

2.Vladimir S. Bagotsky, "Fuel Cells- Problems and Solutions", Second Edition, Wiley, 2012

WEB RESOURCES:

Prof. SubhasishBasuMajumder, Electrochemical Energy Storage, NPTEL Course, https://nptel.ac.in/courses/113105102.

Prof. PK Das, Energy conservation and waste heat recovery, NPTEL Course,

https://nptel.ac.in/courses/112105221.

ME606206 SOLAR ENERGY TECHNOLOGIES						
Course Category: Program Core	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- Application of solar energy technologies in various fields like power generation, air conditioning and desalination.
- Economic feasibility of solar technology for suitable application.

UNIT I SOLAR RADIATION **9**

Sun-earth geometric relationship, nature of solar radiation, global, beam and diffuse radiation, hourly, daily and seasonal variation of solar radiation, estimation of terrestrial solar radiation- measurement of solar radiation, solar charts - solar radiation data.

UNIT 2 SOLAR PHOTOVOLTAIC AND PHOTOCHEMICAL APPLICATION **9**

Solar PV technology - stationary and concentrated PV - standalone systems - grid connected systems - hybridization, synchronization and power evacuation - site selection and land requirements - design of solar cells: cell parameters limits-losses in solar cells – analysis of PV cells-manufacture of solar cells and panels-photo catalytic reaction-solar reactors.

UNIT 3 SOLAR COLLECTORS AND SOLAR HEATING SYSTEM **9**

Flat plate collector-liquid type, air type, glazing-evacuated tube collector-concentrating collector-parabolic trough collector, Fresnel reflectors & lens. Solar water heating system: natural, forced-solar air heating system – configuration, collector design, air-preheating-solar industrial process heating: textile and milk processing.

UNIT 4: SOLAR COOLING AND PASSIVE SOLAR TECHNIQUES **9**

Solar space cooling and refrigeration-vapour compression cycle, absorption air-conditioning (NH3-H2O &LiBr- H2O). Passive space heating-types-fundamental concept and generalized passive design methods, passive space cooling, controlling solar input, movement of air, evaporative cooling, nocturnal and radiative cooling.

UNIT 5 SOLAR ECONOMICS AND APPLICATION **9**

Present worth method to analyse feasibility of project / policy alternatives. Solar stirling power system, solar distillation, solar still: simple solar still, solar desalination techniques, non-convecting solar ponds, solar disinfection of water and air, solar desiccant dehumidification system, solar cookers.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the basics of solar radiation

CO2:To have knowledge on solar photovoltaic and photochemical engineering

CO3:Be able to understand the solar collector and its heating application.

CO4:Realize the application of passive solar techniques and solar cooling methods

CO5:Understand the solar economics and real time application of solar energy.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.D.YogiGoswami,"Principles of solar engineering",3rd edition, CRC press, 2015.

REFERENCE BOOKS:

1.HP Garg and J Prakash,"Solar Energy: Fundamentals and Applications", Tata McGraw Hill, 2010

2.Suhatme and Nayak, “Solar Energy: Principles of Thermal Collection and Storage”, Tata McGraw Hill, 2008

3.H P Garg, M Dayal, G Furlan, “Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications”,Springer, 2007.

4.Edward E. Anderson, “Fundamentals for solar energy conversion”, Addison Wesley Publ. Co, 1983.

5.Anne Grete Hestnes, Robert Hastings, BjarneSaxhof, “Solar Energy Houses: Strategies, Technologies Examples”,Earthscan Publications, 1st edition, 2003

WEB RESOURCES: https://archive.nptel.ac.in/courses/115/103/115103123/

ME606207GREEN ENERGY SOURCES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- The concept of various forms of renewable sources of energy
- Stand alone and grid connected renewable energy systems.
- Conceptualize the implementation of Hybrid renewable energy systems

UNIT 1 INTRODUCTION & SOLAR ENERGY **9**

Renewable energy scenario in India – importance of renewable energy sources. Environmental aspects of energy utilization- CO2 Emission Potentials – Achievements– Applications. Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- measurements

UNIT 2 SOLAR COLLECTORS **9**

Effects of constituents of Exhaust gas emission on environmental condition of earth (N2 , CO2, CO, NOx, SO2, O2) Pollution created by Exhaust gas emission in atmosphere. Green house effect, Factors affecting green house effect. Study of Global Carbon Budget, Carbon foot print and Carbon credit calculations. Emission norms as per Bharat Standard up to BS – IV and procedures for confirmation on production.

UNIT 3 WIND ENERGY **9**

Wind resource assessment -site selection - wind energy conversion devices – classification - Types of wind energy systems – Performance of wind turbine generator - applications - Safety and Environmental Aspects.

UNIT 4 OTHER RENEWABLE ENERGY SOURCES **9**

Fuel cell – principle of working- various types - construction and applications. Biogas - generation - types of biogas Plants Small hydro - Geothermal energy- site selection, construction, environmental issues

UNIT 5: HYBRID RENEWABLE ENERGY SYSTEMS & OCEAN ENERGY TECHNOLOGIES **9**

Wave Energy - Tidal energy - site selection, construction, environmental issues Introduction to Hybrid Renewable Energy System - Need for Hybrid Systems- Range and type of Hybrid systems Quantitative study of Diesel-PV and Wind-PV systems -

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain environmental impact of using fossil fuels

CO2:Explain the concept of solar energy harvesting by various methods

CO3:Enumerate the basics of Wind Energy conversion system and its impacts

CO4:Describe various types other renewable energy sources and their harvesting methods

CO5:Explain the concept of Hybrid energy systems

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Twidell, J.W. and Weir, A., "Renewable Energy Sources", EFN Spon Ltd., 2005

2. B.H.Khan, "Non Conventional energy resources", Tata McGraw-Hill Education, 2nd Edition, 2009

3. Sukhatme S P, Nayak J K, “Solar Energy: Principles of Solar Thermal Collection and Storage”, Tata McGraw Hill, 2008
4. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Private Limited, 2012
5. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press , Third edition, 2012
REFERENCE BOOKS:
1. Kothari D. P & Singal K. C & Ranjan, Rakesh, “Renewable Energy Sources and Emerging Technologies”, PHI Learning Private Limited, New Delhi, 2013.
2. Tasneem Abbasi & Abbasi Sa, “Renewable Energy Sources”, PHI Learning Private Limited, New Delhi, 2013
3. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, Second Edition, John Wiley & Sons, 2013.
4. Rashid .M. H “power electronics Hand book”, Academic press, 2001
WEB RESOURCES:
https://nptel.ac.in/courses/103107157
https://archive.nptel.ac.in/courses/103/107/103107157/

ME606208 MICRO AND NANO SCALE ENERGY TRANSPORT (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understand the fundamental principles of energy transport at the micro and nano scales.
- Develop knowledge of various energy transport mechanisms, including heat conduction, phonon transport, and electron transport.

UNIT 1 INTRODUCTION MICRO/NANOSCALE ENERGY TRANSPORT | **9**

Introduction to energy transport at different length and time scales, types of energy carriers, Importance of interfaces and boundaries in micro/nano scale transport,

UNIT 2 FUNDAMENTALS OF QUANTUM MECHANICS | **9**

Micro/Nano scale Conduction and Radiation- Quantum mechanics and statistical thermodynamics, Schrodinger equation and applications.

UNIT 3 ENERGY IN WAVE PARTICLES | **9**

Transport phenomena applied to micro-nano scale, basic heat transfer and kinetic theory, transport phenomena, photons, electrons, phonons, energy carriers, energy transport, heat transport, energy levels, statistical behavior, internal energy, waves and particles, scattering, heat generation,Quantum statistics, Bose

UNIT 4 NANO FLUIDS | **9**

Rarified Gas flows, slip mechanisms, Extended Navier-Stokes equation in microchannel flow. Liquid transport in mini/micro channels forced convection, effects of roughness and property variation

UNIT 5: MICRO/NANO SCALE TRANSPORT IN FLUIDS | **9**

Applications of micro channels and nanofluids in electronic cooling, micro heat pipes, and microfluidic devices, Measurement techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamental principles of energy transport and the unique challenges associated with micro and nano systems.

CO2:Describe and analyze the various mechanisms of energy transport at the micro and nano scales.

CO3:Apply mathematical models and theoretical concepts to analyze heat conduction, electron, and phonon transport in micro and nano structures.

CO4:Gain knowledge of energy harvesting techniques and their applications in micro and nano systems, including thermoelectric and photovoltaic energy conversion.

CO5:Evaluate and design thermal management strategies for microelectronics devices, considering heat dissipation and cooling techniques.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Nanoscale energy transport and conversion, Gang Chen, Oxford University Press, 2005
2. Microscale and Nanoscale Heat Transfer, C.B Sobhan and G.P Peterson, CRC press, 2008

REFERENCE BOOKS:

1. Microscale energy Transport, C-L. Tien, A. Majumdar, and F.M. Gerner, Taylor & Francis, 1998.
2. Heat Transfer Physics, Massoud Kaviany, Cambridge University Press, 2008.
3. Heat and Fluid Flow in Microscale and Nanoscale Structures, M. Faghri and B. Sunden (Eds.), WIT

Press, Southampton, 2004.
WEB RESOURCES: https://nptel.ac.in/courses/112106222

ME606209-DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To provide the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
- To analyze topology of the stand-alone and grid connected photo-voltaic systems.

UNIT I INTRODUCTION TO HYBRID ELECTRIC VEHICLES | **9**

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance

UNIT 2 HYBRID ELECTRIC DRIVE-TRAINS | **9**

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

UNIT 3 ELECTRIC PROPULSION | **9**

Introduction to electric components used in hybrid and electric vehicles, Configuration and control- DC Motor Drives, Induction Motor drives, Permanent Magnet Drives, Switched Reluctance Drives.

UNIT 4 SOLAR PHOTOVOLTAICS | **9**

Equivalent circuit of PV Cell- Photovoltaic cell-characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode-Blocking diode- Boost converter based Maximum power point tracking (MPPT)-MPPT algorithms: P&O and Incremental conductance algorithm

UNIT 5: FUEL CELL AND HYBRID RENEWABLE ENERGY SYSTEMS | **9**

Fuel cell – principle of working of phosphoric acid Fuel cell –VI Characteristics of Fuel cell-.Introduction to Hybrid Renewable Energy System - Need for Hybrid Systems- Range and type of Hybrid systems-Quantitative study of Diesel-PV and Wind- PV system

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Identify the importance of hybrid electric vehicle

CO2:Explicate the different train topologies and power flow control in electric vehicles

CO3:Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources

CO4:Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.

CO5:Outline the need for the hybrid PV system and fuel cell technology.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Nanoscale energy transport and conversion, Gang Chen, Oxford University Press, 2005

2. Microscale and Nanoscale Heat Transfer, C.B Sobhan and G.P Peterson, CRC press, 2008

REFERENCE BOOKS:

1. Microscale energy Transport, C-L. Tien, A. Majumdar, and F.M. Gerner, Taylor & Francis, 1998.

2. Heat Transfer Physics, Massoud Kaviany, Cambridge University Press, 2008.

3. Heat and Fluid Flow in Microscale and Nanoscale Structures, M. Faghri and B. Sunden (Eds.), WIT

Press, Southampton, 2004.
WEB RESOURCES: https://onlinecourses.nptel.ac.in/noc21_ee112

ME606210-ELECTRIC VEHICLES AND RENEWABLE ENERGY(NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- To provide the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
- To analyze topology of the stand-alone and grid connected photo-voltaic systems.

UNIT I INTRODUCTION TO HYBRID ELECTRIC VEHICLE — **9**

Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving,

UNIT 2 ELECTRIC DRIVES — **9**

Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor

UNIT 3 ENERGY STORAGE — **9**

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle,

UNIT 4 SOLAR PV — **9**

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems

UNIT 5: OTHER ENERGY SOURCES — **9**

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell : Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Identify the importance of hybrid electric vehicle

CO2: understand the different types of drives and control.

CO3:understand comprehensively about different types of Storage systems

CO4:Understand and analyse the fundamental concepts of solar PV systems

CO5:Outline the need for the hybrid PV system technology.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Nanoscale energy transport and conversion, Gang Chen, Oxford University Press, 2005
2. Microscale and Nanoscale Heat Transfer, C.B Sobhan and G.P Peterson, CRC press, 2008

REFERENCE BOOKS:

1. Microscale energy Transport, C-L. Tien, A. Majumdar, and F.M. Gerner, Taylor & Francis, 1998.
2. Heat Transfer Physics, Massoud Kaviany, Cambridge University Press, 2008.

3. Heat and Fluid Flow in Microscale and Nanoscale Structures, M. Faghri and B. Sunden (Eds.), WIT Press, Southampton, 2004.
WEB RESOURCES: https://onlinecourses.nptel.ac.in/noc21_ee112

VERTICAL 3
LOGISTICS AND SUPPLY CHAIN MANAGEMENT

ME606301-WAREHOUSING AUTOMATION					
Course category: program core	**Course type: theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To familiarize the student with the basic concept of the most common automations from light to heavy
- To familiarize the student with the basic concept of the supply chain including Logistics, warehousing, IT as well as distribution and planning.

UNIT I: INTRODUCTION **9**

Overview of the Traditional Warehouse Operations -Warehouse Automation Systems: Over-view, Applications, Costs, Benefits, ROI – Receiving Automation: Pallet Inverter -Palletizers.

UNIT 2IMPORT AND EXPORT PROCESS **9**

Transportation Strategy Considerations: An Overview of the Import Process -An Overview of the Export Process -Bonding Issues for Exporters -Negotiating Rates -Insurance and Liability -E-Logistics and the Internet -UN Module regulation -introduction to carriage of dangerous goods.

UNIT 3AUTOMATION **9**

Material Flow Automation -Conveyors -Lifts -Automated Guided Vehicles -Monorail

UNIT 4AUTOMATIC LOADING **9**

Picking/Outbound Automation : Pick / Put To Light -A Frame -Automated Order Selection – Pick-N-Go -Outbound Sorters -Automatic Truck Loading .

UNIT 5SAFETY RULES AND PROCEDURE **9**

The safety rules and 'Procedures to be observed in a Warehouse -Hazardous cargo – Procedure for Identification of Hazardous Cargo -safety data sheet-Instructions to handle hazardous cargo -Familiarization with the industry. Health, Safety & Environment -safety Equipment's and their uses -5S Concept on shop floor. Personal protective Equipment's (PPE) and their uses.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Recognize the Knowledge of the common and latest automation solutions for ware-housing

CO2: Understand and Recognize the costs and pre-requisites for each automation solution.

CO3: Able to complete the analysis and to select the most appropriate solution for ware-house automation

CO4: Enhance the applications of latest automation solutions for ware-housing

CO5: Understand automation solutions and theoretical circuits .

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Industrial Automation and Robotics: A.K.Gupta and S K Arora

2. Advanced Industrial Automation and its Application: Ravindra Sharma Industrial Control Electronics Devices, Systems, & Applications 3D Edition Author: Terry Bartler Publisher: Delmar
REFERENCE BOOKS:
1. Warehouse Management: Automation and Organisation of Warehouse and Order Picking Systems (Intralogistik) , Hardcover – Import, 13 October 2006 by Michael Hompel (Author), Thorsten Schmidt (Author)
2. Adapt or Die: Your Survival Guide to Modern Warehouse Automation Paperback – November 20, 2020by Jeremy Bodenhamer
WEBRESOURCES::https://f.hubspotusercontent30.net/hubfs/7221586/Gated%20Content/The%.pdf

ME606302-BUSINESS PROCESS RE-ENGINEERING

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand concepts and philosophy of Business Process Reengineering.
- To learn various BPR and alternate methodologies – TQM, Work Study and ISO standards.

UNIT 1: PROCESS VIEW OF BUSINESS | **9**

Definition and Dimensions of Business Process, Generic Process Framework, The Capability Maturity Model Integration (CMMI), Design Process and Design Quality, Design Concepts

UNIT 2: METHODOLOGIES AND TECHNIQUES & APPLICATIONS | **9**

Introduction and History of BPR, Definition and Benefits of BPR, BPR Model, BPR Methodology Selection Guidelines, Steps to implement BPR: Reengineering Approaches :a) Big Bang Approach, b) Incremental Approach, c) Evolutionary Approach, BPR Methodologies: a) Hammer/Champy Methodology, b) Davenport Methodology, c) Manganelli/Klein Methodology, d) Kodak Methodology; Comparison of various methodologies. Case: Dabbawala of Mumbai, A Case Analysis using BPR methodologies

UNIT 3: CRITICAL SUCCESS FACTORS ANALYSIS | **9**

Reengineering Success Factors, Risks in BPR, Barriers to BPR, Case: Analysis on "Pillsbury: Customer Driven Reengineering", Barriers Management, Case: "Walmart China- Supply Chain Transformation"

UNIT 4: OTHER IMPROVEMENT APPROACHES | **9**

Optimization Techniques, Process Simplification, Case: "Aviation Spare Parts Supply Chain Management Optimization at Cathay Pacific Airways Ltd". TQM: ISO 9000 – QMS/EMS/IMS, Quality Policy, Quality Manual, SIPOC, Procedure Manual, Work Sheets, Quality Audit, Six Sigma, QMS, ISO in Higher Education Institutions, IACBE Accreditation in Education, Restructuring, 5 S Technique, Benchmarking, Work Study, Knowledge Management

UNIT 5: INFORMATION TECHNOLOGY AND BPR | **9**

Role of IT in Reengineering, Criticality of IT in Business Process, BPR Team Characteristics, Threads of BPR in Various Phases, Case: "Otis Elevator: Accelerating Business Transformation with IT", BPR, SAP and ERP, Elements of ERP, Applications of ERP**TOTAL: 45 PERIODS**

Course Outcomes: At the end of the course, the student will be able to

CO1: Understanding various BPR methodologies and their applications

CO2: Understanding the critical success factors for implementing BPR.

CO3: Appreciate various alternative techniques of BPR – TQM, Work Study, Benchmarking.

CO4: Basic understanding of ISO standard 9001:2015, IACBE and their applications in industry.

CO5: Analyze and integrate issues and challenges of applying tools/techniques of Information Technology for BPR and learn to apply them in the industry.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. R. Radhakrishnan, S. Balasubramanian. (2010). Business Process Reengineering, Text and Cases. Prentice Hall of India, New Delhi.

2. Jayanti Natarjan. (2002). Business Process Reengineering. TMH, New Delhi,

3. Kapoor Rajneesh. (2001). Business Process Redesign. Global Business Press, Delhi.

REFERENCE BOOKS:

1.Dimitris, N. Chorafas. Integrating ERP, CRM, Supply Chain Management and Smart Materials. ISBN 0-8493-1076-8

2.Richard Johnson Management, (2001). Processes for Quality Operations. Vision Books.

3.Roger S. Pressman (2005). Software Engineering – A Practitioner's Approach, 6th Edition. Mcgraw- Hill International Edition..

WEBRESOURCES:

https://www.researchgate.net/publication/303370824_Business_process_reengineering_a_recent_review

ME606303- TOTAL QUALITY MANAGEMENT					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know about the quality management philosophies and Framework.
- To study the employee involvement and Supplier partnership.
- Apply modern tools to improve quality of the product

UNIT 1: INTRODUCTION **9**

Introduction - Need, evolution and definition of quality - Dimensions of manufacturing and service quality - Basic concepts, definition and framework of TQM - Contributions of Deming, Juran and Crosby –Barriers.

UNIT 2: TQM PRINCIPLES **9**

Leadership - Strategic quality planning, Quality statements - Customer focus, orientation, satisfaction, complaints and retention - Employee involvement - Motivation, Team and Teamwork, Recognition and Reward, Performance appraisal - Supplier partnership - Partnering, Supplier selection, Supplier Rating - Continuous process improvement - PDSA cycle, 5s and Kaizen.

UNIT 3: TQM TOOLS AND TECHNIQUES **9**

Quality circles - Quality Function Deployment (QFD) - Taguchi quality loss function -TPM - Concepts, improvement needs - Quality cost, types and its analysis techniques - Performance measures.

UNIT 4: APPLICATION OF TQM TOOLS AND TECHNIQUES **9**

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 and types - criteria for getting Quality awards.

UNIT 5: QUALITY SYSTEMS **9**

Need for ISO 9000 - ISO 9000-2000 Quality System - Elements, Documentation, Quality auditing- QS 9000 - ISO 14000 - ISO 17025 - Concepts, Requirements and Benefits - Case studies of TQM.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Explain the quality management philosophies and Framework.

CO2: Discuss the need of customer expectations, employee involvement and Supplier partnership

CO3: Analyse the TQM tools and Techniques to improve the product and process Quality..

CO4: Apply modern tools to improve quality of the product

CO5: Describe ISO 9001, Environmental Management Standards and ISO 14001 certification process.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Dale H Besterfiled, —Total Quality Management‖, Pearson Education Asia, 3rd Edition, 2012.

2. Ramachandran S, —Total Quality Management‖, Air Walk Publications, 3rd Edition 2014.

3. Suganthi L and Anand Samuel, —Total Quality Management‖, Prentice Hall (India) Pvt. Ltd., 2006

REFERENCE BOOKS:

1. James R Evans and William M Lindsay, ―The Management and Control of Quality‖, 6th Edition, Cengage Learning, 2019.
2. Oakland J S, ―TQM - Text with Cases‖, Butterworth - Heinemann Ltd., Oxford, 3rd Edition, 2012
WEBRESOURCES: https://www.researchgate.net/publication/312054032_total_quality_management

ME606304-PROJECT MANAGEMENT (Common to MAE, MECH and AERO)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To outline the need for Project Management
- To highlight different techniques of activity planning

UNIT 1: INTRODUCTION TO PROJECT MANAGEMENT AND SELECTION	**9**
Objectives of Project Management- Importance of Project Management- Types of Projects Project Management Life Cycle- Project Selection – Feasibility study: Feasibility Steps in feasibility study.	
UNIT 2: PROJECT PLANNING AND IMPLEMENTATION	**9**
Project Scope- Estimation of Project cost – Cost of Capital – Project Representation and Preliminary Manipulations - Basic Scheduling Concepts - Resource Levelling – Resource Allocation.	
UNIT 3: PROJECT MONITORING AND CONTROL	**9**
Setting a base line- Project management Information System – Indices to monitor progress. Importance of Contracts in projects- Teamwork in Project Management - Attributes of a good project team – Formation of effective teams – stages of team formation.	
UNIT 4: PROJECT CLOSURE	**9**
Project evaluation- Project Auditing – Phases of project Audit- Project closure reports Guidelines for closeout reports.	
UNIT 5: SPECIAL TOPICS IN PROJECT MANAGEMENT	**9**
Computers, e-markets and their role in Project management- Risk management Environmental Impact Assessment. Case studies in Project management.**TOTAL: 45 PERIODS**	

Course Outcomes: At the end of the course, the student will be able to

CO1:Discuss complete structure of project management and analyse the scope of project planning

CO2: Identify different project selection method

CO3: Explain the importance of project monitoring and control

CO4: Define the guidelines required for project control and its controlling Techniques.

CO5: Define the risk-market and their roll in project management.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Khanna, R. B. (2011), Project Management, PHI Learning Private Limited, New Delhi. Kendrick, Tom (2004), The Project Management Toolkit: 100 Tips and Techniques for Getting the Job Done Right, AMACOM Books: Boston, MA

2. Martin, Paula & Karen Tate (1997), The Project Management Memory Jogger: A Pocket Guide for Project Teams, Goal/QPC: Salem, NH.

3. Kendrick, Tom (2006), Results without Authority: Controlling a Project When the Team Doesn't Report to You, AMACOM Books: Boston, MA. Kloppenborg, T. (2014).

REFERENCE BOOKS:

1.McNamara, Carter (2006), Field Guide to Nonprofit Program Design, Marketing and Evaluation, 4th ed.,

Authenticity Consulting, LLC: Toronto.
2 Snead, G. Lynne (2002), The Project Management Scorecard: Measuring the Success of Project Management Solutions, Butterworth-Heinemann: Oxford.
WEB RESOURCES: https://open.umn.edu/opentextbooks/textbooks/456

ME606305-INDUSTRIAL PSYCHOLOGY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The aim of this course is to develop an awareness of major perspectives in Industrial Psychology.

UNIT I: INTRODUCTION **9**

Introduction: The role of the psychologist in industry, the field of occupational Psychology: Study of behaviour in work situation and applications of Psychological principles to problems of selection, Placement, Counselling and training

UNIT 2: DESIGN OF WORK ENVIRONMENTS **9**

Design of Work Environments: Human engineering and physical environment techniques of job analysis, Social environment: Group dynamics in Industry Personal psychology, Selection, training, placement, promotion, counselling, job motivations, job satisfaction. Special study of problem of fatigue, boredom and accidents

UNIT 3: UNDERSTANDING CONSUMER BEHAVIOR **9**

Understanding Consumer Behavior: Consumer behaviour, study of consumer preference, effects of advertising, Industrial morale: The nature and scope of engineering psychology, its application to industry

UNIT 4: WORK METHODS **9**

Work Methods: Efficiency at work, the concept of efficiency, the work curve, its characteristics, the work methods; hours of work, nature of work, fatigue and boredom, rest pauses. The personal factors; age abilities, interest, job satisfaction, the working environment, noise, illumination, atmospheric conditions, increasing efficiency at work; improving the work methods, Time and motion study, its contribution and failure resistance to time and motion studies, need for allowances in time and motion study

UNIT 5: WORK AND EQUIPMENT DESIGN **9**

Work and Equipment Design: Criteria in evaluation of job-related factor, job design, human factors, Engineering information, input processes, mediation processes, action processes, methods design, work space and its arrangement, human factors in job design. Accident and Safety: The human and economic costs of accidents, accident record and statistics, the causes of accidents situational and individual factors .

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understanding of key concepts, theoretical perspectives, and trends in industrialpsychology.

CO2: Evaluate the problems thorough and systematic competency model.

CO3: Analyse the problems present in environment and design a job analysis method.

CO4: Create a better work environment for better performance.

CO5: Design a performance appraisal process and form for the human behavior.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Tiffin, J and McCormic E.J., Industrial Psychology, Prentice Hall, 6th Edn., 1975.
2. McCormic E.J., Human Factors Engineering and Design, McGraw Hill, 4th Edn.,1976.
3. Mair, N.R.F., Principles of Human relations

REFERENCE BOOKS:

1. Gilmer, Industrial Psychology
2. Dunnete, M.D., Handbook of Industrial and Organizational Psychology

Web resources: https://library.wbi.ac.id/repository/143.pdf

ME606306-RESOURCE MANAGEMENT TECHNIQUES

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The student should be made to: x Be familiar with resource management techniques. x Learn to solve problems in linear programming and Integer programming. x Be exposed to CPM and PERT.

UNIT 1: INTRODUCTION AND LINEAR PROGRAMMING	**9**

Principal components of decision problem – Modeling phases – LP Formulation and graphic solution – Resource allocation problems – Simplex method – Sensitivity analysis.

UNIT 2: DUALITY AND NETWORKS	**9**

Definition of dual problem – Primal – Dual relation ships – Dual simplex methods – Post optimality analysis – Transportation and assignment model – Shortest route problem.

UNIT 3: INTEGER PROGRAMMING	**9**

Cutting plan algorithm – Branch and bound methods, Multistage (Dynamic) programming.

UNIT 4: CLASSICAL OPTIMISATION THEORY:	**9**

Unconstrained external problems, Newton – Ralphson method – Equality constraints – Jacobean methods – Lagrangian method – Kuhn – Tucker conditions – Simple problems.

UNIT 5: QUEUEING THEORY AND REPLACEMENT MODELS	**9**

Network diagram representation – Critical path method – Time charts and resource leveling – PERT.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Formulate the linear programming problems.

CO2: Analyse transportation and assignment problems.

CO3: Develop the scheduling systems

CO4: Analyse CPM and PERT methods.

CO5: Describe the different inventory modals.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1 Paneer Selvam, „Operations Research", Prentice Hall of India, 2002
2.Vohra, "Quantitative Techniques in Management", Tata Mc Graw Hill, 2002
3. Anand Sarma, "Operation Research", Himalaya Publishing House, 2003
REFERENCE BOOKS:
1. K. Malik, S. K. Yadav, S. R. Yadav, Optimization Techniques. I K International Publishing House Pvt. Ltd; First Edition, 2013.
2. PK Gupta, D.S Hira Operations Research. S Chand seventh revised edition, 2014.
3. Sharma S.D, Operation research Theory,Methods and Application, 17th Edn., Kedar Nath Ram Nath Publication, 2010.
WEB RESOURCES: https://www.scribd.com/document/347822440/rmt-4-1-pdf

ME 606307-ENTERPRISE RESOURCE PLANNING					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To enable the students to build up an integrated real-time view of core business processes.
- To understand the status of business commitments.
- To develop business management software - usually a suite of integrated applications.

UNIT 1: OVERVIEW OF ENTERPRISE RESOURCE PLANNING **9**

Business functions and Business processes – role of enterprise - Enterprise Resource Planning (ERP); Definition of ERP – common ERP myths – reasons for the growth of ERP market - History of ERP - Material Requirement Planning (MRP) – closed loop MRP - Manufacturing Resource Planning (MRP II) – Enterprise Resource Planning (ERP I and ERPII) – Evolution of ERP.

UNIT 2: STRUCTURE AND BENEFITS OF ENTERPRISE RESOURCE PLANNING **9**

Importance of ERP to a company – ERP architectures: mainframe, two tier, three tier – Justifying ERP investments -benefits of ERP system – information integration – reduction of lead time – on-time shipment – cycle time reduction – customer satisfaction Risks of ERP – process risks – technological risks implementation issues

UNIT 3: MODULES OF ENTERPRISE RESOURCE PLANNING **9**

- Modules of ERP – Accounting and Finance, Sales and Distribution, Production & Materials Management – Human Resource management – Plant and Maintenance, Quality Management – Integration of ERP, supply chain and customer relationship applications.

UNIT 4: IMPLEMENTATION OF ENTERPRISE RESOURCE PLANNING **9**

Implementation of ERP – implementation life cycle - Phases, transition strategies – ERP package selection -Implementation process – Role of vendors, consultants and user in ERP implementation – Challenges to successful ERP implementation – Critical Success and failure factor – operation and maintenance.

UNIT 5: ENTERPRISE RESOURCE PLANNING TECHNOLOGY **9**

Technologies related to ERP – Management information system (MIS), Decision Support System (DSS) – Executive Information System (EIS) – Business Process Reengineering (BPR) – Supply Chain Management (SCM) – Customer Relationship Management (CRM) – E – commerce.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: To gain knowledge about the evolution and importance of ERP.

CO2: To understand the concepts and architecture of ERP system.

CO3: To understand the functional modules of ERP and its integration.

CO4: To develop an idea for the implementation plan of ERP industries.

