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 AND AUTOMATION ENGINEERING

CURRICULUM

III TO VIII SEMESTER

&

SYLLABUS

(III TO VI SEMESTER) & INTERDISCIPLINARY SERVICE COURSES

(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 originate the department into a centralized learning, teaching and research domain to produce proficient Mechanical and Automation Engineers encapsulated with entrepreneurship skill to compete the modernized automation Industries with their technical knowledge.
DEPARTMENT MISSION
• To develop the student's technical skill to the excel level of Mechanical and Automation engineers by offering standard engineering education by means of excellent teaching methodologies and creating professionalism with their learning's. • To strengthen the student capability of extracting knowledge and prepare them to compete the current scenario in Automated Industries and Research. • To amalgamate the technically enriched student to the streamline of Human values, ethics, communication skills, lifelong learning throughout the life and to work as a teamwork as well as individual.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
Sl. No.	**PEOs**
PEO1	To utilize science and engineering principles together with modern tools in solving control and automation engineering problems, design high quality engineering systems, as well as propose implementable solutions for related interdisciplinary problems.
PEO2	To apply cross functional knowledge, modern computational concepts and tools to accommodate changing needs of society.
PEO3	To apply high standards in the performance of their professional work with ethical, societal and environmental awareness

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 modeling 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	Projects / Higher

		the broadest context of technological change.	Studies

PROGRAM SPECIFIC OUTCOMES (PSOs)
PSO1: Ability to understand and perform manufacturing and production systems encapsulated with automation. **PSO2:** Ability to carry out mechanical and electronic systems design and coding for robotic applications.

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 MachinaryLaboratory(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								
1	510303	Project Work	EEC	Practical	0	0	20	10
		Total			**0**	**0**	**20**	**10**

VERTICAL 1: ENERGY TECHNOLOGIES (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: 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 5: MANUFACTURING ENGINEERING (Common to MAE&MECH)								
1	MA606201	ComputerIntegratedManufacturing	PE	Theory	3	0	0	3
2	MA606202	Industry4.0	PE	Theory	3	0	0	3
3	MA606203	FlexibleManufacturingSystems(CommontoMAE,MECH,AERO)	PE	Theory	3	0	0	3
4	MA606204	AdditiveManufacturingProcesses	PE	Theory	3	0	0	3
5	MA606205	LeanManufacturing	PE	Theory	3	0	0	3
6	MA606206	RapidPrototyping	PE	Theory	3	0	0	3
7	MA606207	Theoryofmetalcutting	PE	Theory	3	0	0	3
8	MA606208	SteelQuality:RoleofSecondaryRefining&ContinuousCasting (NPTEL)	PE	Theory	3	0	0	3
9	MA606209	LaserBasedManufacturing(NPTEL)	PE	Theory	3	0	0	3
10	MA606210	Forming(NPTEL)	PE	Theory	3	0	0	3
VERTICAL 6: AUTOMATION								
1	MA606301	MachineLearning	PE	Theory	3	0	0	3
2	MA606302	IndustrialAutomationandControl(NPTEL)	PE	Theory	3	0	0	3
3	MA606303	IndustrialAutomationsystem	PE	Theory	3	0	0	3
4	MA606304	SmartMobilityandIntelligentVehicles	PE	Theory	3	0	0	3
5	MA606305	ArtificialIntelligenceandExpertSystem	PE	Theory	3	0	0	3
6	MA606306	ManufacturingAutomation(NPTEL)	PE	Theory	3	0	0	3
7	MA606307	MicroprocessorinAutomation	PE	Theory	3	0	0	3
8	MA606308	Robotics:BasicsandSelectedAdvancedConcepts(NPTEL)	PE	Theory	3	0	0	3
9	MA606309	MicrocontrollersandPLC	PE	Theory	3	0	0	3
10	MA606310	FieldandServiceRobotics	PE	Theory	3	0	0	3
VERTICAL 7: DIVERSIFIED COURSES GROUP 1								
1	MA606401	IndustrialLayoutDesignandSafety	PE	Theory	3	0	0	3
2	MA606402	AutomationSystemDesign	PE	Theory	3	0	0	3
3	MA606403	MechanicalVibrationsandControls	PE	Theory	3	0	0	3
4	MA606404	DesignofJigsandFixtures	PE	Theory	3	0	0	3
5	MA606405	OperationsResearch	PE	Theory	3	0	0	3
6	MA606406	WeldingTechnology	PE	Theory	3	0	0	3
7	MA606407	TurboMachinery	PE	Theory	3	0	0	3
8	MA606408	DesignforQuality,ManufacturingandAssembly (NPTEL)	PE	Theory	3	0	0	3
9	MA606409	OilHydraulicsandPneumatics(NPTEL)	PE	Theory	3	0	0	3
10	MA606410	AdvancedOperationsResearch(NPTEL)	PE	Theory	3	0	0	3
VERTICAL 8: DIVERSIFIED COURSES GROUP 2								
1	MA606501	MaintenanceEngineering	PE	Theory	3	0	0	3
2	MA606502	DesignofPressureVessels	PE	Theory	3	0	0	3
3	EE606604	VirtualInstrumentation(CommontoMAE&EEE)	PE	Theory	3	0	0	3
4	MA606503	ComputationalFluidDynamics	PE	Theory	3	0	0	3
5	MA606504	FluidPowerControlSystem	PE	Theory	3	0	0	3
6	MA606505	HydraulicsandPneumatics	PE	Theory	3	0	0	3
7	MA606506	IndustrialNetworking	PE	Theory	3	0	0	3
8	MA606507	FunctionalandConceptualDesign(NPTEL)	PE	Theory	3	0	0	3

9	MA606508	VehicleDynamics(NPTEL)	PE	Theory	3	0	0	3
10	MA606509	Microfluidics(NPTEL)	PE	Theory	3	0	0	3

INSTITUTE ELECTIVE I									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	MA607116	Non-Destructive Testing	MAE	IE	Theory	3	0	0	3
2	MA607117	Unconventional Machining Process	MAE	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE II									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	MA607215	Sensors and Instrumentation	MAE	IE	Theory	3	0	0	3
2	MA607216	Engineering Economics	MAE	IE	Theory	3	0	0	3
3	MA607217	Process planning and Cost Estimation	MAE	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE III									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	MA607315	Robot Motion Planning	MAE	IE	Theory	3	0	0	3
2	MA607316	Intellectual Property Rights	MAE	IE	Theory	3	0	0	3
INSTITUTE ELECTIVE IV									
S.No	**Course code**	**Course Name**	**Dept**	**Classification**		**L**	**T**	**P**	**C**
1	MA607414	Disaster Management	MAE	IE	Theory	3	0	0	3
2	MA607415	Human resource management	MAE	IE	Theory	3	0	0	3
3	MA607416	Hazardous Waste Management	MAE	IE	Theory	3	0	0	3

SYLLABUS

SEMESTER III

IC630017 NUMERICAL METHODS AND STATISTICS (Common to MECH and MAE)						
Course Category: Industrial 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. When data series are organised as columns, interpolation occasionally aims to predict the future and should be representative 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-PO 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

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

TEXTBOOKS:

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)
WEB RESOURCES:
https://archive.nptel.ac.in/courses/127/106/127106019/
https://onlinecourses.nptel.ac.in/noc21_ma45/preview

ME630201 ENGINEERING THERMODYNAMICS (Common to MECH and 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-PO 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

1- 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

UINT 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-PO 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	-	-

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

TEXT BOOKS

1. BansalR.K.,**"ATextbookofFluidMechanicsandHydraulicsMachines",**LaxmiPublication,India, (2015)
2. RajputR.K.,**"FluidMechanicsandHydraulicMachines",**S.Chand&CompanyLtd.,New Delhi,(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:

1. https://www.academia.edu/48949774/A_Textbook_of_Fluid_Mechanics_and_Hydraulic_Machines_by_R_K_Rajput
2. https://library.iitd.ac.in/index.php/node/81773

ME630203 MANUFACTURING TECHNOLOGY(Common to MECH and MAE)						
Course Category: Program Core	**Course Type: Theory**	**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 I 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-PO 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

1- 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://onlinecourses.nptel.ac.in/noc22_me28/preview

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

CO-PO 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	-	-

1- 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://onlinecourses.nptel.ac.in/noc23_me140/preview

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:

- Toimpart knowledgeofcharacteristicsoffluids

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/submergible 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: 45 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 theefficiencyof thePelton 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: 45 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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	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**	**1.5**	
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 — **10**

1. Numbers – 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 — **10**

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 — **10**

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: 30 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-PO 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

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 (general, binomial,). Students will use the normal distribution's fundamentals to calculate probability. Implement a normal distribution. Check out a normal distribution.

UNIT I 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-PO 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:
1. M.K. JAIN, S.R.K. IYENGAR and R.K. JAIN "Numerical methods: for scientific and engineering computation" 2013. 6th ed.,
2. M.K. JAIN "Numerical solutions to differential equation" Wiley Eastern New Delhi 2015.
3. DEVORE, J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning , New Delhi, 8th Edition, 2014.
4. S.C. GUPTA AND V.K. KAPOOR "Fundamentals of mathematical statistics" Elevanth thoroughly revised ed., Sultan Chand & Sons educational publishers, New Delhi (June 2003)
5. T. VEERARAJAN, "Probability, Statistics and Random Processes" Tata McGraw-Hill Publishing Company Limited, New Delhi(2006)
REFERENCE BOOKS:
1. VEERARAJAN.T AND RAMACHANDRAN. T " Numerical Methods with Programming in C" second Ed., Tata Mc. Graw Hill Publishing. Co. Ltd (2007)
2. SANKARARAO.K " Numerical Methods for Scientists and Engineers" -3rd edition Printice Hall of India Private Ltd. New Delhi-(2007).
3. 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.
WEB RESOURCES:
HTTPS://ARCHIVE.NPTEL.AC.IN/COURSES/104/104/104104086/
https://onlinecourses.nptel.ac.in/noc22_ma80/preview

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-PO 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/

https://archive.nptel.ac.in/courses/113/105/113105024/

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

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: 45 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 loading.	1
5.	Steam Boiler with turbine setup	1
6.	Natural convection-vertical cylinder apparatus	1
7.	Forced convection inside tube apparatus	1
8.	Thermal conductivity measurement apparatus	1
9.	Emissivity measurement apparatus	1
10.	Parallel/counter flow heat exchanger apparatus	1
11.	Two stage reciprocating air compressor	1
12	Refrigeration test rig	1
13.	Air-conditioning 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 for single cylinder four stroke diesel engine and two stroke petrol 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**	**1.5**	
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	**10**

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 Rule
16. Data Interpretation (Tabulation, Bar Chart, Pie Chart, Line Graphs)

UNIT 2 :LOGICAL REASONING	**10**

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 | **10**

1. Concord
2. Cloze Passage
3. Analogies or Reverse Analogies
4.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: 30 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-PO 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

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	**6**
Governors - Types - Centrifugal governors –Porter &Proell governor, Hartnell&Hartung governor – Characteristics - Effect of friction - Controlling Force Gyroscopes - Gyroscopic couple - Gyroscopic stabilization.	
LIST OF EXPERIMENTS	**15**
Study of Ackerman's Steering Gear Mechanism. To study various types of gears. To study various types of gear trains. To draw velocity diagram of slider crank mechanism. To draw acceleration diagram of four bar mechanism. To draw displacement diagram, velocity diagram & acceleration diagram of cam follower.	
	TOTAL: 45 PERIODS

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, then apply it to appropriate environments.

CO2: Construct & Design different CAM profiles for given conditions using graphical & Theoretical methods

CO3: Analyze the static and dynamic force in mechanical systems and determine the energy stored in flywheel and balancing of rotating masses.

CO4: Apply the fundamental concepts of vibration to determine the natural frequency of free and forced vibrations.

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

CO-PO 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. 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 International Publishers, 2006.
5. A. Ghosh and A.K Mallick, "Theory of Mechanisms and Machines", Edition: 1, Affiliated East- West Pvt. Ltd , 2008.

WEB RESOURCES:

1. https://nptel.ac.in/courses/112/106/112106270/
2. https://nptel.ac.in/courses/112/101/112101096/

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

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

COURSE OBJECTIVES:

- To impart knowledge on basic principles of instrumentation and metrology, to study the working principle of metrological instruments.
- To become an expert in the field of measurements and to inculcate the knowledge of various types of measuring instruments and its applications.

UNIT I: 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 II: 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 III: 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 IV: 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 V: 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: 45 PERIODS

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-PO 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/

https://nptel.ac.in/courses/112106179

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 I: SIMPLE STRESSES **6**

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 II: DESIGN OF KEY, SHAFTS AND COUPLINGS **6**

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 III: DESIGN OF TEMPERORARY JOINTS AND PERMANENT JOINTS **6**

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 IV: DESIGN OF SPRINGS AND ENGINE COMPONENTS **6**

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 V: DESIGN OF BEARINGS **6**

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.

TOTAL: 30+15 PERIODS

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-PO 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. BhandariV.B,"Design of Machine Elements",4th Edition,TataMcGraw-HillEducation,NewDelhi,2017.
2. Richard G.Budynas and J.KeithNisbett., "Shigley's Mechanical Engineering Design",10th Edition (SIE),Tata McGraw-Hill Education,NewDelhi,2017
3. JosephShigley,CharlesMischke,RichardBudynas and Keith Nisbett, "Mechanical Engineering Design",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.KurtMarshek,"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/
https://archive.nptel.ac.in/courses/112/105/112105124/

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:

- Tosupplementtheprinciplesoflearning kinematicsandDynamicsofMachineryandtounderstandthe measuring devices areusedfordynamictesting.

LIST OF EXPERIMENTS

1. Determination of Mass moment of inertia of flywheel and axle system.
2. Motorizedgyroscope–Study of gyroscopiceffect and couple.
3. Governor-Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and HartnellGovernors.
4. Cams–Camprofiledrawing.
5. Cams-Motioncurvesandstudy ofjumpphenomenon.
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. Balancingof rotatingmasses and reciprocatingmasses.
10. Determinationoftransmissibilityratiousingvibratingtable.

TOTAL: 45 PERIODS

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

CO1: Tomakethestudents understandthe moment of inertia of flywheel.

CO2: Tomakethestudents understandthe concept of gyroscopic effect.

CO3: Demonstrate the working principle of governors.

CO4: Analyzevarious typesof transmissions, applybalancing in machinesystems.

CO5: Analyzevarious types of CAMSand gears.

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	-		-	-	-	-	-	-	-

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
- To familiarize the students with constructional features of CNC machine tools

LIST OF EXPERIMENTS

1. Study of different types of CNC Machines.
2. Study of different control systems and NC codes.
3. Program for Turning, Facing operation and Machining.
4. Program for circular interpolation, taper turning operation and Machining.
5. Program for thread cutting operation and Machining.
6. Program using Do-Loop and Sub-routine and Machining.
7. Program for profile milling operation, circular interpolation and Machining.
8. Program for Circular, rectangular pocket milling and Machining.
9. CAM Programming and CNC milling.
10. CAM Programming and CNC Turning.

TOTAL: 45 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 CNC Wire EDM.

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	-		-	-	-	-	-	-	-

SEMESTER - VI

ME660210-HEAT AND MASS TRANSFER
(Common to MECH & MAE)

Course Category: Program Core	**Course Type: Theory with Project Component**	**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.

UNITI: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.

UNITII: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 III: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.

UNITIV: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.

UNITV: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: Understandingthe physics involvedinvariousheattransfermechanisms.

CO2: Applyingtheknowledgeofmathematicsandanalyzethedifferentsituationsinwhichheattransfer is involved.

CO3: Toanalyzetheeffectofdifferentboilingregimesandcondensationandalsothroughtheproper use of modelling can able to choose different heat exchangers for specific applications.

CO4: Tobeabletocalculateheattransferrate,timerequiredforheatingor, coolingandobtainingthetemperaturedistribution withrespecttothe domainofanalysis underdifferentsituations.

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

Mapping of Cos with POs and PSOs

	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:

1. https://nptel.ac.in/courses/112/106/112106270/
2. https://archive.nptel.ac.in/content/syllabus_pdf/112101097.pdf

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 – I 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 – II 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 - III 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 – IV 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.