CO5: To gain knowledge about the technologies related to ERP.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation
TEXT BOOKS:
1. Alexis Leon, "Enterprise Resource Planning", Tata McGraw Hill, Publishing Company Limited, New Delhi, 2ndEdition, 2008
2.Vinoth Kumar Garg and Bharat Vakhana, "Enterprise Resource Planning, Strategy", Jaisco Publishing House,1999.
3. Vinoth Kumar Garg and Venkitakrishnan, "Enterprise Resource Planning, Concepts and Practice", PHI LearningPvt. Ltd, 2003.
REFERENCE BOOKS:
1. Dimpi Srivastava, Aarti Batra,"ERP systems", I.K. International Publishing House, New Delhi, 2010.
2. Daniel E. O'Leary, "Enterprise Resource Planning (ERP) Systems", Cambridge University Press, 2000.
3. Mary Summer, "Enterprise Resource Planning",Pearson Education, 2005.
WEBRESOURCES: http://ebooks.lpude.in/management/mba/term_3/dcap302_dcap514_enterprise_resource_planning.pdf

ME606308-BUSINESS DEVELOPMENT:FROM START TO SCALE(NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge onequips the learners with various concepts and frameworks for establishing and growing businesses.

UNIT-1 BUSINESS FUNDAMENTALS **9**

Business Fundamentals-Understanding Business Development, Marketing and Business Development, Markets and Marketing, Strategy Formulation, Business Development Cases. Business Development Strategies- Successful Businesses, Industry and Market, Vision, Mission and Strategy, Goals, Case Studies of Business Development Excellence

UNIT 2: INDUSTRY STRUCTURE AND COMPANY ANALYSIS **9**

Industry Structure and Company Analysis-Industry and Business, Porter's Five Forces Theory, Industrial Transformations, Competitive Strategies, Company Analysis. Market and Competitor Analysis- Industry, Market and Business, Industry and Market Analysis, Market Structures,Demand Forecasting,Competitor Analysis. Connecting with Customers- Customer Characteristics,Customer Typologies, Market Research and Design Thinking, Customer bonding, Customer Relationship Management

UNIT 3: BUSINESS AND MARKET SEGMENTS **9**

Business and Market Segments- Market and Market Descriptors, Market and Product Segmentation, Product-Market Segmentation, Segmentation Deep Dive,Market Attractiveness and Competitive Positioning. Branding and Pricing- Branding, Brand Organisation, Advertising and Communication,Servitization, Pricing. Corporate Development- A New IT Start-up, An FMCG Start-up, A Logistics Start-up, A Nutraceuticals Start-up, A Telecom Fightback.

UNIT 4: BUSINESS DEVELOPMENT STRUCTURES **9**

Business Development Structures- Collaborations,Strategic Alliances,Joint Ventures, Subsidiaries Mergers and Acquisitions. Business Development Competencies- Value Chain Competencies, Functional Competencies,Negotiation Skills, Cultural Skills,Leadership Attributes

UNIT 5: STRATEGIES FOR MARKETS AND INDUSTRIES **9**

Strategies for Markets and Industries-Growth Strategies, Growth Examples,Fragmented Industries and Emerging Industries, Mature Industries and Declining Industries, Global Industries and New Businesses. Business Development Case Studies- Business Transformation, Strategic Alliances for Growth, Business Turbulence, Creating Value, From Start to Scale, In Closing

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: start-ups and entrepreneurial firms as well as established small, medium, and large companies for crafting and executing their growth journey

CO2: to create new opportunities

CO3: The growth of existing businesses

CO4: The creation of new ones

CO5: Able to pursue new opportunities

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	2	2	1	2	-	-	2	1	1
CO2	2	1	2	2	2	2	2	1	2	1	2	2	1	1
CO3	1	2	2	2	2	2	-	1	2	1	2	2	1	1
CO4	2	1	2	1	1	2	2	-	2	1	2	1	1	1
CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Michael E. Porter, Competitive Strategy, New York: Free Press, 1980 Orville C. Walker, Jr., and John W. Mullins, Marketing Strategy: A Decision-Focused Approach, McGraw Hill, 2011

2. Philip Kotler and Gary Armstrong, Principles of Marketing, Englewood Cliffs, NJ, Prentice Hall, 1989 Philip Kotler, Leven Lane Keller, Marketing Management, Pearson, 2017W. Chan Kim and Renee Mauborgne, Blue Ocean Strategy, Harvard Business Review Press, 2017

REFERENCE BOOKS:

1. Charles W L Hill, Gareth R Jones and Melissa A Schilling, Strategic Management, Cengage Learning, 2015Thomas L. Wheelen, J. David Hunger, Alan N. Hoffman, and Charles E. Bamford, Strategic Management and Business Policy: Globalization, Innovation, and Sustainability, Pearson, 2015

2. Rao, C B, Strategic Management, Practice and Philosophy for India Inc, Notion Press, 2021

WEBRESOURCES:https://onlinecourses.nptel.ac.in/noc23_mg61/preview

ME606309 - PATENT LAW FOR ENGINEERS AND SCIENTISTS (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on depth understanding of patent law to engineers and scientists.

UNIT 1: INTRODUCTION	**9**

Introduction to the Indian Patent System Patent Laws as Concepts; Understanding the Patents Act, 1970; Understanding the Patents Rules, 2003;Preliminary Sections; Preliminary Rules; What's New in the Patents (Amendment) Rules, 2016; Easy way to read the Patents Act and Rules. Patentability of Inventions Statutory Exceptions to Patentability; Novelty and Anticipation; Inventive Step; Capable of Industrial Application; Person Skilled in the Art

UNIT 2: PATENT SPECIFICATION & APPLICATION	**9**

Patent Specification Provisional and Complete Specifications; Structure of a Patent Specification—Title, Abstract, Description, Claims, etc.; Reading a Patent Specification—Fair basis, Enabling Disclosure, Definiteness, Priority; Introduction to Patent Drafting. Patent Prosecution: Patent Applications Patent Application—Who Can Apply, True and First Inventor, How to Make a Patent Application, What to include in a Patent Application, Types of Patent Applications, Patents of Addition, Dating of Application;

UNIT 3PATENT PROSECUTION	**9**

Patent Prosecution: Publication and Examination - I Publication of Application; Request for Examination; Examination of Application—First Examination Report. Patent Prosecution: Publication and Examination – II Expedited Examination of Application; Search for Anticipation—Procedure, withdrawal of Application; Consideration of Report of Examiner.

UNIT 4 GRANTS AND RIGHTS	**9**

Patent Prosecution: Opposition Pre-grant opposition; Post-grant opposition; Wrongful obtaining of invention; Mention of Inventor; Opposition in General. Patent Prosecution: Practice at the Patent Office- I Secrecy Provisions; Grant of Patents; Rights Conferred by Grant; Rights of Co-Owners; Term of Patent; Restoration of Lapsed Patents; Patent Office and Patent Prosecution, Surrender; Revocation—Grounds for Revocation; Register of Patents, Patent Office and its Establishment; Patent Agents; Use and Acquisition by Government; Penalties.

UNIT 5 LICENSING	**9**

Compulsory Licensing Compulsory Licensing—Working of Patents, Grounds for Grant of Compulsory License, Revocation; Patent Licensing; Patent Enforcement, International Arrangements and Other Miscellaneous Provisions Intellectual Property Appellate Board; Declaratory Suits, Infringement Suits; International Application—Convention Application, PCT Application, Application Designating India, Multiple Priorities; PCT Timeline; Fees—Application, In Relation to Grant of Patents; Timelines, Application, Examination, Publication etc. **TOTAL: 45 PERIODS**

Course Outcomes: At the end of the course, the student will be able to

CO1: be beneficial for candidates preparing for the Patent Agent Examination

CO2: know the requirements of patentability

CO3: Patent Prosecution

CO4: Know Business Development Structures

CO5: To get patent rights

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	2	2	1	2	-	-	2	1	1
CO2	2	1	2	2	2	2	2	1	2	1	2	2	1	1
CO3	1	2	2	2	2	2	-	1	2	1	2	2	1	1
CO4	2	1	2	1	1	2	2	-	2	1	2	1	1	1
CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Feroz Ali, The Law of Patents, LexisNexis

2. Ronald D. Slusky, Invention Analysis and Claiming – A Patent Lawyer's Guide, Second Edition, American Bar Association, 2012.

REFERENCE BOOKS:

1. Feroz Ali, The Touchstone Effect – The Impact of Pre-grant Opposition on Patents, LexisNexis, 2009.

WEB RESOURCES: https://onlinecourses.nptel.ac.in/noc22_hs29/preview

ME606310- BUSINESS ANALYSIS FOR ENGINEERS(NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study of subjects such as organizational behaviour, financial management, and strategy and includes summer projects & internships.
- To get ideas about Critical thinking, problem-solving, and decision-makingBusiness Analysis Planning and Monitoring.

UNIT 1: INTRODUCTION **9**

Introduction to Business Analysis for Engineers, Introduction to Accounting, Accounting Principles – 1,Balance Sheet Fundamentals, Accounting Principles – 2,Introduction to Income Statement & Double Entry, Double Entry Examples – 1, Double Entry Examples – 2.

UNIT 2: FINANCIAL ACCOUNTING **9**

Preparation of Financial Statement, Cash Flow Statement 1, Cash Flow Statement 2, Special Accounts Illustrations, Final Illustrative Example, Summary of Financial Accounting, Introduction to Management Accounting & Behaviour of Costs.

UNIT 3: INVENTORY MANAGEMENT **9**

Cost-Volume Relationship, Cost-Objects & Variance, Labour & Over Heads Variance Analysis, Cash Conversion Cycle, Inventory Management, What is Strategy, Poter's Diamond Model, Industry Analysis, Industry Analysis & Sources of Strategy.

UNIT 4: VALUE CHAIN ANALYSIS **9**

The Need for Value, Value Chain Analysis, Corporate Portfolio Analysis, External & Internal Environ Analysis, Models for Strategy, Ans off matrix, Porter's Generic Strategy, Prahlad's Core Competency, Case study to understand strategy, Blue ocean and conclusion.

UNIT 5: ECONOMICS **9**

Introduction to Economics, Introduction to GDP, Supply vs Demand, Price & Income Elasticity and Utility, Macroeconomic Variables, Fiscal & Monetary Policy, Union Budget & Conclusion.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Critical thinking, problem-solving, and decision-making

CO2: Business Analysis Planning and Monitoring

CO3: Elicitation and Collaboration.

CO4: Strategy Analysis

CO5: Solution Evaluation.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Business Analysis 4th Edition, Kindle Editionby Debra Paul (Author), James Cadle (Author), Malcolm Eva (Author), Craig Rollason (Author), & 1 more Format: Kindle Edition
2. Business Analysis Techniques: 99 essential tools for success Paperback – September 23, 2014by James Cadle (Author), Debra Paul (Author), Paul Turner (Author)
REFERENCE BOOKS:
1. International Institute of Business Analysis; 3rd edition (April 15, 2015)
WEB RESOURCES: https://archive.nptel.ac.in/courses/110/106/110106050/

VERTICAL 4: COMPUTATIONAL ENGINEERING

ME606401 – COMPUTATIONAL SOLID MECHANICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand knowledge of statics and dynamics of solids.

UNIT 1: FINITE ELEMENT METHOD IN SOLID MECHANICS **9**

Features of a finite element code- Introduction to ABAQUS/CAE and ABAQUS-Structural elements-Continuous beams –Shells.

UNIT 2: FINITE ELEMENT METHOD FOR STATIC LINEAR ELASTICITY **9**

Derivation and implementation of a basic 2D FE code with triangular constant strain elements-Generalization of finite element procedures for linear elasticity: interpolation and numerical integration in 1D, 2D and 3D-Deriving finite element equations - constructing variational forms; mixed methods.Accuracy and convergence; the Patch.

UNIT 3: ADVANCED ELEMENT FORMULATIONS **9**

Shear locking and incompatible mode elements-Volumetric locking: reduced integration and Bbar methods-Mixed (hybrid) elements

UNIT 4: FINITE ELEMENT METHOD IN NONLINEAR PROBLEMS **9**

Small strain hypoelastic materials-Small strain viscoplasticity-Large strain elasticity-Large strain visco-plasticity

UNIT 5: TIME DEPENDENT AND DYNAMIC PROBLEMS **9**

First-order systems - the diffusion equation-Explicit time integration – the Newmark method-Implicit time integration-Modal analysis and modal time integration.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Familiar with the theoretical basis for FEA in solid mechanics

CO2: Able to set up and solve solid mechanics problems using ABAQUS

CO3: Able to develop user elements and user materials for ABAQUS

CO4: Able to use an IDE/Git for writing and debugging code, version control, and collaboration

CO5: Able to understand the modelling and time analysis

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Srinath.L.S.,"Advanced mechanics of Solids", Tata McGraw-Hill Publishing Company Ltd (2009)
2. Lakshminarayanan.H.V.,"Solid Mechanics", CBS Publishers (2018)
3. Chandra,"Fundamentals of Mechanics",Cambridge University Press (2013)

REFERENCE BOOKS:

1. Crandall "An introduction to Mechanics of Solids",McGraw-Hall,1957
2. Shames," An introduction to Solid Mechanics", Pearson (2015)
3. Fung.Y.C,"Classical and Computational Solid Mechanics ,World Scientific(2020)

WEB RESOURCES:

https://ethz.ch/content/dam/ethz/special-interest/mavt/mechanical-systems/mm-dam/documents/Notes/CompMech_Notes.pdf ttps://www.worldscientific.com/worldscibooks/10.1142/4134#t=aboutBook

ME606402 – COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand knowledge of fluid dynamics and heat transfer characteristics

UNIT 1: COMPUTATIONAL FLUID FINITE DIFFERENCE ANALYSIS | **9**

Finite Difference Method -Explicit, Implicit-ADI Formulation Stability Analysis- Conservative and Transportive Properties –Upwinding-Artificial Viscosity- Second Upwind-Higher order Upwinding and some Important IssuesFinite Volume Method- First Derivatives; FVM-Equations with Second Derivatives

UNIT 2: FINITE VOLUME METHODS AND DERIVATIVES | **9**

Applications of Knowledge and Setting up an Algorithm-Finite Volume Method (FVM-preliminary concepts)FVM-Equations with First Derivatives-FVM Equations with Second DerivativesFinite Element Method-FEM-Galerkin Weighted Residual Method

UNIT 3: VORTICITY AND STREAM FUNCTIONAL ANALYSIS | **9**

FEM-Elemental contributions and formation of Global Matrix-Vorticity Stream Function Approach (Formulation and Algorithm)-Vorticity Stream Function Approach (Application to Curvilinear Geometry)-SIMPLE Algorithm (Continuity and Momentum Equations)

UNIT 4: ALGORITHM AND COMPLEX GEOMETRY EQUATIONS | **9**

SIMPLE Algorithm (Momentum Equations and Pressure Solver)-MAC Algorithm (The MAC Method and Discretization of the Equations)-MAC Algorithm (Pressure - Velocity Iteration and the Solution)MAC Algorithm (Solution of Energy Equation); A Finite Volume Method to solve NS Equations in 3D Complex Geometry ;

UNIT 5: VELOCITY PROFILE OF COMPUTATIONAL FLOW | **9**

Turbulent Flow and Heat Transfer (preliminaries)-Prandtl's mixing length and universal velocity profileMathematical Approaches to Turbulent Flows-Advanced RANS Models-Large Eddy Simulation (LES) of Turbulence.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Provide the student to use the modern CFD software for the analysis of complex fluid-flow systems.

CO2: Improve the student's understanding of the basic principles of fluid mechanics.

CO3: Improve the student's research and communication skills using a self-directed, detailed study of a complex fluid-flow problem and to communicate the results in written form.

CO4: The student will demonstrate an ability to describe various flow features in terms of appropriate fluid mechanical principles and force balances.

CO5: The studentsable to demonstrate the results of this detailed fluid-flow study in a written format.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1.S V Patankar.,"Numerical Heat Transfer and Fluid Flow",Hemisphere Publishing (2018)
2.G. Biswas," Computational Fluid Dynamics," Narosa Publishing House (2013)
3.Anderson," Computational Fluid Mechanics and Heat Transfer", CRC Press (Taylor and Francis)(2020)

REFERENCE BOOKS:

Fletcher "Computational Technique for Fluid Dynamics, Vol. 1 and Vol.",Springer verlag (1991)
Tannehill, "Computational Fluid Mechanics and Heat Transfer",CRC Press (2012).
Gupta,"Applied Computational and Fluid Dynamics",Wiley (2019)

WEB RESOURCES:https://onlinecourses.nptel.ac.in/noc22_me101/preview

ME606403 – COMPUTATIONAL BIO MECHANICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To offer a hands-on training in computational modelling of biomechanical phenomena ranging from cellular to tissue to organ scales

UNIT 1: INTRODUCTION **9**

Scope of mechanics in medicine, mechanics of bone structure, determination of in-vivo elastic modulus. Biofluid mechanics, flow properties of blood.

UNIT 2: MECHANICS OF PHYSIOLOGICAL SYSTEMS **9**

Heart valves, power developed by the heart, prosthetic valves. Constitutive equations forsoft tissues, dynamics of fluid flow in cardiovascular system and effect of vibration – shearstresses in extra-corporal circuits.

UNIT 3: ORTHOPAEDIC MECHANICS **9**

Mechanical properties of cartilage, diffusion properties of articular cartilage, mechanical properties of bone, kinetics and kinematics of joints, Lubrication of joints.

UNIT 4: MATHEMATICAL MODELS **9**

ntroduction to Finite Element Analysis, Mathematical models - pulse wave velocities in arteries, determination of in-vivo elasticity of blood vessel, dynamics of fluid filled

UNIT 5: ORTHOPAEDIC APPLICATIONS **9**

Dynamics and analysis of human locomotion - Gait analysis (determination of instantaneous joint reaction analysis), occupant response to vehicular vibration. Mechanics of knee joint during standing and walking. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

CO2: An ability to function on multi-disciplinary teams

CO3: An ability to identify, formulate, and solve engineering problems

CO4: An ability to communicate effectively.

CO5: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Dhanjoo N. Ghista, "Bio-mechanics of Medical Devices", Marcel Dekker, 1980.
2. HaufredClynes, "Bio-medical Engineering Systems", McGraw Hill, 1998.
3. Dhanjoo N. Ghista, "Orthopaedic Mechanics", Academic Press, 1990.

REFERENCE BOOKS:

1. Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues", Springer-Verlag, 1998.
2. M.Prakash, "Computational Bio Mechanics",Discory Publishing (2009).
3. Pritam Pain,"Advances in Computational Approaches in Biomechanics," IGI Global Publishers. (2022)

WEB RESOURCES: http://www.profedf.ufpr.br/rodackibiomecanica_arquivos/Books

ME606404 – ADVANCED STATISTICS AND DATA ANALYTICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To overcome the statistical calculations and graphical representations of data; in the analysis of probability and variables

UNIT 1: PERMUTATIONS & COMBINATIONS **9**

Definitions and Relations between them, Simple examples based on them.Binomial theorem (Without Proof) Simple examples based on it. Actual expansion, To find rth term. To find coefficient of certain term.

UNIT 2: PROBABILITY THEORY **9**

Definition of terms used in probability, Definition of probability, Definition ofconditional probability, Bays theorem.Addition and multiplication rules of probability. Examples on probability using permutation and combination.

UNIT 3: MATHEMATICAL EXPECTATION **9**

Definition of Mathematical Expectation of Univariate& Bivariate discrete andomvariable . Addition & Multiplication laws of mathematical expectation for discrete random variables only. Variance of discrete random variable.Simple Examples.

UNIT 4: FOUNDATION OF BUSINESS ANALYTICS **9**

Introduction to Business Intelligence & Analytics-Evolution of Business Analytics-Emergence of Business Analytics as a Competitive Strategy-Data Lifecycle & Data Collection Methods-
Introduction to Big Data-Sources of Data-Building a Data Strategy to Create business value

UNIT 5: DESCRIPTIVE ANALYTICS & STATISTICAL INFERENCE **9**

Tools R - (Basics, Advantages & Limitations)-Advance Probability and Probability Models-
Central Tendency & Dispersion-Data Types & Structure, Variables & Distribution-Bayes Theorem-Central Limit Theorem & Confidence Interval-Hypothesis Testing-Linear Regression.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Students will formulate complete, concise, and correct mathematical proofs.

CO2: Students will frame problems using multiple mathematical and statistical representations of relevant structures and relationships and solve using standard techniques.

CO3: A result of an experiment is called an outcome. The sample space of an experiment is the set of all possible outcomes.

CO4: Student will understand what data are, how they are collected, the role of metadata in understanding a given set of data, and how to assess the quality/reliability of data.

CO5: Students will demonstrate intermediate proficiency in the visualization of data to communicate information and patterns that exist in the data.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Gupta ,"Fundamentals of applied Statistics" Sultan Chand and Sons (2014)
2. Sharms," Quantitative techniques for managerial techniques,"Macmillian (2009)
3. Anil Maheswari,"Data Analytics",McGraw Hill Education(2017)

REFERENCE BOOKS:

1. Medhi,"Statistical Methods: An Introductory Text", New Age International Publishers (2006)

2. Elhance,"Fundamentals of Statistics",KitabMahal Publishers (2018)
3. Andrew,"Practical Statistics for Data Scientists",Orielly Media(2020)

WEB RESOURCES: https://www.simplilearn.com/resources/data-science-business-analytics/ebooks

ME606405 – MACHINE LEARNING FOR INTELLIGENT SYSTEMS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To understand knowledge of Machine Learning based mathematical analysis

UNIT 1: BINARY FUNCTIONS ON MACHINE LEARNING **9**

Machine learning introduction,Definition of binary classification, instance space, target function, training examples.Unweighted k-nearest neighbor (kNN) rule.WeightedkNN.Effect of selecting k.Supervised learning for binary classification, multi-class,classification, regression, and stuctured output prediction.kNN for regression and collaborative filtering.

UNIT 2: ALGORITHM AND DECISION TREE LEARNING **9**

Hypothesis space, consistency, and version space List-then-eliminate algorithmClassifying with a decision tree Representational power of decision treesTDIDT decision tree learning algorithm Splitting criteria for TDIDT learning.

UNIT 3: ERROR PREDICTION AND STATISTICAL TEST **9**

Training error, Test error, prediction error Independently identically distributed (i.i.d) data Overfitting Occam's Razor Model selection Controlling over fitting in decision trees Train/validate/test split and k-fold cross-validation Statistical tests for assessing learning results

UNIT 4: LINEAR PROGRAMMING AND CONVERGENCE PERCEPTRON **9**

Linear programming for linear classification(Batch) Perceptron learning algorithmConvergence of Perceptron Margin of linear classifiersConvergence of PerceptronOnline Mistake Bound Learning. Optimal hyperplanes and marginsHard-margin Support Vector Machine.

UNIT 5: SUPPORT VECTOR MACHINE AND KERNEL SYSTEMS **9**

Soft-margin Support Vector Machine in Primal SVM optimization problem inDual PerceptronDual SVM optimization problemConnections between dual and primalBounds on the leave-one-out error of SVMsInput space and feature spaceKernels as a method for non-linear learning-learningKernels for learning with non-vectorial data.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Students will formulate complete the Machine learning and KNN systems.

CO2: Students will frame problems using multiple algorithm and decision tree learning.

CO3: A result of the course the student able to understand error prediction and statistical test.

CO4: Student will understand the linear programming and convergence problems.

CO5: Students able to go around the SVM optimization technique and Kernel systems.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. ShaiShalev-Shwartz, Shai Ben-David, "Understanding Machine Learning - From Theory to Algorithms", Cambridge University Press, 2014.
2. Imbens, Rubin, Causal Inference for Statistical Social Science, Cambridge, 2015
3. Schoelkopf, Smola, "Learning with Kernels", MIT Press, 2001

REFERENCE BOOKS:

1. Kevin Murphy, "Machine Learning - a Probabilistic Perspective", MIT Press, 2012.
2. Cristianini, Shawe-Taylor, Introduction to Support Vector Machines,Cambridge University Press, 2000
3. EthemAlpaydin, "Introduction to Machine Learning", MIT Press, 2004.

WEB RESOURCES:https://Machine-Learning-Intelligent-Decision-Algorithms-ebook/dp/B086R9X871

ME606406 – THEORY OF COMPUTATION AND VISUALIZATION					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand knowledge of basic computation models, their properties and the necessary mathematical techniques to prove more advanced attributes of models

UNIT 1: AUTOMATA FUNDAMENTALS EXPRESSIONS AND LANGUAGES	**9**

Formal Proofs-Finite Automata – deterministic and nondeterministic, regular operations- Regular Expression, Equivalence of DFA, NFA and REs, closure properties Non regular languages and pumping lemma, DFA Minimization,

UNIT 2: CONTEXT FREE GRAMMAR AND LANGUAGES	**9**

CFGs, Chomsky Normal Form, Non CFLs and pumping lemma for CFLs PDAs, Equivalence of PDA and CFG, Properties of CFLs, DCFLs

UNIT 3: FOUNDATIONS FOR DATA VISUALIZATION	**9**

Introduction to Visualization – Visualization stages – Experimental Semiotics
based on Perception – Gibson‘s Affordance theory – A Model of Perceptual Processing – Costs and Benefits of Visualization – Types of Data.

UNIT 4: COMPUTER VISUALIZATION	**9**

Non-Computer Visualization – Computer Visualization: Exploring Complex Information Spaces –Fisheye Views – Applications – Comprehensible Fisheye views – Fisheye views for 3D data – Non Linear Magnification – Comparing Visualization of Information Spaces – Abstraction in computer Graphics – Abstraction in user interfaces.

UNIT 5: MULTIDIMENSIONAL VISUALIZATION	**9**

1D, 2D, 3D – Multiple Dimensions – Trees – Web Works – Data Mapping: Document
Visualization – Workspaces.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Students will formulate to learn deterministic-non deterministic expressions.

CO2: Students will learn context free grammar languages with properties.

CO3: To learn about different Visualization Techniques.

CO4: To study the Interaction techniques in information visualization fields

CO5: To understand various abstraction mechanisms.

CO’s PO’s&PSO’s MAPPING

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

1- low, 2 - medium, 3 - high, ‘-' no correlation

TEXT BOOKS

1. Anuradha, "Theory of Computation", Technical Publications (2022)
2. Colin Ware “Information Visualization Perception for Design”,3rd edition, Morgan Kaufman 2012.
3. Thomas Strothotte, “Computer Visualization–Graphics Abstraction and Interactivity”, Springer Verlag Berlin Heiderberg 1998.

REFERENCE BOOKS:

1. Dilip Kumar Sulatnia, " Theory of Computation", Tech-Max Publications.(2022)
2. Chaomei Chan, “Information Visualization”,Beyond the horizon, 2nd edition, Springer Verlag, 2004.

3. Pauline Wills, “Visualisation: A Beginner’s Guide”, Hodder and Stoughlon, 1999.

WEB RESOURCES:

https://fuuu.be/polytech/INFOF408/Introduction-To-The-Theory-Of-Computation-Michael-Sipser.pdf
http://www.ornl.gov/info/ornlreview/v30n3-4/visual.htm
www.ulb.tu-darmstadt.de/tocs/5943970X.pdf

ME606407– FOUNDATIONS OF COMPUTATIONAL MATERIALS MODELLING (NPTEL)

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand knowledgeof simulations of lattice and symmetry crystallography,

UNIT 1: MD SIMULATIONS BRAVIAS LATTICES AND SYMMETRY **9**

Introduction to the course-Some applications of MD simulations-Introduction to Bravais lattices and constructing simple crystals with MATLAB-Introduction to symmetry - 1-Symmetry Elements - 1

UNIT 2: PLANE GROUPS AND CRYSTALLOGRAPHY **9**

Symmetry elements-2Plane groups and their Hermann-Maugin (HM) symbolsGlide reflection; Examples of writing point group symbols; Wyckoff positionsGenerating 2D crystal with MATLAB using Bilbao crystallography website

UNIT 3: SPACE GROUPS AND TRANSLATIONAL SYMMETRY **9**

Symmetry of space groups-Hernannmaugin symbols of space groups-Translational symmetry operators-The Space groups-Generation of crystals

UNIT 4: STATISTICAL MECHANICS AND PHASE SPACE **9**

Introduction to statistical mechanics-3-Statistical mechanics-1-Statistical mechanics 2-Basic introduction to mechanics-Introduction to phase space.

UNIT 5: PHASE TIME AVERAGE AND MOLECULAR SIMULATOR **9**

Introduction to phase average and time average-Canonical ensemble; Partition function-Basic introduction to MD-Input script for LAMMPS 1-Input script for LAMMPS 2-Input script for LAMMPS 3-Input script for LAMMPS 4

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Students will have knowledge about MD simulations and symmetry.
CO2: Students will learn plane groups of crystal materials.
CO3: To learn about space groups and translational of crystals.
CO4: To study the statistical mechanics and phase diagram on crystals.
CO5: To understand the molecular simulator and phase average on crystals.

CO’s PO’s&PSO’s MAPPING

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

1- low, 2 - medium, 3 - high, ‘-' no correlation

TEXT BOOKS

1. Richard LeSar,”Introduction to Computational Materials”,Material Research Society (2013).
2. Glustino,”Materials Modeling using Density Functional Theory: Properties and Predictions Paperback” Oxford Publications(2014)
3. AmitaDua,”Molecular Spectroscopy: Quantum to spectrum”Atlantic Publications (2022)

REFERENCE BOOKS: 1. Dilip Kumar Sulatnia, " Theory of Computation", Tech-Max Publications.(2022)
WEB RESOURCES:
1.https://archive.nptel.ac.in/courses/112/106/112106289/ 2.http://www.nitttrc.edu.in/nptel/courses/video/112106289/lec1.pdf

ME606408–COMPUTATIONAL FLUID DYNAMICS USING FINITE VOLUME METHOD (NPTEL)

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand knowledge of basic computation equations and mathematical techniques to prove more advanced attributes of models.

UNIT 1 : COMPUTATIONAL FLUID DYNAMICS GOVERNING EQUATIONS	**9**
Review of governing equations-Classification of governing equations- Overview of numerical solution methods	
UNIT 2 : STEADY AND UNSTEADY DIFFUSION EQUATIONS	**9**
Steady diffusion equation on structured meshes- Unsteady diffusion equation on structured meshes	
UNIT 3 : FORM OF CONVECTION AND DIFFUSION	**9**
Diffusion in unstructured meshes- Convection and diffusion- Higher-order schemes	
UNIT 4 : CONVECTION AND DIFFUSION MESHES AND LINEAR SYSTEM	**9**
Convection and diffusion on unstructured meshes- Linear system solvers	
UNIT 5 :INCOMPRESSIBLE FLOW IN FLUIDS	**9**
Incompressible flow field calculation- Staggered and co-located formulation. **TOTAL: 45 PERIODS**	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1. Students will have knowledge on governing equations.

CO2: Students will learn about steady and unsteady diffusion equations.

CO3: To learn about space groups and translational of crystals.

CO4: To study the mathematical model of unstructured meshes.

CO5: To learn about incompressible fluid flow system.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Numerical Heat Transfer and Fluid Flow, Suhas V. Patankar, Hemisphere, New York, 1980.
2. An Introduction to Computational Fluid Dynamics - The Finite Volume Method, H. K. Versteeg and W. Malalasekra, Pearson Education, 2017.
3. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press, 2010.

REFERENCE BOOKS:

1. The Finite Volume Method in Computational Fluid Dynamics, F. Moukalled, L. Mangani, M. Darwish, Springer, 2015
2. Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric, Springer, 2002

WEB RESOURCES:

http://www.gidropraktikum.narod.ru/Moukalled-et-al-FVM-OpenFOAM-Matlab.pdf

http://ftp.demec.ufpr.br/disciplinas/TM702/Versteeg_Malalasekera_2ed.pdf

ME606409–FOUNDATION OF COMPUTATIONAL FLUID DYNAMICS (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand knowledge computational fluid dynamics governing ,Diffusion, convections, linear equations.

UNIT 1 : STREAM FLOW IN COMPUTATIONAL MECHANICS | **9**

Introduction-Review of basic fluid mechanics- Review of equations and importance of terms- Review of equations (contd.) and non-dimensionalization-Vorticity-Stream function equation, classification of equation and the solution nature- Classification of equations (contd.), types of boundary conditions anddescription about standard test cases.

UNIT 2 : COMPUTATIONAL FLUID DYNAMICS AND FUNCTIONS | **9**

Steps involved in CFD, Information about Computational domain and grid with illustration- Information about grid (contd.); Taylor's series expansion- Taylor's series expansion, CD / FD / BD for first & second derivative- FD formula for non-uniform mesh; mixed derivative- Derivation for higher derivative; FD formula by Polynomial procedure

UNIT 3 : MATHEMATICAL ANALYSIS OF CFD | **9**

Different Approximation Methods- Properties associated with discretization- Errors due to approximation and their analysis – consistency, convergence- Stability analysis- FD formulation for model equations and explanation.

UNIT 4 : FORMULATION OF 1D,2D AND 3D EQUATIONS | **9**

FV formulation for diffusion equation – 1D- Example and extension to 2D and 3D- FV formulation for convection and diffusion equation- Treatment of convective terms - different interpolations.

UNIT 5 :FUNCTIONAL ANALYSIS OF CFD | **9**

Illustration on the performance by different approximation for convection terms- Time integration methods- Arrangement of variables; Introduction to Pressure velocity coupling, MAC- SIMPLE- Variants of SIMPLE, Projection Method.**TOTAL: 45 PERIODS**

Course Outcomes: At the end of the course, the student will be able to

CO1. Students will learn the stream flow in computational mechanics.

CO2: Students will learn about computational fluid dynamics and functions.

CO3: To learn about the mathematical analysis of CFD.

CO4: To study the formulation of dimensional equations.

CO5: To learn the functional analysis of CFD

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Anderson, D.C., J.C, Tannehil, and R.H.Fletcher, Computational Fluid Mechanics, Hemisphere Publishing Corporation, NewYork.
2. Ferziger, J.H. and M.Peric, Computational Methods for Fluid Dynamics, Springer, 3rd Edition, 2002

REFERENCE BOOKS:

1. Versteeg, H.K. and W.Malalasekera, An Introduction to Computational Fluid Dynamics – The Finite Volume method, Second Edition, 2007.
2. Chung, T.J., Computational Fluid Dynamics,Cambridge University Press,2002.

WEB RESOURCES:
https://onlinecourses.nptel.ac.in/noc20_me64/preview

ME606410– COMPUTATIONAL FLUID DYNAMICS FOR TURBO MACHINERY (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand knowledge computational fluid dynamics in Turbo machines, Hydraulic turbines and Gas turbines.

UNIT 1 : INTRODUCTION TO FLUID FLOWS	**9**
Introduction to Fluid Flow- Flow field, Stresses on fluid element, Newtonian fluid- Non Newtonian fluid, Classification of flow, Analysis of flow.	
UNIT 2 : INTEGRAL ANALYSIS AND DIFFERENTIAL ANALYSIS	**9**
Integral analysis, Control volume, Generalised conservation equation- Mass and linear momentum conservation in CV- Differential Analysis- Navier-Stokes equation for 2D incompressible flow	
UNIT 3 : INTRODUCTION TO TURBOMACHINE	**9**
Basic Thermodynamics- Turbomachines: Definition and classification- Dimensional Analysis- Representation of Turbomachines and Definition of velocity- Euler's energy equation- Real fluid flow and efficiency of turbomachine.	
UNIT 4 : PERFORMANCE OF PUMPS AND HYDRAULIC TURBINES	**9**
Pumps-Pumping Systems-Hydraulic Turbines: Pelton Turbine-Hydraulic Turbines: Reaction Turbines-Cavitation in Hydroturbomachines	
UNIT 5 :PERFORMANCE OF STEAM AND GAS TURBINES	**9**
Introduction to compressible flow-Steam and Gas Turbine: Introduction and classification-Steam and Gas Turbine : h-s Plots and velocity triangle.	
TOTAL: 45 PERIODS	

Course Outcomes: At the end of the course, the student will be able to

CO1. Students will have knowledge on fluid flow systems.

CO2: Students will learn about mathematical analysis of fluids.

CO3: Student will learn about derivations of turbomachines.

CO4: To study the performance of pumps and hydraulic turbines.

CO5: To study the performance of steam and gas turbines.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS

1. Fluid Mechanics and Thermodynamics of Turbomachinery, by Cesare Hall , Ph.D. Dixon, S.L., B.Eng. Butterworth-Heinemann Inc 2013

2. The Design of High-Efficiency Turbomachinery and Gas Turbines, by Wilson David Gordon , KorakiantisTheodosios.PHI Learning Private Limited-2016

REFERENCE BOOKS:

1. Fluid Dynamics and Heat Transfer of Turbomachinery,BudugurLakshminarayana, John Wiley & Sons, Inc.1995

WEB RESOURCES:

https://drive.google.com/file/d/1R1yfgjqDX86s8d9zgcNrpmkqlVCeGD0i/view?pli=1

VERTICAL 5: DIVERSIFIED COURSES GROUP

ME606501 DESIGN OF JIGS, FIXTURES AND PRESS TOOLS

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the functions and design principles of Jigs, fixtures and press tools
- To gain proficiency in the development of required views of the final design.

UNIT 1 : PURPOSE TYPES AND FUNCTIONS OF JIGS AND FIXTURE | **9**

of tool design- Function and advantages of Jigs and fixtures – Basic elements -principles of location – Locating methods and devices – Redundant Location – Principles of clamping -pneumatic and hydraulic actuation Standard parts – Drill bushes and Jig buttons – Tolerances and materials used.

UNIT 2 : JIGS AND FIXTURES | **9**

Design and development of jigs and fixtures for given component- Types of Jigs – Post, Turnover, Channel, latch, box, pot, angular post jigs – Indexing jigs – General principles of milling, Lathe, boring, broaching and grinding fixtures – Assembly, Inspection and Welding fixtures – Modular fixturing systems- Quick change fixtures.

UNIT 3: PRESS WORKING TERMINOLOGIES AND ELEMENTS OF DIES AND STRIP | **9**

Press working terminology-Presses and press accessories-Computation of capacities and tonnage requirements. Elements of progressive combination and compound dies:Die block-die shoe. Bolster plate-punch plate-punch holder-guide pins and bushes – strippers –knockouts-stops –pilots-Selection f standard die sets strip lay out-strip lay out calculations

UNIT 4: BENDING AND DRAWING DIES | **9**

Difference between bending and drawing – Blank development for above operations – Types of Bending dies – Press capacity – Spring back – knockouts – direct and indirect – pressure pads -Ejectors – Variables affecting Metal flow in drawing operations – draw die inserts – draw beads- ironing – Design and development of bending, forming, drawing, reverse redrawing and combination dies – Blank development for axisymmetric, rectangular and elliptic parts – Single and double action dies.

UNIT 5:FORMING TECHNIQUES AND EVALUATION | **9**

Bulging, Swaging, Embossing, coining, curling, hole flanging, shaving and sizing, assembly, fine Blanking dies – recent trends in tool design- computer Aids for sheet metal forming Analysis – basic introduction – tooling for numerically NC machines- setup reduction for work holding – Single minute exchange of dies

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Summarize the different methods of Locating Jigs and Fixtures and Clamping principles

CO2 :Design and develop jigs and fixtures for given component

CO3 :Discuss the press working terminologies and elements of cutting dies

CO4: Distinguish between Bending and Drawing dies.

CO5 :Discuss the different types of forming techniques

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Joshi, P.H. Jigs and Fixtures, Second Edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 2010.

2.Joshi P.H Press tools – Design and Construction, wheels publishing, 1996
REFERENCE BOOKS:
1.ASTME Fundamentals of Tool Design Prentice Hall of India.
2.Design Data Hand Book, PSG College of Technology, Coimbatore.
3.Donaldson, Lecain and Goold Tool Design, 5th Edition, Tata McGraw Hill, 2017.
4.Hoffman Jigs and Fixture Design, Thomson Delmar Learning, Singapore, 2004.
5.Kempster, Jigs and Fixture Design, Third Edition, Hoddes and Stoughton, 1974.
6.Venkataraman. K., Design of Jigs Fixtures and Press Tools, Tata McGraw Hill, New Delhi, 2005.
WEB RESOURCES:
https://www.wiley.com/en-gb/Design+of+Jigs,+Fixtures+and+Press+Tools-p-9781119155652

MA606403 MECHANICAL VIBRATION AND CONTROLS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The main objective of course is to present fundamentals to a modern treatment of vibrations, the control strategies using active and passive control methods.

UNIT 1 : BASICS OF VIBRATION **9**

Introduction, classification of vibration: free and forced vibration, undamped and damped vibration, linear vibration, response of damped and undamped systems under harmonic force, analysis of single degree systems, torsional vibration – determination of natural frequencies and critical speed of shafts.

UNIT 2 : VIBRATION REDUCTION AT THE SOURCE: **9**

Balancing, Balancing of Rigid Rotors, Balancing Machines, Field Balancing, Balancing of Flexible Rotors, Vortex Induced Vibration, Detuning and Decoupling.

UNIT 3: VIBRATION CONTROL BY STRUCTURAL DESIGN **9**

Damping Models and Measures, Origin of Structural Damping, Damping-Stress Relationship, Selection Criteria for Linear Hysteretic Materials, Combined Fatigue-Strength Damping Criteria, Design for Enhanced Material Damping.

UNIT 4: DYNAMIC VIBRATION ABSORBERS **9**

Dynamic Vibration Neutralizers, Self-tuned Pendulum Neutralizer, Optimum Design of Damped Absorbers, Auxiliary Mass with Damper, Gyroscopic Absorber, Impact Absorber, Absorbers attached to Continuous Systems, Special types of Absorbers, Applications of DVA.

UNIT 5:ACTIVE VIBRATION CONTROL **9**

Closed Loop Control, Classical Control System, Piezoelectric Sensors and Actuators, Vibration Control of Flexible Beam, Energy Harvesting System introduction, Isolators with Complex Stiffness, Isolators with Coulomb Damping, Three Element Isolators, Two-stage Isolators, Suspension systems, Applications of Isolators. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1 Explain basics of sound, noise and vibration; as well as their control strategies.

CO2 : Derive equations of motion for undamped one-dimensional vibrations, and solve problems of damped free vibrations.

CO3 : Analyse and solve problems of forced vibrations involving frequency response curves, phase angle plots, vibration isolation and transmissibility.

CO4 :Analyse and solve problems involving vibrations of systems having more than one degree of freedom.

CO5 : Recall and explain concepts involving vibrations of continuous systems.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Ambekar. A. G., Mechanical Vibrations and Noise Engineering", Prentice Hall of India Pvt. Ltd., 2006.

2.Singiresu S. Rao, "Mechanical Vibrations", Pearson Education Incorporated, 2017.

REFERENCE BOOKS:

1.Benson H. Tongue, "Principles of Vibrations", Oxford University, 2007.

2.David A. Bies and Colin H. Hansen, "Engineering Noise Control – Theory and Practice", Spon Press,

2009.
3.Grover. G.K., edited by Nigam. S. P., “Mechanical Vibrations”, Nem Chand and Bros., 2014.
4.JulianHappian-Smith – “An Introduction to Modern Vehicle Design”, Butterworth-Heinemann, 2001.
5.William T. Thomson, “Theory of Vibration with Applications”, Taylor and Francis, 2003.
WEB RESOURCES:
https://www.wiley.com/en-gb/mechanical+vibrations-p-9781119155652
https://www.springerprofessional.de/en/vibration/19392834

ME606502 INSTRUMENTATION FOR ENGINEERS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

Ability to understand and analyze Instrumentation systems and their applications to various industries.
To gain proficiency in the measurements of required product of the final form.

UNIT 1 : MEASUREMENT OF ACCELERATION, VIBRATION AND DENSITY | **9**

Accelerometers :- LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers - Mechanical type vibration instruments - Seismic instruments as accelerometer - Vibration sensor - Calibration of vibration pickups - Units of density and specific gravity - Baume scale and API scale - Pressure type densitometers - Float type densitometers - Ultrasonic densitometer - gas densitometer.

UNIT 2 : PRESSURE MEASUREMENT AND GAUGES | **9**

Units of pressure - Manometers, different types, Elastic type pressure gauges, Bourdon tube, bellows and diaphragms - Electrical methods:- Elastic elements with LVDT and strain gauges -Capacitive type pressure gauge - Piezo resistive pressure sensor-Resonator pressure sensor - Measurement of vacuum-McLeod gauge-Thermal conductivity gauge-Ionization gauges - Cold cathode type and hot cathode type - calibration of pressure gauges -Dead weight tester.

UNIT 3: THERMOMETERS AND THERMISTORS | **9**

Definitions and standards - Primary and secondary fixed points - Calibration of thermometers - Different types of filled in system thermometers - Sources of errors in - filled in systems and their compensation - Bimetallic thermometers - RTD - characteristics and signal conditioning-3 lead and 4 lead RTDs – Thermistors.

UNIT 4: TEMPERATURE MEASUREMENT | **9**

Thermocouples - Laws of thermocouple - Fabrication of industrial thermocouples - Signal conditioning for thermocouple - isothermal block reference junctions - Commercial circuits for cold junction compensation - Response of thermocouple - Special techniques for measuring high temperature using thermocouple.

UNIT 5:RADIATION | **9**

Radiation fundamentals - Radiation methods of temperature measurement - Total radiation pyrometers - Optical pyrometers - Two colour radiation pyrometers - Fiber optic sensor for temperature measurement.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At The End Of The Course, The Student Will Be Able To

CO1: To know the Measurement techniques of Acceleration, Vibration And Density

CO2: Able to understand Pressure Measurement methods.

CO3: Learn the usage of Thermometers And Thermistors

CO4: Temperature Measurement

CO5: To know the radiation measurement and their effects.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Joshi, P.H. Jigs and Fixtures, Second Edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 2010.

2.Joshi P.H Press tools – Design and Construction, wheels publishing, 1996
REFERENCE BOOKS:
1.ASTME Fundamentals of Tool Design Prentice Hall of India.
2.Design Data Hand Book, PSG College of Technology, Coimbatore.
3.Donaldson, Lecain and Goold Tool Design, 5th Edition, Tata McGraw Hill, 2017.
4.Hoffman Jigs and Fixture Design, Thomson Delmar Learning, Singapore, 2004.
5.Kempster, Jigs and Fixture Design, Third Edition, Hoddes and Stoughton, 1974.
6.Venkataraman. K., Design of Jigs Fixtures and Press Tools, Tata McGraw Hill, New Delhi, 2005.
WEB RESOURCES:

ME606503 AUTOMOBILE ENGINEERING					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**3**	**3**

COURSE OBJECTIVES:

- Tostudytheconstructionand working principleofvariouspartsofanautomobile.
- Tostudythepracticefor assembling and dismantlingofenginepartsandtransmissionsystem
- Tostudyvarioustransmission systemsofautomobile.
- Tostudy aboutsteering,brakes andsuspensionsystems
- Tostudy alternativeenergysources

UNIT 1 : VEHICLESTRUCTUREANDENGINES **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 2 : 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 3: TRANSMISSION SYSTEMS **9**

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Overdrive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

UNIT 4: 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 5: 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: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Recognize the various parts of the automobile and their functions and materials.

CO2: Discuss the engine auxiliary systems and engine emission control.

CO3: Distinguish the working of different types of transmission systems.

CO4: Explain the Steering, Brakes and Suspension Systems.

CO5: Predict possible alternate sources of energy for IC Engines.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

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.HeinzHeisler, “Advanced Engine Technology,” SAE International Publications USA, 1998.
3.JosephHeitner, “Automotive Mechanics,” Second Edition, East-West Press, 1999.
4.Martin W, Stockel and Martin T Stockle , “Automotive Mechanics Fundamentals,” The Good heart - WillCox Company Inc, USA ,1978.
5.Newton, Steeds and Garet, “Motor Vehicles”, Butterworth Publishers,1989.
WEB RESOURCES:https://www.iare.ac.in/sites/default/files/IAE%20LT.pdf

ME606504 REVERSE ENGINEERING					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Applying the fundamental concepts and principles of reverse engineering in product design and development.
- Applying the concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.
- Applying the concept and principles of material identification and process verification in reverse engineering of product design and development.
- Analysing the various legal aspect and applications of reverse engineering in product design and development.
- Understand about 3D scanning hardware & software operations and procedure to generate 3D model.

UNIT1:INTRODUCTION & GEOMETRIC FORM | **9**

Hours Definition – Uses – The Generic Process – Phases – Computer Aided Reverse Engineering - Surface and Solid Model Reconstruction – Dimensional Measurement – Prototyping.

UNIT 2 : MATERIAL CHARACTERISTICS AND PROCESS IDENTIFICATION | **9**

Hours .Alloy Structure Equivalency – Phase Formation and Identification – Mechanical Strength – Hardness –Part Failure Analysis – Fatigue – Creep and Stress Rupture – Environmentally Induced Failure Material Specification - Composition Determination - Microstructure Analysis - Manufacturing Process Verification.

UNIT 3: DATA PROCESSING | **9**

Hours Statistical Analysis – Data Analysis – Reliability and the Theory of Interference – Weibull Analysis – Data Conformity and Acceptance – Data Report – Performance Criteria – Methodology of Performance Evaluation – System Compatibility.

UNIT 4:3D SCANNING AND MODELLING | **9**

Hours Introduction, working principle and operations of 3D scanners: Laser, White Light, Blue Light - Applications- Software for scanning and modelling: Types- Applications- Preparation techniques for Scanning objects- Scanning and Measuring strategies - Calibration of 3D Scanner- Step by step procedure: 3D scanning - Geometric modelling – 3D inspection- Case studies.

UNIT 5: INDUSTRIAL APPLICATIONS | **9**

Hours Reverse Engineering in the Automotive Industry; Aerospace Industry; Medical Device Industry. Case studies and Solving Industrial projects in Reverse Engineering.Legality: Patent – Copyrights –Trade Secret – Third-Party Materials.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1 Apply the fundamental concepts and principles of reverse engineering in product design and development

CO2 Apply the concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.

CO3 Apply the concept and principles of material identification and process verification in reverse engineering of product design and development.

CO4 Apply the concept and principles of data processing, part performance and system compatibility in reverse engineering of product design and development.

CO5 Analyse the various legal aspect

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	3	-	1	-	-	-	1	-	3	-
CO2	3	2	-	-	3	-	-	-	-	-	-	-	-	2

CO3	-	2	-	-	3	-	-	-	-	-	-	-	-	2
CO4	-	2	2	-	-	-	-	-	-	-	-	-	-	-
CO5	3	3	2	-	-	-	-	-	-	-	-	-	-	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Robert W. Messler, Reverse Engineering: Mechanisms, Structures, Systems & Materials, 1st Edition, McGraw-Hill Education, 2014

2. Wego Wang, Reverse Engineering Technology of Reinvention, CRC Press, 2011 .

REFERENCE BOOKS:

1. Scott J. Lawrence , Principles of Reverse Engineering, Kindle Edition, 2022

2. Kevin Otto and Kristin Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall, 2001

3. Kathryn, A. Ingle, "Reverse Engineering", McGraw-Hill, 1994

4. Linda Wills, "Reverse Engineering", Kluver Academic Publishers,

5.Vinesh Raj and KiranFernandes, "Reverse Engineering: An Industrial Perspective", SpringerVerlag London Limited 2008.

WEB RESOURCES:

https://classes.engineering.wustl.edu/2009/fall/ese405/405chapter1.pdf

https://www.ieor.iitb.ac.in/acad/courses/ie646

ME606505 NUCLEAR ENGINEERING						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To introduce to the students, the various concepts in the design of nuclear reactors and power plants.
- To make students familiar with the important concepts applicable in the design of nuclear plants and reactors, their fundamental performance principles, concepts and modeling techniques.

UNIT 1 : REACTOR HEAT GENERATION **9**

Energy release and deposition, Heat generation parameters, Neutron flux distributions and power profiles in reactor cores, Power peaking factors, Heat generation in the structure, Reactor shutdown heat generation.

UNIT 2 : REACTOR HEAT REMOVAL **9**

Heat transfer via thermal conduction, Thermal properties of fuel materials, Radial steady-state temperature distribution in fresh fuel and restructured fuel elements, Heat transfer via convection in single-phase coolants, Radial heat transfer from fuel element to coolant, Hydraulic flow in heated channels, heat transfer coefficients, Axial steady-state temperature distribution in fuel elements, Boiling heat transfer in nuclear reactors, Pressure drop through primary coolant loop, Heat removal and pumping power.

UNIT 3: NUCLEAR REACTOR DESIGN **9**

Hot channel, hop spot factors, statistical methods, Overall hot channel factor, Applications of hot channel factors, Determination of reactor core characteristics (thermal – hydraulic analysis), Thermal design limits and safety margins, Figures of merit for core thermal performance.

UNIT 4: DESIGNS OF NUCLEAR POWER PLANTS **9**

Pressurized Water reactors, Boiling water reactors, gas-cooled reactors, heavy water reactors, liquid metalcooled fast reactors transient analysis (dynamics and safety) Temperature coefficients of reactivity, reactivity feedback, Loss-of-cooling accidents, Reactivity insertion accidents, Containment pressurization process, Response of a PWR pressurizer to load changes, Nuclear Power Plant control.

UNIT 5: ENERGY SOURCES AND DEVICES **9**

Stability of nucleus: mass defect (problems), binding energy; Nuclear energy: light water nuclear power plant, breeder reactor. Solar energy conversion: Principle, working and applications of solar cells; Recent developments in solar cell materials and examples.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Gain some fundamental knowledge about nuclear physics.

CO2: Acquire knowledge about nuclear reactor.

CO3: understand about nuclear fuels and will become capable of handling nuclear waste.

CO4 Understand about core thermal design.

CO5: Predict possible alternate energy.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. N. E. Todreas, M. S. Kazimi, , "Nuclear Systems I: Thermal Hydraulic Fundamentals" , Taylor & Francis, Edition II, 1993

REFERENCE BOOKS:

1. J. R. Lamarsh, A. J. Baratta, "Introduction to Nuclear Engineering", Prentice-Hall, 2001.
2. J. J. Duderstadt, L. J. Hamilton, "Nuclear Reactor Analysis", John Wiley & Sons, 1976
3. . Y. A. Cengel, R. H. Turner, "Fundamentals of Thermal-Fluid Sciences", McGraw-Hill, 2001.

WEB RESOURCES:https://leverageedu.com/blog/nuclear-engineering/
https://archive.nptel.ac.in/content/syllabus_pdf/115102017.pdf

ME606506 PRODUCTION PLANNING AND CONTROL

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the concept of production planning and control act work study.
- To apply the concept of product planning.
- To prepare the manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).

UNIT 1 : 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 2 : 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 3: 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 multi product system.

UNIT 4: 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 controlMaterial requirement planning kanban – Dispatching-Progress reporting and expediting- Manufacturing lead time-Techniques for aligning completion times and due dates.

UNIT 5: 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 and ERP.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1:The students can able to prepare production planning and control act work study,

CO2:The students can able to prepare product planning,

CO3:The students can able to prepare production scheduling,

CO4:The students can able to prepare Inventory Control.

CO5:They can plan manufacturing requirements manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).

CO's PO's&PSO's MAPPING

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

CO5	3	3	2	-	-	-	-	-	-	-	-	-	-	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. James. B. Dilworth, "Operations management – Design, Planning and Control for manufacturing and services" Mcgraw Hill International edition 1992.

2. MartandTelsang, "Industrial Engineering and Production Management", First edition, S. Chand and Company, 2000.

REFERENCE BOOKS:

1. Chary. S.N., "Theory and Problems in Production & Operations Management", Tata McGraw Hill, 1995.
2. Elwood S.Buffa, and RakeshK.Sarin, "Modern Production / Operations Management", 8th Edition John Wiley and Sons, 2000
3. Jain. K.C. & Aggarwal. L.N., "Production Planning Control and Industrial Management", Khanna Publishers, 1990
4. KanishkaBedi, "Production and Operations management", 2nd Edition, Oxford university press, 2007.
5. Melynk, Denzler, " Operations management – A value driven approach" Irwin Mcgraw hill.

WEB RESOURCES:

http://www.geethanjaliinstitutions.com/engineering/coursefiles/downloads/mech/ppc.pdf

https://www.managementstudyguide.com/production-planning-and-control.htm

MA606408-DESIGN OF QUALITY, MANUFACTURING AND ASSEMBLY (NPTEL)

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To identify the manufacturing constraints that influence the design of parts and part systems. Students will be introduced to the Design for Manufacturability (DFM) methodology.
- Students will be motivated to understand infeasible or impractical designs.

UNIT I INTRODUCTION **9**

Design philosophy steps in Design process - General Design rules for manufacturability - basic principles of design Ling for economical production - creativity in design. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection process selection charts.

UNIT 2: MACHINING PROCESS **9**

Overview of various machining processes - general design rules for machining - Dimensional tolerance and surface roughness - Design for machining - Ease - Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts. Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.

UNIT 3: METAL JOINING **9**

Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints. Forging - Design factors for Forging - Closed dies forging design - parting lines of dies drop forging die design - general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

UNIT 4: ASSEMBLY& ASSEMBLY TRANSFER SYSTEMS **9**

Development of the assemble process, choice of assemble method assemble advantages social effects of automation. Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

UNIT 5: DESIGN OF MANUAL ASSEMBLY **9**

Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and. fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the quality aspects of design for manufacture and assembly

CO2: Apply Boothroyd method of DFM for product design and assembly

CO3: Apply the concept of DFM for casting, welding, forming and assembly

CO4: Identify the design factors and processes as per customer specifications

CO5: Apply the DFM method for a given product

CO's PO's&PSO's MAPPING

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

CO4	2	3	2	2	3	1	1	-	-	-	1	2	1	1
CO5	2	2	2	1	3	1	1	-	-	-	1	2	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed. 2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y. 1990

REFERENCE BOOKS:

1. Computer Aided Assembly London/ A Delbainbre/.
2. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight/CRC Press/2010

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/106/112106249/

MA606409-OIL HYDRAULICS AND PNEUMATICS (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Tounderstand the basic concepts of fluid power, types and properties.
- To understand various hydraulic pumps and its applications.
- To understand about pneumatic valves.
- To study about the concepts of design of hydraulic and pneumatic circuits.
- To understand the various applications of hydraulics and pneumatics

UNIT I INTRODUCTION TO FLUID POWER | **9**

Introduction, Global fluid power Scenario, Basic system of Hydraulics-Major advantages and disadvantages, Comparison among Electrical, Hydraulics and Pneumatics System, Principles of Hydraulic Fluid power, Hydraulic Symbols,Types, Properties, physical characteristics & functions of hydraulic Oils, Classification Mineral based, Fire resistant& Biodegradable Oils, Filters, Contaminations, location of filter.

UNIT 2: HYDRAULIC PUMPS, MOTORS, VALVE AND ACTUATORS | **9**

Classification of hydraulic pumps, Gear Pumps, Vane Pumps, Piston Pumps, Axial piston pumps, Hydraulic motors, Direction control valves, Pressure control valves, Flow control valves, Non-return valves, Reservoirs, Accumulators, Heating & cooling devices, Hoses. Types of Hydraulic Actuators, Selection criterion of Actuators, Linear and Rotary Actuators, Hydrostatic Transmission Systems.

UNIT 3: INTRODUCTION TO PNEUMATICS | **9**

Types & Selection criteria for Air Compressors, Air receiver, Pipeline Layout, Air filter, Pressure regulator and Lubricator (FRL unit),Types of Pneumatic Cylinders & Air motors, Cushion assembly, mounting Arrangements, Pneumatic Direction control valves, Quick exhaust, Time delay Shuttle and Twin pressure valves.

UNIT 4: DESIGN OF HYDRAULIC AND PNEUMATIC CIRCUITS | **9**

Basic hydraulic circuits, Industrial hydraulic circuits, Power losses in flow control circuits, Basic pneumatic circuits, Development of single Actuator Circuits, Development of multiple Actuator Circuits, Cascade method for sequencing

UNIT 5: APPLICATIONS | **9**

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 handlingin CNC Machine tools — Low cost Automation — Hydraulic and Pneumatic power packs.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate components for hydraulic and pneumatic systems and their applications.

CO2: Interpret functions of different hydraulic valves and make use of them in circuit design.

CO3: Interpret functions of different pneumatic valves and make use of them in circuit design.

CO4: Design and analyze hydraulic and pneumatic circuits for specific applications.

CO5: To understand the applications of Hydraulic and Pneumatic circuits

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Fluid Power with Applications by Anthony Esposito, Pearson.
2. Fluid Power: Generation, Transmission and Control, Jagadeesha T., ThammaiahGowda, Wiley.

REFERENCE BOOKS:

1. Industrial Hydraulics by John Pippenger and Tyler Hicks, McGraw Hill.
2. Oil Hydraulic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill.
3. Hydraulic and Pneumatic Controls: Understanding made Easy, K.ShanmugaSundaram, S.Chand& Co Book publishers, New Delhi, 2006 (Reprint 2009)
4. Basic Pneumatic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill.