Mapping of Cos with POs and PSOs

	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-HillEducation,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. Robert L Norton,"MachineDesign-AnIntegrated Approach",PearsonEducation,NewDelhi,2013.

REFERENCE BOOKS:

1. Maitra G.M.,PrasadL.V.,"HandbookofMechanicalDesign"2nd Edition,TataMcGraw-Hill Education,New Delhi, 2001.
2. Prabhu.T.J.,"Designof Transmission Elements",Mani Offset,Chennai,2000.
3. StevenR.Schmid,BernardJ.Hamrock,Bo.O.Jacobson,"Fundamentals of MachineElements",3rd edition, CRC Press,2014.
4. Sundararajamoorthy T.V, Shanmugam .N, "Machine Design", Anuradha Publications,Chennai,2018.
5. Ugural A.C, "Mechanical Design – An Integral Approach", McGraw-Hill Book Co,2009.
6. PSG College of Technology,"Design Data",Kalaikathir Achchagam,2016.
7. R.S.Khurmi,"A textbook of Machine Design",S.Chand& Co,NewDelhi,2015.

WEB RESOURCES :

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

https://onlinecourses.nptel.ac.in/noc24_me71/preview

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:

The general objectives of the course are to enable the students to

- 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-PO MAPPING

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

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

TEXT BOOKS:

1. IbrahimZeid"MasteringCADCAM"TataMcGraw-HillPublishingCo.2009
2. Mikell.P.Groover"Automation,ProductionSystemsandComputerIntegratedManufacturing",PrenticeHall ofIndia,2008.
3. RadhakrishnanP,SubramanyanS.andRajuV.,"CAD/CAM/CIM",2ndEdition,NewAgeInternational (P)Ltd, NewDelhi,2010.

REFERENCE BOOKS:

1. ChrisMcMahonandJimmieBrowne"CAD/CAMPrinciples","PracticeandManufacturingmanagement "Second Edition,PearsonEducation,1999.
2. DonaldHearnandM.PaulineBaker"ComputerGraphics "'.PrenticeHall,Inc,2014.
3. Foley,WanDam,FeinerandHughes-"Computergraphicsprinciples&practice"PearsonEducation -2003
4. WilliamMNeumannandRobertF.Sproul"PrinciplesofComputerGraphics",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.ReghandHenryW.Kreabber,"ComputerIntegratedManufacturing",3rdEdition,Pearson Education, 2004.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/102/112102101/
https://nptel.ac.in/courses/112102102

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.

LIST OF EXPERIMENTS

1. Heat Transfer Through Composite Wall
2. Critical Heat Flux Apparatus
3. Measurement of Surface Emissivity
4. Heat Transfer Through Forced Convection
5. Heat Pipe Demonstration
6. Heat Transfer Through Lagged Pipe
7. Heat Transfer Through Natural Convection Effectiveness of Parallel/counter flow heat exchanger.
8. Heat Transfer Through Pin-Fin
9. Stefan Boltzman's Apparatus
10. Transient Heat Conduction Apparatus
11. Condensation Apparatus

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.

MappingofCOswith POs andPSOs

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	-		-	-	-	-	-	-	-

SEMESTER-VI						
PSNCollegeof EngineeringandTechnology		Degree:B.E.		Regulation:2022		
Department	**MECHANICALENGINEERING**	BranchCode		10		
SubjectCode	**510109**	L	T	P	C	
SubjectTitle	**CAD&CAMLAB**	0	0	3	2	

COURSE OBJECTIVE:

- 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:

A) Introduction of 3D Modeling software

Exercises in basic part modeling of components in 3D modeling software. Modeling and assembly of following machine elements using 3D Modeling software.

1. Shaft Coupling
2. Plummer Block
3. Screw Jack
4. Universal Joint
5. Machine Vice
6. Stuffing box
7. Connecting rod
8. Piston
9. Crankshaft

Preparation of Bill of materials and tolerance data sheet

LIST OF SOFTWARE (FOR A BATCH OF 30 STUDENTS)

- **Solid Works 2019 -60 users.**

B) CAM

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

COURSE OUTCOME:

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

CO1: Create 3D geometric modeling of industrial components with the use of CAD packages

CO2: Do manual part programming and to machine simple components using CNC machines

CO3: Generate part programming using CAM software.

Mapping of COs with POs and PSOs

COs/POs	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

ME660504-TRAINING IN CENTRE FOR EXCELLENCE (Common to MECH & MAE)						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		0	**0**	**2**	**1**	
COURSE OBJECTIVES:						
Thegeneral objectives of the course are to enable the students to • Understand the basic fundamentals of Mechatronics. • To provide an overview of fundamentals of automation. • To understand the application in engineering mechanisms.						
UNIT– I ROBOTICS						9
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.						
UNIT– II MECHATRONICS						9
Introduction: Definition and Introduction to Mechatronics Systems. Modeling &Simulation of Physical systems Overview of Mechatronics Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.						
UNIT– III SENSORS FUNDAMENTALS AND ITS APPLICATIONS						9
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.						
UNIT– IV PROGRAMMABLE LOGIC CONTROLLER						9
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.						
UNITVKINEMATICS OF MACHINES						9
Kinematics and Dynamics, Mechanisms and Machines, Plane and Space Mechanisms, Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion. Mobility and range of movement - Kutzbach and Grubler's criterion, Number Synthesis, Grashof's criterion. Displacement analysis of plane mechanisms– graphical and analytical methods.						
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 in Robotics						
CO2: To understand the principle working in mechatronics.						
CO3: To learn the fundamentals of sensors.						
CO4: To formulate different type of programming for PLC with applications.						
CO5: To understand various link mechanisms in automation.						

CO-PO 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
CO4	3	2	3	3	1	2	-	-	2	2	2	3	3	2
CO5	3	2	2	2	2	2	-	-	2	2	2	2	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, LifeSkills,EmotionalIntelligence, ThoughtsofEthics, Value Education, Dimensions of Ethics, Profession and professionalism, ProfessionalAssociations, Professional Risks, Professional Accountabilities, Professional Success, Ethics and Profession.

UNIT II: BASIC THEORIES	6

Basic Ethical Principles, Moral Developments, Deontology, Utilitarianism, Virtue Theory, Rights Theory, Casuist Theory, Moral Absolution, Moral Rationalism, Moral Pluralism, EthicalEgoism, Feminist Consequentialism,MoralIssues,MoralDilemmas,MoralAutonomy.

UNIT III: PROFESSIONAL PRACTICES IN ENGINEERING	6

Professions and Norms of Professional Conduct,NormsofProfessionalConductvs.Profession;Responsibilities,ObligationsandMoralValues in Professional Ethics, Professional codes of ethics, the limits of predictability andresponsibilities of the engineering profession, Central Responsibilities of Engineers – TheCentrality of Responsibilities of Professional Ethics; lessons from 1979 American AirlinesDC-10CrashandKansas CityHyattRegencyWalkawayCollapse.

UNIT IV: WORK PLACE RIGHTS & RESPONSIBILITIES	6

Ethics in changing domains of Research, Engineersand Managers; Organizational Complaint Procedure, difference of Professional Judgmentwithin the Nuclear Regulatory Commission (NRC), the Hanford Nuclear Reservation. Ethicsinchangingdomainsofresearch-TheUSgovernmentwidedefinitionofresearchmisconduct, research misconduct distinguished from mistakes and errors, recent history ofattention to research misconduct, the emerging emphasis on understanding and fosteringresponsible conduct,responsibleauthorship,reviewing&editing.

UNIT V: GLOBALISSUESINPROFESSIONALETHICS	6

Introduction–CurrentScenario,TechnologyGlobalization of MNCs, International Trade, World Summits, Issues, Business Ethics andCorporateGovernance,SustainableDevelopmentEcosystem,EnergyConcerns,OzoneDeflection, Pollution, Ethics in Manufacturing and Marketing, Media Ethics; War Ethics; BioEthics,IntellectualPropertyRights

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 socialissues.

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

CO3:Acquiring knowledge of various roles of EngineerIn applying ethical principles at various professionallevels

CO4:Professional Ethical values and contemporary issues

CO5:Excelling in competitive and challenging environmentto contribute to industrial growth.

CO-PO 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. ProfessionalEthics:R.Subramanian,OxfordUniversityPress,2015.
2. EthicsinEngineeringPractice&Research,CarolineWhitbeck,2e,CambridgeUniversityPress 2015.

REFERENCE BOOKS:

1. EngineeringEthics,ConceptsCases:CharlesEHarrisJr.,MichaelSPritchard,MichaelJ Rabins,4e,Cengagelearning,2015.
2. BusinessEthicsconcepts&Cases:ManuelGVelasquez, 6e, PHI, 2008.

WEB RESOURCES:

https://onlinecourses.nptel.ac.in/noc22_mg54/preview
https://archive.nptel.ac.in/noc/courses/noc19/SEM2/noc19-hs35/

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, different types of condensers and list the application of gas turbine power plants and inter cooling of combined cycle.

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-PO 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
https://onlinecourses.nptel.ac.in/noc22_me73/preview

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 climate variation and its effects on the building heat load.
- To learn building material characteristics and their influence on building heatingcooling load for all weather conditions.
- To study various conversation 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, Troubleshooting of electric heat, 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, Green Buildings andSystems, 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

Practical:Dismantling and assembly practices of Air conditioner, Performance test on Refrigeration test Rig.

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 using acceptedEngineering 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-PO 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 refueling- 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-PO 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://archive.nptel.ac.in/courses/103/102/103102015/

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-PO 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:
1. Khurmi R.S. & Gupta J.K., "Refrigeration and Air Conditioning", S.Chand Publication, (2009) 2. Arora C.P., "Refrigeration and Air Conditioning", Tata McGraw Hill, New Delhi, (2008)
REFERENCE BOOKS: 1. Roy J. Dossat, "Principles of Refrigeration", Pearson Education, (2007) 2. Jordon and Priester, "Refrigeration and Air Conditioning", Prentice Hall of India Pvt. Ltd., New Delhi, (2015) 3. Stoecker N.F. and Jones, "Refrigeration and Air Conditioning", TMH, New Delhi, (2011) 4. Jones, "Air Conditioning Engineering",Edward Amold Publication (2010))
Web resources:
https://archive.nptel.ac.in/courses/112/107/112107208/
https://archive.nptel.ac.in/courses/112/105/112105129/

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 carburetor, 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

•• Measure operating characteristics of IC Engines. • Compare the experimental results with theoretical trends.

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-PO 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://nptel.ac.in/courses/112104033

https://archive.nptel.ac.in/courses/112/103/112103262/

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-PO 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://archive.nptel.ac.in/courses/101/104/101104084/
https://onlinecourses.nptel.ac.in/noc23_ae11/preview

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-PO 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. 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://archive.nptel.ac.in/courses/112/106/112106064/
https://archive.nptel.ac.in/noc/courses/noc15/SEM1/noc15-me03/

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. A wide range of inverse techniques including classical techniques, probabilistic techniques as well as modern techniques involving Machine Learning will be covered.

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.

	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.

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/
https://archive.nptel.ac.in/courses/112/106/112106309/

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 5MECHANISM - STRATEGIES	**9**

Instability in liquid propellant rockets and gas turbine afterburners– 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:Solvethe problem of internal combustion and multi-stage operation by applying BLTE.

CO-PO 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.

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.

WEB RESOURCES:

https://nptel.ac.in/courses/112106290
https://onlinecourses.nptel.ac.in/noc22_me33/preview

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:Investigatecompressible flow having normal shock.

CO-PO 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.

REFERENCE BOOKS:

1. Gas Dynamics, Zucker &Biblarz, 2nd ed. Wiley India.
2. (2)Gas Dynamics , Liepmann&Roshko, Dover Publications.
3. (3)Dynamics and Thermodynamics of compressible flow, A. Shapiro.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/106/112106196/
https://archive.nptel.ac.in/courses/101/108/101108086/

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 the cost effectiveness and eco-friendliness of Fuel Cells
- To study in detail on the hydrogen production methodologies, possible applications and various storage options

UNIT I 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-PO 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://onlinecourses.nptel.ac.in/noc22_ch66/preview

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 fuels.

• 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-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.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://archive.nptel.ac.in/content/storage2/courses/112104033/

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 I 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-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.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
https://onlinecourses.nptel.ac.in/noc23_ch76/preview

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-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. 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:
https://archive.nptel.ac.in/courses/113/105/113105102/
https://onlinecourses.nptel.ac.in/noc23_me127/preview

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 and 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-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. 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:

https://onlinecourses.nptel.ac.in/noc20_mm20/
https://onlinecourses.nptel.ac.in/noc19_me60/preview

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

COURSE OBJECTIVES:

- 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-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.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/
https://archive.nptel.ac.in/courses/112/105/112105051/

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

COURSE OBJECTIVES:

- 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 I 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 systemsQuantitative 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-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. 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 I 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-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. 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 https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-me25/

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 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 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-PO 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 https://archive.nptel.ac.in/courses/112/106/112106064/

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-PO 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 https://onlinecourses.nptel.ac.in/noc21_ee112/preview

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 impart knowledge on
- 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 and the expected benefits of the different solutions

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-PO 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%20Definitive%20Guide%20to%20Warehouse%20Automation%20Magaya.pdf https://nptel.ac.in/courses/112102011

ME606302-BUSINESS PROCESS RE-ENGINEERING

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

COURSE OBJECTIVES:

To impart knowledge on

- To understand concepts and philosophy of Business Process Reengineering.
- To learn various BPR and alternate methodologies – TQM, Work Study, ISO standards practice the industry
- To understand and analyze the role of Information Technology and change management in the implementation of BPR.
- To expose practically BPR implementation and best practices through research papers and case discussions.

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, Requirement Engineering, 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 associated with 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 and their applications

CO4: Basic understanding of ISO standard 9001:2015, IACBE and their applications

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-PO 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
https://nptel.ac.in/courses/110105083

ME606303- TOTAL QUALITY MANAGEMENT					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- quality management philosophies and Framework.
- employee involvement and Supplier partnership
- to improve the product and process Quality..
- 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 to TQM.

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-PO 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, Indian Reprint 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 https://archive.nptel.ac.in/courses/110/104/110104080/

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 impart knowledge on

- To outline the need for Project Management
- To highlight different techniques of activity planning
- Project Planning & Management

UNIT 1: INTRODUCTION TO PROJECT MANAGEMENT AND PROJECT SELECTION	**9**
Objectives of Project Management- Importance of Project Management- Types of Projects Project Management Life Cycle- Project Selection – Feasibility study: Types of 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-PO 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). Contemporary project management. Nelson Education
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.
3.Tate, Karen (2001), Getting Started in Project Management, Wiley: New York.
WEB RESOURCES: https://open.umn.edu/opentextbooks/textbooks/456 https://onlinecourses.nptel.ac.in/noc24_mg01/preview

ME606305-INDUSTRIAL PSYCHOLOGY						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

The aim of undergoing this course is to develop an awareness of the major perspectives underlying the field of Industrial Psychology and understanding for the potential Industrial Psychology has for society and organizations now and in the future

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 related to accident reduction.

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-PO 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. 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 https://onlinecourses.nptel.ac.in/noc21_hs49/preview

ME606306-RESOURCE MANAGEMENT TECHNIQUES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

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-PO 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

https://archive.nptel.ac.in/courses/110/105/110105069/

ME 606307-ENTERPRISE RESOURCE PLANNING						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

To impart knowledge on

- 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.
- To create integrated software system to manage the business and automate back office functions.

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-PO 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. 7.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 https://archive.nptel.ac.in/courses/110/105/110105083/

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:

- equips the learners with various concepts and frameworks for establishing and growing businesses
- Focusing on customers and markets, the course covers the foundational as well as advanced constructs of business development.

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

CO2: to create new opportunities

CO3: The growth of existing businesses

CO4: The creation of new ones

CO5: Able to pursue new opportunities

CO-PO 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
WEB RESOURCES: https://onlinecourses.nptel.ac.in/noc23_mg61/preview https://archive.nptel.ac.in/courses/110/106/110106164/

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:

Depth understanding of patent law to engineers and scientists. This course will help person with a science background to understand the fundamentals of patent law

know the requirements of patentability

learn how to read and interpret patent specifications, analyze patent office procedures and court cases and develop the basic understanding for drafting a patent specification

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-PO 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
https://onlinecourses.nptel.ac.in/noc20_hs55/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 impart knowledge on
business and economic concepts through the study of subjects such as organizational behaviour, financial management, and strategy and includes summer projects & internships.
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-PO 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/ https://archive.nptel.ac.in/content/syllabus_pdf/110106050.pdf

VERTICAL4: MATERIALS SCIENCES

MA606101-COMPOSITEMATERIALS					
CourseCategory:ProgramCore	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSEOBJECTIVES:

- This course is designed as an introductory course on "Composite Materials". The courseobjectivesaretoTrainstudentsoncompositematerials–definition,advantages and classification.
- Equip students with knowledge on composite strengthening addition of components and their production routes.

UNIT1: INTRODUCTIONTOTHECOMPOSITEMATERIAL **9**

Introduction and overview of composite materials and their need – Enhancement of properties,classification of composites–Matrix-Polymermatrixcomposites(PMC),Metalmatrixcomposites(MMC),Ceramicmatrixcomposites(CMC),Applicationofcomposites.

UNIT2: REINFORCEMENTSMATERIALSANDMATRIX **9**

Metallic,Polymer,CeramicandCompositefibres,WhiskersandParticulates,Nano-fillersusedinpolymercomposites,Reinforcementfibres,WovenfabricsandNon-wovenrandommats–CommonlyusedMatrices(Metalmatrix,Polymermatrix,Ceramicmatrix,Inter-metallicmatrix, Carbon-Carboncomposites),BasicRequirementsinSelectionofconstituents

UNIT3:MANUFACTURINGMETHODS **9**

Handandspraylay-up,injectionmoulding,resininjection,filamentwinding,pultrusion,centrifugalcastingandprepregs.Fibre/MatrixInterface,mechanical.Measurementofinterfacestrength.Characterizationofsystems;carbonfibre/epoxy,glassfibre/polyester,et

UNIT4:MECHANICALPROPERTIESOFCOMPOSITES **9**

Introduction, Strength of Materials Approach, Geometrical aspects–volumeandweightfraction.Unidirectionalcontinuousfibre,discontinuousfibers,Shortfibersystems,woven reinforcements–
MechanicalTesting:Determinationofstiffnessandstrengthsofunidirectionalcomposites;tension,compression, flexure andshear

UNIT5:RECENTDEVELOPMENTSINCOMPOSITES **9**

Self-healingcomposites, Molecular composites,MicroandNano composites, Bio-composites,Lefthandedcomposites,Stifferthanstiffcomposites,Carbon/carboncomposites(Advantagesand limitationsofcarbonmatrix).

TOTAL:45PERIODS

COURSEOUTCOMES: Attheendofthecourse,thestudentwillbeableto

CO1:Abilitytoidentifytheneed,physicalandmechanicalpropertiesandsomecommonmanufacturing techniquesofthecomposites

CO2:Describethepropertiesofvariousreinforcementsofcompositematerials

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-PO 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
TEXTBOOKS:
1.MathewsF.L.andRawlingsR.D.,"CompositeMaterials:EngineeringandScience",1stEdition,Chapmanand Hall,London,England,1994.
2.ChawlaK.K.,"Compositematerials",SecondEdition,Springer–Verlag,1998.
REFERENCEBOOKS:
1.MathewsF.L.andRawlingsR.D.,Compositematerials:EngineeringandScience,ChapmanandHall,London, England,1stedition,1994.
2.StrongA.B.,FundamentalsofCompositeManufacturing,SME,1989.
3.SharmaS.C.,Compositematerials,NarosaPublications,2000.
4.Mallick,P.K,CompositeMaterialsTechnology:ProcessandProperties,Hanser,NewYork,1990.
5.MathewsF.L.andRawlingsR.D.,Compositematerials:EngineeringandScience,ChapmanandHall,London, England,1stedition,1994.
WEBRESOURCES: https://home.iitk.ac.in/~mohite/Composite_introduction.pdf https://archive.nptel.ac.in/courses/101/104/101104010/

MA606102- TRIBOLOGY					
CourseCategory:ProgramCore	**CourseType:Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSEOBJECTIVES:

- 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.

UNIT1: INTRODUCTIONTOTRIBOLOGY **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.

UNIT2: 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.

UNIT3: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

UNIT4: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

UNIT5: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:45PERIODS

COURSEOUTCOMES: Attheendofthecourse,thestudentwillbeableto

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-PO 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

TEXTBOOKS:

1."IntroductiontoTribology",B.Bhushan,JohnWiley&Sons,Inc.,NewYork,2002

2."EngineeringTribology",PrasantaSahoo,PHILearningPrivateLtd,NewDelhi,2011.

REFERENCEBOOKS:
1.“IntroductiontoTribologyinbearings”,B.C.Majumdar,WheelerPublishing.
2.“Tribology,FrictionandWearofEngineeringMaterial”,I.M.Hutchings,EdwardArnold,London,1992.
3.“Engineering Tribology”, G. W. Stachowiak and A. W.Batchelor,Butterworth-Heinemann,1992.
4.“FrictionandWearofMaterials”,ErnestRabinowicz,JohnWiley&sons,1995.
5.“BasicLubricationTheory”,A.Cameron,EllisHardwoodsLtd.,UK
WEBRESOURCES: https://edurev.in/p/68841/What-is-Tribology- https://archive.nptel.ac.in/courses/112/102/112102014/

MA606104POLYMERTECHNOLOGY					
CourseCategory:ProgramCore	CourseType:Theory	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES:

Theobjectiveofthecourseistoprovideknowledgeandunderstandingofthelinkbetweenpolymerchemicalstructure,physicalproperties,processingmethodsandultimateapplications.

UNIT1:GENERALASPECTSOFPOLYMERS **9**

Classification of polymers- natural and synthetic – thermoplastic and thermosetting. Types andmechanism of polymerization: addition (free radical, cationic, anionic and living); condensationand copolymerization– Functionality-degree of polymerization. Techniques of polymerization:Bulk,emulsion,solutionand suspension.

UNIT2:PROPRTIESOFPOLYMER **9**

ChemistryofpolymerizationIntroductiontotypesofpolymerization,emulsion,solution.MechanismofPolymerization–Co-polymerization:Introduction,freereadical,IonicandCopolymerization–Kineticsofpolymerization–freeradicalchaincopolymerization.

UNIT3:ELASTOMERSANDAPPLICATIONORIENTEDPOLYMERS **9**

NaturalRubber,Styrene–butadiene,Polyisopropane–Neoprene,Siliconerubber,Thermoplastic elastomers, Resins – PVC, Silicon Oil and resins, fibrous Polymers – Nylon 66,Polyacrylonitrile.

UNIT4:MIXINGANDMOULDINGPROCESS **9**

Additiveandmixingprocess,differenttypesofmixingdevices,Typesofmould–ejectorsystem–ejectionntechniques–mouldcooling–CAD/CAM,Extrusion,Moulding,InjectionMoulding,SpecialMoulding techniques.

UNIT5:POLYMERCOMPOSITES **9**

FibrousandLaminatedCompositesHybridComposites–MatrixResins–UnsaturatedPolyester-VinylEster–Epoxy-PhenolFormaldehyde–UreaFormaldehyde,Catalysts,Fillers,Reinforcements,Additivesfor Composites.

TOTAL:45PERIODS

COURSEOUTCOMES:Attheendofthecourse,thestudentwillbeableto

CO1:Understandthefundamentalsofpolymerandmechanism

CO2:Selectappropriatetechniquesofpolymerization.

CO3:Understandtheknowledgeofdevelopingnewformulationandproductsfromelastomers.

CO4:Applythemechanismandeffectivenessofpolymerizationinmakingfinishedmaterials

CO5:Understandthemanufactureandpropertiesofapplicationorientedindustrialapplications.

CO-POMAPPING

	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,'-'nocorrelation

TEXTBOOKS:

1.Birley,Haworth,Batchelor,PhysicsofPlastics–ProcessingPropertiesandMaterialsEngineering,HamerPublication,1992.

2.F.W.Billmayer,TextBookofPolymerScience,3rdedition,JohnWileyandsons,NewYork,2002.

3.RichardG.Griskey,PolymerProcessEngineering,ChapmanandHall,1995.

REFERENCEBOOKS:

1. PolymerChemistry:APracticalApproach(ThePracticalApproachinChemistrySeries)1stEdition FredJ.DavisOxfordUniversity Press20042.
2. APracticalCourseinPolymerChemistryS.H.Pinner,BoroughPolytechnicLondon,PergamonPress,NewYork,1961 3.

PolymerSciencebyGowarikarV.R,JohnWileyandSons1986.
WEBRESOURCES:
https://archive.nptel.ac.in/courses/113/105/113105028/
https://ocw.mit.edu/courses/3-064-polymer-engineering-fall-2003/pages/lecture-notes/

MA606105SMARTMATERIALS

CourseCategory:ProgramCore	CourseType:Theory	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES:

- TheObjectivesofthecoursearethemakethestudentslearnabout
- Familiarizethesmartmaterialanditsroleindevelopingintelligentsystems.
- IntroducethestudentswithLBHSandHBLSsmartmaterial.
- Exposethestudentsinsmartsystemdevelopmentanduses.

UNIT1:INTRODUCTIONTOSMARTMATERIAL **9**

Definition,classifications–needforsmartmaterial–componentsofsmartmaterials–smartsystem applications– Closed loop and Open loop Smart Structures– the role of smart materials indeveloping intelligentsystems andadaptivestructure

UNIT2:SHAPEMEMORYALLOYS **9**

Introduction–shapememoryeffect,Application–Processingandcharacteristics–Phenomenology– Influence of stress on characteristic temperatures– Modelling of shape memoryeffect.Vibrationcontrolthroughshapememoryalloys– Designconsiderations,multiplexingembedded NiTiNOLactuators.

UNIT3:PIEZOELECTRICANDMAGNETOSTRICTIVEMATERIAL **9**

Piezoelectricmaterial–Constitutiverelationship,electrochemicalcouplingcoefficientspiezoelectric constant – piezo ceramic material – polycrystalline vs single crystal piezoelectricmaterials– polyvenyldenefluoride.Magnetostrictivematerials:Magentomechanicalcouplingcoefficient–Jouleeffect– Villarieffect–Matteucieffect–Wiedemanneffect.

UNIT4:BIOMATERIALS **9**

Biomaterials: Metallic biomaterials like 316L stainless steel–Co-Cr Alloys, Titanium Ti6Al4V,Ceramic biomaterials like Alumina– Zirconia, Carbon Hydroxyapatite – Polymeric biomaterialslike Ultra high molecular weight polyethylene– Polyurethane, Processing and Applications ofbiomaterials.

UNIT5:BULKMETALLICGLASSES **9**

Bulk metallic glasses (BMG): Various methods for BMG production– Classification of BMG– Propertiesand behaviorsof BMG–Thermodynamicaspectsof stability– PotentialapplicationsofBMG,ProcessingandApplicationsofBMG.

TOTAL:45PERIODS

COURSEOUTCOMES:Attheendofthecourse,thestudentwillbeableto

CO1:Illustratetheapplicationofsmartmaterial

CO2:Discussthedesignconsiderationsofshapememoryalloy.

CO3:DescribetheConstitutiverelationshipofPiezoelectricandMagnetostrictivematerial

CO4:UnderstandthefundamentalsofBiomaterials

CO5:ApplytheBMAsmartmaterialsonindustrialapplications

CO-POMAPPING

	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,'-'nocorrelation

TEXTBOOKS:

1."SmartStructures– AnalysisandDesign",A.V.Srinivasan,CambridgeUniversityPress,NewYork,2001,(ISBN:0521650267).

2."SmartMaterialsandStructures",M.V.GandhiandB.S.ThompsonChapmen&Hall,London,1992 (ISBN:0412370107)

3."FoundationofMEMS,byChangLiu.PearsonEducation.(ISBN:9788131764756)

REFERENCEBOOKS:
1.Brainculshaw,SmartStructuresandMaterials,ArtechHouse,2000
2.Gauenzi.P,SmartStructure,Wiley2009
3.Cady.W.G,Piezoelectricity,DoverPublication
WEBRESOURCES:
https://archive.nptel.ac.in/courses/112/104/112104251/
https://nptel.ac.in/courses/112104173

MA606106ELECTRICAL,ELECTRONIC SANDMAGNETICMATERIAL					
CourseCategory:ProgramCore	**CourseType:Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSEOBJECTIVES:

- TheObjectivesofthecoursearetounderstandtheimportanceofvariousmaterialsusedin electrical,electronicsandmagnetic applications.
- Acquiringknowledgeonthepropertiesofelectrical,electronicsandmagneticmaterials.
- Knowingthefundamentalconceptsinsemiconductingmaterials.
- Gettingequippedwiththematerialsusedinopticalandoptoelectronicapplications.

UNIT1: DIELECTRICMATERIALS **9**

DielectricasElectricFieldMedium,leakagecurrents,dielectricloss,dielectricstrength,breakdownvoltage, breakdown in soliddielectrics, liquid dielectrics,electricconductivity insolid,liquidandgaseousdielectrics,Ferromagneticmaterials,propertiesofferromagneticmaterialsinstaticfields,spontaneous,polarization,curiepoint,anti-ferromagneticmaterials,piezoelectricmaterials,pyroelectric materials.

UNIT2:MAGNETICMATERIALS **9**

Classificationofmagneticmaterials,spontaneousmagnetizationinferromagneticmaterials,magneticAnisotropy,Magnetostriction,diamagnetism,magneticallysoftandhardmaterials,specialpurposematerials,feeblymagneticmaterials,Ferrites,castandcementpermanent magnets,ageingofmagnets.Factorsaffectingpermeabilityandhysteresis.

UNIT3:SEMICONDUCTORMATERIALS **9**

Properties of semiconductors, Silicon wafers, integration techniques, Large and very large scaleIntegrationtechniques.Conceptofsuperconductivity;theoriesandexamplesforhightemperaturesuperconductivity;discussiononspecificsuperconductingmaterials;commentson fabricationandengineeringapplications.

UNIT4:MATERIALSFORELECTRICALAPPLICATIONS **9**

Materials used for resistor, rheostats, heater, transmission line structures, stranded conductors,bimetalsfuses,softandhotsolders,electriccontactmaterials,electriccarbonmaterials,thermocouple materials. Solid, Liquid and Gaseous insulating materials, Effect of moisture oninsulation

UNIT5: OPTICALANDOPTOELECTRONICMATERIALS **9**

Principlesofphotoconductivity–effectofimpurities–principlesofluminescence-laserprinciples -He-Ne, injection lasers, LED materials – binary, ternary photoelectronic materials –LCD materials -photo detectors – applications of optoelectronic materials – optical fibres andmaterials– electroopticmodulators–Kerreffect– Pockelseffect.

TOTAL:45PERIODS

COURSEOUTCOMES:Attheendofthecourse,thestudentwillbeableto

CO1:Understandvarioustypesofdielectricmaterials,theirpropertiesinvariousconditions.

CO2:Evaluatemagneticmaterialsandtheirbehavior

CO3:Evaluatesemiconductormaterialsandtechnologies

CO4:Selectsuitablematerialsforelectricalengineeringapplications

CO5:Identifyrightmaterialforopticalandoptoelectronicapplications

CO-POMAPPING

	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,'-'nocorrelation

TEXTBOOKS:

1.PradeepFulay,Electronic,MagneticandOpticalmaterials,CRCPress,taylorandFrancis,2ndillustrated edition,2017.

2.RKRajput,AcourseinElectricalEngineeringMaterials,LaxmiPublications,2009.
REFERENCEBOOKS:
1.TKBasak,AcourseinElectricalEngineeringMaterials,NewAgeSciencePublications,2009
2.TTTIMadras,ElectricalEngineeringMaterials,McGrawHillEducation,2004.
3.AdrianusJ.Dekker,ElectricalEngineeringMaterials,PHIPublication,2006.
WEBRESOURCES:
https://archive.nptel.ac.in/content/storage2/courses/112108150/pdf/PPTs/MTS_16_m.pdf
https://www.youtube.com/watch?v=aNb6Ta-3U7A

MA606107FRACTUREMECHANISM					
CourseCategory:ProgramCore	**CourseType:Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSEOBJECTIVES:

- TheObjectivesofthecoursearethemakethestudentslearnabout
- Familiarizethesmartmaterialanditsroleindevelopingintelligentsystems.
- IntroducethestudentswithLBHSandHBLSsmartmaterial.
- Exposethestudentsinsmartsystemdevelopmentanduses.