WEB RESOURCES: https://archive.nptel.ac.in/courses/112/106/112106300/

MA606410-ADVANCED OPEATIONS RESEARCH (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Tounderstand the basic concepts of operational research.
- To introduce fundamental issues in production planning and inventory
- To introduce the concepts of decision theory.
- To study about the concepts of gaming theory for strategic planning
- To focus the various problems on project scheduling and techniques

UNIT I INTRODUCTION TO OPERATIONAL RESEARCH | **9**

Basics of Operational Research: Origin & Development of Operational Research, Definition and Meaning of Operational Research, Different Phases of an Operational Research Study, Scope and Limitations of Operational Research, Mathematical Modeling of Real Life Problems.

UNIT 2: PRODUCTION AND INVENTORY MANAGEMENT | **9**

Introduction to inventory systems, inventory classification and its use in controlling inventory.Deterministic inventory models: Economic order quantity (EOQ) model, EOQ with finite supply, EOQ with backorders, EOQ with constraints, All-units quantity discounts model.

UNIT 3: DECISION THEORY | **9**

Decision making without and with experimentation. Decision Trees. Utility theory. Decision under risk: expected value, expected value - variance, aspiration - level, and most likely future criteria. Decision under uncertainty: Laplace and Minimax (Maxmin) criteria.

UNIT 4: GAMING THEORY | **9**

Concepts of Game problem. Two- person zero-sum game. Pure and Mixed strategies. Saddle point and its existence. Fundamental Theorem of Rectangular games. Concept of Dominance. Dominance and Graphical method of solving Rectangular games. Relationship between rectangular game and Linear Programming Problem. Solving rectangular game by Simplex method.

UNIT 5: SCHEDULING TECHNIQUES | **9**

Project Scheduling: PERT and CPM with known activity times. Critical Path Analysis, Various types of floats. Probability considerations in PERT. Updating of PERT charts. Project crashing. Formulation of CPM as a linear programming problem. Resource leveling and resource scheduling.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Demonstrate concepts of operational research and linear programming.

CO2: To study the concepts and various techniques in production and inventory management.

CO3: To understand the basics of decision theory.

CO4: To understand the basic concepts of gaming theory for strategic planning.

CO5: To understand the various techniques of scheduling theory.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall, 9th Edition, 2010.
2. A. Ravindran, D. T. Phillips and James J. Solberg: Operations Research- Principles and Practice, John Wiley & Sons, 2005.

REFERENCE BOOKS:

1. J. D. Weist, F. K. Levy: A Management Guide to PERT/ CPM. 2nd Edition, PHI, 1967 (Reprint 2007).
2. Edward A. Silver, David F. Pyke and Rein Peterson: Inventory Management and Production Planning and Scheduling, John Wiley, 3rd Edition, 1998.
3. J. W. Pratt, H. Raiffa, R. Schlaifer: Introduction to Statistical Decision Theory, The MIT Press, 1995
4. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/106/112106131/

https://www.digimat.in/nptel/courses/video/112106131/L06.html

VERTICAL 6: MATERIALS SCIENCES

MA606101- COMPOSITE MATERIALS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- This course is designed as an introductory course on "Composite Materials". The course objectives are to Train students on composite materials–definition, advantages and classification.
- Equip students with knowledge on composite strengthening addition of components and their production routes.
- Familiarize students about the properties and response of composite structures subjected to mechanical loading.

UNIT 1: INTRODUCTION TO THE COMPOSITE MATERIAL **9**

Introduction and overview of composite materials and their need – Enhancement ofproperties, classification of composites – Matrix-Polymermatrix composites (PMC), Metal matrixcomposites(MMC),Ceramicmatrixcomposites(CMC),Application of composites.

UNIT 2: REINFORCEMENTSMATERIALS AND MATRIX **9**

Metallic,Polymer,CeramicandCompositefibres,WhiskersandParticulates, Nano-fillers used in polymer composites, Reinforcement fibres, Woven fabrics and Non-wovenrandommats – Commonly used Matrices (Metal matrix, Polymer matrix, Ceramic matrix, Inter-metallicmatrix,Carbon-Carboncomposites), BasicRequirementsinSelectionofconstituents

UNIT 3: MANUFACTURING METHODS **9**

Hand and spray lay - up, injection moulding, resin injection, filamentwinding,pultrusion,centrifugalcastingandprepregs.Fibre/MatrixInterface,mechanical.Measurementof interfacestrength.Characterizationofsystems;carbonfibre/epoxy, glassfibre/polyester.

UNIT 4: MECHANICALPROPERTIESOF COMPOSITES **9**

Introduction, Strength of Materials Approach, Geometricalaspects– volumeandweightfraction.Unidirectionalcontinuousfibre,discontinuousfibers,Shortfibersystems,wovenreinfo rcements –Mechanical Testing: Determination of stiffness and strengthsof unidirectionalcomposites; tension, compression, flexureand shear

UNIT 5: RECENT DEVELOPMENTS IN COMPOSITES **9**

Self-healing composites, Molecular composites, Micro andNanocomposites, Bio-composites, Left handed composites, Stiffer than stiff composites, Carbon /carboncomposites(Advantages and limitationsofcarbon matrix).**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Ability to identify the need, physical and mechanical properties in manufacturing of composites

CO2: Describe the properties of various reinforcements of composite materials

CO3: Demonstrateapracticalunderstandingofcompositepropertiesandfabricationtechniques.

CO4: Identify and understand the basic mechanical behaviour of composite materials and make sound prediction on the likely behaviour of new combinations of materials

CO5: Apply the choices made for using certain types of composites in certain applications with reference to composite properties

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	2	-	-	1	-	-	-	1	1	1
CO2	2	-	2	-	2	-	-	1	-	-	-	2	1	1

CO3	2	3	-	-	3	-	-	1	-	-	-	2	1	1
CO4	2	-	3	2		-	-	1	-	-	-	1	1	1
CO5	2	-	3	-	2	-	-	1	-	-	-	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Mathews F. L. and Rawlings R. D., "Composite Materials: Engineering and Science", 1st Edition, Chapman and Hall, London, England, 1994.
2. Chawla K. K., "Composite materials", Second Edition, Springer – Verlag, 1998.

REFERENCE BOOKS:

1. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, ChapmanandHall, London, England,1stedition, 1994.
2. StrongA.B.,Fundamentalsof CompositeManufacturing,SME,1989.
3. SharmaS.C.,Compositematerials,NarosaPublications,2000.
4. Mallick, P.K, Composite Materials Technology: Process and Properties, Hanser, New York,1990.
5. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, ChapmanandHall, London, England,1stedition, 1994.

WEB RESOURCES:https://home.iitk.ac.in/~mohite/Composite_introduction.pdf

MA606102- TRIBOLOGY

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Tribology deals with design of fluid containment systems like seals and gasket, Lubrication of surfaces in relative motion to achieve reduced friction and wear.
- The structure of the bearing and the nature of fluid flow determine the loads that can be supported.

UNIT 1: INTRODUCTION TO TRIBOLOGY | **9**

Introduction to tribology - History of tribology - Tribology in design, tribology in industry Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity- Interdisciplinary Approach - Economic Benefits.

UNIT 2: FRICTION AND WEAR | **9**

Friction - Causes of Friction, friction theories, Adhesion Theory, Abrasive Theory, friction of metals and non-metals, Laws of Rolling Friction. Types of wear –Classification and mechanisms of wear, 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 3: LUBRICANTS AND LUBRICATION TYPES | **9**

Types and properties of Lubricants – Testing methods – Hydrodynamic Lubrication – Elasto–hydrodynamic lubrication- Boundary Lubrication – Solid Lubrication- Hydrostatic Lubrication, Introduction to hydrostatic lubrication, hydrostatic step bearings

UNIT 4: BEARING MATERIALS | **9**

Commonly used bearings materials, and properties of typical bearing materials - Advantages and disadvantages of bearing materials. Materials for rolling Element bearings – Materials for fluid film bearings – Materials for marginally lubricated and dry bearings.

UNIT 5: SURFACE ENGINEERING | **9**

Concept and scope of surface engineering- Surface modifications – Transformation Hardening, surface fusion – Thermo chemical processes – Surface coatings – Plating and anodizing – Fusion Processes – Vapour Phase processes -

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamentals of tribology and associated parameters.

CO2: Ability to identify different types of sliding and rolling friction, Wear and related theories

CO3: Ability to distinguish among the different Lubricant regime.

CO4: To Select proper bearing materials and lubricants for a given tribological application.

CO5: Apply the principles of surface engineering for different applications of tribology.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1."Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002

2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.

3.“Engineering Tribology”, J. A. Williams, Oxford Univ. Press, 2005.
REFERENCE BOOKS:
1. “Introduction to Tribology in bearings”, B. C. Majumdar, Wheeler Publishing.
2. “Tribology, Friction and Wear of Engineering Material”, I. M.Hutchings, Edward Arnold, London,1992.
3. “Engineering Tribology”, G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann,1992.
4. “Friction and Wear of Materials”, Ernest Rabinowicz, John Wiley & sons,1995.
5. “Basic Lubrication Theory”, A. Cameron, Ellis Hardwoods Ltd., UK
WEB RESOURCES:https://edurev.in/p/68841/What-is-Tribology-

MA606103 - MECHANICAL BEHAVIOUR OF MATERIAL					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The students able to understand basics of material structures and properties
- The students able to study the dislocation theories of plasticity behaviour.

UNIT 1: FUNDAMENTAL OF ELASTICITY **9**

Basic equations of elasticity: Strain – displacement relations, Stress – strain relations,bulk modulus, Shear modulus–Analysis of Strain and strain; atomistic basis–Nonlinear in crystalline materials: pseudoelasticity–Rubber elasticity: latex to DNA, Viscoelasticity: elasticity and fluidity, Plane state of stress, Mohr's diagram for 3dimensional state of stress.

UNIT 2: PLASTIC DEFORMATION OF METALS **9**

Elements of the theory of plasticity, Plastic deformation of single crystals, Dislocation theory, Strengthening mechanism– Tension test–Crystalline structure in metal–, mechanism of plastic deformation– factors affecting plastic deformation, strain hardening– recovery, recrystallization and grain growth–Mechanisms in crystalline materials and noncrystalline materials

UNIT 3: FRACTURE AND FRACTURE MECHANISM **9**

Fracture and Fracture Mechanics, Types of fracture, basic mechanism of ductile and brittle fracture–Griffiths theory of brittle fracture. Izod and Charpy Impacts tests– Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, determination of DBTT. Fracture mechanics–introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC–introduction to COD, J integral

UNIT 4: 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

UNIT 5: STRENGTHENING MECHANISMS **9**

cold working, grain size strengthening– Solid solution strengthening, martensitic strengthening, precipitation strengthening, dispersion strengthening, fibre strengthening, examples of above strengthening– mechanisms from ferrous and non-ferrous systems– simple problems. Yield point phenomenon–strain aging and dynamic strain aging.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the Basic field equations of linear elastic solids, force, stress, strain

CO2: Understand stress, strain, deformations, relation and plastic deformation in solids.

CO3: Ablity to understand about the fundamental of fracture mechanics

CO4: Ability to evaluate and Justify the safe use of materials for engineering application in high temperature

CO5: Ablity to apply their knowledge of strengthening mechanism in ferrous and nonferrous systems.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.William F. Hosford, Mechanical Behaviour of Materials, Cambridge University Press, New York, USA, 2005.

2.Marc A. Meyers and Krishan Kumar Chawla, Mechanical Behaviour of Materials, 2nd revised eds, Cambridge University Press, New York, USA, 2008.

3. M.A. Meyers and K.K. Chawla, Mechanical Behavior of Materials

REFERENCE BOOKS:

1 D.W.A. Rees, Basic Engineering Plasticity, Elsevier India, New Delhi, 2008

2. John D. Verhoeven, Fudamentals of Physical Metallurgy, Wiley, 1975.

3. Donald R. Askeland and Pradeep P. Phule, The Science and Engineering of Materials, 4th Eds, Thomson, Singapore, 2003.

WEB RESOURCES: https://www.youtube.com/watch?v=ASa5we7o1Ps

MA606104 POLYMER TECHNOLOGY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The objective of the course is to provide knowledge and understanding of the link between polymer chemical structure, physical properties, processing methods and ultimate applications.

UNIT 1: GENERAL ASPECTS OF POLYMERS | **9**

Classification of polymers- natural and synthetic – thermoplastic and thermosetting. Types and mechanism of polymerization: addition (free radical, cationic, anionic and living); condensation and copolymerization– Functionality-degree of polymerization. Techniques of polymerization: Bulk, emulsion, solution and suspension.

UNIT 2: PROPRTIES OF POLYMER | **9**

Chemistry of polymerization: Introduction to types of polymerization, emulsion, solution. Mechanism of Polymerization– Co-polymerization: Introduction, free readical, Ionic and Co polymerization– Kinetics of polymerization– free radical chain co polymerization.

UNIT 3: ELASTOMERS AND APPLICATION ORIENTED POLYMERS | **9**

Natural Rubber, Styrene – butadiene, Polyisopropane – Neoprene, Silicone rubber, Thermoplastic elastomers, Resins – PVC, Silicon Oil and resins, fibrous Polymers – Nylon 66, Polyacrylonitrile.

UNIT 4: MIXING AND MOULDING PROCESS | **9**

Additive and mixing process, different types of mixing devices, Types of mould – ejector system – ejection ntechniques – mould cooling – CAD/CAM, Extrusion, Moulding, Injection Moulding, Special Moulding techniques.

UNIT 5: POLYMER COMPOSITES | **9**

Fibrous and Laminated Composites Hybrid Composites – Matrix Resins – Unsaturated Polyester -Vinyl Ester – Epoxy- Phenol Formaldehyde – Urea Formaldehyde, Catalysts, Fillers, Reinforcements, Additives for Composites.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamentals of polymer and mechanism

CO2: Select appropriate techniques of polymerization.

CO3: Understand the knowledge of developing new formulation and products from elastomers.

CO4:Apply the mechanism and effectiveness of polymerization in making finished materials

CO5: Understand the manufacture and properties of application oriented industrial applications.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992.

2.F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.

3.Richard G.Griskey, Polymer Process Engineering, Chapman and Hall, 1995.

REFERENCE BOOKS:

Polymer Chemistry: A Practical Approach (The Practical Approach in Chemistry Series) 1st Edition Fred J. Davis Oxford University Press 2004 2.

A Practical Course in Polymer Chemistry S. H. Pinner, Borough Polytechnic London, Pergamon Press, New York, 1961 3.

Polymer Science by Gowarikar V.R, John Wiley and Sons 1986.

WEB RESOURCES:https://fac.ksu.edu.sa/sites/default/files/polymer-science-and-technology.pdf

MA606105 SMART MATERILAS

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The Objectives of the course are the make the students learn about
- Familiarize the smart material and its role in developing intelligent systems.
- Introduce the students with LBHS and HBLS smart material.
- Expose the students in smart system development and uses.

UNIT 1: INTRODUCTION TO SMART MATERIAL — **9**

Definition, classifications– need for smart material– components of smart materials– smart system applications– Closed loop and Open loop Smart Structures– the role of smart materials in developing intelligent systems and adaptive structure

UNIT 2: SHAPE MEMORY ALLOYS — **9**

Introduction– shape memory effect, Application– Processing and characteristics– Phenomenology– Influence of stress on characteristic temperatures– Modelling of shape memory effect. Vibration control through shape memory alloys– Design considerations, multiplexing embedded NiTiNOL actuators.

UNIT 3: PIEZO ELECTRIC AND MAGNETOSTRICTIVE MATERIAL — **9**

Piezo electric material – Constitutive relationship, electrochemical coupling coefficients piezoelectric constant – piezo ceramic material – polycrystalline vs single crystal piezoelectric materials – polyvenyldene fluoride. Magnetostrictivematerials: Magento mechanical coupling coefficient– Joule effect–Villari effect– Matteuci effect– Wiedemann effect.

UNIT 4: BIO MATERIALS — **9**

Biomaterials: Metallic biomaterials like 316L stainless steel–Co-Cr Alloys, Titanium Ti6Al4V, Ceramic biomaterials like Alumina– Zirconia, Carbon Hydroxyapatite – Polymeric biomaterials like Ultra high molecular weight polyethylene– Polyurethane, Processing and Applications of biomaterials.

UNIT 5: BULK METALLIC GLASSES — **9**

Bulk metallic glasses (BMG): Various methods for BMG production– Classification of BMG–Properties and behaviors of BMG– Thermodynamic aspects of stability– Potential applications of BMG, Processing and Applications of BMG.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Illustrate the application of smart material

CO2: Discuss the design considerations of shape memory alloy.

CO3: Describe the Constitutive relationship of Piezo electric and Magnetostrictive material

CO4: Understand the fundamentals of Biomaterials

CO5: Apply the BMA smart materials on industrial applications

CO's PO's&PSO's MAPPING

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

CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1."Smart Structures –Analysis and Design", A.V.Srinivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267).

2. "Smart Materials and Structures", M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107)

3. "Foundation of MEMS, by Chang Liu. Pearson Education. (ISBN:9788131764756)

REFERENCE BOOKS:

1.Brain culshaw, Smart Structures and Materials, Artech House, 2000

2. Gauenzi.P, Smart Structure, Wiley 2009

3. Cady.W.G, Piezoelectricity, Dover Publication

WEB RESOURCES:

https://www.tce.edu/sites/default/files/PDF/RV4-Smart-Materials.pdf

http://ae.metu.edu.tr/~yyaman/EPrasad2012/2012_METU_Lecture_1_Introduction_to_Smart_Materials_and_Systems.pdf

MA606106 ELECTRICAL, ELECTRONICS AND MAGNETIC MATERIAL					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The Objectives of the course are to understand the importance of various materials used in electrical, electronics and magnetic applications.
- Acquiring knowledge on the properties of electrical, electronics and magnetic materials.
- Getting equipped with the materials used in optical and optoelectronic applications.

UNIT 1: DIELECTRIC MATERIALS **9**

Dielectric as Electric Field Medium, leakage currents, dielectric loss, dielectric strength, breakdown voltage, breakdown in solid dielectrics, liquid dielectrics, electric conductivity in solid, liquid and gaseous dielectrics, Ferromagnetic materials, properties of ferromagnetic materials in static fields, spontaneous, polarization, curie point, anti-ferromagnetic materials, piezoelectric materials, pyroelectric materials.

UNIT 2: MAGNETIC MATERIALS **9**

Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials, magnetic Anisotropy, Magnetostriction, diamagnetism, magnetically soft and hard materials, special purpose materials, feebly magnetic materials, Ferrites, cast and cement permanent magnets, ageing of magnets. Factors affecting permeability and hysteresis.

UNIT 3: SEMICONDUCTOR MATERIALS **9**

Properties of semiconductors, Silicon wafers, integration techniques, Large and very large scale Integration techniques. Concept of superconductivity; theories and examples for high temperature superconductivity; discussion on specific superconducting materials; comments on fabrication and engineering applications.

UNIT 4: MATERIALS FOR ELECTRICAL APPLICATIONS **9**

Materials used for resistor, rheostats, heater, transmission line structures, stranded conductors, bimetals fuses, soft and hot solders, electric contact materials, electric carbon materials, thermocouple materials. Solid, Liquid and Gaseous insulating materials, Effect of moisture on insulation

UNIT 5: OPTICAL AND OPTOELECTRONIC MATERIALS **9**

Principles of photoconductivity – effect of impurities – principles of luminescence-laser principles -He-Ne, injection lasers, LED materials – binary, ternary photoelectronic materials – LCD materials -photo detectors – applications of optoelectronic materials – optical fibres and materials – electro optic modulators – Kerr effect – Pockels effect.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand various types of dielectric materials, their properties in various conditions.

CO2: Evaluate magnetic materials and their behavior

CO3: Evaluate semiconductor materials and technologies

CO4: Select suitable materials for electrical engineering applications

CO5: Identify right material for optical and optoelectronic applications

CO's PO's&PSO's MAPPING

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

CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1.Pradeep Fulay, Electronic, Magnetic and Optical materials, CRC Press, taylor and Francis, 2nd illustrated edition, 2017.

2.R K Rajput, A course in Electrical Engineering Materials, Laxmi Publications, 2009.

REFERENCE BOOKS:

1.T K Basak, A course in Electrical Engineering Materials, New Age Science Publications, 2009

2.TTTI Madras, Electrical Engineering Materials, McGraw Hill Education, 2004.

3.Adrianus J. Dekker, Electrical Engineering Materials, PHI Publication, 2006.

WEB RESOURCES:

https://www.vssut.ac.in/lecture_notes/lecture1426861925.pdf

https://www.youtube.com/watch?v=aNb6Ta-3U7A

MA606107 FRACTURE MECHANISM					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The Objectives of the course are the make the students learn about
- Familiarize the smart material and its role in developing intelligent systems.
- Introduce the students with LBHS and HBLS smart material.
- Expose the students in smart system development and uses.

UNIT 1: FRACTURE MECHANICS PRINCIPLES **9**

Introduction and historical review – Sources of micro and macro cracks – Stress concentration due to elliptical hole – Strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design – NDT and Various NDT methods used in fracture mechanics – Numerical problems. The Airy stressfunction. Effect of finite crack size. Elliptical cracks, Numerical problems.

UNIT 2: PLASTICITY EFFECTS **9**

Theory of Plastic deformation – Irwin plastic zone correction. Dugdale's approach – the shape of the plastic zone for plane stress and plane strain cases –the plate thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors – Experimental method- Plane strain fracture toughness test – The Standard test, size requirements, etc.

UNIT 3: ENERGY RELEASE RATE **9**

The energy release rate– criteria for crack growth–the crack resistance (R curve) tearing modulus stability– elastic plastic fracture mechanics: Fracture beyond general yield– the crack-tip opening displacement– Experimental determination of CTOD –Paramaters affecting the critical CTOD.

UNIT 4: J INTEGRAL **9**

Use of J integral – Limitation of J integral – Experimental determination of J integral and the parameters affecting J integral – Dynamics and crack arrest: Crack speed and kinetic energy –Dynamic stress intensity and elastic energy release rate – Crack branching. Principles of crack arrest – Crack arrest in practice – Dynamic fracture toughness

UNIT 5: FATIGUE CRACK PROPAGATION AND APPLICATIONS OF FRACTURE MECHANICS **9**

Crack growth and the stress intensity factor – Factors affecting crack propagation – Variable amplitude service loading – Means to provide fail-safety – Paris law – Required information for fracture mechanics approach.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the effects of crack like defects on the performance of Mechanical Engineering

CO2: Apply the concepts of fracture mechanics to select appropriate materials for engineering structures to ensure damage tolerance

CO3: Understand mechanics of crack tip fields and appropriate fracture characterizing parameters like stress intensity factor and J integral.

CO4: Apply the concepts of fracture mechanics to determine critical crack sizes and fatigue crack propagation rates in engineering structures

CO5: Understand the status of academic research in field of fracture mechanics.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
1.Elements of fracture mechanics Prasanth Kumar Wheeter publication 1999
2.Fracture Mechanics: Fundamentals and Applications Anderson CRC press 3rd Ed., 2005
REFERENCE BOOKS:
1.Introduction to fracture mechanics, karenHellanmcgraw Hill 2nd Edition.
2.Engineering fracture mechanics, S.A.Meguid Elsevier Applied science 1989.
WEB RESOURCES:
https://old.amu.ac.in/emp/studym/99995354.pdf
https://old.foundrygate.com/upload/artigos/NgfHfbLxJqz9fcd4L7NbtXdTKKW6.pdf

MA606108 BASICS OF MATERIAL ENGINEERING (NPTEL)					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The Objectives of the course is to introduce the basic concept of the material structure and properties.
- It involves investigating the relationships that exist between the structures and properties of materials.
- Involves, on the basic of these structure-property correlations, designing or engineering the structure of a material to produce a predetermined set of properties.

UNIT 1: INTRODUCTION TO MATERIALS AND CRYSTAL STRUCTURE | **9**

Proprties of the materials, Crystalline and amorphous solids, Crystal structure, Unit cell and primitive cell, Types of lattices (2D and 3D), cubic crystal systems (sc, bcc, fcc), Crystal symmetry and symmetry operation, Crystal Direction and Plane, Miller Indices, Liquid Crystal

UNIT 2: PHASE DIAGRAMS | **9**

Solid –liquid and solid-solid equilibria for metals and alloys, Phaserule, Phase diagram for pure metals (single component system),alloys (binary systems),Micro structural changes during cooling, Lever rule and its applications, Typical phasediagrams Homogeneous and heterogeneous systems, formation of Eutectic, Eutectoidmixtures, Non-equilibrium cooling,

UNIT 3: MECHANICS OF MATERIALS | **9**

Stress & Strain relationship and diagrams for differentmaterials (metals, non-metals, rubbers and plastics and polymers)-Elastic and plasticdeformation-Slip -stress required to move a dislocation; Multiplication of dislocations –Dislocation reactions, Effect on mechanical behavior of materials, Strain hardening/workhardening –Dynamic recovery, recrystallization grain growth. Ductile-Brittle transition

UNIT 4: MATERIAL SELECTION | **9**

Materials for chemical and petrochemical industrial processequipment, Effect of alloying on mechanical and chemical behavior of materials,Applications of heat treatment methods for strengthening of engineering materials.Composite structures and their advantages over conventional materials, Matrix-reinforcementproperties and evaluation of strength properties with different orientation of reinforcement,

UNIT 5: CORROSION | **9**

Stability criteria of materials in chemical/petrochemical industrialenvironments; Corrosion and Oxidation of materials; Basic mechanisms-types of corrosion;Corrosion testing and evaluation; Prevailing methods to combat corrosion; Coatings –metallic non-metallic, passivity, cathodic protection

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the concepts of atomic bonding, crystal structures, imperfections, diffusion, mechanical properties, electron energy, and dislocations as related to processing and performance of engineering materials.

CO2:.Understand the relations between the composition, temperature and phase fractions applied to equilibrium phase diagrams for given material systems

CO3: Enumerate principal stresses and shear stresses for simple two dimensional loadings

CO4:

CO5: To study, measure, monitor, control and prevent corrosion processes, economically and safely.

CO's PO's&PSO's MAPPING

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

CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Materials Science and Engineering,William D. Callister Jr., John Wiley & Sons. Inc, 5th Edition, 2001. 2. Mechanics of Composite Materials, Second Edition, Autar K. Kaw, CRC Press, 2005.

2. "Material Science & Metallurgy For Engineers", Dr. V.D. Kodgire& S. V. Kodgire, Everest Publication

REFERENCE BOOKS:

1. Materials Science and Engineering, V.Raghavan,PHI, 2002 5. Elements of Materials Science and Engineering, H. VanVlack, Addison- Wesley Edn., 1998 6. Materials Science and Engineering,William D. Callister Jr., John Wiley & Sons. Inc, 5th Edition, 2001.

WEB RESOURCES:https://www.madeeasy.in/uploads/examsolution/BasicsofMaterialScienceandEngg.pdf

http://www.bput.ac.in/lecture-notes-download.php?file=lecture_note_152311150152550.pdf

MA6061109 TRANSPORT PHENOMENON IN MATERIALS (NPTEL)

Course Category: Program Core	Course Type: Theory with project	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The Objectives of the course is to introduce the basic concept of the material structure and properties.
- To develop a fundamental knowledge of the physical principles that govern the transport of momentum, energy and mass, with emphasis on the mathematical formulation of the conservation principles.

UNIT 1: TRANSPORT PHENOMENA BY MOLECULAR MOTION	**9**

Vectors/Tensors, Newton's law of viscosity, Newtonian & Non-Newtonian fluids, rheological models, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity.

UNIT 2: ONE DIMENSIONAL MOMENTUM TRANSPORT	**9**

Shell Momentum balances, boundary conditions, velocity profiles, average velocity, momentum flux at the surfaces, of Newtonian and non-Newtonian for flow of a falling film, flow through circular tube, slits, flow through an Annulus, Adjacent flow of two Immiscible fluids. Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal) their applications in fluid flow problems.

UNIT 3: ONE DIMENSIONAL HEAT TRANSPORT	**9**

Shell mass balances, boundary conditions, concentration profiles, average concentration, mass flux at surfaces for Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneouschemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalystand the effectiveness factor,equation of continuity for binary mixtures, equation of change to set updiffusion problems for simultaneous heat and mass transfer.

UNIT 4: ONE DIMENSIONAL MASS TRANSPORT	**9**

Shell mass balances, boundary conditions, concentration profiles, average concentration, mass flux at surfaces for Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneouschemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalystand the effectiveness factor,equation of continuity for binary mixtures, equation of change to set updiffusion problems for simultaneous heat and mass transfer.

UNIT 5: TRANSPORT IN TURBULENT AND BOUNDARY LAYER FLOW	**9**

Turbulence phenomena; phenomenological relations for transfer fluxes; time smoothed equations of change and their applications for turbulent flow in pipes; boundary layer theory; laminar and turbulent hydrodynamics thermal and concentration boundary layer and their thicknesses; analysis of flow over flat surface. Introduction to macroscopic balances for isothermal flow systems, non- isothermal systems and multicomponent systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Students would gain the knowledge of fundamental connections between the conservation laws in heat, mass, and momentum in terms of vector and tensor fluxes

CO2:.To acquire knowledge on momentum, heat and mass transfer in Chemical engineering systems and their analogous behaviour.

CO3: Explain similarities and differences between the descriptions of the combined fluxes and the equations of change for mass, momentum and heat transport.

CO4: Apply the method of dimensional analysis to reformulate and then find the form of solutions of the equations of change, to determine the dependence of the interfacial fluxes on system parameters.

CO5: Able to understand the mechanism of fluids in motion under different conditions.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. R. B. Bird, W.E. Stewart, E.W. Lightfoot, Transport Phenomena, 2nd Revised Edition, John Wiley, 2007

2. Robert, S Brodkey, Harry C. Hershey, "Transport Phenomena A Unified Approach", Brodkey Publishing 2003.

3. Brodkey, R. S., and Hershey, H. C., "Transport Phenomena", McGraw-Hill, 1988

REFERENCE BOOKS:

1. Poirier, D. R., and G. H. Geiger. Transport Phenomena in Materials Processing. Warrendale, PA: TMS, 1994. ISBN: 9780873392723.

2. C. O. Bennett, J. O. Myers, Momentum, Heat and Mass Transfer, 2nd International Student Edition Mc-Graw Hill, 1983.

3. R. Welty, R.W. Wilson, and C.W.Wicks, Rorer G.E, Wilson R.W. "Fundamentals of Momentum Heat and Mass Transfer", 5th Edition, John Wiley, New York, 2007.

WEB RESOURCES:

https://www.notesforgeeks.in/2021/09/ch8791-transport-phenomena-syllabus-2017-regulation.html

MA606110 WELDING PROCESSESS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basics of welding and to know about the various types of welding processes.
- To select and apply knowledge, techniques, skills, and modern tools of the Welding Processes.