UNIT1:FRACTUREMECHANICSPRINCIPLES **9**

Introduction and historical review – Sources ofmicro and macro cracks– Stress concentrationdue to elliptical hole – Strength ideal materials, and Griffith's energy balance approach. Fracturemechanics approach to design – NDT and Various NDT methods used in fracture mechanics – Numericalproblems.TheAirystressfunction.Effectoffinitecracksize.Ellipticalcracks,Numerical problems.

UNIT2:PLASTICITYEFFECTS **9**

Theory of Plastic deformation – Irwin plastic zone correction. Dugdale's approach – the shape ofthe plastic zone for plane stress and plane strain cases –the plate thickness effect, numericalproblems.DeterminationofStressintensityfactorsandplanestrainfracturetoughness:Introduction,estimationofstressintensityfactors–Experimentalmethod-Planestrainfracture toughnesstest–TheStandardtest,sizerequirements,etc.

UNIT3:ENERGYRELEASERATE **9**

Theenergyreleaserate–criteriaforcrackgrowth–thecrackresistance(Rcurve)tearingmodulus stability–elasticplasticfracturemechanics:Fracturebeyondgeneralyield–thecrack-tipopeningdisplacement–ExperimentaldeterminationofCTOD–ParamatersaffectingthecriticalCTOD.

UNIT4:JINTEGRAL **9**

Use of J integral – Limitation of J integral – Experimental determination of J integral and theparameters affecting J integral – Dynamics and crack arrest: Crack speed and kinetic energy –Dynamic stress intensity and elastic energy release rate – Crack branching. Principles of crackarrest – Crackarrestinpractice–Dynamicfracturetoughness

UNIT5:FATIGUECRACKPROPAGATIONANDAPPLICATIONSOFFRACTUREMECHANICS **9**

Crackgrowthandthestressintensityfactor–Factorsaffectingcrackpropagation–Variableamplitudeserviceloading–Meanstoprovidefail-safety–Parislaw–Requiredinformationfor fracturemechanicsapproach.

TOTAL:45PERIODS

COURSEOUTCOMES:Attheendofthecourse,thestudentwillbeableto

CO1:Applytheeffectsofcracklikedefectsontheperformanceof MechanicalEngineering

CO2:Applytheconceptsoffracturemechanicstoselectappropriatematerialsforengineeringstructures to ensuredamage tolerance

CO3:Understandmechanicsofcracktipfieldsandappropriatefracturecharacterizingparameterslike stress intensityfactorandJintegral.

CO4:Applytheconceptsoffracturemechanicstodeterminecriticalcracksizesandfatigue crack propagation rates in engineering structures

CO5:Understandthestatusofacademicresearchinfieldoffracturemechanics.

CO-POMAPPING

	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,'-'nocorrelation

TEXTBOOKS:

1.ElementsoffracturemechanicsPrasanthKumarWheeterpublication1999
2.FractureMechanics:FundamentalsandApplicationsAndersonCRCpress3rdEd.,2005
REFERENCEBOOKS:
1.Introductiontofracturemechanics,karenHellanmcgrawHill2nd Edition.
2.Engineeringfracturemechanics,S.A.MeguidElsevierAppliedscience1989.
WEBRESOURCES:
https://archive.nptel.ac.in/courses/112/106/112106065/
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 testingandevaluation;Prevailingmethodstocombatcorrosion;Coatings–metallicnon-metallic,passivity,cathodicprotection

TOTAL: 45 PERIODS

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

CO1:Understandtheconceptsofatomicbonding,crystalstructures,imperfections,diffusion,mechanicalproperties,electronenergy,anddislocationsasrelatedto

CO2:.Understandtherelationsbetweenthecomposition,temperatureandphasefractionsappliedto equilibriumphase diagramsforgivenmaterialsystems

CO3:Enumerateprincipalstressesandshearstressesforsimpletwodimensionalloadings

CO4: Understand about selection of materials

CO5:Tostudy,measure,monitor,controlandpreventcorrosionprocesses,economicallyandsafely.

CO-PO 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/ https://archive.nptel.ac.in/courses/112/106/112106293/

MA6061109TRANSPORTPHENOMENONINMATERIALS(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.
- 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 homogeneousand heterogeneouschemical reaction, Diffusion in to a falling liquid film, Diffusion andchemical reaction in porous catalystand the effectiveness factor,equation of continuity forbinary mixtures, equation of change to set updiffusion problems for simultaneous heat andmass 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 macroscopicbalances 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:Studentswouldgaintheknowledgeoffundamentalconnectionsbetweentheconservationlawsinheat,mass,andmomentumintermsofvectorandtensorfluxes

CO2:.Toacquireknowledgeonmomentum,heatandmasstransferinChemicalengineering systemsandtheir analogous behaviour.

CO3:Explainsimilaritiesanddifferencesbetweenthedescriptionsofthecombinedfluxesandthe equationsofchangeformass,momentumandheattransport.

CO4: Apply the method of dimensional analysis to reformulate and then find the form ofsolutionsoftheequationsofchange,todeterminethedependenceoftheinterfacialfluxeson system parameters.

CO5:Abletounderstandthemechanismoffluidsinmotionunderdifferentconditions.

CO-PO 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,TransportPhenomena,2ndRevisedEdition,John Wiley,2007

2.Robert,SBrodkey,HarryC.Hershey,"TransportPhenomenaAUnifiedApproach",Brodkey Publishing 2003.

3.Brodkey,R.S.,andHershey,H.C.,"TransportPhenomena",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
https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-me09/

MA606110 WELDING PROCESSESS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

TheObjectivesofthecoursearetofamiliarizewithfundamentalsofWeldingTechnology Tounderstandthebasicsofweldingandtoknowaboutthevarioustypesofweldingprocesses.Toselectandapplyknowledge,techniques,skills,andmoderntoolsoftheWeldingProcesses.

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 Electro slag 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:Applytheknowledgeofweldingfundamentalstosolveweldingproblems

CO2:Understandtheconstructionandworkingprinciplesofgasandarcweldingprocess.

CO3:Understandtheconstructionandworkingprinciplesofresistanceweldingprocess

CO4:Understandtheconceptsonweldjointdesign,weldabilityandtestingofweldments

CO5:AbletounderstandTechniquesofsafetyManagementandsafetyperformancePlanning

CO-PO 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.LittleR.L.,"WeldingandweldingTechnology",TataMcGrawHillPublishingCo.,Ltd.,NewDelhi,34th reprint,2008.

2.ParmerR.S.,"WeldingEngineeringandTechnology",1stEdition,KhannaPublishers,NewDelhi,2008.

3.ParmerR.S.,"WeldingProcessesandTechnology",KhannaPublishers,NewDelhi,1992.

REFERENCE BOOKS:

1.AWS-WeldingHandBook.8thEdition.Vol-2."WeldingProcess"

2.ChristopherDavis."LaserWelding-PracticalGuide".JaicoPublishingHouse.

3.SchwartzM.M."MetalsJoiningManual".McGrawHillBooks,1979

WEB RESOURCES:

https://nptel.ac.in/courses/112107090

https://onlinecourses.nptel.ac.in/noc21_mm01/preview

VERTICAL 5: 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	**10**

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	**10**

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	**8**

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	**8**

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 Production Automation, Process Planning & Quality control in Computer Integrated Manufacturing Systems.

CO2: To acquire the knowledge on quality control, computer aided testing and inspectionmethods.

CO3: To analyse the Computer Aided Process Planning &Control, Material handling, and Artificial intelligence in 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-PO 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	1			1			1				2	1	1
CO4	2		1	2				1				1	1	1
CO5	2		2		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. https://onlinecourses.nptel.ac.in/noc22_me10/preview
2. https://nptel.ac.in/courses/112104289

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.

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-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2											1	1	1
CO2	2	2	2	2								1	1	1
CO3	2	2	2	2	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:
https://onlinecourses.nptel.ac.in/noc20_cs69/preview
https://archive.nptel.ac.in/courses/106/105/106105195/

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.
- Tofamiliarizestudentswithdifferentprocessesinrapidprototypingsystems.
- To be familiar with the characteristics of the different materials those are used in Additive Manufacturing technologies.

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-PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1				1							2	1	1
CO2	1	2	1	2	1							2	1	1
CO3	1	2	2	1	1							2	1	1
CO4	1	2	1	2	1							2	1	1
CO5	1	2	2	2	1							2	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:
https://archive.nptel.ac.in/courses/112/103/112103306/
https://onlinecourses.nptel.ac.in/noc22_me122/preview

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.
- To understand the material handling systems

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 FLEXIBLEMANUFACTURING 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-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1						1	1	1	1	1
CO2	1	2	1	1						1	1	1	1	1
CO3	1	1	2	2							1	1	1	1
CO4	1	2	1	2						1	1	1	1	1
CO5	1	2	1	1						1	1	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.,New AgeInternationalLtd.,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:
https://archive.nptel.ac.in/courses/110/106/110106044/
http://acl.digimat.in/nptel/courses/video/112104289/lec31.pdf

MA606204 – ADDITIVE MANUFACTURING PROCESS						
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- Toknowtheprinciple,methods,possibilitiesandlimitationsaswellasenvironmentaleffects ofAdditive Manufacturingtechnologies.
- Tofamiliarizestudentswithdifferent processesin rapidprototypingsystems.
- Tobefamiliarwiththecharacteristicsofthedifferentmaterialsthoseareusedin AdditiveManufacturingtechnologies.
- UnderstandtheoperatingprinciplesandlimitationsofAdditiveManufacturing processes.

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: CLASSIFICATION OF ADDITIVE MANUFACTURING **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), photo polymerization, liquid thermal polymerization, Solid foil polymerization

UNIT 4: EXTRUSION BASED AND SHEET LAMINATION PROCESSES **9**

Extrusion Based System: FDM-Introduction – Basic Principle – Materials – Applications andLimitations – 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:UnderstandthemethodologytomanufacturetheproductsusingSLAandSGCtechnologiesand studytheirapplications, advantages,and casestudies.

CO3:Identify thesuitablemanufacturingMethodologyforAdditiveManufacturing

CO4:Understandtheextrusionandsheetlaminationprocess.

CO5:UnderstandthemethodologytomanufacturetheproductsusingBioplottertechnologiesandstudytheirapplications,advantages.

CO-PO MAPPING

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

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

TEXT BOOKS:

1.IanGibson,DavidW.Rosen,BrentStucker,"*AdditiveManufacturingTechnologies*",Springer,2009.

2C.K.Chua,K.F.Leong andC.S. Lim, "*RapidPrototyping: Principlesand Applications*",

2nd edition, World Scientific Publishers, 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, Weiyin Ma "*Rapid Prototyping: Laser-Based and Other Technologies*" 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, Paul F. Jacobs, "*Rapid Tooling: Technologies and Industrial Applications*", CRC Press, 2000.
2.M.Burns, "*Automated fabrication*", Prentice-Hall, 1993.
3.Andreas Gebhardt "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing" Hanser Gardner Publication 2011.
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/103/112103306/
https://onlinecourses.nptel.ac.in/noc22_me122/preview

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-PO 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	1							1	1	1
CO3	1	2	2	1	1		2					1	1	1
CO4	1	1	2	2	1		2					1	1	1
CO5	1	2	2	1	1		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:
https://onlinecourses.nptel.ac.in/noc22_ce49/preview
https://archive.nptel.ac.in/courses/112/104/112104188/

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.
- To understand the RP processes.
- To understand the errors in RP.
- Understand the applications of RP.

UNIT 1: INTRODUCTION **5**

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 **10**

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 **18**

Process Physics, Tooling, Process Analysis, Material and technological aspects, Applications, limitations and comparison of various rapid manufacturing processes. Photopolymerization (Stereolithography (SL), Microstereolithography), 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: **5**

Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS.

UNIT 5: RP APPLICATIONS **7**

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-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1										1	1	1
CO2	1	2	2	2	2							2	1	1
CO3	1	2	2	2	2							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:
https://archive.nptel.ac.in/courses/112/104/112104265/
https://onlinecourses.nptel.ac.in/noc22_me74/preview

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 demonstrate the fundamentals of machining processes and machine tools.
- To develop knowledge and importance of metal cutting parameters.
- To develop fundamental knowledge on tool materials, cutting fluids and tool wear mechanisms.
- To design the jigs and fixtures required for machine tools.

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 and reduce temperature developed during machining

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-PO MAPPING

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

https://archive.nptel.ac.in/courses/112/105/112105233/

https://onlinecourses.nptel.ac.in/noc21_me04/preview

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.

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 degassingduring secondary steelmaking

CO2: To understand the temperature control, Cleanliness measures in mould andEntrapments 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-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2											1	1	1
CO2	2	2	1	1	2							1	1	1
CO3	2	2	2	1	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:
https://onlinecourses.nptel.ac.in/noc22_mm12/preview
https://archive.nptel.ac.in/courses/112/106/112106253/

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.
- There is a comprehensive coverage of physical concepts, process characteristics, mathematical formulations along with examples of various laser based manufacturing processes such as of laser machining (cutting), laser forming, laser welding, laser surface treatment and laser based additive manufacturing.
- After completion of the course, the students will have a strong foundation on laser technology and will be able to apply the basic principles, process characteristics in the practical scenarios.

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-PO 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	2	1	1				1	2	1	1
CO3	2	1	2	2	2	1	1				1	2	1	1
CO4	2	2	2	2	2	1	1				1	2	1	1
CO5	2	2	2	1	2	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:
https://onlinecourses.nptel.ac.in/noc22_me92/preview
https://archive.nptel.ac.in/courses/112/103/112103312/

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 provide overview of various sheet metal forming process
- To study the powder metallurgy techniques and Special metal forming processes.
- 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 isosaticpressing.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-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1					1						1	1	1
CO2	1		1		2	2						1	1	1
CO3	1	2	1		2	2						1	1	1
CO4	1	2	1		2	2						1	1	1
CO5	1	1	1		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.
REFERENCE BOOKS:
1. Nagpal G.R, Metal Forming Processes, Khanna publishers, 2005
2. Shiro Kobayashi, Soo-Ik-Oh-Altan T, Metal forming and Finite Element Method, Oxford University Press,1989.
3. Surender kumar, Technology of Metal Forming Processes, Prentice Hall India Publishers,1st Edition, 2008.
WEB RESOURCES:
https://nptel.ac.in/courses/112106153
https://archive.nptel.ac.in/courses/112/107/112107250/

VERTICAL 6: AUTOMATION

MA606301-MACHINE LEARNING					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- To introduce basic machine learning techniques such as regression, classification
- To learn about introduction of clustering, types and segmentation methods
- To learn about fuzzy logic, fuzzification and defuzzification
- To learn about basics of neural networks and neuro fuzzy networks.
- To learn about Recurrent neural networks and Reinforcement learning.

UNIT 1: INTRODUCTION TO MACHINE LEARNING **9**

Philosophy of learning in computers, Overview of different forms of learning, Classifications vs. Regression, Evaluation metrics and loss functions in Classification, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.

UNIT 2: CLUSTERING AND SEGMENTATION METHODS **9**

Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, Mean Shift clustering, K-means clustering application study, Introduction to recognition, K-nearest neighbor algorithm, KNN Application case study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance

UNIT 3: FUZZY LOGIC **9**

Introduction to Fuzzy Sets, Classical and Fuzzy Sets, Overview of Classical Sets, Membership Function, Fuzzy rule generation, Fuzzy rule generation, Operations on Fuzzy Sets, Numerical examples, Fuzzy Arithmetic, Numerical examples, Fuzzy Logic, Fuzzification, Fuzzy Sets, Defuzzification, Application Case Study of Fuzzy Logic for Robotics Application

UNIT 4: NEURAL NETWORKS **9**

Mathematical Models of Neurons, ANN architecture, Learning rules, Multi-layer Perceptrons, Back propagation, Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Application Case Study of Neural Networks in Robotics

UNIT 5:RNN AND REINFORCEMENT LEARNING **9**

Unfolding Computational Graphs, Recurrent neural networks, Application Case Study of recurrent networks in Robotics, Reinforcement learning, Examples for reinforcement learning, Markov decision process, Major components of RL, Q-learning. Application Case Study of reinforcement learning in Robotics

TOTAL: 45 PERIODS

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

CO1: Understand basic machine learning techniques such as regression, classification
CO2. Understand about clustering and segmentation
CO3. Model a fuzzy logic system with fuzzification and defuzzification .
CO4. Understand the concepts of neural networks and neuro fuzzy networks.
CO5. Gain knowledge on Reinforcement learning.

CO-PO MAPPING

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

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

TEXT BOOKS:
1. MichealNegnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Addision Wesley, England, 2011
REFERENCE BOOKS:
1. Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2016 2nd Edition, Springer 2. Simon Haykin, "Neural Networks and Learning Machines: A Comprehensive Foundation", Third Edition, Pearson, delhi 2016. 3. Timothy J Ross, "Fuzzy Logic with Engineering Applications", 4th Edition, Chichester, 2011, Sussex Wiley.
WEB RESOURCES:
1. https://nptel.ac.in/courses/106106139 2. https://onlinecourses.nptel.ac.in/noc23_cs18/preview

MA606302-INDUSTRIAL AUTOMATION AND CONTROL

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

COURSE OBJECTIVES:

To impart knowledge on

1. Understand automation technologies and identify advantages, limitations and applications of the same.
2. Develop ability to recognize, articulate and solve industrial problems using automation technologies.

UNIT 1: PROGRAMMABLE LOGIC CONTROLLER (PLC) AND PLC PROGRAMMING **9**

An overview of PLC, Introduction, definitions and history of PLC, manufacturing and assembly processes, PLC advantages and disadvantages, overall PLC system, CPU, PLC, input and output modules, program recording devices, General programming procedure, Input and Output module interfacing, Relation of digital gate logic to contact / coil logic -Creating ladder diagrams from process control descriptions

UNIT 2: PLC FUNCTIONS: **9**

Timer function, Counter function, Arithmetic function, Number comparison functions, Numbering systems and number conversion function, Skip and Master control relay functions, Jump functions, PLC data move systems, Digital bit functions and applications, Sequencer function.

UNIT 3: ANALOG PLC OPERATIONS **9**

Different PLC operations ,Applications of PLCs:Stepper motor control, Speed control of D.C. motor & Induction motor, Lift/Elevator control, Water level control, Traffic control, Temperature control.

UNIT 4:HMI AND INTRODUCTION TO DISTRIBUTED CONTROL SYSTEM **9**

Architecture, types and specifications, Interfacing and Networking With PLC. SCADA: Introduction, Features and Applications. DCS architecture, Communication Protocol.

UNIT 5: INTRODUCTION TO INDUSTRY 4.0 **9**

History of industrial revolutions, Concept of IR4.0, Typical architecture of IR4.0, Design principles and major role players in IR4.0, Advantages and Challenges.

TOTAL: 45 PERIODS

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

CO1: Understand the basics of PLC programming.
CO2: Understand the different parameters of PLC and analyze different functions of PLC.
CO3: Design different process control applications through ladder logic.
CO4: Build and experiment with PLC based SCADA systems for various industrial applications.
CO5: Distributed Control System and Industry standard 4.0

CO-PO MAPPING

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

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

TEXT BOOKS:

1. William Bolton, "Programmable Logic Controllers", 4th Edition, Elsevier.
2. L.A. Bryan and E. A. Bryan, "Programmable Controllers – Theory and implementation," Second edition, An Industrial text company publication, USA, 1997.
3. Richard L. Shell and Ernest L. Hall, "Handbook of industrial automation," CRC press 2000.

REFERENCE BOOKS:

1. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers", 5th Ed., PHI, 2012.
2. John R. Hackworth, Fredrick D. Hackworth Jr., "Programmable Logic Controllers: Programming Methods and Applications", Pearson,

WEB RESOURCES:

https://onlinecourses.nptel.ac.in/noc21_me67/preview

MA606303-INDUSTRIAL AUTOMATION SYSTEM

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

COURSE OBJECTIVES:

To impart knowledge on

- To educate on design of signal conditioning circuits for various applications.
- To Introduce signal transmission techniques and their design.
- Study of components used in data acquisition systems interface techniques
- To educate on the components used in distributed control systems
- To introduce the communication buses used in automation industries.

UNIT 1: INTRODUCTION **9**

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems : Modbus & Profibus.

UNIT 2: AUTOMATION COMPONENTS **9**

Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT 3: COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS **9**

Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation.

UNIT 4: PROGRAMMABLE LOGIC CONTROLLERS **9**

Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.

UNIT 5: DISTRIBUTED CONTROL SYSTEM **9**

Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.

TOTAL: 45 PERIODS

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

CO1: Design a signal conditioning circuits for various application
CO2: Acquire a detail knowledge on data acquisition system interface and DCS system
CO3: Understand the basics and Importance of communication buses in applied automation Engineering
.CO4: Ability to design PLC Programmes by Applying Timer/Counter and Arithmetic and Logic Instructions Studied for Ladder Logic and Function BIock
CO5: Able to develop a PLC logic for a specific application on real world problem

CO-PO MAPPING

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

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

TEXT BOOKS:
1.S.K.Singh, “Industrial Instrumentation”, Tata Mcgraw Hill, 2nd edition companies,2003. 2. C D Johnson, “Process Control Instrumentation Technology”, Prentice Hall India,8th Edition, 2006. 3. E.A.Parr, Newnes ,NewDelhi,“Industrial Control Handbook”,3rd Edition, 2000
REFERENCE BOOKS:
1. John W. Webb and Ronald A. Reis, “Programmable Logic Controllers: Principles and Applications”, 5th Edition, Prentice Hall Inc., New Jersey, 2003. 2. Frank D. Petruzella, “Programmable Logic Controllers”, 5th Edition, McGraw- Hill, New York, 2016. 3. Krishna Kant, “Computer - Based Industrial Control”, 2nd Edition, Prentice Hall, New Delhi, 2011. 4.Gary Dunning, Thomson Delmar,“Programmable Logic Controller”, CeneageLearning, 3 rd Edition,2005.
WEB RESOURCES:
1. https://archive.nptel.ac.in/courses/108/105/108105062/ 2. https://nptel.ac.in/courses/108105063 3. https://onlinecourses.nptel.ac.in/noc21_me67/preview

MA606304-SMART MOBILITY AND INTELLIGENT VEHICLES					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- The objectives of the course are:
- To introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles.
- To learn Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, LIDAR Sensor Technology and Systems and other sensors for automobile vision system.
- To learn Basic Control System Theory applied to Autonomous Automobiles.

UNIT 1: INTRODUCTION TO AUTOMATED, CONNECTED, AND INTELLIGENT VEHICLES **9**

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles. Case studies: Automated, Connected, and Intelligent Vehicles

UNIT 2 :SENSOR TECHNOLOGY FOR SMART MOBILITY **9**

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems

UNIT 3: CONNECTED AUTONOMOUS VEHICLE **9**

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy

UNIT 4: VEHICLE WIRELESS TECHNOLOGY & NETWORKING **9**

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts– Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks

UNIT 5: CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY **9**

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues

TOTAL: 45 PERIODS

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

CO1: Recognize the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles.
CO2: Select the concept of remote sensing and the types of sensor technology needed to implement remote sensing.
CO3: Familiar with the concept of fully autonomous vehicles.
CO4: Apply the basic concepts of wireless communications and wireless data networks.
CO5: Analyze the concept of the connected vehicle and its role in automated vehicles.

CO-PO MAPPING

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

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

TEXT BOOKS:
1. “Intelligent Transportation Systems and Connected and Automated Vehicles”, 2016, Transportation Research Board 2. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, 2019, Springer
REFERENCE BOOKS:
1. Tom Denton, “Automobile Electrical and Electronic systems, Roult edge”, Taylor & Francis Group, 5th Edition, 2018
WEB RESOURCES:
https://elearn.nptel.ac.in/shop/iit-workshops/completed/e-mobility-and-electric-vehicle-engineering/
https://appleacademicpress.com/smart-mobility-and-intelligent-transportation-systems-for-commercial-and-hazardous-vehicles-/9781774915387

MA606305-ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEM					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on 1. To understand Basic Concepts of Artificial Intelligence and Expert Systems.
2.To provide knowledge on Various Techniques and Tools involved in Artificial Intelligence

UNIT 1: INTRODUCTION **9**

History, Definition of AI, Emulation of human cognitive process, knowledge search trade off, stored knowledge, semantic nets. An abstract view of modelling, elementary knowledge. Computational logic, analysis of compound statements using simple logic connectives, predicate logic, knowledge organization and manipulation, knowledge acquisition.

UNIT 2: PROGRAMMING AND LOGICS IN ARTIFICIAL INTELLIGENCE **9**

LISP and other programming languages- introduction to LISP, syntax and numerical function, LISP and PROLOG distinction, input output and local variables, Interaction and recursion, property list and arrays alternative languages, formalized symbolic logicsproperties of WFRS, non-deductive inference methods. Inconsistencies and uncertaintiesTruth maintenance systems, default reasoning and closed world assumption, Model and temporary logic.

UNIT 3: SEARCH METHODS AND KNOWLEDGE REPRESENTATION **9**

Fuzzy logic - concepts, Introduction to Fuzzy logic with examples, probabilistic reasoning, Bayesian probabilistic inference, Dempstor Shafer theory, possible world representation, AdHoc methods. Structure knowledge: Graph, frames and related structures, Object oriented representation- object classes, message and methods, simulation examples using OOPS programs, OOP languages. Search and control strategies - Concepts, search problems, uniformed or Blined search, searching AND – OR graphs.

UNIT 4: KNOWLEDGE ORGANISATION AND COMMUNICATION IN EXPERT SYSTEMS **9**

Matching techniques- Need for matching, matching problem, partial matching, Fuzzy matching, RETE matching algorithm. Knowledge organization- Indexing and retrieval techniques, integration of knowledge in memory organization systems, Perception, communication and Expert systems. Overview of Linguistics, Basic passim techniques, semantic analysis and representation structures, natural language generation and system.

UNIT 5: PATTERN RECOGNITION AND LEARNING TECHNIQUES **9**

Pattern recognition system- understanding speech recognition, Image transformation, low level processing, medium and high level processing, vision system architecture, Rule based system architecture, knowledge acquisition and validation, knowledge system building tools, use of AI and ES in manufacturing and design, types of learning- general learning model, performance measures, learning automate genetic algorithm, learning by induction - LEX,ID3,INDUCE systems.

TOTAL: 45 PERIODS

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

CO1: Understand the Basics about Artificial Intelligence and Expert Systems.
CO2: Understand the Programming Logics in Artificial Intelligence.
CO3: Understand Various search methods in Artificial Intelligence.
CO4:Understand the Knowledge about the Expert Systems.
CO5: Understand The Image processing and analysis.

CO-PO MAPPING

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

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

TEXT BOOKS:
1. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education series in AI', 3rd Edition, 2009. 2. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', Prentice Hall of India Pvt. Ltd,2001 3. Eugene Charniak, Drew Mc Dermot, 'Introduction to Artificial intelligence', Addison Wesley Longman Inc.,2009
REFERENCE BOOKS:
1.George. F, William. A. Stubblefield, 'Artificial intelligence and the design of expert systems', The Benjamin Cummins Publishing Co., Inc 2nd Edition, 1992. 2. Robert J Schalkoff, 'Artificial intelligence An Engineering Approach', McGraw Hill International Edition, 1990
WEB RESOURCES:
https://onlinecourses.nptel.ac.in/noc21_cs79/preview
https://nptel.ac.in/courses/106105077

MA606306-MANUFACTURING AUTOMATION					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

To know about the Automation and types of Automations in the industries.

To understand the different Automated flow lines in the Industries.

To perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.

To perform a sequence of automated or mechanized assembly operations Flexible manufacturing system (FMS)—a highly automated machine cell that produces part

To know product families often consists of workstations comprising CNC machine tools.

UNIT 1: INTRODUCTION **9**

Types and strategies of automation, pneumatic and hydraulic components circuits, Automation in machine tools, Mechanical Feeding and to changing and machine tool control transfer the automation

UNIT 2: AUTOMATED FLOW LINES **9**

Methods or work part transport transfer Mechanical buffer storage control function, design and fabrication consideration. Analysis of Automated flow lines: General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines

UNIT 3: ASSEMBLY SYSTEM AND LINE BALANCING **9**

Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

UNIT 4: AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS **9**

Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT 5: FUNDAMENTALS OF INDUSTRIAL CONTROLS **9**

Review of control theory, logic controls, sensors and actuators, Data communication and LAN in manufacturing. Business process Re-engineering: Introduction to BPE logistics, ERP, Software configuration of BPE.

TOTAL: 45 PERIODS

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

CO1: Students will understand the process of automation and types.

CO2: Students will get exposure to workstation, which refers to the location in the factory where some well-defined task or operation is accomplished by an automated machine..

CO3: Worker-and-machine combination or a worker using hand tools.

CO4: Understand the Automated Material handling equipments and types.

CO5: Student gets exposure on portable power tools.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. M.P.Groover 3e - Automation, Production Systems and Computer Integrated Manufacturing, PHI,2009.
2. Frank Lamb - Industrial Automation , Mc Graw Hill,2013

REFERENCE BOOKS:
1. Nick Dawkins - Automation and Controls 2. Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - Computer Aided Manufacturing, Pearson 2009 3. Peter G. Martin and Gregory Hale - Automation Made Easy
WEB RESOURCES:
1. https://onlinecourses.nptel.ac.in/noc22_me50/preview https://archive.nptel.ac.in/courses/112/104/112104288/

MA606307-MICROPROCESSOR IN AUTOMATION					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

- Study the Architecture of 8085 microprocessor.
- Study the Architecture of 8086 microprocessor.
- Learn the design aspects of I/O and Memory Interfacing circuits.
- To gain knowledge in automation in industries.

UNIT 1: 8086 MICROPROCESSOR **9**

Architecture – Pin description – Operating modes – Registers – Interrupts – Bus cycle – Addressing modes – Typical configuration of 8086 system – Overview of Instruction set.

UNIT 2: 80286 MICROPROCESSOR **9**

Functional block diagram - Modes of operation – Real and protected mode – Memory management and protection features

UNIT 3: 80386, 80486 PROCESSORS **9**

80386: Functional block diagram - Programming model - Addressing modes and instruction set overview – Address translation - Modes of operation - 80486 processor - Functional block diagram - Comparison of 80386 and 80486 processors.

UNIT 4: PENTIUM MICROPROCESSOR **9**

Introduction – Architecture – Special Pentium registers – Memory management

UNIT 5: TOTALLY INTEGRATED AUTOMATION **9**

Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure. Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI

TOTAL: 45 PERIODS

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

CO1: Design and implement programs on 8085 microprocessor.
CO2: Design and implement programs on 8086 microprocessor.
.CO3: Design I/O circuits.
CO4: Design Memory Interfacing circuits.
CO5: Knowledge of PLC & PAC automation

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Barry B Brey, "The Intel Microprocessor 8086/8088, 80186/80188, 80286, 80386, 80486 Pentium and Pentium processor, Pentium II,III,4 , Prentice Hall of India, New Delhi, 2005.

2 Douglas V Hall, "Microprocessors and Interfacing: Programming and Hardware", McGraw Hill, New Delhi, 2005.

3. John.W.Webb& Ronald A. Reis, "Programmable logic controllers: Principles and Applications", Prentice Hall India, 2003.

REFERENCE BOOKS:

2 Myke Pred ko, "Programming and Customising the PIC Microcontroller, "McGraw Hill, USA, 1998

3. Win C C Software Manual, Siemens, 2003

WEB RESOURCES:
https://nptel.ac.in/courses/117104072
https://archive.nptel.ac.in/courses/112/103/112103293/

MA606308-ROBOTICS :Basics and selected Advanced concepts					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge on

1. To understand Basic Concepts of Artificial Intelligence and Expert Systems.
2. To provide knowledge on Various Techniques and Tools involved in Artificial Intelligence

UNIT 1: INTRODUCTION **9**

Historical Perspective-Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots. Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axisrobots. Five axis and Six axis robots. Work envelope of Four and Five axis robots, Workspace fixtures

UNIT 2: DYNAMIC ANALYSIS , FORCES AND TRAJECTORY PLANNING **9**

Introduction, Langrangian mechanics, Effects of moments of Inertia, Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.