UNIT 1:INTRODUCTION TO WELDING PROCESSES	**9**

Definition, Terms used in welding, Advantages, Classification of welding processes. Gas and Arc Welding,Brazing and Soldering, Shielded metal arc Welding, Resistance Welding, Solid state welding.

UNIT 2: GAS AND ARC WELDING PROCESSES	**9**

Fundamental principles – Air Acetylene welding, Oxyacetylene welding, Carbon arc welding, Shielded metal arc welding, Submerged arc welding, TIG & MIG welding, Plasma arc welding and Electroslag welding processes - advantages, limitations and applications.

UNIT 3: RESISTANCE WELDING PROCESSES	**9**

. Spot welding, Seam welding, Projection welding, Resistance Butt welding, Flash Butt welding, Percussion welding and High frequency resistance welding processes - advantages, limitations and applications.

UNIT 4: DESIGN OF WELD JOINTS, WELDABILITY AND TESTING OF WELDMENTS	**9**

Various weld joint designs – Welding defects – causes and remedies - Weldability of Aluminium, Copper, and Stainless steels. Destructive and non destructive testing of weldments

UNIT 5: SAFETY IN WELDING	**9**

Concept of safety, Safety regulations: Safety act, laws of safety, Introduction to The Factories Act 1948, Factories act amendments in 1987, First Aid: Concept of first aid, Essential features of first aidSafety in welding, Safety precautions against fire, Safety management technique, Safety equipments, Safety during Welding operations.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the knowledge of welding fundamentals to solve welding problems

CO2: Understand the construction and working principles of gas and arc welding process.

CO3: Understand the construction and working principles of resistance welding process

CO4: Understand the concepts on weld joint design, weldability and testing of weldments

CO5: Able to understand Techniques of safety Management and safety performance Planning

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Little R.L., "Welding and welding Technology", Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.

2. Parmer R.S., “Welding Engineering and Technology”, 1st Edition, Khanna Publishers, New Delhi, 2008.
3. Parmer R.S., “Welding Processes and Technology”, Khanna Publishers, New Delhi, 1992.
REFERENCE BOOKS:
1. AWS- Welding Hand Book. 8th Edition. Vol- 2. “Welding Process”
2. Christopher Davis. “Laser Welding- Practical Guide”. Jaico Publishing House.
3. Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979
WEB RESOURCES:
https://nptel.ac.in/courses/112107090
https://www.twi-global.com/technical-knowledge/faqs/what-is-welding

VERTICAL 7: MANUFACTURING ENGINEERING

MA606201-COMPUTER INTEGRATED MANUFACTURING					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce the concepts of automation, group technology integrated to Computer aided design and manufacturing.
- To obtain an overview on computer aided process planning.
- To impart the knowledge of forecasting, scheduling capacity planning, shop-floor control in manufacturing systems and the concept of JIT manufacturing.
- To impart the basic knowledge of quality control, inspection methods and computer-aided testing.
- To classify and summarize the manufacturing systems, and integration of CAQC with CAD/CAM

UNIT 1: INTRODUCTION	**9**
Scope of computer integrated manufacturing, product life cycle, production automation. Group technology: Role of group technology in CAD/CAM integration, methods for developing part families, classification and coding, examples of coding systems, facility design using group technology, economics of group technology.	
UNIT 2: COMPUTER AIDED PROCESS PLANNING	**9**
Role of Process Planning, Approaches to process planning- manual, variant, generative approach, Implementation techniques, process planning systems – CAM-I'S CAPP system, MI Plan system, criteria for selecting a CAPP system, benefits and advantages of CAPP	
UNIT 3: INTEGRATIVE MANUFACTURING PLANNING AND CONTROL	**9**
Role of integrative manufacturing in CAD /CAM integration, overview of production control, forecasting, master production schedule, capacity planning, MRP, order release, shop-floor control, quality assurance, planning and control systems, cellular manufacturing, JIT manufacturing philosophy.	
UNIT 4: COMPUTER AIDED QUALITY CONTROL	**9**
Terminology in quality control, Automated inspection principles and methods, computer aided inspection, computer aided testing, contact inspection methods, noncontact inspection methods, integration of CAQC with CAD/CAM.	
UNIT 5: COMPUTER INTEGRATED MANUFACTURING SYSTEMS	**9**
Types of manufacturing systems, machine tools and related equipment, material handling systems, computer control systems, FMS.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the concepts of Computer Integrated Manufacturing Systems.

CO2: To acquire the knowledge on quality control, computer aided testing and inspection methods.

CO3: To analyse the Computer Aided Process Planning &Control, Material handling,AI and FMS

CO4: To design and solve the problems of Forecasting, Scheduling, and capacity planning in manufacturing and assembling.

CO5: To integrate computer aided design and computer aided manufacturing protocols to manufacture products.

CO's PO's&PSO's MAPPING

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

CO5	2	-	3	-	2	-	-	1	-	-	-	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing",Prentice Hall of India, 2008.
2. Mikell P. Groover, and Zimmers, CAD/CAM: Principles and Applications, 3/e, Tata-McGraw hill, 2010.
3. Dr. Sadhu Singh, Computer Aided Design and Manufacturing, Khanna Publishers

REFERENCE BOOKS:

1.M.M.M. Sarcar, K. Mallikarjuna Rao, K. Lalit Narayan, Computer Aided Design and Manufacturing, 2/e, Prentice Hall of India, 2008.

2. Rao. P, N Tewari&T.K. Kundra, "Computer Aided Manufacturing", Tata McGraw Hill Publishing Company, 2000.
3. Craig J.J., "Introduction to Robotics Mechanics and Control", Pearson Education, 2008.

WEB RESOURCES:

1. http://onlinecourses.nptel
2. http://me.emu.edu.tr/majid/

MA606202- INDUSTRY 4.0					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce and familiarize the industry 4.0 and its physical structure and inter-connectivity.
- To understand the architecture, IOT and its protocols
- To understand the advancements in Robotics.
- To learn the IOT, data analytics and Industry 4.0
- To know the obstacles of Industry 4.0

UNIT 1: INDUSTRY 4.O **10**

Digitalization and the Networked Economy - Introduction to Industry 4.0 - Comparison of Industry 4.0 Factory and Today's Factory - Internet of Things (IoT) - Industrial Internet of Things (IIoT) - Smart Devices and Products - Smart Logistics - Support System for Industry 4.0 - Cyber-physical Systems Requirements - Data as a New Resource for Organizations - Cloud Computing - Trends of Industrial Big Data and Predictive Analytics for Smart Business- Architecture of Industry 4.0.

UNIT 2: IOT AND ITS PROTOCOLS **9**

Definitions and Functional Requirements – Motivation – Architecture - Web 3.0 View of IoT – Ubiquitous IoT Applications – Four Pillars of IoT – DNA of IoT - The Toolkit approach for End - User Participation in the Internet of Things. Middleware for IoT: Overview – Communication Middleware for IoT – IoT Information Security. IIoT Reference Architecture - Designing Industrial Internet Systems - Access Network Technology and Protocols Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE 802.15.4 – BAC Net Protocol – Modbus –KNX – Zigbee Architecture – Network layer APS layer – Security.

UNIT 3: ADVANCES IN ROBOTICS IN THE ERA OF INDUSTRY 4.0 **9**

Introduction, Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly.

UNIT 4: APPLICATIONS **8**

The Role of the Internet of Things for Increased Autonomy and Agility in Collaborative Production Environments - Resource Management in the Internet of Things: Clustering, Synchronization and Software Agents - Industry 4.0 in Car Manufacturing – Electronics Manufacturing – IOT Based Building Automation - Agricultural Automation.

UNIT 5: OBSTACLES AND FRAMEWORK CONDITIONS FOR INDUSTRY 4.0 **9**

Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers, comprehensive broadband infra- structure, state support, legal framework, protection of corporate data, liability, handling personal data.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Realize the need of industry 4.0 and its inter-connectivity.

CO2: Interpret the architecture of IOT and its protocols

CO3: Describe Robotic technology and Augmented reality for Industry 4.0

CO4: Plan the uses of IOT, data analytics and Industry 4.0 technologies

CO5: Demonstrate obstacle and framework conditions for Industry 4.0

CO's PO's&PSO's MAPPING

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

CO4	2	2	2	2	2	-	2	-	-	-	-	1	1	1
CO5	2	2	2	1	2	-	-	-	-	-	-	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things, APress, 2016.
2. Duato J, Yalamanchili S, and Lionel Ni, "Interconnection Networks: An Engineering Approach", Morgan Kaufmann Publishers, 2004.
3. Alp Ustundag and Emre Cevikcan,"Industry 4.0: Managing the Digital Transformation".
4. Bartodziej, Christoph Jan,"The Concept Industry 4.0".

REFERENCE BOOKS:

1. Kiran Kumar Pabbathi, "Quick Start Guide to Industry 4.0: One-Stop Reference Guide for Industry 4.0", Createspace Independent Publishing Platform, 2018.
2. Kiran Kumar Pabbathi, "Quick Start Guide to Industry 4.0: One-Stop Reference Guide for Industry 4.0", Createspace Independent Publishing Platform, 2018.
3. Klaus Schwab,"The Fourth Industrial Revolution".
4. Christian Schröder ,"The Challenges of Industry 4.0 for Small and Medium-sized Enterprises".

WEB RESOURCES: www.nptel.ac.in/

MA606203 – FLEXIBLE MANUFACTURING SYSTEMS (COMMON TO MECH, MAE AND AERO)

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Tounderstandmodernmanufacturingsystems.
- TounderstandtheconceptsandapplicationofFlexibleManufacturingSystems.

UNIT 1: INTRODUCTIONOFFMS — **9**

Introduction To FMS– Development of Manufacturing Systems – Benefits – MajorElements - FMS Planning & Implementation Issues – Flexibility– machine, Product, Routing,Operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS,FMSbenefitsandapplications.FeasibilityreportofFMS,advancedcontrolcycleofFMS

UNIT 2: COMPUTER CONTROL AND SOFTWARE FOR FLEXIBLE MANUFACTURING SYSTEMS — **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 3: MATERIALHANDLINGSYSTEM — **9**

Anintroduction,Conveyor-Robots-AutomatedGuidedVehicle(AGV)-Automated Storage Retrieval System (ASRS)- Management technology-Scheduling andloadingofFMS

UNIT 4: GROUP TECHNOLOGY AND JUSTIFICATION OF FMS — **9**

Group Technology- principles, Part classification & coding, Computer AidedProcess Planning(CAPP)-ProductionFlowAnalysisandCellularManufacturing.Retrieval&Generativetypeprocessplanningsystem.Economic justification of FMS- application of possibility distributions in FMS systems justification.

UNIT 5: 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: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Ability to perform Planning, Scheduling and control of Flexible Manufacturing systems

CO2: Explainprocessingstationsand materialhandlingsystemsusedinFMSenvironments.

CO3: DesignandanalyzeFMSusingsimulationandanalyticaltechniques.

CO4: UnderstandtoolmanagementinFMS.

CO5: Understand the applications in machining and design philosophy.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. WilliamWLuggen,"*FlexibleManufacturingCellsandSystem*"PrenticeHallofInc NewJersey,1991..

2Reza A Maleki,"*FlexibleManufacturingsystem*" Prentice Hallof Inc NewJersey,1991.

3. JohnELenz,"*FlexibleManufacturing*"marcelDekkerIncNewYork,1989.

4. Jha, N.K. "Handbook of flexible manufacturing systems", Academic Press Inc., 1991.

5. Groover M.P., "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt., New Delhi, 1996.

REFERENCE BOOKS:
1.P.RadhakrishnanandS.Subramanyan,"*CAD/CAM/CIM*",WileyEasternLtd.,NewAgeInternationalLtd.,1994.
2.M.P. Groover, "*Automation, Production Systems and ComputerIntegrated Manufacturing*",PrenticeHallOfIndiaPvt.,NewDelhi,1996.
3. Raouf, A. and Ben-Daya, M., Editors, "Flexible manufacturing systems: recent development", Elsevier Science, 1995.
WEB RESOURCES: www.nptel.ac.in/

MA606204 – ADDITIVE MANUFACTURING PROCESS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know the principle, methods, possibilities and limitations as well as environmental effects of Additive Manufacturing technologies.
- Understand the operating principles, capabilities and limitations of Additive Manufacturing processes.
- Describe the important process parameters for bio-manufacturing and determine the suitable additable technique for bio- manufacturing.

UNIT 1: INTRODUCTION **9**

Overview – Need - Development of Additive Manufacturing Technology -Principle – AM Process Chain-Classification –Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Applications- Benefits – Case studies.

UNIT 2: CAD and Reverse Engineering **9**

CAD and Reverse Engineering: Basic Conceptualization, CAD model preparation – conversion to STL - STL file manipulation - Part Orientation and support generation – Model Slicing –Tool path Generation – Transfer to AM - Machine setup, build, removal and clean up, post processing. Data Processing for Additive Manufacturing Technology - Software's for Additive Manufacturing Technology: MIMICS, MAGICS.

UNIT 3: CLASSIFICATIONOFADDITIVEMANUFACTURING **9**

Classification of different RP techniques – based on raw materials, layering technique (2-D or 3-D)and energy sources: Process technology, Stereo-lithography (SL), photopolymerization,liquidthermalpolymerization,Solidfoilpolymerization

UNIT 4: EXTRUSION BASED AND SHEET LAMINATION PROCESSES **9**

Extrusion Based System: FDM-Introduction – Basic Principle – Materials – Applications and Limitations – Bioextrusion. Sheet Lamination Process: LOM- Gluing or Adhesive bonding – Thermal bonding.

UNIT 5: PRINTING PROCESSES AND BEAM DEPOSITION PROCESSES **9**

Droplet formation technologies – Continuous mode – Drop on Demand mode – Three Dimensional Printing – Advantages – Bioplotter - Beam Deposition Process: LENS- Process description – Material delivery – Process parameters – Materials – Benefits – Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: DemonstratetheknowledgeofAdditiveManufacturing

CO2:Understand the methodology to manufacture the products using SLA and SGC technologies and study their applications, advantages, and case studies.

CO3: IdentifythesuitablemanufacturingMethodologyforAdditiveManufacturing

CO4: Understand the extrusion and sheet lamination process.

CO5: Understand the methodology to manufacture the products using Bio plotter technologies and study their applications, advantages.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. IanGibson,DavidW.Rosen,BrentStucker,"AdditiveManufacturingTechnologies",Springer,2009.

2
C.K.Chua,K.F.LeongandC.S.Lim,"RapidPrototyping:PrinciplesandApplications",2nd edition,WorldScientificPublishers,2003.

3. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

3. K.Patri,Venuvinod,WeiyinMa"RapidPrototyping: Laser-BasedandOtherTechnologies"Springer, 2004.

4. Ian Gibson, David W.Rosen, Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer , 2010.

REFERENCE BOOKS:

1. D.Peter,J.Hilton,PaulF.Jacobs,"RapidTooling:TechnologiesandIndustrial Applications",CRCPress,2000.

2. M.Burns,"Automatedfabrication",Prentice-Hall,1993.

3. Andreas Gebhardt "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing" Hanser Gardner Publication 2011.

WEB RESOURCES: www.nptel.ac.in/

MA606205 - LEAN MANUFACTURING					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basics concepts of lean manufacturing
- To familiarize students to design cells in a way that some measure of performance is improved, and plant equipment's overall equipment effectiveness is increased.
- To impart the concepts of JIT.
- To introduce the concepts of Set Up Time Reduction, TQM, 5S, and VSM concepts.
- To familiarize Six Sigma and Pre-Production Planning (3P).

UNIT 1: INTRODUCTION	**9**

Objectives and principles of lean manufacturing, traditional Vs lean manufacturing, value creation and waste elimination, Introduction to lean manufacturing tools.

UNIT 2: CELLULAR MANUFACTURING AND TOTAL PRODUCTIVE MAINTENANCE (TPM)	**9**

Cellular Manufacturing – Types of Layouts, Principles of Cell layout, Implementation. TPM – Pillars of TPM, Principles and implementation of TPM.

UNIT 3: JIT	**9**

Introduction - elements of JIT - uniform production rate - pull versus push method- Kanban system - small lot size - quick, inexpensive set-up - continuous improvement.

UNIT 4: SET UP TIME REDUCTION, TQM, 5S, VSM	**9**

Set up time reduction – Definition, philosophies, and reduction approaches. TQM – Principles and implementation. 5S Principles and implementation - Value stream mapping - Procedure and principles.

UNIT 5: SIX SIGMA AND PRE-PRODUCTION PLANNING (3P)	**9**

Six Sigma – Definition, statistical considerations, variability reduction, Six Sigma implementation, challenges and applications, design of experiments, steps in experimental design. 3P – Introduction, Implementation of 3P Approach, pros and cons of 3P Approach.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: The student will demonstrate basic understanding and knowledge of lean manufacturing and its tools..

CO2: The student will describe basic knowledge of cellular manufacturing and total productive maintenance

CO3: The student will explain basic understanding of JIT.

CO4: The student will demonstrate the knowledge of set up time reduction, TQM, 5S, VSM approaches.

CO5: The student will explain the basic understanding of six sigma and Pre-Production Planning (3P).

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Design and Analysis of Lean Production Systems, Ronald G. Askin& Jeffrey B. Goldberg, John Wiley & Sons, 2003.
2. Mikell P. Groover (2002) Automation, Production Systems and CIM.
3.Rother M. and Shook J, 1999 Learning to See: Value Stream Mapping to Add Value and Eliminate Muda ‘, Lean Enterprise Institute, Brookline, MA
3. Dr. Sadhu Singh, Computer Aided Design and Manufacturing, Khanna Publishers
4. Michael Wader, Lean Tools: A Pocket Guide to Implementing Lean Practices, Productivity and Quality Publishing Pvt Ltd, 2002

REFERENCE BOOKS:

1. Allan R. Coletta (2017), The Lean 3P Advantage A Practitioner's Guide to the Production, CRC Press.
2. Masaaki Sato, The Toyota Leaders – An Executive Guide, Vertical Inc, New York, 2008.
3. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008. 2. Ross PJ,
4. Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

WEB RESOURCES: www.nptel.ac.in/

MA606206 – RAPID PROTOTYPING

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Select the feasible RP process
- To obtain an overview on CAD modelling and data processing.
- Understand the applications of RP.

UNIT 1: INTRODUCTION — **9**

Introduction: Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process. Distinction between RP and CNC, other related technologies.

UNIT 2: CAD MODELLING AND DATA PROCESSING FOR RP — **9**

CAD model preparation, Data interfacing: formats (STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP), conversation, validity checks, repair procedures; Part orientation and support generation, Support structure design, Model Slicing algorithms and contour data organization, direct and adaptive slicing, Tool path generation.

UNIT 3: RP PROCESSES — **9**

Process Physics, Tooling, Process Analysis, Material and technological aspects, Applications, limitations and comparison of various rapid manufacturing processes,Powder Bed Fusion (Selective laser Sintering (SLS), Electron Beam melting (EBM)), Extrusion-Based RP Systems (Fused Deposition Modelling (FDM)), 3D Printing, Sheet Lamination (Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC)), Beam Deposition (Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD)).

UNIT 4: ERRORS IN RP PROCESSES: — **9**

Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS.

UNIT 5: RP APPLICATIONS — **9**

Application – Material Relationship, Application in Design , Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture. RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Biomolecules.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Distinguish RP and other related technology

CO2: Understand and use techniques for processing of CAD models for rapid prototyping.

CO3: Apply fundamentals of rapid prototyping techniques

CO4: Use appropriate tooling for rapid prototyping process.

CO5: Create component with RP applications.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Rapid prototyping: Principles and Applications – Chua C.K., Leong K.F. and LIM C.S, World Scientific publications , Third Edition, 2010.

2. Noorani R, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons.

3.Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley

4.Gibson D W Rosen, Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.

5. Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography by Paul F.Jacobs, McGraw Hill

REFERENCE BOOKS:

1.Liou W L, Liou F W, Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press.

2. Rapid prototyping Technologies: Kenneth Cooper, CRC Press, 2001

3. Rapid Prototyping, Principles and Applications byRafiq I. Noorani, Wiley & Sons.

WEB RESOURCES: www.nptel.ac.in/

MA606207– THEORY OF METAL CUTTING					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The course provides students with fundamental knowledge and principles in material removal processes.
- To develop knowledge and importance of metal cutting parameters.
- To develop fundamental knowledge on tool materials, cutting fluids and tool wear mechanisms.

UNIT 1: MECHANICS OF METAL CUTTING **9**

Geometry of Metal Cutting Process, Chip formation, Chip Thickness ratio, radius of chip curvature, cutting speed, feed and depth of cut - Types of Chips, Chip breakers. Orthogonal and Oblique cutting processes-definition, Forces and energy calculations (Merchant's Analysis) - Power consumed – MRR – Effect of Cutting variables on Forces, Force measurement using Dynamometers.

UNIT 2: SINGLE POINT CUTTING TOOL **9**

Various systems of specifications, single point cutting tool geometry and their inter-relation. Theories of formation of built-up edge and their effect, design of single point contact tools throwaway inserts.
Cutting tool Materials: Carbon and Medium alloy steels, High Speed steels, Cast-Cobalt alloys, Carbides, Coated tools, Alumina based ceramics, Carbon boron Nitride, SNB Ceramics, Whisker-Reinforced tool materials.

UNIT 3: MULTIPOINT CUTTING TOOLS **9**

Drill geometry, design of drills, Rake and Relief angles of twist drill, speed, feed and depth of cut, machining time, forces, end and face milling cutters, cutting speed and feed – machining time – design - form cutters.
Grinding: Specifications of grinding of grinding wheel, mechanics of grinding, Effect of Grinding conditions on wheel wear and grinding ratio. Depth of cut, speed, machining time, temperature, power.

UNIT 4: TOOL LIFE AND TOOL WEAR **9**

Theories of tool wear-adhesion, abrasive and diffusion wear mechanisms, forms of wear, Tool life criteria and machinability index. Types of sliding contact, real area of contact, laws of friction and nature of frictional force in metal cutting. Effect of Tool angle.
Cutting Temperature: Types of cutting fluids, Sources of heat in metal cutting, influence of metal conditions. Temperature distribution, zones, experimental techniques, analytical approach. Use of tool-work thermocouple for determination of temperature. Temperature distribution in Metal Cutting. Cutting fluids: Functions of cutting fluids, types of cutting fluids, properties, selection of cutting fluids.

UNIT 5: TOOL DESIGN **9**

Determination of shank size for single point carbide tools, Determining the insert thickness for carbide tools. Design of jigs and fixtures: Basic principles of location and clamping; Locating methods and devices. Jigs-Definition, Types. General consideration in the design of Drill jigs, Drill bushing, Methods of construction. Fixtures- Vice fixtures, Milling, Boring, Lathe Grinding fixtures.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Students will be able to analyze cutting forces in turning, drilling and milling

CO2: Students will be able to adjust varies parameters in the machining process.

CO3: Students will be able to reduce the cost of machinery

CO4: Students will be able to prevent failures of cutting tool.

CO5: Students will be able to design the jig and fixtures.

CO's PO's&PSO's MAPPING

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

CO5	1	1	2	-	2	-	-	-	-	-	-	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Metal Cutting Principles , M C Shaw , Oxford and IBH Publications, New Delhi,1969

2. Fundamentals of Machining , Boothryd , Edward Amold publishers Ltd. 1975

3. Bhattacharya A, Metal Cutting: Theory and Practice, New Central Book Agency, Kolkata, 2007

4. Winston A. Knight and Geoffrey Boothroyd, Fundamentals of Machining and Machine Tools, 3/e, Taylor & Francis Group, 2005.

REFERENCE BOOKS:

1. Fundamentals of Metal cutting and Machine tools , B.L.Juneja, G. S. Sekhom and Nitin Seth, New Age International publishers

2. Tool Engineering, G.R.Nagpal, Khanna Publishers

3. Trent, E. M. and P. K. Wright, Metal Cutting, 4th edition., Butterworth-Heinemann, 2000

WEB RESOURCES: www.nptel.ac.in/

MA606208 –STEEL QUALITY: ROLE OF SECONDARY REFINING & CONTINUOUS CASTING (NPTEL)

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Give a brief introduction to the importance of secondary refining and continuous casting in achieving the desirable cleanliness and surface quality of cast and hot rolled steels
- The steelmaking chemistry for the refining reactions in secondary steelmaking.
- To find out the defects and remedial actions.
- To identify the quality problem and rectification

UNIT 1: INTRODUCTION	**9**
Concept of steel quality – Control of residuals ans impact on quality – Non-metallic inclusions – Evaluation of residuals and inclusions – Cleanliness requirements for different applications. Limitations of primary steel making and importance of secondary refining – Deoxidation – Prevention of slag carryover – Desulphurisation – Degassing – Secondary refining process.	
UNIT 2: TEMPERATURE CONTROL, CLEANLINESS AND CASTING	**9**
Injection of Calcium – Different routes and temperature control – Decarburisation – Cleanliness measures in ladle and Tundish – Cleanliness measures in mould. Nature and distribution of entrapments in casting – Genesis of entrapment – Effect of vertical vis-avis carved mould – Quality of cast product – Role of concast process, caster design and steel grade – Primary cooling in caster mould.	
UNIT 3: ROLE OF CHEMISTRY	**9**
Heat transfer in mould – Role of mould oscillation – cast structure and dendrite size – Role of chemistry part I, Role of chemistry part II – Role of segregation part I, of segregation part II. Deleterious effect of Phosphorus – Strength of solidifying strand – Brittle zone near solidus – Strength and Toughness of solid shell – Role of chemistry on solidification behaviour.	
UNIT 4: DEFECTS	**9**
Sticking vis-à-vis depression behaviour – Role of chemistry on bulging or depression tendency Part I, Role of chemistry on bulging or depression tendency Part II, Effect of cast grain size – Brittle temperature regions - Typical cracks and defects Part I, Typical cracks and defects Part II.	
UNIT 5: REMEDIAL MEASURES AND CASTING PARAMETERS	**9**
Remedial measures to control defects Part I, Remedial measures to control defects Part II, Remedial measures to control defects Part III, Grade - Specific casting parameters Part I, Grade - Specific casting parameters Part II, Identification of genesis of quality problems through metallographic investigation Part I, Identification of genesis of quality problems through metallographic investigation Part II, Identification of genesis of quality problems through metallographic investigation Part III,	
TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the refining reactions for deoxidation, desulphurisation and degassing during secondary steelmaking

CO2: To understand the temperature control, Cleanliness measures in mould and Entrapments in casting.

CO3: To understand the role of chemistry, Role of segregation and effect of Prosperous.

CO4: To assess casting defects, understand symptoms and causes.

CO5: To take remedial action on defect parts and to identify the quality problems.

CO's PO's&PSO's MAPPING														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	1	1	1
CO2	2	2	1	3	2	-	-	-	-	-	-	1	1	1
CO3	2	2	2	3	2	-	-	-	-	-	-	1	1	1
CO4	2	2	2	2	2	-	-	-	-	-	-	1	1	1
CO5	2	2	2	2	2	-	-	-	-	-	-	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. A.Ghosh , Secondary Steelmaking -- Principles & Applications , CRC Press , Florida , USA , 2001 M.M.Wolf , Continuous Casting , Vol.9 , Warrendale , PA, Iron & Steel Society, 1997
2. . P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
3. H. F. Taylor and M. C. Flemings, "Foundry Engineering", Wiley Eastern, 1st Edition, 1959, ISBN: 9780471848431.

REFERENCE BOOKS:

1. P. R. Beeley, "Foundry Technology", Butterworth-Heinemann, 2nd Edition, 2001, ISBN: 9780750645676
2. R. W. Heine, C. R. Loper and P. C. Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2 nd Edition, 2017, ISBN: 9780070993488.
3. P. L. Jain, "Principles of Foundry Technology", Tata McGraw Hill, 2nd Edition, 1987, ISBN: 9780074516980

WEB RESOURCES:

1. http://onlinecourses.nptel
2. http://steeluniversity.org

MA606209 – LASER BASED MANUFACTURING (NPTEL)					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The course emphasizes the fundamental concepts of the laser technology viz. principle of working, characteristics, types, monitoring and control.

UNIT 1: INTRODUCTION — **9**

Lasers in Manufacturing: Importance and Applications - Fundamentals of Laser Technology – Laser system: construction and types – principle of operation – Types of Laser cutting and kerf geometry – Types of Lasers in material removal – process and performance parameters – A case study on cutting a circular part using CO_2 Laser Machine

UNIT 2: MECHANISM OF LASER WELDING AND LASER FORMING — **9**

Mechanisms of Laser Welding Part – I and Part – II, Effects of process parameters during Laser welding and study of defects in welding beads – A case study on welding of Mild Steel sheets using 2.5 KW CO_2 Laser Machine.

Material Forming and fundamentals of Laser Forming – Mechanisms of Laser Forming – Process parameters and their effects on the performance of Laser Forming

UNIT 3: SURFACE TREATMENT — **9**

Surface Treatment and application of Laser – Laser surface hardening – Laser surface alloying – Laser Cladding

UNIT 4: ADDITIVE MANUFACTURING — **9**

Additive Manufacturing Technologies – Laser scanning stereo lithography – Selective Laser Sintering and Selective Laser Melting – Process and performance parameters of Laser Based Additive manufacturing Technologies.

UNIT 5: LASERS IN AUTOMATION — **9**

Lasers in Manufacturing Automation – CNC for Laser Based Manufacturing – CAD for Laser Based Manufacturing – Laser assisted Material Forming – Effect of Coatings, 3D Laser Forming and Micro forming. **TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: To understand the concepts of Laser manufacturing and Mechanism of Laser cutting.

CO2: To acquire the knowledge on Laser Welding and Laser Forming

CO3: To acquire knowledge of Surface Treatment using Laser.

CO4: To Implement the Laser Technology in Additive manufacturing

CO5: To implement the Automation techniques in Laser Based Manufacturing.

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Steen, W. M., Laser Material Processing, Springer-Verlag, London, 2005.

2. Dahotre, N. and Samant, A., Laser Machining of Advanced Materials, CRC Press, London, 2015.

3. Joshi, S. N. and Dixit, U. S., Laser Based Manufacturing, Springer India, 2015.

REFERENCE BOOKS:
1. Sugioka, K., Meunier, M., and Piqué, A., Laser Precision Microfabrication, Springer-Verlag, Berlin, Heidelberg, 2010.
2.Ion, J. C., Laser Processing of Engineering Materials, Elsevier, 2005
3. Advance Micro and nano Manufacturing Technology, S.N.Joshi, P.Chandra. 2022, Springer
WEB RESOURCES: . http://onlinecourses.nptel

MA606210 – FORMING (NPTEL)

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge on the mechanism involved in plastic deformation and parameter representation.
- Enable students to understand various bulk forming process and its recent technology.
- To introduce the significance of surface treatment and industrial application of metal forming

UNIT 1: FUNDAMENTALS OF FORMING — **9**

Fundamentals concepts of metal forming – Materials and their structure – Mechanical behaviours of crystalline materials – Material behaviour in metal forming

UNIT 2: STRESS, STRAIN, ELASTICITY AND PLASTICITY — **9**

Stress transformation and Mohr's circle – Strain transformation – Elasticity – Plasticity – Slab method of forming analysis – Slip line field method of analysis – Upper bound analysis.