UNIT 3: LOCALIZATION AND MAPPING **9**

Magnetic and optical position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual and motion sensing systems. Localization, Map based localization, Markov localization, Kalman filter localization Error propagation model, Probabilistic map based localization, Autonomous map building, Simultaneous localization and mapping (SLAM),

UNIT 4: MOTION CONTROL **9**

Collisions free path planning and sensor-based obstacle avoidance. Motion controlling methods, kinematic control, dynamic control and cascaded control.

UNIT 5: MODERN MOBILE ROBOTS **9**

Introduction, Swarm robots, cooperative and collaborative robots, mobile manipulators, autonomous mobile robots.

TOTAL: 45 PERIODS

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

CO1:Utilize kinematics analysis of robotic manipulators and Perform Workspace analysis of a Robotic System.

CO2:Describe the construction of robotic manipulators and Plan off-line Robot trajectories to meet desired End-Effector tasks.

CO3: Summarize the different types of localization approach.

CO4:Design collisions free path planning..

CO5:Summarize the different types of Swarm robots, Cooperative and Collaborative robots.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Kelly, A ―Mobile Robotics: Mathematics, Models, and Methods‖, Cambridge University Press, USA, 2013.

2. Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA, 2010.

REFERENCE BOOKS:
1Siegwart,R Nourbakhsh, and Scaramuzza, ―Introduction to Autonomous Mobile Robots‖, MIT Press, USA, 2011. 2. Thrun, W Burgard, D Fox, Probabilistic Robotics, MIT Press, USA, 2005.
WEB RESOURCES:
1. https://onlinecourses.nptel.ac.in/noc21_me37/preview https://archive.nptel.ac.in/courses/112/108/112108298/

MA606309- MICROCONTROLLERS AND PLC

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

COURSE OBJECTIVES:

- To introduce the basic features, programming methods and applications of Micro controllers
- To study about programming in microcontroller
- Discuss different applications in microcontroller
- To know about the design of systems using PLC is introduced in detail.
- To know about the applications in PLC

UNIT 1:MICROCONTROLLER **9**

Introduction, Comparing Microprocessors and Microcontrollers, Z-80, 8051, PIC Micro Controllers, PIC Development Tools. The Micro Controller Survey, 4Bit, 8Bit, 16 Bit and 32 Bit Micro Controllers. Develop Systems for Micro Controllers. Micro Controllers Architecture: 8051 Architecture, PIC Architecture, 8051 Micro Controller Hardware, Input/Output Pins, Ports and Circuits, External Memory, Counter and Timers, Serial Data Input/Output, (SLE: Interrupts).

UNIT 2: MICRO CONTROLLER PROGRAMMING & APPLICATIONS **9**

Simple programming exercises- key board and display interface –Control of servo motor, stepper motor control- Application to automation systems.

UNIT 3: PLC **9**

Programmable Logic Controllers: Introduction – Parts of PLC – Principles of operation – PLC sizes – PLC hardware components – I/O section Analog I/O Section Analog I/O modules – digital I/O modules CPU processor memory module – Programming devices – PLC programming Simple instructions - Latching relays PLC ladder diagram, Applications of PLC - Simple materials handling applications, Automatic control of warehouse door, Automatic lubrication of supplier Conveyor belt, Motor control.

UNIT 4: SCADA **9**

Introduction to SCADA. TAG's – Types – Analog – Digital – Strings – Memory – I/O tags. PCSCADA-Memory analog/digital/string tag. PLC-SCADA – I/O analog/digital/string tag. Features of SCADA – Dynamic process graphic – Real-time and historical trending – Alarms – Recipe management – Security – Device connectivity – Script for logic development – Database connectivity. Case studies.

UNIT 5: DISTRIBUTED CONTROL SYSTEM **9**

Introduction to DCS – Centralized versus Distributed control system. Components of DCS – Field Control Station – Operator Station – Communication Bus. Human Interface Station, Engineering Station – Communication Gateway – Bus converter. Programming and Simulation.

TOTAL: 45 PERIODS

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

CO1: The students will learn the basic of microcontroller
CO2 : Gain the knowledge on microcontroller and its programming.
CO3: Acquire knowledge on PLC and do simulation using PLC for different industrial applications.
CO4: Gain knowledge on SCADA.
CO5: Be able to apply the distributed control system for automation.

CO-PO MAPPING

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

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

TEXT BOOKS:
1. Muhammad Ali Mazdi ,J.G.Mazdi and R.D.McKinlay The 8051 Microcontroller& Embedded systems Using assembly and C 2nd Edition Pearson Education , Inc ,2006
2 Udayasankara.v and Mallikarjunaswamy .M.S ,8051 Microcontroller, Hardware, Software and Applications ,Tata McGraw Hill Education Pvt Limited. New Delhi ,2009.
REFERENCE BOOKS:
1. Valdes-Perez, Microcontrollers: Fundamentals and Applications with PIC, Taylor and Francis, Indian Reprint, 2013.
2. Bolton , "Programmable Logic Controllers 5th Edition Newnes, ,2009
3. Parr, "Programmable Controllers: An Engineers Guide", 3rd Edition, Elsevier, Indian Reprint, 2013
WEB RESOURCES: 1. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108105088/lec25.pdf 2. https://nptel.ac.in/content/storage2/courses/112103174/pdf/mod3.pdf

MA606310-FIELD SERVICE ROBOTICS

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

COURSE OBJECTIVES:

To impart knowledge on

1. The applications and current trend in field and service robot
2. Path planning algorithms inside a field/service robot for navigation
3. Interaction interface concepts for humanoid robot

UNIT 1: INTRODUCTION **9**

History of service robotics – Present status and future trends – Need for service robots – applications examples and Specifications of service and field Robots. Non conventional Industrial robots.

UNIT 2: ROBOT KINEMATICS **9**

Kinematic Models and Constraints – Maneuverability – Workspace – Control

UNIT 3: LOCALIZATION **9**

Introduction - Bayes filter – Kalman Filter – Extended Kalman Filter - Information Filter - Histogram Filter - Particle Filter – Challenges of Localization- Map Representation- Probabilistic Map based Localization-Monte carlo localization Landmark based navigation-Globally unique localization Positioning beacon systems- Route based localization.

UNIT 4: PLANNING AND NAVIGATION **9**

Introduction-Path planning overview- Global path planning – A* Algorithm - local path planning - Road map path planning- Cell decomposition path planning-Potential field path planning-Obstacle avoidance – Path control.

UNIT 5: HUMANOIDS **9**

Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications.

TOTAL: 45 PERIODS

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

CO1: Describe the applications and current trend in field and service robot
CO2: Explain about the kinematic modelling of mobile robots
CO3: Apply and program robot for reactive concepts for robot interaction with human, between machines and among robots
.CO4: Analyze the concepts of balancing legged robots and interaction interface concepts for humanoid robot
CO5: Implement path planning algorithms inside a field/service robot for navigation

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2011.

REFERENCE BOOKS:

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "ProbabilisticRobotics", MIT Press, 2005.

2. Karsten Berns, Ewald Von Puttkamer, “AutonomousLandVehiclesSteps towards Service Robots”, Vieweg Teubner Springer, 2009.
3. Bruno Siciliano, Oussama Khatib, Springer Hand book of Robotics, Springer, 2008.
WEB RESOURCES:
https://nptel.ac.in/courses/112104316
https://nptel.ac.in/courses/107106090

VERTICAL 7: DIVERSIFIED COURSES

GROUP 1

MA606401-INDUSTRIAL LAYOUT DESIGN AND SAFETY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- The students will be able to Identify equipment requirements for a specific process and for various locations and working conditions.
- Understand the difficulties during the design and implementation of the plant layout.
- The students will able to design an efficient plant layout.
- To achieve an understanding of principles of safety management.
- To enable the students to learn about various functions and activities of safety department.

UNIT I PLANT LOCATION **9**

Selection of plant locations, territorial parameters, considerations of land, water, electricity, location for waste treatment and disposal, further expansion's Safe location of chemical storages, LPG, LNG, CNG, acetylene, ammonia, chlorine, explosives and propellants

UNIT 2: PLANT LAYOUT **9**

Safe layout, equipment layout, safety system, fire hydrant locations, fire service rooms, facilities for safe effluent disposal and treatment tanks, site considerations, approach roads, plant railway lines, security towers. Safe layout for process industries, engineering industry, construction sites, pharmaceuticals, pesticides, fertilizers, refineries, food processing, nuclear power stations, thermal power stations, metal powders manufacturing, fireworks and match works

UNIT 3: WORKING CONDITIONS **9**

Principles of good ventilation, purpose, physiological and comfort level types, local and exhaust ventilation, hood and duct design, air conditioning, ventilation standards, application. Purpose of lighting, types, advantages of good for various work, standards illumination, glare and its effect, lighting requirements Housekeeping, principles of 5S.

UNIT 4: SAFETY CONCEPTS AND TECHNIQUES **9**

History of Safety movement –Evolution of modern safety concept- general concepts of management – planning for safety for optimization of productivity -productivity, quality and safety-line and staff functions for safety-budgeting for safety-safety policy. Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, evaluation of performance of supervisors on safety.

UNIT 5: SAFETY AUDIT **9**

Components of safety audit, types of audits, audit methodology, non-conformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats – implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.

TOTAL: 45 PERIODS

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

CO1: To provide provided with the knowledge of the process of analyzing and developing information to produce a plant layout based on the locations and working conditions.

CO2: To educate the students about the basic things of work conditions which includes ventilation, comfort, lighting and its effect based on various nature of work.

CO3: To provide knowledge on effective and safe layout design of an industry.

CO4: To understand the functions and activities of safety engineering department

CO5: To carry out a safety audit and prepare a report for the audit.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2											1	1	1
CO2	2	2	2	2								1	1	1
CO3	2	2	2	2	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. "Accident Prevention Manual for Industrial Operations", N.S.C.Chicago, 13th Edition 2009.
2. Blake R.B., "Industrial Safety" Prentice Hall, Inc., New Jersey, 3rd Edition 2000.

REFERENCE BOOKS:

1. Dan Petersen, "Techniques of Safety Management", McGraw-Hill Company, Tokyo, 1981.
2. Heinrich H.W. "Industrial Accident Prevention" McGraw-Hill Company, New York, 1980
3. John Ridley, "Safety at Work", Butterworth and Co., London, 1983
4. Lees, F.P., "Loss Prevention in Process Industries" Butterworth publications, London, 2nd edition, 1990.
5. "Safety and Good House Keeping", N.P.C., New Delhi, 1985.
6. APPLE M. JAMES "Plant layout and material handling", 3rd edition, John Wiley and sons.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/110/105/110105094/

https://onlinecourses.nptel.ac.in/noc20_mg43/preview

MA606402-AUTOMATION SYSTEM DESIGN

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

COURSE OBJECTIVES:

- To learn about the basics and performance of measurement systems
- To learn in detail about different sensors
- To learn about development of embedded systems for real world applications
- To learn about typical peripherals of microcontrollers
- To introduce the concepts of robotic system and its components

UNIT I MEASUREMENTS AND MEASURING SYSTEMS **9**

Methods of measurement-Instruments- Classification of instruments- Functions of instruments and measurement systems-Elements of a generalized measurement system. Measurement system performance: Static characteristics- Dynamic characteristics. Errors in measurement and their statistical analysis.

UNIT 2: SENSORS / TRANSDUCERS **9**

Definition, Types, Basic principle and applications. Potentiometers - Inductance transducers -Capacitance transducers - Piezoelectric transducers - Hall effect transducers - rotary encoders – Accelerometers – Gyroscope. Photo Diode/ Photo Transistor as sensors, LVDT, Strain Gauge, Tactile, IR and Ultrasonic sensors. Vision and motion Sensors. Digital transducers: Principle and Construction.Temperature, Flow, velocity, pressure, displacement, position, force and torque measurement.

UNIT 3: EMBEDDED SYSTEMS **9**

Principles of good ventilation, purpose, physiological and comfort level types, local and exhaust ventilation, hood and duct design, air conditioning, ventilation standards, application. Purpose of lighting, types, advantages of good for various work, standardsillumination, glare and its effect, lighting requirements Housekeeping, principles of 5S.

UNIT 4: MICROCONTROLLERS **9**

Introduction to ARM based Microcontrollers – Architecture, Peripherals - Input/Output ports, Timers, ADC, DAC, PWM, Quadrature Encoder, UART, I2C, SPI, Advanced communication interfaces. Interfacing of sensors and actuators. Application development – Robotics & Automation

UNIT 5: ROBOTICS **9**

Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot programming. Application of Robots. DC Motors, Gearing and Efficiency, RC Servo Motors, Brushless DC Motor, Stepping motors, Motor Control.

TOTAL: 45 PERIODS

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

CO1: Identify the functional elements, concepts and performance of various measurement systems

CO2: Explain the working of different types of sensors

CO3: Identify various hardware and software architectures in embedded systems

CO4: Describe the detailed architecture, internal modules and addressing modes of ARM based processor

CO5: Outline the fundamentals of robotics and its components

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1										1	1	1
CO2	1	2	2	2	2							2	1	1
CO3	1	2	2	2	2							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. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019. 2. A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", DhanpatRai& Co. (P) Limited, 2015.
REFERENCE BOOKS:
1. Murthy, D.V.S., "Transducers and Instrumentation", 2nd Edition, Prentice Hall of India, 2011. 2. Nakra, B.C. and Chaudhry, K.K., "Instrumentation, Measurement and Analysis", 4th Edition, Tata McGraw Hill, 2016. 3. SaurabhChandrakarNileshBhaskarraoBahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019. 4. Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989. 5. L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002. 6. Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
WEB RESOURCES:
https://nptel.ac.in/courses/112102011
https://archive.nptel.ac.in/courses/112/103/112103293/

MA606403-MECHANICAL VIBRATIONS AND CONTROL					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Introduction to Vibrations Free vibration of single-degree-of-freedom systems
- Harmonically excited vibration

UNIT I INTRODUCTION **9**

Types of vibrations, Definitions, Simple Harmonic Motion (S.H.M.), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier theorem and problems.

UNIT 2: UNDAMPED FREE VIBRATIONS **9**

Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and Problems.

UNIT 3: DAMPED FREE VIBRATIONS **9**

Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and Problems.

UNIT 4: FORCED VIBRATIONS **9**

Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping and Problems.

UNIT 5: VIBRATION MEASURING INSTRUMENTS **9**

Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Whirling of shafts with and without damping, discussion of speeds above and below critical speeds and Problems.

TOTAL: 45 PERIODS

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

CO1: To provide the knowledge about types of vibrations and its various principles.

CO2: To educate the students about undamped free vibrations.

CO3: To provide knowledge on damped free vibrations

CO4: To understand about forced vibration analysis.

CO5: To study about principle and types of vibration measuring instruments.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. L. Meirovitch, Elements of Vibration Analysis, McGraw Hill, 2nd edition, 1986.
2. L. Meirovitch, Principles and Techniques of Vibrations, Prentice Hall International (PHIPE), 1997

REFERENCE BOOKS:

1. W. T. Thomson and M. D. Dahleh, Theory of Vibration with Applications, 5th edition, Pearson, 1997.
2. F. S. Tse, I. E. Morse and R. T. Hinkle, Mechanical Vibrations, 2nd edition, CBS Publications, 2004.
3. J. S. Rao and K. Gupta, Introductory course on Theory and Practice of Mechanical Vibrations, 2nd edition, New Age Publication, 1999.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/107/112107087/

https://archive.nptel.ac.in/courses/112/103/112103112/

MA606404-DESIGN OF JIGS AND FIXTURES					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Understand the basics of Jigs and fixtures.
- Know the Location and clamping.
- Comprehend the mounting of Jigs and Fixtures on machine tool.
- Understand the different types of Fixtures.

UNIT I BASICS OF JIGS AND FIXTURES **9**

Introduction – Jigs and Fixtures – Difference between Jigs and Fixtures – Advantages of jigs and Fixtures –Economy and cost - Elements of Jigs and Fixtures – Fool Proofing – Materials used in Jigs and Fixtures - Degrees of Freedom – 12 degrees of freedom – 6point location principle – (or) 3-2-1 principle of location – Essential features of Jigs and Fixtures – General Design Principles – Design steps – Common defects in Jigs design.