UNIT 3: FORGING, ROLLING, EXTRUSION — **10**

Forging: Classification of forging processes – Analysis of axisymmetric upset forging – Analysis of plane strain upsetting – Analysis of disc forging – Forging defects.

Rolling: Introduction to rolling processes Introduction – Rolled products – Rolling mills – Typical rolling processes – Analysis of strip rolling -1, Analysis of strip rolling -2, Cold strip rolling – more accurate analysis – Rolling defects.Extrusion: Introduction to extrusion process – Analysis of cold extrusion – Further analysis and extrusion defects.

UNIT 4: DRAWING OF WIRES, BARS, TUBES & SHEET METAL — **9**

Basics of bar / wire drawing – Analysis of drawing 0 Further aspects of drawing.

Sheet metal forming operations: Cutting and related operations – Bending sheet metal – Other sheet metal forming operations.

Drawing of sheet metals: Deep drawing – Drawability and formability.

UNIT 5: POWDER FORMING & NONCONVENTIONAL FORMING — **8**

Powder forming – Pilgering – Semi solid forming – Hot isosatic pressing.

Deformation zone, formability and workability: Deformation geometry – Workability – Formability – Thermal effects and friction.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamental concepts of forming, material structure and behaviours.

CO2: Understand the material properties and forming analysis.

CO3: Understand the process and analysis of forging, Rolling and Extrusion

CO4: Understand and analysis of drawing of wire, bars and sheet metal.

CO5: Study the powder forming, deforming of metals and able to design the tools

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Altan T, Metal forming – Fundamentals and applications – American Society of Metals, Metals park,1983.

2. Helmi A Youssef, Hassan A. El-Hofy, Manufacturing Technology: Materials, Processes and Equipment, CRC publication press, 1stEdition,2017.

3. Marciniak Z, Duncan J.L, Hu S.J, Mechanics of Sheet Metal Forming, Butterworth-Heinemann,2ndEdition, 2002.

VERTICAL 7: DIVERSIFIED COURSES GROUP 2

MA606501- MAINTENANCE ENGINEERING

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- The student to understand the principles, functions and practices adapted in the industry for the successful management of maintenance activities. The course will help students to understand the objectives of maintenance, condition monitoring, and maintenance techniques.

UNIT 1: PRINCIPLES AND PRACTICES OF MAINTENANCE PLANNING — **9**

Introduction -Basic Principles of maintenance planning – Objectives and principles of Need of Maintenance Management activity – Maintenance Policies -Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Strategies and options in Maintenance management – Maintenance economics

UNIT 2: MAINTENANCE POLICIES – PREVENTIVE MAINTENANCE — **9**

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication – TPM. Maintenance Planning and Control: Establishing a Maintenance Plan-Preliminary considerations, Systematic method of Maintenance Plan and schedule planning and schedule of Plant shut downs.

UNIT 3: 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. criterion of evaluation. Spare Parts Management: Capacity utilization, cost reduction approach to spares, reliability and quality of spares, spare parts procurement, inventory control of spare parts.

UNIT 4: REPAIR METHODS FOR BASIC MACHINE ELEMENTS — **9**

Maintenance practices on production machines- Lathe, Drilling, Milling, Welding, Shaper Use of computer in maintenance, Machine Reconditioning. Evaluation of Maintenance Management: Need for evaluation a to z objectives, Repair methods for beds, slide ways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location.

UNIT 5: REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT — **9**

Reliability – Definition, failure data, failure density, failure rate, mean failure rate, types of failures, failure rate curve. System Reliability- series, parallel and mixed configuration – reliability increasing techniques. Safety – Definition – methods of enhancing safety – modern industrial scenarios- safety tools – case studies – quantification of safety - code and standards- hazards and its management.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the principles and practices of maintenance planning for an organization

CO2: Discuss maintenance policies with special reference to preventive maintenance

CO3: Predict appropriate condition monitoring (CM) techniques and instruments

CO4: Distinguish various repair methods for basic machine elements

CO5: Summarize repair methods for material handling equipment

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:
1. Srivastava S.K., “Industrial Maintenance Management”, – S. Chand and Co.,1981
2, Venkataraman .K “Maintenance Engineering and Management”, PHI Learning, Pvt. Ltd.,2007
3. Bhattacharya S.N., “Installation, Servicing and Maintenance”, S. Chand and Co.,1995
REFERENCE BOOKS:
1. White E.N., “Maintenance Planning”, I Documentation, Gower Press, 1979.
2. Garg M.R., “Industrial Maintenance”, S. Chand & Co., 1986.
3. Higgins L.R., “Maintenance Engineering Hand book”, McGraw Hill, 5th Edition, 1988
WEB RESOURCES:
1. https://nptel.ac.in/courses/112105048 2. https://nptel.ac.in/courses/101104071

MA606502 - DESIGN OF PRESSURE VESSELS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The course aims to impart basic knowledge of design of Pressure Vessels and Piping System.
- It is also aimed to introduce use of various standards used for the Pressure Vessel Design.

UNIT 1: STRESSES IN PRESSURE VESSEL **9**

Introduction to stresses in pressure vessel and its application- stresses in circular plate-Stresses in cylinder, Thermal stresses-Bending of circular plates of uniform thickness-Bending of centrally loaded circular plates.

UNIT 2: DESIGN OF VESSELS USING CODES **9**

Introduction to ASME cods for pressure vessel design-Pressure vessel and related components' design using ASME codes-Supports for short vertical vessels-stress concentration at a variable thickness transition section in a cylindrical vessel-Design of nozzles.

UNIT 3: SUPPORT DESIGN FOR PRESSURE VESSELS **9**

Bolted Flanges – RF and FF flanges – Gasket loading behavior – Application of ASME equations for flange analysis and bolt design.Design of Supports – Lug support – Support skirts – Saddle support.

UNIT 4: DESIGN CONSIDERATION IN PRESSURE VESSEL **9**

Buckling of pressure vessels: Elastic Buckling of circular ring and cylinders under external pressure-Failure of thick walled cylinders or tubes under external pressure-Buckling under combine External pressure and axial loading-Fatigue failure, high strength, light weight pressure vessels resistant to external high pressures found in undersea exploration.

UNIT 5: PIPING ANALYSIS **9**

Flow diagram-Piping layout and piping stress analysis; Flexibility factor and stress intensification factor-Design of piping system as per B31.1 piping code-Piping components: bends, tees, bellows and valves. Types of piping supports and their behavior -Introduction to piping Codes and Standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Analyse thin plates and shells for various types of stresses

CO2: Design shells, end closures and nozzles of pressure vessels using ASME codes

CO3: understand thePressure Vessel Supports.

CO4: understand the Pressure Vessel Designing.

CO5: Analyse piping systems.

CO-PO MAPPING:

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Dr. P. C. Sharma, D. K. Aggarwal "Machine Design" ,S. K. Kataria & Sons (Publishers), 2010.

2. Richard G. Budynas , "Shigley's Mechanical Engineering Design " McGraw Hill; Eleventh edition 2020

3. Phillip Ellenberger,"Pressure Vessels: The ASME Code", McGraw Hill,2021

REFERENCE BOOKS:

1.Robert L Mott ,"Machine Elements in Mechanical Design", Pearson Publisher, 2020.

2.Henry H Bednar, "Pressure vessel Design Hand book", CBS publishers and distributors,2nd edition,2010

3. Design of Machine Elements by C.S.Sharma& Kamlesh Purohit, Prentice Hall of India Pvt. Ltd.2002

WEB RESOURCES:

1. https://archive.nptel.ac.in/courses/103/107/103107143/
2. https://archive.nptel.ac.in/content/storage2/courses/103103027/pdf/mod6.pdf

VIRTUAL INSTRUMENTATION

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic virtual instrumentation concepts.
- To learn the basics of Data Acquisition System.

UNIT 1: INTRODUCTION — **9**

Evolutions of VI, advantages, block diagram and architecture of a virtual instrument-Graphical programming, and comparison with conventional programming.

UNIT 2: VI PROGRAMMING — **9**

Controls and indicators- Labels and Text –Shape, size and color- – Data type, Format, Precision and representation – Data types – Data flow programming-Editing – Debugging and Running a Virtual Instrument – Concept of subVI.

UNIT 3: PROGRAMMING STRUCTURE — **9**

FOR Loops, WHILE Loops, CASE Structure, Formula nodes, Sequence structures- Attribute modes Local and Global variables.

UNIT 4: ARRAYS AND CLUSTERS — **9**

Arrays and Clusters– Array Operations – Bundle – Bundle/Unbundle by name, graphs and charts – String and file I/O.

UNIT 5: HARDWARE INTERFACING — **9**

DAQ – Block diagram – Description - basic system components of a signal conditioning system- Interfacing with LabVIEW- Introduction to myRIO.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Paraphrase the basics of VI

CO2: Identify the difference between Graphical and text programming.

CO3: Apply concepts of VI for programming structures and loops.

CO4: Understand the arrays and clusters

CO5: Describe about DAQ architecture and its function

CO-PO MAPPING:

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Gary Johnson, Richard Jennings, Lab VIEW Graphical Programming, McGraw Hill, New York, fourth Edition, 2006.

2. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI Publishers, New Delhi, Second Edition 2010.

REFERENCE BOOKS:

1. Lab VIEW: Basics I & II Manual, National Instruments, Bangalore, 2005.
2. D Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.

WEB RESOURCES:

HTTPS://NPTEL.AC.IN/COURSES/108105064

https://archive.nptel.ac.in/courses/108/105/108105064/

MA606503- COMPUTATIONAL FLUID DYNAMICS						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						

- The evolution of the major theories, approaches, methodologies and programming techniques in Computational fluid dynamics.
- The development of various fluid flow governing equations from the conservation laws of motion and Fluid mechanics.
- The rigorous and comprehensive treatment of numerical methods in fluid flow and heat transfer problems in engineering applications.
- The environment and usage of commercial Computational Fluid Dynamics packages and carry out research in interdisciplinary applications.

UNIT 1: INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	**9**
Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Numerical Methods Programming fundamentals, simple coding techniques for numerical problems.	
UNIT 2: GOVERNING EQUATIONS OF FLUID FLOW AND HEAT TRANSFER	**9**
Governing Equations of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, NavierStokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions.	
UNIT 3: PARTIAL DIFFERENTIAL EQUATIONS AND ITS NUMERICAL BEHAVIOUR	**9**
The Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching problems. Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behaviour of Hyperbolic, Parabolic and Elliptic equations.	
UNIT 4: DISCRETIZATION AND NUMERICAL METHODS OF PDES	**9**
Basic aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, uniform and unequally spaced grid points. Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians. Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion; Grid Generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, and Parabolic Grid Generation	
UNIT 5: SOLUTION METHODS AND APPLICATIONS OF NUMERICS TO SIMPLE PROBLEMS	**9**
Parabolic Partial Differential Equations: Finite difference formulations, Explicit methods – FTCS, Richardson. Implicit methods – Lasonen and Crank-Nicolson; Finite Volume Method For Structured and Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches, Numerical Solution of Quasi 1D Flow equation and 2D heat conduction equation.	
	TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: The basics of computational fluid dynamics and its applications in various industries as a tool for fluid analysis.

CO2: Develop the governing equations for computational fluid dynamics CFD analysis by setting appropriate boundary conditions.

CO3: Identify different CFD techniques available for relevant partial differential equations to get analytical solutions for fluid flow

CO4: Analyze the numerical solution of fluid flow problems using discretization methods to minimise the

errors and Distinguish various grid generation and transformation techniques.

CO5: Outline the concepts of finite volume method and its difference from finite difference method to solve basic fluid flow model in the real world applications.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Jiri Blazek,"Computational Fluid Dynamics Principles and Applications", Butterworth-HeinemannCompany, March 25, 2015

2. Hoffman, K.A., and Chiang, S.T., "Computational Fluid Dynamics", Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.

3.Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", McGraw Hill Book Company, 2002

REFERENCE BOOKS:

1. Chung, T.J., "Computational Fluid Dynamics", Cambridge University Press, 2003

2. Muralidhar K and Sundararajan., "Computational Fluid Flow & Heat Transfer", 2009

WEB RESOURCES:

1. https://nptel.ac.in/courses/112105045
2. https://onlinecourses.nptel.ac.in/noc21_me126/preview

MA606504- FLUID POWER CONTROL SYSTEM						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To know the advantages and applications of Fluid Power Engineering and Power Transmission System. To learn the Applications of Fluid Power System in automation of Machine Tools and others Equipments.

UNIT 1: GENERAL INTRODUCTION AND CONTROL SYSTEM COMPONENTS **9**

Introduction to Fluid Power, Advantages, Applications –Fluids – Properties of Fluids - Basic Principle of Fluid Power. Hydraulic pumps, Classification Performance, characteristics, pump selection, - Hydraulic ActuatorsLinear, Rotary, Selection, and Characteristics. Control system components-Hydraulic valves – Pressure, Flow, and Direction control - Applications

UNIT 2: HYDRAULIC CIRCUITS **9**

Fluid power symbols - Hydraulic circuits - Location of Flow control valves Regenerative, Synchronizing, Sequencing, Intensifier- Accumulator– Types, Applications.

UNIT 3: HYDRAULIC CIRCUIT DESIGN **9**

Design of Hydraulic circuits - selection of components - Hydraulic circuit for shapers, Surface Grinding machine Vertical milling machine, Forklift ,Hydraulic press, Safety circuits -Automatic reciprocating system, Robot Arm – Hydrostatic Transmission – Power Pack.

UNIT 4: PNEUMATIC SYSTEMS **9**

Basic concepts and principles of pneumatic circuits, Relative merits and demerits over hydraulic Systems, Pneumatic conditioners – filters, regulators, lubricators, mufflers, Air dryers. Pneumatic actuators, pneumatic circuits, Hydro Pneumatics- Pneumatic logic controls, Electro hydraulic systems – Servo Systems

UNIT 5: DESIGN & SELECTION **9**

Design of pneumatic circuits – classic – cascade – step counter – selection criteria for pneumatic components – PLC applications in fluid power control. Installation and Maintenance of Hydraulic and Pneumatic power packs – fault finding – principles of low cost automation, case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Identify and analyse the functional requirements of a fluid power transmission system for a given application.

CO2: Visualize how a hydraulic will work to accomplish the function.

CO3:Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro- pneumatics for a given application.

CO4: Understand the basic concepts of Pneumatic circuit, actuators and servo system.

CO5: Develop a comprehensive circuit diagram by integrating the components selected for the given application.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Anthony Esposito,"Fluid Power with applications",Pearson Education, 2000

2. Ernst, W., Oil Hydraulic Power and its IndustrialApplications, New York: McGraw Hill,2002

3.Lewis,E.E., and H.Stern, Design of Hydraulic Control Systems, New York: McGraw Hill.2003

REFERENCE BOOKS:

1. Dudleyt A. Pease and John j. Pippenger, Basic Fluid Power, Prentice Hall, 1987.
2. JamcoL.Johnson, Introduction to fluid Power, Eswar Press, 2003.
3. Majumdar S.R,"Pneumatic systems-Principles and Maintenance", Tata McGraw Hill, 1995.

WEB RESOURCES:

1. https://archive.nptel.ac.in/courses/112/106/112106175/
2. https://archive.nptel.ac.in/courses/112/106/112106300/

MA606505- HYDRAULICS AND PNEUMATICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- This course will give an appreciation of the fundamental principles, design and operation of hydraulic and pneumatic components and systems and their application in manufacturing and mechanical systems

UNIT 1: FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS **9**

Introduction to Fluid power- Advantages and Applications- Fluid power systems –Types of fluids Properties of fluids – Basics of Hydraulics – Pascal's Law-Principles of flow – Friction loss- Work, Power and Torque. Problems Sources of Hydraulic power: Pumping Theory – Pump Classification Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criterion of Linear, Rotary- Fixed and Variable displacement pumps- Problems.

UNIT 2: HYDRAULIC ACTUATORS AND VALVES **9**

Hydraulic Actuators: Cylinders– Types and construction, Application, Hydraulic cushioning - Hydraulic motors Control Components: Direction control, Flow control and Pressure control valves-Types, Construction and Operation- Servo and Proportional valves - Applications – Types of actuation. Accessories: Reservoirs, Pressure Switches- Applications- Fluid Power ANSI Symbols – Problems.

UNIT 3: HYDRAULIC SYSTEMS **9**

Accumulators, Intensifiers, Industrial hydraulic circuits- Regenerative, Pump Unloading,Double-pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization,Fail-safe, Speed control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical Hydraulic servo systems.

UNIT 4: PNEUMATIC SYSTEMS **9**

Properties of air– Perfect Gas Laws - Compressors- Filter, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust valves, Pneumatic actuators, Design of pneumatic circuit cascade method Electro pneumatic circuits, Introduction to Fluidics, Pneumatic logic circuits.

UNIT 5: 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 a Pick and Place application and tool handling in a CNC machine. -Low cost Automation – Hydraulic and Pneumatic power packs- case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Choose hydraulic and pneumatic elements and demonstrate the applicability of fluid power systems for engineering applications

CO2: Select actuators and control Valve components for Desired Systems .

CO3: Design and Analyze circuits in hydraulic systems for various industrial needs.

CO4: Design and Analyze circuits in Pneumatic systems for various industrial needs.

CO5: Design and trouble shoot the hydraulic and pneumatic circuits for Applications.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Anthony Esposito,"Fluid Power with applications",Pearson Education, 2000
2.Shanmugasundaram.K, "Hydraulic and Pneumatic Controls", Chand & Co, 2006
3.Lewis,E.E., and H.Stern, Design of Hydraulic Control Systems, New York: McGraw Hill.2003

REFERENCE BOOKS:

1. Dudleyt A. Pease and John j. Pippenger, Basic Fluid Power, Prentice Hall, 1987.
2. Srinivasan.R, "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008
3. Majumdar S.R,"Pneumatic systems-Principles and Maintenance", Tata McGraw Hill, 1995.

WEB RESOURCES:

1. https://archive.nptel.ac.in/courses/112/106/112106300/
2. https://archive.nptel.ac.in/courses/112/105/112105047/

MA606506–INDUSTRIAL NETWORKING					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Basic knowledge about networking in industries.
- Understand the evolution of computer networks using the layered network architecture.
- Understand the concepts of data communications.
- Be familiar with the Transmission media and Tools.

MODULE 1: INTRODUCTION	**9**
Architecture, structure, functions, components, and models of the Internet and other computer networks.	
MODULE 2: MODBUS	
Overview – Protocol structure – Function codes – Modbus plus protocol -Data Highway – AS interface (AS-i) -Device Net: Physical layer – Topology – Device taps – Profibus PA/DP/FMS: Protocol stack – System operation.	
MODULE 3:ETHERNET SYSTEMS	**9**
IEEE/ISO standards – Medium access control – frames – Reducing collisions – Auto negotiation -LAN system components – Structured cabling – Industrial Ethernet – Troubleshooting Ethernet. CAN BUS: Concepts of bus access and arbitration – CAN: Protocol-Errors: Properties – detection -processing – Introduction to CAN 2.0B	
MODULE 4:	**9**
Transport reliability, network scaling, redundancy and network uptime. Security and network services. DHCP, NAT, VPN's and time protocols-SysLog - SNMP and Netflow.	
MODULE 5:APPLICATIONS	**9**
Automotive communication technologies – Design of automotive X-by-Wire systems, – The LIN standard – The IEC/IEEE Train communication network: Applying train communication network for data communications in electrical substations.	
TOTAL: 45HOURS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Apply the concepts of data communications and to design computer networks using subnetting and routing concepts.

CO2: Compare the various medium access control techniques

CO3: Compare and contrast the characteristics of physical layer.

CO4: Analyze the different protocols.

CO5: Compare and contrast the different network components.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Steve Mackay, Edwin Wright, Deon Reynders and John Park, Practical Industrial Data Networks: Design, Installation and Troubleshooting, Newnes (Elsevier), 2004
2. Practical Filebus, DeviceNet and Ethernet for Industry, IDC Technology, 2006

REFERENCE BOOKS:

1. Richard Zurawski, The Industrial Communication Technology Handbook, Taylor and Francis, 2005
2. Albert Lozano-Nieto, RFID Design Fundamentals and Applications, CRC Press, 2011

WEB RESOURCES:

1. https://nptel.ac.in/courses/106105183
https://onlinecourses.nptel.ac.in/noc20_cs69/preview

MA606507- FUNCTIONAL AND CONCEPTUAL DESIGN

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Introduce Engineering Design as a structured process, different from the Conventional DesignEngineering. Learn the importance of Systematic Design Process in Product Design Identify variousstеps involved in the design process. Learn the importance of function and form in the design process

Week1: Introduction, Birth and Growth of a Product
Week 2:Types of Design, Stage-Gate and Spiral Design, Stages in New Product Development, Laboratory
Week 3: Reverse Engg. and Redesign, Technical Questioning and Mission Statement, Mission Statement.
Week 4: Identifying Customer Needs, Customer Need Analysis, Product Specifications
Week 5: Need - Metric Matrix, Establishing Target Specifications, HoQ,
Week 6: Functional Decomposition, FAST Method
Week 7: Function Structure (Flow Method), Flow Method
Week 8: Product and Portfolio Architecture, Portfolio Architecture Selection Laboratory
Week 9: Product Architecture, Identification of Modules.
Week 10: Concept Development, Intuitive Methods, Laboratory
Week 11: Logical Method- TRIZ, Concept Selection, Laboratory
Week 12: Concept Scoring, Laboratory exercise 1

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the basic concepts of design types, product development and reverse engineering

CO2: Develop the product and analysis using design methods.

CO3: Understand the concept of Product and Portfolio Architecture, Portfolio Architecture

CO4: Concept Development, Intuitive Methods for needs.

CO5: Logical Method- TRIZ, Concept Selection

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Kevin Otto &Krisitn Wood, Product Design, Pearson Education
2. D.G. Ullman, The Mechanical Design Process, McGraw- Hill, 2015
3. G. Pahl and W.Beitz, Engineering Design- A systematic Approach, Springer, 2007.

REFERENCE BOOKS:

1. "Axiomatic Design – Advances and Applications", by Nam P. Suh, the Oxford University Press
2. "Creating Breakthrough Products – Innovation from Product Planning to Program Approval", by Jonathan Cagan and Craig M. Vogel, Financial Times, Prentice Hall
3. "Product Design and Development", (the third edition), Karl T. Ulrich and Steven D. Eppinger, the McGraw-Hill Companies, Inc.

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc20_de10/preview
2. https://nptel.ac.in/courses/107106089

MA606508 – VEHICLE DYNAMICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand a foundation of engineering principles and analytical method to explain the performance of an automotive vehicle, concerning acceleration performance, braking performance, aerodynamics and rolling resistance, ride, tire dynamics, suspension system, steer ability, stability, cross country ability and smoothness running of an automotive vehicle

UNIT 1: INTRODUCTION TO VEHICLE DYNAMICS	**5**
Longitudinal Dynamics -Vehicle Load Distribution – Acceleration and Braking -Brake Force Distribution, Braking Efficiency and Braking Distance - Longitudinal dynamics of a Tractor-Semi Trailer	
UNIT 2: TIRE MECHANICS – AN INTRODUCTION	**11**
Mechanical Properties of Rubber - Slip, Grip and Rolling Resistance - Tire Construction and Force Development - Contact Patch and Contact Pressure Distribution	
UNIT 3:A SIMPLE TIRE MODEL	**6**
Lateral Force Generation - Ply Steer and Conicity - Tire Models – Magic Formula - Classification of Tire Models and Combined Slip	
UNIT 4:LATERAL DYNAMICS	**7**
Bicycle Model - Stability and Steering Conditions - Understeer Gradient and State space Approach – Handling Response of a Vehicle - Mimuro Plot for Lateral Transient Response - Parameters affecting vehicle handling characteristics	
UNIT 5:EVALUATION OF VEHICLE HANDLING	**7**
Vertical Dynamics Rollover Prevention - Half Car Model - Quarter Car Model N o i s e , Vibration and Harshness – Random Processes	
TOTAL: 36 PERIODS	

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Build a strong understanding of the fundamental concepts which are at work in a vehicle which is in motion.

CO2: Know the basics of tire models and mechanical properties

CO3: Use the techniques and methods acquired during this course to create vehicle system models within the MATLAB/Simulink environment

CO4: Learn how to analyse the dynamic response of a race car through simulations conducted within the MATLAB/Simulink environment

CO5: Demonstrate knowledge of the overall Modelling & Simulation landscape within Automotive/Motorsport Vehicle Dynamics

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

REFERENCE BOOKS:

1. Pacejka, Hans. Tire and vehicle dynamics.Elsevier, 2005
2. Wong, Jo Yung. Theory of ground vehicles. John Wiley & Sons, 2001.
3. Moore, Desmond F."The friction of pneumatic tyres." (1975).

4. Jazar, Reza N.Vehicle dynamics: theory and application. Springer, 2008
5. Gillespie, Thomas D. Fundamentals of vehicle dynamics, 1992

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc24_ee30/preview
2. https://ed.iitm.ac.in/~shankarram/Course_Files/ED5220/ED5220.htm

MA606509 – MICROFLUIDICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The fundamentals of fluid flows at micro-scale including intermolecular forces, low Re flows,slip theory, capillary flows and electrokinetics are discussed. The principles ofmicrofabrication with silicon and polymer substrates are illustrated. Theory and design of various microfluidic components including micropumps, micromixers, microvalves etc

MODULE 1: INTRODUCTION **2**

Origin, Definition,Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

MODULE 2: MICRO-SCALE FLUID MECHANICS **10**

- Intermolecular forces,States of matter, Continuum assumption, Governing equations, Constitutive relations.
- Gas and liquid flows,Boundary conditions,Slip theory, Transition to turbulence, Low Re flows,Entrance effects. Exact solutions, Couette flow,Poiseuille flow,Stokes drag on asphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels.
- Hydraulic resistance and Circuit analysis,Straight channel of different cross-sections, Channels in series and parallel.

MODULE 3:CAPILLARY FLOWS **2**

Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

MODULE 4:ELECTROKINETICS **7**

- Electro hydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electro-osmotic flow, Ideal EOF with back pressure, Cascade electroosmotic micro pump, EOF of power-law fluids.
- Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP ,Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere.
- Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric

MODULE 5:MICROFABRICATION TECHNIQUES **7**

- Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding.
- Polymer micro fabrication, PMMA/COC/PDMS substrates, micro molding, hot embossing, fluidic interconnections.

MODULE 6: MICROFABRICATION TECHNIQUES 10

- Micropumps, Check-valve pumps,Valve-less pumps,Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps.
- Microvalves,Pneumatic valves, Thermopneumatic valves, Thermomechanical valves,Piezoelectric valves,Electrostatic valves,Electromagnetic valves, Capillary force valves.
- Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers,Physics of mixing,Pe-Re diagram of micromixers,
- Parallel lamination,Sequential lamination, Taylor-Aris dispersion. Droplet generators,Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction,

Dropletformation, breakup and transport.

- Microparticle separator, principles of separation and sorting of microparticles, design and applications.
- Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

MODULE 7: FEW APPLICATIONS OF MICROFLUIDICS	2

Drug delivery, Diagnostics,Bio-sensing

TOTAL: 40HOURS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: knowledge on: general properties of microfluidic systems

CO2: understand physics involved in gas and liquid flow in microchannels, surface forces dominating in the microscale

CO3: skills on: solving simple problems of gas and liquid flows in microchannels

CO4: Designing a microchannel system, evaluation of the appropriate experimental technique for the study of a given flow problem.

CO5: Design a Pumps and valves using advanced microchannel techniques.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

REFERENCE BOOKS:

1. Nguyen, N. T., Werely,S. T., Fundamentals and applications of Microfluidics,Artech house Inc., 2002
2. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008
3. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
4. Tabeling,P., Introduction to microfluidics, Oxford University Press Inc., 2005.
5. Kirby,B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.

WEB RESOURCES:

1. https://nptel.ac.in/courses/112105187
2. HTTPS://NPTEL.AC.IN/COURSES/112106169
3. CAPILLARY FLOWS :https://youtu.be/XVeE-Lb0EPU
4. MICROFABRICATION TECHNIQUES:https://youtu.be/JssvezRY8bQ

INSTITUTE ELECTIVE I

ME607118QUALITY CONTROL AND RELIABILITY ENGINEERING

Course Category: Program Core	Course Type: Theory with practical Component	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the concept of SQC
- To understand process control and acceptance sampling procedure and their application. To learn the concept of reliability

UNIT1:INTRODUCTION AND PROCESS CONTROL FOR VARIABLES — **9**

Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance, Quality control: Quality cost-Variation in process causes of variation – Theory of control chart- uses of control chart –X chart, R chart and - process capability - process capability studies and simple problems. Six sigma concepts.

UNIT 2 : PROCESS CONTROL FOR ATTRIBUTES — **9**

Control chart for attributes –control chart for non conformings– p chart and np chart – control chart for nonconformities– C and U charts, State of control and process out of control identification in charts, pattern study.

UNIT 3: ACCEPTANCE SAMPLING — **9**

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling techniques – O.C. curves – producer's Risk and consumer's Risk. AQL, LTPD, AOQL concepts-standard sampling plans for AQL and LTPD- uses of standard sampling plans.

UNIT 4: LIFE TESTING – RELIABILITY — **9**

Life testing – Objective – failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate – Weibull model, system reliability, series, parallel and mixed configuration – simple problems. Maintainability and availability – simple problems. Acceptance sampling based on reliability test – O.C Curves.

UNIT 5: QUALITY AND RELIABLITY — **9**

Reliability improvements – techniques- use of Pareto analysis – design for reliability – redundancy unit and standby redundancy – Optimization in reliability – Product design – Product analysis – Product development–Product life cycles.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1 Summarize the concept of Quality and Process control for variables

CO2 Apply the process control for attributes

CO3 Explain the concept of sampling and to solve problems

CO4 Explain the concept of Life testing

CO5 Explain the concept Reliability and techniques involved

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. Douglas.C. Montgomery, “Introduction to Statistical quality control”, 7th edition, John Wiley 2012.
2. Srinath. L.S., “Reliability Engineering”, Affiliated East west press, 2008.
REFERENCE BOOKS:
1. Besterfield D.H., “Quality Control”, Prentice Hall, 2013.
2. Connor, P.D.T.O., “Practical Reliability Engineering”, John Wiley, 2012
3. Danny Samson, “Manufacturing & Operations Strategy”, Prentice Hall, 1991
4. Grant, Eugene .L “Statistical Quality Control”, McGraw-Hill, 2017
5. Gupta. R.C, “Statistical Quality control”, Khanna Publishers, 2010.
WEB RESOURCES:
https://classes.engineering.wustl.edu/2009/fall/ese405/405chapter1.pdf
https://www.ieor.iitb.ac.in/acad/courses/ie646

ME607119INDUSTRIAL SAFETY					
Course Category: Program Core	**Course Type: Theory with practical Component**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To study the fundamental concept and principles of industrial safety
To study the principles of maintenance engineering.
To Analyzing the wear and its reduction.
To study the faults in various tools, equipment and machines.
To study the periodic maintenance procedures in preventive maintenance

UNIT 1 : INDUSTRIAL SAFETY **9**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT 2 : MAINTENANCE ENGINEERING **9**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT 3: WEAR AND CORROSION AND THEIR PREVENTION **9**

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT 4: FAULT TRACING **9**

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler,vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT 5: PERIODIC AND PREVENTIVE MAINTENANCE **9**

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of:i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, Advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the fundamental concept and principles of industrial safety.
CO2 : Apply the principles of maintenance engineering.
CO3 :Analyse the wear and its reduction.
CO4 :Evaluate faults in various tools, equipments and machines.
CO5 : Apply periodic maintenance procedures in preventive maintenance.

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	-	-	-	-	1	-	-	1	1	2
CO2	2	1	2	1	-	-	-	-	1	-	-	1	1	2
CO3	2	1	2	1	-	-	-	-	1	-	-	1	1	2

CO4	2	1	2	1	-	-	-	-	1	-	-	1	1	2
CO5	2	1	2	1	-	-	-	-	1	-	-	1	1	2
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1.L M Deshmukh, Industrial Safety Management, Tata McGraw-Hill Education, 2005

2.Charles D. Reese, Occupational Health and Safety Management: A Practical Approach, CRC Press, 2003.

REFERENCE BOOKS:

1.EdwardGhali, V. S. Sastri, M. Elboujdaini, Corrosion Prevention and Protection: Practical Solutions, John Wiley & Sons, 2007.

2.Garg, HP, Maintenance Engineering, S. Chand Publishing.

3.J Maiti, Pradip Kumar Ray, Industrial Safety Management: 21st Century Perspectives of Asia, Springer, 2017

4.R. Keith Mobley, Maintenance Fundamentals, Elsevier, 2011.

5.W. E. Vesely, F. F. Goldberg, Fault Tree Handbook, Create space Independent Pub, 2014

WEB RESOURCES:

https://www.wiley.com/en-gb/Design+of+Jigs,+Fixtures+and+Press+Tools-p-9781119155652

https://www.springerprofessional.de/en/design-of-jigs-fixtures-and-press-tools/19392834

INSTITUTE ELECTIVE II

ME607218SPACE TECHNOLOGY					
Course Category: Program Core	**Course Type: Theory with practical Component**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understand the fundamentals of aerospace propulsion.
- Understand the orbit mechanics and orbit maneuvers.
- Acquire the knowledge of satellite attitude dynamics and space mission operations.

UNIT1:FUNDAMENTALS OF ROCKET PROPULSION AND TRAJECTORIES – SPACEMISSION — **9**

Types-Space environment-launch vehicle selection.; Introduction to rocket propulsion- fundamentals of solid propellant rockets- Fundamentals of liquid propellant rockets-Rocket equation, Two dimensional trajectories of rockets and missiles-Multi-stage rockets-Vehicle sizing-Two multi-stage rockets-Trade-off ratios-Single stage to orbit- Sounding rocket- Aerospace plane Gravity turn trajectories-Impact point calculation-Injection conditions-Flight dispersions.

UNIT 2 : ATMOSPHERIC REENTRY — **9**

Introduction-Steep Ballistic Reentry, Ballistic Orbital Reentry, Skip Reentry, Double-Dip Reentry, Aero-braking, Lifting Body Reentry.

UNIT 3: FUNDAMENTALS OF ORBIT MECHANICS, ORBIT MANEUVERS — **9**

Two-body motion, Circular, elliptic, hyperbolic, and parabolic orbits-Basic Orbital Elements, Ground trace In-Plane Orbit changes, Hohmann Transfer, Bielliptical Transfer, Plane Changes, Combined Maneuvers, Propulsion for Maneuvers.

UNIT 4:SATELLITE ATTITUDE DYNAMICS — **9**

Torque free Axi-symmetric rigid body-Attitude Control for Spining Spacecraft - Attitude Control for Non-spinning Spacecraft - The Yo-Yo Mechanism - Gravity - Gradient Satellite- Dual Spin Spacecraft- Attitude Determination.

UNIT 5: SPACE MISSION OPERATIONS — **9**

Supporting Ground Systems Architecture and Team interfaces, Mission phases and Core operations, Team Responsibilities, Mission Diversity, Standard Operations Practices.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1 Distinguish the types of aerospace propulsion.

CO2 Determine the attitude of the satellites.

CO3 Support the space mission operations.

CO4 Ability to understand satellite Attitude Dynamics

CO5 To understand space mission operations

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.W.E. Wiesel, Spaceflight Dynamics, McGraw Hill,2nd edition,2014,ISBN-13: 978- 9332901650.

2. J.W. Cornelisse, Rocket Propulsion and Space Dynamics, J.W. Freeman & Co., Ltd., London, 1982.

REFERENCE BOOKS:

1.Vincet L. Pisacane, Fundamentals of Space Systems, Oxford University Press, 2005.

2. J.Sellers /Understanding Space: An Introduction to Astronautics , McGraw Hill, 2nd edition,2000,ISBN-13: 978-0072424683

3. Francis J Hale /Introduction to Space Flight, Pearson, 1993,ISBN-13: 978- 0134819129.

4. CharlesD.Brown /Spacecraft Mission Design, AIAA education Series, 1998.

5. Meyer Rudolph X /Elements of Space Technology for aerospace Engineers, Meyer Rudolph X, Academic Press, 1999.

WEB RESOURCES:https://archive.nptel.ac.in/content/syllabus_pdf/101106046.pdf

ME607219RENEWABLE ENERGY TECHNOLOGIES						
Course Category: Program Core	**Course Type: Theory with practical Component**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To know the Indian and global energy scenario
- To learn the various solar energy technologies and its applications.
- To explore the various bio-energy technologies.
- To study the ocean and geothermal technologies.

UNIT1:ENERGY SCENARIO **9**

Indian energy scenario in various sectors – domestic, industrial, commercial, agriculture, transportation and others – Present conventional energy status – Present renewable energy statusPotential of various renewable energy sources-Global energy status-Per capita energy consumption - Future energy plans

UNIT 2 : SOLAR ENERGY **9**

Solar radiation – Measurements of solar radiation and sunshine – Solar spectrum - Solar thermal collectors – Flat plate and concentrating collectors – Solar thermal applications – Solar thermal energy storage – Fundamentals of solar photo voltaic conversion – Solar cells – Solar PV Systems – Solar PV applications.

UNIT 3: WINDENERGY **9**

Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment - Horizontal axis wind turbine – components - Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.

UNIT 4:BIO-ENERGY **9**

Bio resources – Biomass direct combustion – thermochemical conversion - biochemical conversionmechanical conversion - Biomass gasifier - Types of biomass gasifiers - Cogeneration –- Carbonisation – Pyrolysis - Biogas plants – Digesters –Biodiesel production – Ethanol production - Applications.

UNIT 5: OCEAN AND GEOTHERMAL ENERGY **9**

Small hydro - Tidal energy – Wave energy – Open and closed OTEC Cycles – Limitations – Geothermal energy – Geothermal energy sources - Types of geothermal power plants – Applications - Environmental impact.**TOTAL: 45 PERIODS**

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1 Discuss the Indian and global energy scenario

CO2 Describe the various solar energy technologies and its applications

CO3 Explain the various wind energy technologies

CO4 Explore the various bio-energy technologies

CO5 Discuss the ocean and geothermal technologies

CO's PO's&PSO's MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Fundamentals and Applications of Renewable Energy | Indian Edition, by Mehmet Kanoglu, Yunus A. Cengel, John M. Cimbala, cGraw Hill; First edition

2. Renewable Energy Sources and Emerging Technologies, by Kothari, Prentice Hall India Learning Private Limited; 2nd edition

REFERENCE BOOKS:

1.Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 2012.
2. Rai.G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2014.
3. Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2009.
4. Tiwari G.N., “Solar Energy – Fundamentals Design, Modelling and applications”, Alpha Science Intl Ltd, 2015.
5. Twidell, J.W. & Weir A., “Renewable Energy Resources”, EFNSpon Ltd., UK, 2015.
WEB RESOURCES:
https://classes.engineering.wustl.edu/2009/fall/ese405/405chapter1.pdf
https://www.ieor.iitb.ac.in/acad/courses/ie646

INSTITUTE ELECTIVE III

ME607317-NANO TECHNOLOGY

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand the basic scientific concepts of nanoscience.
- Understand the properties of nano materials, characterization of materials, synthesis and fabrication.

UNIT 1: BASIC CONCEPTS OF NANOSCIENCE **9**

Introduction of nanomaterials - History of nanomaterials - Size effect of Nanomaterials: Size, shape, density, melting point, wet ability and specific surface area - Surface to Volume Ratio – Energy at the Nanoscale - Quantum Confinement Effects –Nanosized metals, alloys, semiconductors, ceramics – classification based on the dimensionality: nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, nanotubes, quantum wells, metal based nanostructures, nanocomposites, carbon nanotubes

UNIT 2: SYNTHESIS OF NANOMATERIALS **9**

Bottom-up, Top-down Approach - Inert gas condensation, Plasma arc technique, Ion sputtering, Laser ablation, Ball Milling, Molecular beam epitaxy (MBE), Chemical vapour deposition (CVD) method, Ultrasonication, Chemical precipitation and co-precipitation, Sol-Gel synthesis; Microemulsions synthesis, Hydrothermal, Solvothermal synthesis methods, Microwave assisted synthesis.

UNIT 3: CHARACTERIZATION TECHNIQUES **9**

X-ray diffraction (XRD), SEM, EDAX, AFM, TEM, Elemental mapping, FTIR, UVVisiblespectrophotometer, Laser Raman Spectroscopy, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), X-ray Photoelectron Spectroscopy (XPS), Electrochemcial Characterization measurements, Nanoindentation.

UNIT 4: PROPERTIES OF NANOSTRUCTURED MATERIALS **9**

Mechanical behaviour: Modes of Deformation - Elastic and Plastic Deformation - Mechanical Stiffness - tensile strength- Fracture - Toughness - Superplasticity - Hardness -Micro-hardness - wear resistance and corrosion resistance behaviour - Hall-Petch Relation - Fundamentals of Nanomechanics and Nanotribology - Thermal properties: Thermal conductivity, thermal expansion and thermal expansion coefficient - Electrical properties: Electrical conductivity, band gap tuning, band gap determination - Magnetic properties: Magnetic hysteresis - Superparamagnetism - Optical properties of nanostructures.

UNIT 5: APPLICATIONS OF NANOMATERIALS **9**

Functional graphene- carbon nanotube and polymer composite applications in defence and aerospace. Nanomaterials for solar Cells- Nanoscale catalysts for energy and automobile industries. Rechargeable batteries based on nanomaterials- Nanomaterials for electrodes and wearable electronics- Nano based coating and paints.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: understand the fundamentals of nanoscience

CO2: recognize the different methods of synthesizing nanomaterials

CO3: identify the exact characterization technique to analyze different properties

CO4: describe the different properties of nanomaterials

CO5: explain the various applications of nanomaterials in different fields

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	2	2	2	1	2	-	-	2	1	1
CO2	2	1	2	2	2	2	2	1	2	1	2	2	1	1

CO3	1	2	2	2	2	2	-	1	2	1	2	2	1	1
CO4	2	1	2	1	2	2	2	-	2	1	2	1	1	1
CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Nanostructures & Nanomaterials: Synthesis, Properties &Applications, G. Cao, Imperial College Press, 2004.

2. Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009

3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A. Muller, A. K. Cheetham (Eds), Wiley-VCH Verlag, 2004.

REFERENCE BOOKS:

1.. Impedance spectroscopy: Theory, Experiment and applications, E. Barsoukov, J. R. McDonald, John Wiley & Sons Ltd, 2000.

2.Nanostructures and nanomaterials: Synthesis, properties and applications, G. Cao, Imperial College Press, 2006.

WEB RESOURCES: https://youtu.be/ebO38bbq0_4

ME607318 STANDARDS,QUALITY CONTROL AND INSPECTION					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

To impart knowledge on

- •.To learn about additive manufacturing standards
- • To study the material characterization for additive manufacturing
- • To know the process control and quality management in additive manufacturing

UNIT 1: ADDITIVE MANUFACTURING STANDARDS	**9**

Introduction to standards for Additive Manufacturing, Importance of standards, Importance of Quality Management, Standards, Quality Control, And measurement Sciences. History of formation of committee for standards. Work plan and roadmap of Joint Committee between ASTM, ISO. Priority areas on Additive Manufacturing Standards, List of different types of Standards for Additive manufacturing

UNIT 2: MEASUREMENT SCIENCE AND DATA FORMAT FOR ADDITIVE MANUFACTURING	**9**

Introduction to measurement science, challenges, Additive Manufacturing Materials, processes, parts and Uncertainties, Additive Manufacturing Modelling and Simulation, Potentials of Measurement science, typical applications, Data format in Additive Manufacturing – New Developments- Scanning Technology-Contact scanners and Non-contact scanners.

UNIT 3: MATERIAL CHARACTERIZATION FOR ADDITIVE MANUFACTURING	**9**

Introduction to Material Characterization –Types. Liquid Materials Characterization Techniques-rheology and wetting behaviour –curing characteristics-liquid density. Solid materials characterization techniques-Filament Diameter Consistency, density, porosity, Moisture content, thermal properties. Micro structure of filament Mechanical properties. Powder material characterization Techniques-powder size measurements-chemical composition, Flow characteristics.

UNIT 4: PROCESS CONTROL AND MODELING	**9**

Introduction to qualification-Definition and Terms, equipment qualification and general test, Four stages for qualification. Motivation for process control, Monitoring sensors, visual imaging, Thermal sensing, Displacement sensing. Measured of In-Process Control Research-SLM, EBM, DED, Wire Fed DED. Commercial solutions on process modelling, simufact additive, ESI-Additive Manufacturing, Netfabb Simulation.

UNIT 5: QUALITY MANAGEMENT FRAME WORK IN ADDITIVE MANUFACTURING	**9**

Need for Quality management frame work, Leader ship and commitment, planning, Additive Manufacturing support, Additive manufacturing operation, performance Evaluation, PDCA Frame work cycle, Roles of regulatory and certification bodies, Proposed Framework For Additive Manufacturing Implementation-User inputs, product knowledge, Equipment qualification, process knowledge, continuous process verification.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Understand the various additive manufacturing standards.

CO2: Select a suitable additive manufacturing standards for a given application.

CO3: Understand the material characterization and its types for additive manufacturing systems.

CO4: Select a suitable process control for additive manufacturing systems.

CO5: Understand the quality management frame work in additive manufacturing.

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	2	2	2	1	2	-	-	2	1	1

CO2	2	1	2	2	2	2	2	1	2	1	2	2	1	1
CO3	1	2	2	2	2	2	-	1	2	1	2	2	1	1
CO4	2	1	2	1	2	2	2	-	2	1	2	1	1	1
CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Chee Kai Chua , Chee How Wong and Wai Yee Yeong," Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing", Singapore Centre for 3D Printing, Academic press, Singapore, 1st Edition, 2017

REFERENCE BOOKS:

1.Ben Redwood, Filemon Schöffer, Brian Garret, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs, 2017

2.Chee Kai Chua, "3D Printing and Additive Manufacturing: Principles and Applications", World Scientific, 5th edition, 2017

WEB RESOURCES: https://youtu.be/oIG_NDb2g3U

INSTITUTE ELECTIVE IV

ME607417 - ROBOTICS AND MECHANICAL ACTUATORS

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- undamentals of robot‟s configurations for the design
- Identify a suitable gripper and sensor system of the robot
- Select suitable on drive systems for various actuations of robot
- Develop robot programs for the specific applications

Design the Unmanned Aerial Vehicle with fixed wing, multi-copter and flapping wing (K3).

UNIT 1: INTRODUCTION TO ROBOTICS **9**

Introduction - Automation – Robotics - Brief History, Basic Concepts of Robotics such as Definition, Three laws, Elements of Robotic Systems, i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems based on various parameters such as work volume, type of drive, etc., Associated parameters, i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Industrial applications of the robot.

UNIT 2: GRIPPERS AND SENSORS FOR ROBOTICS **9**

ITypes of Grippers, guidelines for the robotic gripper, Force analysis for various basic gripper systems. Sensors for Robots - Need for sensors- Types of Sensors used in Robotics, Classification and Selections of sensors, applications of sensors. The vision system of a robot.

UNIT 3: DRIVES AND CONTROL FOR ROBOTICS **9**

Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closedloop control.

UNIT 4: PROGRAMMING AND LANGUAGES FOR ROBOTICS **9**

IRobot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., - case studies

UNIT 5: UNMANNED AERIAL VEHICLE **9**

Unmanned Aerial Vehicle (UAV) - Taxonomy –Need –definition- applications- Remote sensing, Aerial mapping, Disaster response, Surveillance Search and rescue, Transportation Payload delivery. Development strategy of Fixed wing UAVs - Multi-copter UAV- Flapping wing UAV- Swarm Robot - case study.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Explain the fundamentals of robot‟s configurations for the design

CO2: Identify a suitable gripper and sensor system of the robot

CO3: Select suitable on drive systems for various actuations of robot

CO4: Develop robot programs for the specific applications

CO5: Design the Unmanned Aerial Vehicle with fixed wing, multi-copter and flapping wing

CO's PO's&PSO's MAPPING

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

CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

CO-PO MAPPING

TEXT BOOKS:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education, 2014

2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, 2006

3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2019.

REFERENCE BOOKS:

1.R. K. Mittal, I. J. Nagrath, Robotics and Control, Tata McGraw Hill Publishing CoLtd, New Delhi, 2003.

2.S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., 2020

3.J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer, 1997.

WEB RESOURCES: https://archive.nptel.ac.in/courses/112/101/112101098/

ME607418 FAILURE ANALYSIS AND NDT TECHNIQUES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- To understand the various Non-Destructive Testing methods in manufacturing defects.
- To understand the various mechanisms involved in NDT techniques.
- To know the industrial applications of NDT and recent trends in NDT.

UNIT 1: INTRODUCTION **9**

NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT. Visual inspection – Unaided and aided. Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Leak testing standards, types and industrial applications.

UNIT 2: MAGNETIC PROPERTY BASED TESTS **9**

Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism. Eddy Current Testing - Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Lift-off factor and edge effects, Skin effect, Inspection frequency; Coil Arrangements Types of arrangement, Types of circuit, Applications, advantages, Limitations, Interpretation/Evaluation.

UNIT 3: ULTRASONIC TESTING **9**

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction.

UNIT 4: RADIOGRAPHY TESTING **9**

Principles of radiography – Sources of X-rays and rays – Equipment – general radiographic procedure - Radiographic film, paper and screens – radiographic attenuation and penetration – Acceptance standards – Safety in radiography – Special radiography techniques (Fluoroscopy, Xeroradiography).

UNIT 5: FAILURE ANALYSIS MISCELLANEOUS TESTING METHODS AND APPLICATIONS **9**

Failure rate, mode and code – failure generation – Failure Analysis: fault tree analysis (FTA), Event Tree Analysis (ETA), Root cause Analysis (RCA) – Root Cause Failure Analysis (RCFA) – Failure Modes and Effects Analysis (FMEA) – Failure Mode and Effect Criticality Analysis (FMECA) – Weibull analysis.Acoustic Emission Technique – crack depth gauges – thermography – surface texture analysis – leak test - multiphase flow analysis – principles. Applications of NDT in railways, nuclear, chemical, aerospace, automobile and coal mining industries – case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Differentiate Liquid Penetrant testing and visual inspection.

CO2: Explain magnetization based NDT methods

CO3: Explore with Ultrasonic testing of materials.

CO4: Understand the principle of radiographic testing

CO5: Apply the recent trends in NDT to the industrial requirements

CO's PO's&PSO's MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	2	1	2	2	1	2	2	1	2	-	-	2	1	1
CO2	2	2	2	2	2	2	2	1	2	1	2	2	1	1
CO3	1	2	2	2	2	2	-	1	2	1	2	2	1	1
CO4	2	1	2	2	2	2	2	-	2	1	2	1	1	1
CO5	2	2	2	2	1	2	-	2	2	1	2	1	1	1
1- low, 2 - medium, 3 - high, '-' no correlation														

TEXT BOOKS:

1. Jayamangal Prasad, C. G. Krishnadas Nair, Non-Destructive Test and Evaluation of Materials", Tata McGraw-Hill Education, 2nd edition, 2017

2. Baldev Raj, T.Jayakumar, M.Thavasimuthu, "Practical Non-Destructive Testing", Narosa Publishing House, Reprint 2019.

3. Ravi Prakash, "Non-Destructive Testing Techniques", New Age International Publishers, 1st revised Edition, 2010.

4. . Bhattacharya S.N., "Installation, Servicing and Maintenance", S. Chand and Co., 2nd Edition, 2001.

REFERENCE BOOKS:

1.Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd edition New Jersey,2005.

2.Charles, J. Hellier, "Handbook of Non-destructive evaluation", McGraw Hill, New York 2013.

3.ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing, 3rd Edition.

WEBRESOURCES: https://www.ndeed.org/GeneralResources/MethodSummary/MethodSummary.htm
• https://nptel.ac.in/courses/112105182/.

PSN COLLEGE OF ENGINEERING AND TECHNOLOGY

(An Autonomous Institution Recognised by AICTE, New Delhi
and Affiliated to Anna University, Chennai)
Accredited with A+ Grade by NAAC. An ISO 9001:2015 Certified Institution
Melathediyoor, Tirunelveli – 627 152

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum approved by Board of Studies of
Mechanical Engineering for semester VII to VIII
Under Regulation 2022

INSTITUTE VISION
To emerge as a pioneer institute inculcating engineering education, skills, research, values and ethics.
INSTITUTE MISSION
• To achieve greater heights of excellence in technical knowledge and skill development through innovative teaching and learning practices. • To develop the state of art infrastructure to meet the demands of technological revolution. • To improve and foster research in all dimensions for betterment of society. • To develop individual competencies to enhance innovation, employability and entrepreneurship among students. • To instill higher standards of discipline among students, inculcating ethical and moral values for societal harmony and peace.

DEPARTMENT VISION
To emerge as a preeminent department to produce quality Mechanical Engineering Graduates to meet national and global needs.
DEPARTMENT MISSION
• To educate students to be creative, inquisitive and innovation to become quality engineer and entrepreneurs. • To instil advanced knowledge with research capabilities for global careers and higher studies. • To inculcate moral and ethical standards in life and career.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
Sl. No.	**PEOs**
PEO1	The Graduates of Mechanical Engineering program will excel in technical knowledge, innovation and entrepreneurial skills.
PEO2	The Graduates will be able to design and develop various Mechanical Systems for interdisciplinary and multi-disciplinary applications.
PEO3	The Graduates will exhibit ethical attitude, human values, leadership quality and ability to solve engineering problems to a broader social context.

PROGRAM OUTCOMES			
PO'S No.	**KNOWLEDGE**	**STATEMENT**	**APPLIANCE**
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of Complex engineering problems.	Theory/ Practical / Project work
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.	Theory / Practical / Projects
3	Design / Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the needs with appropriate consideration for the public health and safety, and the cultural, Societal and environmental considerations.	Theory / Practical / Projects

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.	Theory / Practical
5	Modern Tool usage	Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	Theory / Practical / Project work
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.	Theory / Industrial visit / In plant training
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.	Theory / Industrial Visit/ In plant Training
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Theory / Industrial visit / In plant training
9	Individual and Team Work	Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.	Projects
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.	Projects/ Seminar/ Mini Project
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.	Projects
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.	Projects / Higher Studies

PROGRAM SPECIFIC OUTCOMES (PSOs)
PSO1: Design, model and analyse mechanical systems and components using CAD tools and select suitable manufacturing processes. **PSO2:** Formulate, analyze and provide the solution to thermal engineering related problems to meet industrial competitiveness.

SUMMARY SHEET

Semester wise Credits									**Credits Total**
Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	
Credits	**21**	**21**	**21.5**	**21.5**	**22**	**22**	**25**	**10**	**165**

Sl.No	Course code	Course Name	Classification		L	T	P	C
SEM - 01								
1	IC610001	Professional English I	IC	Theory	2	0	0	2
2	IC610002	Matrices and Calculus	IC	Theory	2	1	0	3
3	IC610003	Engineering Physics	IC	Theory	3	0	0	3
4	IC610004	Engineering Chemistry	IC	Theory	3	0	0	3
5	CS610005	Problem Solving and 'C' Programming	IC	Theory	3	0	0	3
6	ME610006	Engineering Graphics with CAD	IC	Theory with Practical Component	2	0	2	3
7	IP610101	Physics & Chemistry Laboratory	IC	Practical	0	0	3	1.5
8	IP610102	Programming in 'C' Laboratory	IC	Practical	0	0	3	1.5
9		NCC/NSS/NSO *	IM	Institute Mandatory	1	0	0	0
10	IC610007	tamilmarabu/Heritage of Tamil	IC	Theory	1	0	0	1
		Total			**17**	**1**	**8**	**21**
SEM - 02								
11	IC620008	Professional English II	IC	Theory with Practical Component	2	0	2	3
12	IC620009	Transforms & Partial Differential Equations	IC	Theory	2	1	0	3
13	IC620010	Engineering Materials (for Non Circuit Branches)	IC	Theory	3	0	0	3
	IC620011	Semiconductor Physics(for Circuit Branches)						
14	ME620012	Engineering Mechanics(for Non Circuit Branches)	PC	Theory with project	3	0	0	3
	CS620013	Fundamentals of Artificial Intelligence (for Circuit Branches)						
15	CS620014	Python Programming	IC	Theory	3	0	0	3
16	ME620015	Basic Engineering	IC	Theory	3	0	0	3
17	IP620103	Python Laboratory	IC	Practical	0	0	3	1.5
18	IP620104	Engineering practice laboratory	IC	Practical	0	0	3	1.5
19	IM610401	Environmental Studies	IM	Institute Mandatory	2	0	0	0
20	IC620016	Tamils and technology	IC	Theory	1	0	0	1

		Total			**25**	**1**	**8**	**22**
SEM – 03								
21	IC630017	Numerical Methods and Statistics (Common to MECH & MAE)	IC	Theory	3	0	0	3
22	ME630201	Engineering Thermodynamics (Common to MECH & MAE)	PC	Theory	3	0	0	3
23	ME630202	Fluid Mechanics and Machinery (Common to MECH, Aero and MAE)	PC	Theory	3	0	0	3
24	ME630203	Manufacturing Technology (Common to MECH & MAE)	PC	Theory with project	3	0	0	3
25	ME630204	Strength of materials(Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
26		Professional elective-1	PE	Theory	3	0	0	3
27	ME630301	Fluid Mechanics and Machinery (Common to MECH , MAE &AERO)	PC	Practical	0	0	3	1.5
28	ME630302	Manufacturing Technology Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
29	ME630501	Integrated Aptitude Skills - I (Lower)	EEC	skill based course	0	0	1	0.5
30	IM630402	Universal Human Values	IM	Theory	2	0	0	0
		Total			**19**	**0**	**9**	**21.5**
SEM – 04								
31	IC640018	Boundary value problems and probability distributions (Common to MECH & MAE)	IC	Theory	3	0	0	3
32	ME640205	Engineering Materials and Metallurgy (Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
33	ME640206	Thermal Engineering (Common to MECH & MAE)	PC	Theory with project	3	0	0	3
34	EE640901	Electrical Drives and Control (Common to MECH & MAE)	PC	Theory	3	0	0	3
35		Professional elective-2	PE	Theory	3	0	0	3
36		Institute elective -1	IE	Theory	3	0	0	3
37	ME640303	Thermal Engineering Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
38	EE640902	Electrical Drives and Control Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
39	ME640502	Integrated Aptitude Skills - II (Lower)	EEC	skill based course	0	0	1	0.5
40		Inplant Training (2 Weeks)	IM					0
		Total			**17**	**0**	**9**	**21.5**
SEM – 05								

41	ME650207	Theory of Machines (Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
42	ME650208	Engineering Metrology and Measurements(Common to MECH & MAE)	PC	Theory with project	3	0	0	3
43	ME650209	Design of Machine Elements (Common to MECH & MAE)	PC	Theory	2	1	0	3
44		Institute elective -2	IE	Theory	3	0	0	3
45		Professional elective-3	PE	Theory	3	0	0	3
46		Professional elective-4	PE	Theory	3	0	0	3
47	ME650304	Dynamics of Machinary Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
48	ME650305	Computer Numerical Control Laboratary (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
49	ME650503	Integrated Aptitude Skills - I (Higher)	EEC	skill based course	0	0	2	1
50	ME650801	BIS	PM	Theory	2	0	0	0
		Total			**19**	**0**	**10**	**22**
SEM – 06								
51	ME660210	Heat and Mass Transfer (Common to MECH & MAE)	PC	Theory with project	2	1	0	3
52	ME660211	Design of Transmission Systems(Common to MECH & MAE)	PC	Theory with Practical Component	2	0	2	3
53	ME660212	CAD/CAM/CAE(Common to MECH & MAE)	PC	Theory	3	0	0	3
54		Institute elective -3	IE	Theory	3	0	0	3
55		Professional elective-5	PE	Theory	3	0	0	3
56		Professional elective-6	PE	Theory	3	0	0	3
57	ME660306	Heat Transfer Laboratory(Common to MECH & MAE)	PC	Practical	0	0	3	1.5
58	ME660307	CAD/CAM Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
59	ME660504	Training in Centre for excellence - BOSCH	EEC	skill based course	0	0	2	1
60	IM660403	Professional Ethics(Common to MECH & MAE)	IM	Theory	2	0	0	0
61		Internship	IM					0
		Total			**19**	**0**	**10**	**22**
SEM – 07								
62	ME670213	Principles of Management	PC	Theory	3	0	0	3
63	ME670214	Finite Element Analysis (Common to MECH & MAE)	PC	Theory with project	3	0	0	3