UNIT 2: PRINCIPLES OF LOCATION **9**

Principles of location – location point – types of locators – pins and studs – V block – cup and cone location points – adjustable locating points – special adjustable stops – location from finished holes in the work – Diamond pin locator – Cam operated 'V' locator – Quick action 'V' locator - Six-point location of a three-legged object – Location of a cylinder on a v-block.

UNIT 3: CLAMPING **9**

Principles of clamping – types of clamping – lever clamp – hinged clamp – two-way clamp – swinging clamp – wedge clamp – eccentric clamping arrangement – quick action clamp – Cam operated clamp – quarter turn screw – Toggle clamp – Pneumatic and hydraulic clamps – Washers - 'C' washer – spherical and flat washers.

UNIT 4: JIGS AND BUSHINGS AND DRILL JIGS **9**

Jig Bushing: Materials for jig bushing - press fit bushing – Fixed renewable bushing – slip renewable bushing – liner bushing – screw bushing – miscellaneous type of drill bushings – bushing specifications. Drill Jigs: Open drill jig plate drill jig – plate drill jig – template drill jig – channel drill jig – turn over drill jig – angle plate drill jig – closed box drill jig – leaf drill jig – post jig – indexing drill jig – universal drill jig - design of template and leaf jig.

UNIT 5: PRINCIPLE OF FIXTURE DESIGN **9**

Introduction - principles of fixture design – element of fixtures – design consideration of locators and clamps for fixtures – types of fixtures – design of turning fixtures – mandrels – type of mandrels – boring fixtures – milling fixtures – essentials of milling fixtures – method of locating milling fixtures with respect to cutter position – grinding fixtures – surface grinding and cylindrical grinding fixtures – broaching fixtures – internal and external broaching fixtures – welding fixtures

TOTAL: 45 PERIODS

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

CO1: To understand and identify the differences between jigs and fixtures and explain the possible degrees of freedom.

CO2: To educate the students about the identify the location of jigs and fixtures

CO3: To provide knowledge on clamping procedure of jigs and fixtures.

CO4: To understand the mountings of jigs and fixtures on the machine tool

CO5: To carry out a safety audit and prepare a report for the audit.

CO-PO MAPPING

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

1- low, 2 - medium, 3 - high, '-' no correlation
TEXT BOOKS:
1) Tool Design by Donaldson, Lecain, Goold 2) Introduction to Jig and Tool Design by MHA. Kempster(Viva Books Pvt. Ltd.-Delhi) 3) Jigs and Fixtures by Joshy(TMH)
REFERENCE BOOKS:
1) Tool Engineering & Design by GR. Nagpal(Khanna publishers) 2) Jig and fixture design- 5th edition by Hoffman 3) Jigs and Fixtures by Grant
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/105/112105127/
https://archive.nptel.ac.in/courses/112/105/112105126/

MA606405-OPERATIONS RESEARCH

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

COURSE OBJECTIVES:

- The course aims at building capabilities in the students for analysing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints.
- The objective of this course is to enable the student to understand and analyse managerial and engineering problems to equip him to use the resources such as capitals, materials, productions, controlling, directing, staffing, and machines more effectively.

UNIT I LINEAR MODELS **9**

The phase of an operation research study – Linear programming – Graphical method– Simplex algorithm – Duality formulation – Sensitivity analysis

UNIT 2: TRANSPORTATION MODELS AND NETWORK MODELS **9**

Transportation Assignment Models –Traveling Salesman Problem-Networks models – Shortest route– Minimal spanning tree – Maximum flow models –Project network – CPM and PERT networks – Critical path scheduling – Sequencing models.

UNIT 3: INVENTORY MODELS **9**

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

UNIT 4: QUEUEING MODELS **9**

Queueing models - Queueing systems and structures – Notation parameter – Single server and multi-server models – Poisson input – Exponential service – Constant rate service – Infinite population – Simulation.

UNIT 5: DECISION MODELS **9**

Decision models – Game theory – Two-person zero sum games – Graphical solution- Algebraic solution– Linear Programming solution – Replacement models – Models based on service life – Economic life– Single / Multi variable search technique – Dynamic Programming – Simple Problem.

TOTAL: 45 PERIODS

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

CO1: To understand and identify the concepts of linear programming and its analysis.

CO2: To determine the optimal strategy for transportation concepts

CO3: To provide knowledge on inventory models and its concepts involved

CO4: To understand the concepts of queueing models.

CO5: To understand the concepts of decision models.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Taha H.A., "Operations Research", Sixth Edition, Prentice Hall of India, 2003.

REFERENCE BOOKS:

1. Shennoy G.V. and Srivastava U.K., "Operation Research for Management", Wiley Eastern,1994.
2. Bazara M.J., Jarvis and Sherali H., "Linear Programming and Network Flows", John Wiley,1990.
3. Philip D.T. and Ravindran A., "Operations Research", John Wiley, 1992.

4. Hillier and Libeberman, “Operations Research”, Holden Day, 1986
5. Budnick F.S., “Principles of Operations Research for Management”, Richard D Irwin, 1990.
6. Tulsian and Pasdey V., “Quantitative Techniques”, Pearson Asia, 2002.

WEB RESOURCES:

1 https://nptel.ac.in/courses/110106062
https://archive.nptel.ac.in/courses/111/107/111107128/

MA606406-WELDING TECHNOLOGY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Understand the basics of Jigs and fixtures.
- Know the Location and clamping.
- Comprehend the mounting of Jigs and Fixtures on machine tool.
- Understand the different types of Fixtures.

UNIT I GAS AND ARC WELDING PROCESS **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 2: RESISTANCE WELDING PROCESS **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 3: SOLID STATE WELDING PROCESS **9**

Cold welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction welding, Forge welding, Roll welding and Hot pressure welding processes - advantages, limitations and applications.

UNIT 4: OTHER WELDING PROCESS **9**

Thermit welding, atomic hydrogen welding, Electron beam welding, Laser Beam welding, Friction stirs welding, Under Water welding, Welding automation in aerospace, nuclear and surface transport vehicles.

UNIT 5: DESIGN OF WELD JOINTS, WELDALIBILITY AND TESTING **9**

Various weld joint designs – Welding defects – causes and remedies - Weldability of Aluminium, Copper, and Stainless steels. Destructive and nondestructive testing of weldments.

TOTAL: 45 PERIODS

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

CO1: To understand about the concepts of Gas and Arc Welding Process.

CO2: To educate the students about the resistance welding process.

CO3: To provide knowledge on solid state welding process.

CO4: To understand about thermit welding and various other types of welding methods.

CO5: To educate about design of welding joints.

CO-PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2				1							2	1	1
CO2	2	2	1	2	2		1					2	1	1
CO3	2	2	2	1	2	1						2	1	1
CO4	2	2	2	2	2							2	1	1
CO5	2	2	2	2	2							2	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. Davis A.C., "The Science and Practice of Welding", Cambridge University Press, Cambridge, 1993

4. Nadkarni S.V. “Modern Arc Welding Technology”, Oxford IBH Publishers, 1st Edition, 2005.
5. Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979.
6. Tylecote R.F. “The Solid Phase Welding of Metals”. Edward Arnold Publishers Ltd. London.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/103/112103263/

https://nptel.ac.in/courses/112103263

MA606407-TURBOMACHINERY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To learn classification of turbomachines, To calculate energy transfer through a turbomachine
- To understand energy transfer and losses in centrifugal compressors, axial fans and steamturbines

UNIT I INTRODUCTION TO TURBO MACHINES **9**

Introduction to Turbomachines. Classification of Turbomachines. Second Law of Thermo dynamics - turbine/compressor work, Nozzle/diffuser work. Fluid equations - continuity, Euler's, Bernoulli's equation and its applications. Expansion and compression processes, Reheat Factor, Preheat Factor.

UNIT 2: FUNDAMENTAL CONCEPTS OF AXIAL AND RADIAL MACHINES **9**

Euler ‘s equation of energy transfer, vane congruent flow, influence of relative circulation, thickness of vanes, number of vanes on velocity triangles, slip factor, Stodola, Stanitz and Balje‘s slip factor, suction pressure and net positive suction head, phenomena of cavitation in pumps, concept of specific speed, shape number, axial, radial and mixed flow machines, similarity laws.

UNIT 3: CENTRIFUGAL COMPRESSOR **9**

Centrifugal compressor: Types, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery. Slip factor, Stanitz and Stodolas formula’s, Effect of inlet mach numbers, Pre whirl, Performance

UNIT 4: AXIAL FLOW COMPRESSORS **9**

Axial Flow Compressors: Flow Analysis, Work, and velocity triangles, Efficiencies, Thermodynamic analysis. Stage pressure rise, Degree of reaction, Stage Loading, General design, Effect of velocity, Incidence, Performance

UNIT 5: GAS DYNAMICS **9**

Fundamental thermodynamic concepts, isentropic conditions, Mach numbers, and area, Velocity relations, Dynamic Pressure, Normal shock relation for perfect gas. Supersonic flow, oblique shock waves. Normal shock recoveries, detached shocks, Aerofoil theory.

TOTAL: 45 PERIODS

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

CO1: Ability to design and calculate different parameters for turbo machines

CO2: To educate the fundamental concepts of Axial and Radial Machines

CO3: To provide knowledge on centrifugal compressors.

CO4: To understand about the concepts of axial flow compressors.

CO5: To study about basics of gas dynamics.

CO-PO 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	2	1	1				1	2	1	1
CO3	2	2	2	2	2	1	1				1	2	1	1
CO4	2	2	2	2	2	1	1				1	2	1	1
CO5	2	2	2	1	2	1	1				1	2	1	1

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

TEXT BOOKS:

1. Principles of Turbo Machines/DG Shepherd / Macmillan
2. Turbines, Pumps, Compressors/Yahya/ Mc Graw Hill

REFERENCE BOOKS:

1. A Treatise on Turbo machines / G. Gopal Krishnan and D. Prithviraj/ SciTech
2. Gas Turbine Theory/ Saravanamuttoo/ Pearson
3. STurbo Machines/ A Valan Arasu/ Vikas Publishing House Pvt. Ltd.

WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/104/112104305/ https://nptel.ac.in/courses/101101058

MA606408-DESIGN OF QUALITY, MANUFACTURING AND ASSEMBLY					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**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-PO 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	2	1	1				1	2	1	1
CO3	2	2	2	2	2	1	1				1	2	1	1
CO4	2	2	2	2	2	1	1				1	2	1	1
CO5	2	2	2	1	2	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/
https://onlinecourses.nptel.ac.in/noc19_me48/preview

MA606409-OIL HYDRAULICS AND PNEUMATICS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**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.

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-PO 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	2	1	1				1	2	1	1
CO3	2	2	2	2	2	1	1				1	2	1	1
CO4	2	2	2	2	2	1	1				1	2	1	1
CO5	2	2	2	1	2	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/ https://onlinecourses.nptel.ac.in/noc22_me36/preview

MA606410-ADVANCED OPEATIONS RESEARCH					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Tounderstand the basic concepts of operational research.
- To introduce fundamental issues in productional 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-PO 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	2			2			1				2	1	1
CO4	2		2	2				1				1	1	1
CO5	2		2		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.nptelvideos.com/course.php?id=768

VERTICAL 8: DIVERSIFIED COURSES

GROUP2

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

MA607116-NON-DESTRUCTIVE TESTING					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Principles of various NDT techniques.
- The equipment required for the NDT.
- The procedure followed in NDT techniques.
- Applications of NDT and recent trends in NDT

UNIT I VISUAL INSPECTION AND EDDY CURRENT TESTING **9**

Scope and advantages of NDT, Comparison of NDT with DT, classifications of NDT VisualInspectionEquipment used for visual inspection -Magnifying Glass Magnifying Mirror,Microscope Borescope , endoscopes or endoprobes Flexible Fiber Optic Borescope , Videolmagescope .Eddy Current Testing- Principle, Advantages, Disadvantages Factors AffectingEddy Current Response-Material Conductivity Permeability - Frequency- Geometry-Proximity(Lift off)-Typical Applications, limitations ,Types of Probes.

UNIT 2: LIQUID PENETRANT TESTING **9**

Liquid penetration testing- Introduction, Principle, Equipment, Procedures, Characteristicsofpenetrants-developers - Evaluation - hazards Precautions,advantages,limitations andapplications.

UNIT 3: MAGNETIC PARTICLE TESTING **9**

Principle of Magnetic Particle Testing-different methods to generate magnetic fields -MagneticParticle Testing Equipment- Magnetic Particle Testing Procedures Method of De-MagnetizationMagneticParticle Medium-Evaluation of Indications and Acceptance Standards- magneticparticle test- applications, advantages and limitations.

UNIT 4: RADIOGRAPHIC TESTING **9**

X-ray radiography principle, equipment & methodology - Type of Industrial Radiation sourcesand Application-Radiographic exposure Factors and Technique- GAMA Ray and X-RayEquipment-Radiographic Procedure - Radiograph Interpretation, Radiography Image Quality indicators-Radiographic Techniques- Film Processing-Methods of Viewing RadiographsRadiographicTesting Procedures for welds. Precautions against radiation hazards.

UNIT 5: ULTRASONIC TESTING **9**

Introduction, Principle of operation Type of Ultrasonic Propagation- Ultrasonic probes. Types ofTransducers -Ultrasonic Testing Techniques. Method for Evaluating Discontinuities-UltrasonicTesting Procedures for different component -applications, advantages and limitations,Documentation, Applications in inspection of castings, forgings, Extruded steel parts, bars,pipes, rails and dimensions measurements.

TOTAL: 45 PERIODS

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

CO1: To understand the basic principles of Non-Destructive testing and its types.

CO2: To study the concepts of liquid penetrant testing and its applications.

CO3: Understand the principles, processes and applications of Magnetic particle testing.

CO4: Identify the principles, processes and applications of Radiographic Testing

CO5: Understand the principles, processes and applications of Ultrasonic testing.

CO-PO 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	2			2			1				2	1	1
CO4	2		2	2				1				1	1	1
CO5	2		2		2			1				1	1	1

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

TEXT BOOKS:
1. J Prasad, CG K Nair, "Non-Destructive Testing and Evaluation of Materials", Tata McGrawHill Education Private Limited
REFERENCE BOOKS:
1. American Metals Society, "Non-Destructive Examination and Quality Control", Metals HandBook, Vol.17, 9th Ed, Metals Park, OH, 1989. 2. Bray, Don.E and Stanley, Roderic.K, "Nondestructive Evaluation: A Tool in Design,Manufacturing, and Service. Revised", CRC Press New York, Edition 1997.
WEB RESOURCES:
https://archive.nptel.ac.in/courses/113/106/113106070/
https://nptel.ac.in/courses/113106070

MA607117-UNCONVENTIONAL MACHINING PROCESS

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

COURSE OBJECTIVES:

- Understand the need and importance of non-traditional machining methods and process selection.
- Gain the knowledge to remove material by thermal evaporation, mechanical energy process.
- Apply the knowledge to remove material by chemical and electro chemical methods.
- Analyze various material removal applications by unconventional machining process.

UNIT I INTRODUCTION TO MODERN MACHINING PROCESS **9**

Introduction – Need for non-traditional machining methods-Classification of modern machining processes – considerations in process selection. Materials. Applications. Ultrasonic machining – Elements of the process, mechanics of metal removal process, parameters, economic considerations, applications and limitations, recent development.

UNIT 2: MECHANICAL MACHINING AND ELECTRO CHEMICAL PROCESS **9**

Abrasive Jet Machining, Water Jet Machining and Abrasive Water Jet Machining: Basic principles, equipment, process variable, and mechanics of metal removal, MRR, application andlimitations.Electro – Chemical Processes: Fundamentals of electro chemical machining, electrochemical grinding, electro chemical honing and deburring processes, metal removal rate in ECM, Tool design, Surface finish and accuracy, economic aspects of ECM – Simple problems for estimation of metal removal rate.

UNIT 3: THERMAL METAL REMOVAL PROCESS **9**

Thermal Metal Removal Processes: General Principle and applications of Electric Discharge Machining, Electric Discharge Grinding and electric discharge wire cutting processes – Power circuits for EDM, Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, methods surface finish and machining accuracy, characteristics of spark eroded surface and machine tool selection. Wire EDM, principle, applications.