64	ME670215	Mechatronics and Robotics	PC	Theory with Practical Component	2	0	2	3
65		Institute elective -4	IE	Theory	3	0	0	3
66		Professional elective-7	PE	Theory	3	0	0	3
67		Professional elective-8	PE	Theory	3	0	0	3
68	ME670308	3D Printing (Common to MAE)	PC	Practical	0	0	3	1.5
69	ME670309	Computer Aided Simulation and Analysis Laboratory (Common to MECH & MAE)	PC	Practical	0	0	3	1.5
70	MG670019	Innovation Entrepreneurship and Startups	IC	Theory	3	0	0	3
71	ME670505	Advanced career development	EEC	skill based course	0	0	2	1
		Total			**20**	**0**	**10**	**25**
SEM - 08								
72	ME680506	Project Work	EEC	Practical	0	0	20	10
		Total			**0**	**0**	**20**	**10**

VERTICAL 1: THERMAL SCIENCES (COMMON TO MAE & MECH)								
1	ME606101	Power Plant Engineering	PE	Theory	3	0	0	3
2	ME606102	Heating Ventilation and Air Conditioning	PE	Theory	3	0	0	3
3	ME606103	Thermal Management of Batteries and Fuel Cells	PE	Theory	3	0	0	3
4	ME606104	Refrigeration and Air Conditioning	PE	Theory	3	0	0	3
5	ME606105	Internal Combustion Engine	PE	Theory	3	0	0	3
6	ME606106	Air Breathing Engines	PE	Theory	3	0	0	3
7	ME606107	Design of thermal systems	PE	Theory	3	0	0	3
8	ME606108	Inverse Methods in Heat Transfer (NPTEL)	PE	Theory	3	0	0	3
9	ME606109	Fundamentals of combustion for propulsion (NPTEL)	PE	Theory	3	0	0	3
10	ME606110	Fundamentals of Gas Dynamics (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 2: ENERGY TECHNOLOGIES (COMMON TO MAE&MECH)								
1	ME606201	Fuel Cell and Hydrogen Technology	PE	Theory	3	0	0	3
2	ME606202	Alternate Energy Fuels	PE	Theory	3	0	0	3
3	ME606203	Bio Energy Conversion Technologies	PE	Theory	3	0	0	3
4	ME606204	Energy Storage Devices	PE	Theory	3	0	0	3
5	ME606205	Energy Conservation and Waste heat recovery	PE	Theory	3	0	0	3
6	ME606206	Solar energy technologies	PE	Theory	3	0	0	3
7	ME606207	Green energy sources	PE	Theory	3	0	0	3
8	ME606208	Micro and nano scale energy transport (NPTEL)	PE	Theory	3	0	0	3
9	ME606209	Design and Optimization of Energy systems (NPTEL)	PE	Theory	3	0	0	3
10	ME606210	Electric vehicles and Renewable energy (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 3: LOGISTICS AND SUPPLY CHAIN MANAGEMENT (COMMON TO MAE&MECH)								
1	ME606301	Warehousing Automation	PE	Theory	3	0	0	3
2	ME606302	Business Process Re-engineering	PE	Theory	3	0	0	3
3	ME606303	Total Quality Management	PE	Theory	3	0	0	3
4	ME606304	Project Management (Common to MAE,MECH,AERO)	PE	Theory	3	0	0	3
5	ME606305	Industrial psychology	PE	Theory	3	0	0	3
6	ME606306	Resource management techniques	PE	Theory	3	0	0	3
7	ME606307	Enterprise resource planning	PE	Theory	3	0	0	3
8	ME606308	Business Development: From Start to Scale (NPTEL)	PE	Theory	3	0	0	3
9	ME606309	Patent Law for Engineers and Scientists (NPTEL)	PE	Theory	3	0	0	3
10	ME606310	Business Analysis for Engineers (NPTEL)	PE	Theory	3	0	0	3

VERTICAL 4: COMPUTATIONAL ENGINEERING								
1	ME606401	Computational Solid Mechanics	PE	Theory	3	0	0	3
2	ME606402	Computational Fluid Dynamics and Heat transfer	PE	Theory	3	0	0	3
3	ME606403	Computational Bio Mechanics	PE	Theory	3	0	0	3
4	ME606404	Advanced Statistics and Data Analytics	PE	Theory	3	0	0	3
5	ME606405	Machine Learning for Intelligent Systems	PE	Theory	3	0	0	3
6	ME606406	Theory on Computation and Visualization	PE	Theory	3	0	0	3
7	ME606407	Foundations of Computational Materials Modelling (NPTEL)	PE	Theory	3	0	0	3
8	ME606408	Computational Fluid Dynamics using Finite Volume Method (NPTEL)	PE	Theory	3	0	0	3
9	ME606409	Foundation of Computational Fluid Dynamics (NPTEL)	PE	Theory	3	0	0	3
10	ME606410	Computational Fluid Dynamics for Turbo machinery(NPTEL)	PE	Theory	3	0	0	3
VERTICAL 5: DIVERSIFIED COURSES GROUP I								
1	ME606501	Design of Jigs, Fixtures and Press Tools	PE	Theory	3	0	0	3
2	MA606403	Mechanical Vibrations and Controls	PE	Theory	3	0	0	3
3	ME606502	Instrumentation for engineers	PE	Theory	3	0	0	3
4	ME606503	Automobile Engineering	PE	Theory	3	0	0	3
5	ME606504	Reverse Engineering	PE	Theory	3	0	0	3
6	ME606505	Nuclear Engineering	PE	Theory	3	0	0	3
7	ME606506	Production Planning and Control	PE	Theory	3	0	0	3
8	MA606408	Design for Quality, Manufacturing and Assembly (NPTEL)	PE	Theory	3	0	0	3
9	MA606409	Oil Hydraulics and Pneumatics (NPTEL)	PE	Theory	3	0	0	3
10	MA606410	Advanced Operations Research (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 6: MATERIALS SCIENCES(COMMON TO MAE&MECH)								
1	MA606101	Composite Materials	PE	Theory	3	0	0	3
2	MA606102	Tribology	PE	Theory	3	0	0	3
3	MA606103	Mechanical Behaviour of Materials	PE	Theory	3	0	0	3
4	MA606104	Polymer Technology	PE	Theory	3	0	0	3
5	MA606105	Smart Materials	PE	Theory	3	0	0	3
6	MA606106	Electrical, Electronic and Magnetic materials	PE	Theory	3	0	0	3
7	MA606107	Fracture mechanics	PE	Theory	3	0	0	3
8	MA606108	Basics of Materials Engineering (NPTEL)	PE	Theory	3	0	0	3
9	MA606109	Transport Phenomena in Materials (NPTEL)	PE	Theory	3	0	0	3
10	MA606110	Welding Processes (NPTEL)	PE	Theory	3	0	0	3

VERTICAL 7: MANUFACTURING ENGINEERING(COMMON TO MAE&MECH)								
1	MA606201	Computer Integrated Manufacturing	PE	Theory	3	0	0	3
2	MA606202	Industry 4.0	PE	Theory	3	0	0	3
3	MA606203	Flexible Manufacturing Systems(Common to MAE,MECH,AERO)	PE	Theory	3	0	0	3
4	MA606204	Additive Manufacturing Processes	PE	Theory	3	0	0	3
5	MA606205	Lean Manufacturing	PE	Theory	3	0	0	3
6	MA606206	Rapid Prototyping	PE	Theory	3	0	0	3
7	MA606207	Theory of metal cutting	PE	Theory	3	0	0	3
8	MA606208	Steel Quality : Role of Secondary Refining & Continuous Casting (NPTEL)	PE	Theory	3	0	0	3
9	MA606209	Laser Based Manufacturing (NPTEL)	PE	Theory	3	0	0	3
10	MA606210	Forming (NPTEL)	PE	Theory	3	0	0	3
VERTICAL 8: DIVERSIFIED COURSES GROUP 2								
1	MA606501	Maintenance Engineering	PE	Theory	3	0	0	3
2	MA606502	Design of Pressure Vessels	PE	Theory	3	0	0	3
3	EE606604	Virtual Instrumentation (Common to MAE & EEE)	PE	Theory	3	0	0	3
4	MA606503	Computational Fluid Dynamics	PE	Theory	3	0	0	3
5	MA606504	Fluid Power Control System	PE	Theory	3	0	0	3
6	MA606505	Hydraulics and Pneumatics	PE	Theory	3	0	0	3
7	MA606506	Industrial Networking	PE	Theory	3	0	0	3
8	MA606507	Functional and Conceptual Design (NPTEL)	PE	Theory	3	0	0	3
9	MA606508	Vehicle Dynamics (NPTEL)	PE	Theory	3	0	0	3
10	MA606509	Micro fluidics (NPTEL)	PE	Theory	3	0	0	3

INSTITUTE ELECTIVE I									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	ME607118	Quality Control & Reliability Engineering	MECH	IE	Theory	3	0	0	3
2	ME607119	Industrial safety	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE II									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	ME607218	Space Technology	MECH	IE	Theory	3	0	0	3
2	ME607219	Renewable Energy Technologies	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE III									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	ME607317	Nano Technology	MECH	IE	Theory	3	0	0	3
2	ME607318	Standards, Quality Control and Inspection	MECH	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE IV									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**S.No**
1	ME607417	Robotics and Mechanical Actuators	MECH	IE	Theory	3	0	0	1
2	ME607418	Failure Analysis and NDT Techniques	MECH	IE	Theory	3	0	0	2

SYLLABUS

SEMESTER VII

ME670213	PRINCIPLES OF MANAGEMENT				
Course Category: Industrial Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

The course aims to familiarize the learner with extant and emerging management theories and practices for reflective and holistic thinking on management principles and practices.

UNIT 1: 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 and contingency 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 2: PLANNING — **9**

Nature and purpose of planning — planning process — types of planning — objectives — setting objectives — policies — Planning premises — Strategic Management — Planning Tools and Techniques — Decision making steps and process.

UNIT 3: ORGANISING — **9**

Decentralization and Delegation; Factors affecting organisational design; Departmentalization; Organisational structures and Organograms: traditional and modern, comparative suitability and changes over time; formal- informal organisations‟ interface.

UNIT 4: DIRECTING AND CONTROLLING — **9**

Motivation- meaning, importance and factors affecting motivation; Leadership- meaning, importance and factors affecting leadership, leadership styles, and followership. Controlling- Principles of controlling; Measures of controlling and accountability for performance.

UNIT 5: SALIENT DEVELOPMENTS AND CONTEMPORARY ISSUES IN MANAGEMENT — **9**

Management challenges of the 21st Century; Factors reshaping and redesigning management purpose, performance and reward perceptions- Internationalisation, Digitalisation, Entrepreneurship & Innovation, Values & Ethics - Case studies on Indian corporates.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Describe the various levels of management and applicability of management principles.

CO2: Evaluate a company’s competitive landscape as per Porter‟s Five-force model.

CO3: Demonstrate various types of authority, delegation and decentralization in authority.

CO4: Demonstrate various types of leadership styles and identify the motivation techniques used by leaders.

CO5: Discuss the impact of emerging issues in management.

CO-PO MAPPING

	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	3	3	3	3	3	1	2	1	-	-	1	3	2	2
CO 2	3	3	1	2	2	2	1	1	-	-	-	3	2	2
CO 3	3	2	3	3	3	3	2	1	-	-	1	3	3	2
CO	3	2	2	1	3	3	1	1	-	-	-	3	3	2

4													
CO 5	3	2	2	2	2	3	2	1	-	-	-	3	3	2

1- low, 2 - medium, 3 - high, '-' no correlation

TEXTBOOKS:

Chhabra, T. N. (2021). Business Organisation and Management. Sun India Publications. New Delhi.

Kumar, P. (2019). Management: Principles and Applications. JSR Publication House LP, Delhi.

Mahajan, J. P., & Mahajan A. (2016). Management Principles and Applications. Vikas Publications.

Tulsian, P. C., & Pandey, V. (2021). Business Organisation& Management. Pearson Education, India

REFERENCE BOOKS:

1. Stephen P. Robbins & Mary Coulter; Management, Pearson Education, 13th Edition, 2017

2. Dr.C.B.Gupta; Principles of Management, Sultan Chand& Sons, 3 rd Edition.

3. Harold Koontz, HienzWeihrich, A RamachandraAryasri; Principles of Management, McGraw Hill, 2nd edition, 2015

WEB RESOURCES:

https://www.toolshero.com/management/14-principles-of-management/

https://open.umn.edu/opentextbooks/textbooks/693

ME670214	FINITE ELEMENT ANALYSIS (Common to MECH & MAE)				
Course Category: Industrial Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To introduce the concepts of Mathematical Modeling of Engineering Problems and to appreciate the use of FEM to a range of Engineering Problems.

UNIT 1:INTEGRAL FORMULATION & VARIATION METHODS — **9**

Methods of engineering analysis –weighted residual methods– general weighted residual statement– weak formulation of the weighted residual statement– principle of stationary total potential (PSTP) – Rayleigh Ritz method– piecewise continuous trial functions– simultaneous linear algebraic equations– Numerical integration – Gaussian quadrature.

UNIT 2:1D BAR & TRUSS ELEMENT — **9**

Introduction to matrix algebra – general steps in FEA – co-ordinates – linear bar element– shape functions– stiffness matrix– application to bar element – quadratic bar element– spring element – truss element – development of element equations– assembly– elemen tconnectivity– global equations.

UNIT 3:PLANE STRESS & PLANE STRAIN ANALYSIS — **9**

Introduction– constant strain triangular element (CST)– strain displacement matrix – stress strain relations– four noded rectangular element – iso-parametric elements– jacobian matrix –natural co-ordinate system and co-ordinate transformation – axisymmetric element.

UNIT 4: DYNAMIC & FLUID FLOW ANALYSIS — **9**

Fundamentals of vibration – equations of motion based on weak form – longitudinalvibration of bars – transverse vibration of beams – consistent & lumped mass matrices – Eigen values & Eigen vectors –Fluid mechanics in 2-D– shape function, stiffness matrix, load vector, assembly – Application.

UNIT 5: HEAT TRANSFER ANALYSIS — **9**

Temperature distribution using weighted residual approach – application to one-dimensional heat transfer problems in bar element – heat transfer analysis in CST element – axisymmetric element – scalarvariable problems in 2-D.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Evaluate the various approximation and elimination methods.

CO2: Explain various numerical engineering problems in 1D bar & Truss element.

CO3: Develop the CST, axisymmetric, iso, super and sub parametric elements.

CO4: Apply the numerical engineering in dynamic and fluid mechanics problems.

CO5: Examine the various applications involved in 1D, 2D heat transfer .

CO-PO MAPPING

	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
CO 1	3	3	3	2	1	-	-	-	-	-	-	2	3	2
CO 2	3	3	3	3	3	-	-	-	-	-	-	2	3	2
CO 3	3	2	3	2	3	-	-	-	-	-	-	2	3	2
CO 4	3	2	1	1	2	-	-	-	-	-	-	2	3	2
CO 5	3	3	3	3	3	-	-	-	-	-	-	2	3	3

2- low, 2 - medium, 3 - high, '-' no correlation

TEXTBOOKS:

Seshu P., **"Text Book of Finite Element Analysis",** Prentice-Hall of India Pvt. Ltd. New Delhi, (2015)

Chennakesava R. Alavala, **"Finite Elements Methods-Basic Concepts and Applications",** Prentice-Hall of India, Eastern Economy Editions, (2016)

REFERENCE BOOKS:
Bhavikatti S.S., **"Finite Element Analysis",** New Age International Publishers, (2017)
Reddy J.N., **"An Introduction to the Finite Element Method",** McGraw-Hill Edition, (2015)
David V. Hutton, **"Fundamentals of Finite Element Analysis",** Tata McGraw-Hill Edition, (2017)
WEB RESOURCES:
https://www.simscale.com/blog/learn-finite-element-analysis-fea/
https://www.ansys.com/en-in/simulation-topics/what-is-finite-element-analysis

ME670215	MECHATRONICS AND ROBOTICS				
Course Category: Industrial Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

Learn core concepts of mechatronics and robotics systems design, as well as microcontroller programming using powerful Arm-based platforms. Use industry standard IDEs to program and control a variety of peripherals, including laser distance detectors, optical sensors and smart actuators.

UNIT 1:INTRODUCTION TO INDUSTRIAL ROBOTS **9**

Robotics definition - robot configurations, robot anatomy, joint system, types of joints, work volume, robot drive systems, precision of movement, robotic sensors and actuators, end effectors, grippers, different types of grippers.

UNIT 2:NUMERICAL CONTROL **9**

Introduction-NC procedure, nc coordinate systems, elements of NC systems, classification of nc systems, advantages and dis-advantages of NC systems, applications of NC, NC manual part programming, apt language.

UNIT 3:ROBOT ACTUATORS AND FEED BACK COMPONENTS **9**

Actuators- pneumatic-hydraulic actuators, electric & stepper motors, comparison, position sensors – potentiometers- resolvers- encoders – velocity sensors-tactile sensors proximity sensors, robot applications in manufacturing.

UNIT 4: CONTROL SYSTEMS IN MECHATRONICS AND ROBOTICS **9**

Open-loop and Closed-loop Control Systems, PID Controllers: Tuning and Implementation, Adaptive and Intelligent Control, Motion Control in Robotics.

UNIT 5: MACHINE VISION AND ARTIFICIAL INTELLIGENCE IN ROBOTICS **9**

Basics of Image Processing, Object Recognition and Pattern Matching, AI Techniques in Robotics: Fuzzy Logic, Neural Networks, Introduction to Machine Learning in Robotics.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand robot anatomy of robot, configuration of different robots, and Describe construction and working of different types of robots.

CO2: Understand the basics of Numerical Control machines and part programming of simple geometries.

CO3: Select appropriaterobot actuator and feedback components such as stepper motor, encoder, resolver.

CO4: Design and implement control strategies for mechatronic and robotic applications.

CO5: Apply AI and machine vision techniques in robotic systems.

CO-PO MAPPING

	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	3	3	2	2	2	-	1	-	-	-	1	3	2	1
CO 2	2	2	1	2	3	1	-	-	-	-	-	2	2	3
CO 3	3	2	2	2	3	-	-	-	-	-	1	2	3	2
CO 4	3	2	3	2	3	1	1	-	-	-	-	2	3	2
CO 5	3	2	2	2	3	1	1	-	-	-	1	2	3	3

3- low, 2 - medium, 3 - high, '-' no correlation

TEXTBOOKS:

Automation, Production Systems and CIM, Mikell P. Groover, Prentice-Hall of India Pvt. Ltd, 2016.

Industrial Robotics -Technology, Programming and Applications (SIE), Nicholas Odrey, Mitchell Weiss,

Mikell Groover, Roger Nagel, Ashish Dutta, McGraw-Hill 2nd Edition, 2017.
Introduction to robotics: analysis, control, applications. Niku, S. B, John Wiley & Sons, 2020.
REFERENCE BOOKS:
Robotics and Control, Mittal R.K & Nagrath IJ, McGraw-Hill, 2017.
An introduction to robot technology. Coiffet, P., &Chirouze, M., Springer Science & Business Media, 2012.
Robotics: Control Sensing, K.S.Fu., R.C.Gonzalez, C.S.G. Lee, Vision and Intelligence Indian Edition, McGraw Hill Book Co., 2008.
WEB RESOURCES:
https://nptel.ac.in/courses/108105063
https://www.arm.com/resources/education/online-courses/mechatronics-and-robotics

ME670308 3D PRINTING LABORATORY					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

The student will be able to

- To gain knowledge and skills related to 3D printing technologies.
- To learn the selection of material, equipment and development of a product for Industry 4.0 environment.
- To understand the various software tools, processes and techniques for digital manufacturing.
- To apply these techniques into various applications.

LIST OF EXPERIMENTS

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components.
3. Exercise on CAD Data Exchange.
4. Generation of .stl files
5. Identification of a product for 3D printing and its process plan.
6. Printing of identified products on an available 3D printing machine.
7. Post processing of 3D printed product.
8. Inspection and defect analysis of the additively manufactured product.

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Develop CAD models for 3D printing.

CO2: Import and Export CAD data and generate .stl file.

CO3: Select a specific material for the given application.

CO4: Select a 3D printing process for an application.

CO5: Produce a product using 3D Printing or Additive Manufacturing (AM).

CO's PO's&PSO's MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P010	P011	PO12	PSO1	PSO2
CO1	2	2	2	2	3	-	-	-	-	-	-	2	-	-
CO2	2	2	-	-	3	-	-	-	-	-	-	-	-	-
CO3	2	1	-	-	3	-	-	-	-	-	-	-	-	-
CO4	2	1	-	1	3	-		-	-	-	-	-	-	-
CO5	2	1	-	2	3	-		-	-	-	-	-	-	-

ME670309 COMPUTER AIDED SIMULATION AND ANALYSIS LABORATORY

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

To analyzing the force, stress, deflection, thermal stress, heat transfer and vibration in mechanical components.

LIST OF EXPERIMENTS

1. Stress analysis of rectangular L bracket.
2. Stress analysis of Cantilever beams.
3. Stress analysis simply supported beams
4. Stress analysis of Cantilever Fixed End Beams
5. Mode frequency analysis of Cantilever beams
6. Mode frequency analysis simply supported beams
7. Mode frequency analysis Fixed beams
8. Harmonic analysis of a 2D component.
9. Thermal stress analysis of a 2D component.
10. Conductive heat transfer analysis of a 2D component.
11. Stress analysis of an axis symmetric component.
12. Conductive Heat transfer analysis of a 3D component

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Find out the effect of force and impact of stress on the mechanical components.

CO2: Calculate the deflection occurring on the mechanical components.

CO3: Get a detailed understanding of the thermal stress creation and its mechanism of spreading in mechanical components.

CO4: Gain knowledge regarding the mechanism of heat transfer in mechanical components.

CO5: Find out the vibration effects on mechanical components.

CO's PO's&PSO's MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P010	P011	PO12	PSO1	PSO2
CO1	2	2	2	2	3	-	-	-	-	-	-	2	-	-
CO2	2	2	-	-	3	-	-	-	-	-	-	-	-	-
CO3	2	1	-	-	3	-	-	-	-	-	-	-	-	-
CO4	2	1	-	1	3	-		-	-	-	-	-	-	-
CO5	2	1	-	2	3	-		-	-	-	-	-	-	-

MG670019	INNOVATION, ENTREPRENEURSHIP, AND STARTUPS				
Course Category: Program Core	**Course Type: Theory with Project**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on the following Topics,

- To Equip students with the knowledge, skills, and mindset necessary to foster innovation, recognize opportunities.
- To develop viable business models, navigate the startup ecosystem.
- To scale entrepreneurial ventures successfully

UNIT 1: FOUNDATIONS OF ENTREPRENEURSHIP AND INNOVATION — **9**

Entrepreneurship: Definitions, Evolution, and Types - Theories of Entrepreneurship - Innovation vs. Invention: Types of Innovation -Product-Process-Business Model - The Role of Startups in Economic Development Case Study: Disruptive Innovation in Startups

UNIT 2: IDEATION, OPPORTUNITY RECOGNITION, AND BUSINESS MODEL DEVELOPMENT — **9**

Ideation Techniques: Brainstorming, Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, and Reverse (SCAMPER), Design Thinking, Theory of Inventive Problem Solving (TRIZ) - Identifying Market Gaps and Unmet Needs - Evaluating Customer Pain Points and Problem-Solution Fit - Business Model Canvas: Deep Dive into the Nine Building Blocks - Value Proposition Design and Customer Segments - Lean Startup Methodology and MVP Development - Case Study: Real-world Startup Examples

UNIT 3: MARKET RESEARCH, CUSTOMER DEVELOPMENT, AND FINANCIAL PLANNING — **9**

Market Research: Tools, Methods, and Best Practices - Customer Behavior and Segmentation - Product-Market Fit: Definition, Importance, and Strategies Financial Planning for Startups: Cash Flow, Unit Economics, and Break-even Analysis Funding Sources - Equity Dilution, Cap Tables, and Investor Negotiations - Case Study: How Startups Achieved Product-Market Fit

UNIT 4: LEGAL, REGULATORY, AND ECOSYSTEM SUPPORT FOR STARTUPS — **9**

Legal Structure - Intellectual Property Rights (IPR), Patents, and Trademarks - Government Policies and Schemes - Role of Incubators, Accelerators, and Angel Investors - Regional vs. Global Startup Ecosystems - Social Entrepreneurship and Impact Ventures Case Study: Successful Social Enterprises

UNIT 5: PITCHING, PRESENTATION SKILLS, AND GROWTH STRATEGIES — **9**

Crafting a Winning Startup Pitch: Key Elements and Structure - Storytelling and Persuasion Techniques for Entrepreneurs - Pitching to Investors: Do's and Don'ts - Managing Investor Q&A and Feedback - Scaling Strategies for Startups - Case Study: How Startups Secured Funding and Scaled

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will be able to

CO1: Understand the fundamentals of innovation and entrepreneurship.

CO2: Develop innovative business ideas and identify market opportunities.

CO3: Conduct market research and create financial strategies.

CO4: Navigate legal and regulatory frameworks.

CO5: Develop effective pitching and presentation skills.

CO-PO MAPPING

	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	3	2	2	2	1	1	1	1	1
CO 2	2	3	2	1	1	2	3	2	2	3	2	1	-	2
CO 3	2	3	2	1	1	1	1	2	2	2	2	1	-	-

CO 4	1	2	2	-	-	3	1	3	3	3	2	1	3	1
CO 5	2	1	2	-	-	2	1	3	2	1	2	2	1	-

4- low, 2 - medium, 3 - high, '-' no correlation

TEXTBOOKS:

Michael Laverty, Chris Little, "Entrepreneurship", Openstax 2020, Texas.

Lee Swanson, "Entrepreneurship and Innovation Toolkit", OPENPRESS.USASK.CA 2017, University of Saskatchewan.

REFERENCE BOOKS:

Dr S Senthil M Arokiaraj at John, "Entrepreneurship Development" Suchitra Publication, 2017, Chennai.

Peter F Drucker, "Innovation and Entrepreneurship" T&F publication 2010.

WEB RESOURCES:

https://onlinecourses.nptel.ac.in/noc21_mg63/preview

ME670505 ADVANCED CAREER DEVELOPMENT					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

To impart knowledge on the following Topics,

•To Help students develop a strong personal and professional brand.

•To provide insights into advanced job search strategies, networking, and industry expectations.

•To prepare students for career advancement through skill development, goal setting, and career planning

LIST OF EXPERIMENTS

1. Defining Your Personal Brand as an Engineer
2. Creating and Optimizing Your LinkedIn and GitHub Profiles
3. Conducting a SWOT Analysis to Identify Unique Skills
4. Crafting an ATS-Friendly Resume for Engineering Careers
5. Developing a Digital Portfolio to Showcase Projects
6. Testing Resume Compatibility with Applicant Tracking Systems (ATS)
7. Aligning Technical Skills and Certifications with Job Roles
8. Designing a Career Roadmap and Job Search Plan
9. Writing Cold Emails and Networking Messages for Job Search
10. Leveraging LinkedIn for Professional Networking and Job Opportunities
11. Leadership and Decision-Making Simulation for Engineers
12. Time Management and Work-Life Balance Planning

TOTAL: 45 PERIODS

Course Outcomes: At the end of the course, the student will be able to

CO1: Develop and articulate a personal brand for career advancement.

CO2: Create a targeted resume and professional portfolio tailored to desired engineering roles.

CO3: Formulate a strategic career plan, including job search tactics and long-term career goals.

CO4: Build and expand a professional network to leverage career opportunities.

CO5: Develop leadership, communication, and adaptability skills for navigating the workplace.

CO's PO's&PSO's MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P010	P011	PO12	PSO1	PSO2
CO1	2	2	2	3	2	3	2	-	2	1	1	1	1	1
CO2	2	3	2	2	1	2	3	1	2	3	2	1	-	2
CO3	2	3	2	1	2	1	1	-	2	2	2	1	-	-
CO4	1	2	2	2	1	3	1	-	3	3	2	1	3	1
CO5	2	1	2	2	1	2	1	-	2	1	2	2	1	-

SYLLABUS

SEMESTER VIII

ME680506	Project Work	L	T	P	C
		0	0	20	10

COURSE OBJECTIVE:

Final year projects represent the culmination of study towards the bachelor of engineering degree. Projects offer the opportunity to apply and extend material learned throughout the program. Assessment is by means of a seminar presentation, submission of a thesis, and a public demonstration of work undertaken.

COURSE CONTENT:

This course will be conducted largely as an individual or small group project under the direct supervision of a member of academic staff. The specific project topic undertaken will reflect the common interests and expertise of the student(s) and supervisor.

1. **Apply Automation Concepts** – Utilize principles of mechanical and automation to develop efficient and sustainable modern solutions.
2. **Analyze AI Impact** – Assess the effects of various AI generation and consumption methods on automation sustainability.
3. **Innovate in automation Technologies** – Develop and implement projects focused on automation solutions such as automobile, and various industries.
4. **Develop Pollution Control Strategies** – Design and evaluate technologies or policies aimed at reducing air, water, and soil pollution caused by industrial and domestic automation use.
5. **Optimize Automation Efficiency** – Explore ways to improve efficiency, reduce carbon foot prints, and enhance efficiency in industrial and house hold systems.
6. **Integrate Smart mechanical Systems** –Investigate the use of smart grids, IOT, and AI-driven energy management systems for optimizing energy usage and reducing waste.
7. **Research Advanced Emission Reduction Technologies** – Study and apply carbon capture, waste-to-energy, and other advanced emission mitigation techniques.
8. **Encourage Circular Economy Practices** – Explore waste recycling, resource recovery, and sustainable manufacturing techniques to minimize pollution.
9. **Strengthen Policy & Regulatory Understanding** – Analyze national and international energy and environmental policies, and propose strategies for effective implementation.
10. **Enhance Problem – Solving & Innovation Skills**– Foster creative solutions to energy and pollution challenges through interdisciplinary research and project- based learning.
11. Provide Solutions for any Problems Identified by Society.
12. Provide Solutions for Problems related to Industrial concern.
13. Additional Features in the existing Devices/Process/Service with creativity and Innovation.

Students will be required to:

- Performa literature search to review current knowledge and developments in the chosen technical area;
- Undertake detailed technical work in the chosen area using one or more of theoretical studies, computer simulations and hardware construction.
- Produce work plan to complete the project within stipulated time
- Deliver a seminar on the general area of work being under taken and specific contributions to that field;
- Prepare an interim report describing the work under taken and results obtained so far; and
- Present the work in a forum involving poster presentations and demonstrations of operational hardware and software

COURSE OUTCOMES:

On successful completion of the course students will be able to:
CO1: Demonstrate a sound technical knowledge of their selected project topic.
CO2: Undertake problem identification, formulation and solution.
CO3: Design engineering solutions to complex problems utilizing a systems approach.
CO4: Conduct an engineering project
CO5: Communicate with engineers and the community at large in written an oral forms.

CO-POMAPPING:

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