UNIT 4: BEAM MACHINING PROCESS **9**

Generation and control of electron beam for machining, theory of electron beam machining, comparison of thermal and non-thermal processes –General Principle and application of laser beam machining – thermal features, cutting speed and accuracy of cut.

UNIT 5: PLASMA MACHINING AND CHEMICAL MACHINING **9**

Application of plasma for machining, metal removing mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries. Chemical machining – principle – maskants – applications.

TOTAL: 45 PERIODS

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

CO1: To teach the need for material removal process and its classification.

CO2: To summaries the principle and process of mechanical machining process.

CO3: Understand the principles, processes and applications of thermal metal removal processes.

CO4: Identify the principles, processes and applications of EBM.

CO5: Understand the principles, processes and applications of Plasma Machining.

CO-PO 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	2			2			1				2	1	1
CO4	2		2	2				1				1	1	1
CO5	2		2		2			1				1	1	1

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

TEXT BOOKS:
1. Advanced Machining Processes / VK Jain / Allied publishers 2. Modern Machining Processes – P. C. Pandey, H. S. Shan/ Mc Graw Hill
REFERENCE BOOKS:
1.Unconventional Manufacturing Processes/ Singh M.K/ New Age Publishers 2.Advanced Methods of Machining/ J.A. McGeough/ Springer International 3.Non-Traditional Manufacturing Processes/ Benedict G.F./ CRC Press
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/105/112105212/
https://nptel.ac.in/courses/112103202

INSTITUTEELECTIVE II

MA607216 –ENGINEERING ECONOMICS					
Course Category: Institute Elective II	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn about the basics of economics and cost analysis related to engineering so as to take economically sound ecisions.
- To applythe economic principles to prices and quantities in competitive supply and demand for goods and for money.
- To know the proceduresofValue Engineering and Cash flow techniques.
- To understand the behavior of humans at organizations with modern management concepts.

UNIT 1: INTRODUCTIONTOECONOMICS **9**

Introduction to Economics- Flow in an economy, Law of supply and demand, Concept of EngineeringEconomics–Engineeringefficiency,Economicefficiency,Scopeof engineering economics-Element of costs, Marginal cost,Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis- V ratio, Elementary economic Analysis –Materialselection for product Design selection fora product, Process planning.

UNIT 2: VALUEENGINEERING **9**

Makeorbuydecision,Valueengineering–Function,aims,Value engineering procedure. Interestformulaeandtheirapplications–Timevalueofmoney,Single payment compound amount factor, Single payment presentworth factor, Equal payment seriessinkingfundfactor,EqualpaymentseriespaymentPresentworthfactor-equal payment series capital recovery factor-Uniform gradient series annual equivalent factor, Effective interest rate,Examplesinallthe methods.

UNIT 3: ECONOMICS ENGINEERING **9**

Methodsofcomparisonofalternatives–presentworthmethod(Revenuedominated cash flow diagram), Futureworth method (Revenue dominated cash flow diagram, cost dominatedcashflowdiagram),Annualequivalentmethod(Revenuedominatedcash flow diagram, cost dominated cash flow diagram), rate of return method,Examplesinallthe methods.

UNIT 4: REPLACEMENTANDMAINTENANCEANALYSIS **9**

Replacement and Maintenance analysis – Types of maintenance, types of replacement problem, determination ofeconomic life of an asset, Replacement of an asset with a new asset– capitalrecoverywithreturnandconceptofchallengeranddefender,Simple probabilistic modelforitems whichfailcompletely.

UNIT 5: DEPRECIATION **9**

Depreciation-Introduction, Straight line method of depreciation, declining balance methodofdepreciation –Sumof the years digits method of depreciation, sinking fundmethodofdepreciation/Annuitymethodofdepreciation,serviceoutputmethodofdepreciation – Evaluationofpublicalternatives- introduction,Examples,Inflation adjusted decisions– proceduretoadjustinflation,Examplesoncomparisonofalternativesanddeterminationof economic life of asset.

TOTAL: 45 PERIODS

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

CO1: Learn the sound knowledge of economics and various types of costs.

CO2: Develop and analyze the contemporary issues and modern practices of costing and market analysis.

CO3: Solve economic problems involving comparison and selection of alternatives by using analytical techniques includingvarious types of cash flow techniques and thus acquire the capability to applying them.

CO4: Enrich their knowledge to know about the replacement policies and maintenance procedures.

CO5: Describe and determine the effect of depreciation and economic case studies and its impact onbudgeting of projects and their outcomes.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. R.Paneerselvam,"EngineeringEconomics",PHI Edition,New delhi, 2013.
2. Suma Damodaran, "Managerial economics", Oxford University Press, 2006.
3. YogeshMaheshwari,"ManagerialEconomics",PHIThirdedition,2012.

REFERENCE BOOKS:

1.A.RamachandraAryasri and V.V.RamanaMurthy,EngineeringEconomicsandFinancialAccounting",McGrawHillEducation (India),NewDelhi,2004.

2. Chan S.Park, "Contemporary Engineering Economics", Prentice Hall of India, 2002.

3.Donald.G. Newman, Jerome.P.Lavelle, "Engineering Economics and analysis" EngineeringPress, Texas, 2002.

WEB RESOURCES:

https://archive.nptel.ac.in/courses/112/107/112107209/

https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-me35/

MA607217-PROCESS PLANNING AND COST ESTIMATION

Course Category: InstituteElective II	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts of Process Planning and estimation and apply different methods of cost estimation in different manufacturing shops and learn the knowledge of process planning and cost estimation in competitive manufacturing systems and organizations.

UNIT 1: INTRODUCTIONTOPROCESS PLANNING — **9**

Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps inprocessselection- Production equipmentandtoolingselection.

UNIT 2: PROCESS PLANNINGACTIVITIES — **9**

Processparameterscalculationforvariousproductionprocesses –Selectionjigsandfixtureselection ofqualityassurancemethods –Setof documentsforprocessplanning-Economicsofprocessplanning-casestudies

UNIT 3: INTRODUCTIONTOCOSTESTIMATION — **9**

Importance of costing and estimation –methods of costing-elements of cost estimation –Types ofestimates–Estimatingprocedure – Estimationlabourcost,materialcost-allocationofoverheadcharges-Calculation ofdepreciation cost

UNIT 4: PRODUCTION COSTESTIMATION — **9**

Estimation of different Types of Jobs - Estimation of Forging Shop, Estimation of Welding Shop,EstimationofFoundryShop

UNIT 5: MACHININGTIME CALCULATION — **9**

Estimation of Machining Time - Importance of Machine Time Calculation- Calculation of MachiningTime for Different Lathe Operations,Drilling and Boring - Machining Time Calculation for Milling,ShapingandPlanning-Machining TimeCalculationforGrinding.

TOTAL: 45 PERIODS

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

CO1: Selecttheprocess,equipmentandtoolsforvariousindustrialproducts.

CO2: Prepareprocess planningactivitychart.

CO3: Discuss the various elements involved in costing and explaintheconceptof costestimation.

CO4: Computethejob ordercostfordifferenttypeofshopfloor.

CO5: Calculatethemachiningtimeforvariousmachiningoperations.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Peter scalon,"Process planning, Design/Manufacture Interface", ElsevierscienceTechnologyBooks,December,2002.

2. SinhaB.P,"MechanicalEstimatingandCosting",Tata-McGrawHillpublishingcompany,1995.

3. Mikell P. Groover, "Automation, Production, Systems and Computer Integrated Manufacturing",PearsonEducation 2001.

REFERENCE BOOKS:

1.ChitaleA.V.andGuptaR.C.,"ProductDesignandManufacturing", 2nd Edition, PHI,2002.

2.OstwalalP.F.andMunezJ.,"ManufacturingProcessesandsystems",9th Edition,John Wiley Edition,1998.

3.RussellR.SandTailorB.W,"OperationsManagement",4thEdition,PHIEdition,2003.
WEB RESOURCES:
https://nptel.ac.in/courses/112107143
https://nptel.ac.in/courses/105103206

MA607215 - SENSORS AND INSTRUMENTATION					
Course Category: Institute Elective II	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Torealizetheconceptsofmeasurementtechnology.
- Tolearnthevarioussensorsusedtomeasurevariousphysicalparameters.
- Tolearnthefundamentalsofsignalconditioning,dataacquisitionandcommunicationsystemsusedin Mechatronics systemdevelopment.
- To learn about the optical, pressure and temperature sensor.
- To understand the signal conditioning and DAQ systems

UNIT 1: INTRODUCTION **9**

BasicsofMeasurement–Classificationoferrors–Erroranalysis–Staticanddynamiccharacteristics of transducers – Performance measures of sensors – Classification of sensors –Sensor calibration techniques – SensorOutputSignalTypes.

UNIT 2: MOTION,PROXIMITYANDRANGINGSENSORS **9**

MotionSensors–Potentiometers,Resolver,Encoders–Optical,Magnetic,Inductive,Capacitive,LVDT–RVDT–Synchro–Microsyn,Accelerometer–GPS,Bluetooth,RangeSensors–RF beacons,UltrasonicRanging,Reflectivebeacons,LaserRangeSensor(LIDAR).

UNIT 3: FORCE,MAGNETICANDHEADINGSENSORS **9**

StrainGage, LoadCell, MagneticSensorstypes,principle,requirementandadvantages:Magnetoresistive–HallEffect–CurrentsensorHeadingSensors– Compass,Gyroscope,Inclinometers.

UNIT 4: OPTICAL,PRESSUREANDTEMPERATURESENSORS **9**

Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm,Bellows,Piezoelectric–Tactilesensors,Temperature–IC,Thermistor,RTD,Thermocouple.Acoustic Sensors– flow andlevelmeasurement,RadiationSensors-SmartSensors-Filmsensor,MEMS& Nano Sensors,LASERsensors.

UNIT 5: SIGNALCONDITIONINGANDDAQSYSTEMS **9**

Amplification–Filtering–SampleandHoldcircuits–DataAcquisition:Singlechannelandmultichanneldataacquisition–Data logging – applications-Automobile, Aerospace, Home appliances, Manufacturing,Environmentalmonitoring.

TOTAL: 45 PERIODS

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

CO1: Recognize with various calibration techniques and signal types for sensors.

CO2:Describe the working principle and characteristics of force, magnetic, heading sensors and transducers.

CO3: Apply the various sensors and transducers in various applications.

CO4: Enrich their knowledge with basicprinciplesofvariouspressureandtemperature, smartsensors.

CO5: Abilityto implementtheDAQsystemswithdifferentsensorsforrealtimeapplications.

CO-PO 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	2
CO2	3	2	3	3	3	-	2	2	-	-	-	2	2	2
CO3	3	2	3	3	3	-	2	2	-	-	-	2	2	2
CO4	3	2	3	3	3	-	2	2	-	-	-	2	2	2
CO5	3	2	3	3	3	-	2	2	-	-	-	2	2	2

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

TEXT BOOKS:

1. ErnestODoebelin,"MeasurementSystems –ApplicationsandDesign",TataMcGraw-Hill,2009.

2. SawneyAKandPuneetSawney,"ACourseinMechanicalMeasurementsandInstrumentationandControl",12th edition,DhanpatRai& Co,NewDelhi,2013.

3. PatranabisD,"SensorsandTransducers",2nd Edition, PHI, NewDelhi, 2011.

REFERENCE BOOKS:

1.C.Sujatha, DyerS.A.,SurveyofInstrumentationandMeasurement,JohnWiley&Sons, Canada, 2001
2.HansKurtTonshoff,Ichiro, "SensorsinManufacturing"Volume1,Wiley-VCH,April, 2001.
3.JohnTurnerandMartynHill,"InstrumentationforEngineersandScientists",OxfordScience Publications,1999.
WEB RESOURCES:
https://archive.nptel.ac.in/courses/108/108/108108147/
https://onlinecourses.nptel.ac.in/noc23_ee105/preview

INSTITUTE ELECTIVE III

MA607316 INTELLECTUAL PROPERTY RIGHTS					
Course Category: Institute Elective III	**Course Type: Theory with project**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries
- To aware about current trends in IPR and Govt. steps in fostering IPR.

UNIT 1: OVERVIEW OF INTELLECTUAL PROPERTY **9**

Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties and Layout Design – Genetic Resources and Traditional Knowledge – Trade Secret - IPR in India : Genesis and development – IPR in abroad - Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Convention, 1967,the Patent Co-operation Treaty, 1970, the TRIPS Agreement, 1994

UNIT 2: PATENTS **9**

Patents - Elements of Patentability: Novelty , Non Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and licence , Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties - Patent office and Appellate Board

UNIT 3: COPYRIGHTS **9**

Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings - Registration Procedure, Term of protection, Ownership of copyright, Assignment and licence of copyright - Infringement, Remedies & Penalties – Related Rights - Distinction between related rights and copyrights

UNIT 4: TRADEMARKS **9**

Concept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) - Non Registrable Trademarks - Registration of Trademarks - Rights of holder and assignment and licensing of marks - Infringement, Remedies & Penalties - Trademarks registry and appellate board

UNIT 5: OTHER FORMS OF IP **9**

Design Design: meaning and concept of novel and original - Procedure for registration, effect of registration and term of protection Geographical Indication (GI) Geographical indication: meaning, and difference between GI and trademarks - Procedure for registration, effect of registration and term of protection

TOTAL: 45 PERIODS

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

CO1: Distinguish and explain various forms of IPRs.

CO2: Identify criteria's to fit one's own intellectual work in particular form of IPRs.

CO3: Analyse rights and responsibilities of holder of Patent, Copyright, Trademark, Industrial design etc

CO4: Apply statutory provisions to protect particular form of IPRs.

CO5: Identify procedure to protect different forms of IPRs national and international level.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	POX8	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. Intellectual Property Rights and the Law, Gogia Law Agency, by Dr. G.B. Reddy
2. Law relating to Intellectual Property, Universal Law Publishing Co, by Dr. B.L.Wadehra
3. IPR by P. Narayanan
REFERENCE BOOKS:
1.Dr.G.B Reddy, "Intellectual Property Rights and Law", Gogia LawAgency. 2.
2.N.R. Subbaram.S. Viswanathan, "Hand book Indian Patent Law and, Practice" Printers and publishers Pvt, Ltd, 2008.
WEB RESOURCES:
https://onlinecourses.nptel.ac.in/noc22_hs59/preview https://archive.nptel.ac.in/courses/110/105/110105139/

MA607315 ROBOT MOTION PLANNING					
Course Category: Institute Elective III	**Course Type: Theory with project**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- This course is an introduction to the principles used to design planning for robots motion.
- The objective of motion planning algorithms is to enable an autonomous mobile robot to determine its movements in a cluttered environment to achieve various goals while avoiding collisions. .

UNIT 1: INTRODUCTION TO ROBOT MOTION PLANNING **9**

Introduction to robot motion control - Definition, Robot Anatomy, Three laws, Classification of robots, Robot terminologies: work volume, Degree of Freedom, resolution, accuracy, Basics of Serial robotic arms and Mobile robots, Transformations, Sampling-Based Motion Planning, Motion planning for Multi robotic systems, motion planning in 3D

UNIT 2: ROBOT PLANNING **9**

Planning: Sensor based planning, Robot sensors and Machine Vision Need for sensors, types of sensors used in Robotics, classification and applications of sensors - Problem setup and modelling assumption, Bug 0, Bug 1, Bug 2 algorithm- motion planning via decomposition search- Configuration space - Free configuration space via sampling - collision detection- Motion planning, roadmap, Human vision Vs Robot Vision, Gradient calculations.

UNIT 3: MOTION CONTROL **9**

Motion Control Path versus Trajectory, Joint space versus Cartesian space descriptions, Point to Point Control, trajectory generation, Continuous Path Control, Force Control, hybrid position/force control system

UNIT 4: PROGRAMMING AND LANGUAGES FOR ROBOTICS PROGRAMMING **9**

Programming and Languages for Robotics 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., Development of languages since WAVE till ROS

UNIT 5: AI AND MACHINE LEARNING IN ROBOTICS **9**

Fundamentals of AI and Machine Learning in Robotics, Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and applications of AI, Use of Machine learning in Robotics.

TOTAL: 45 PERIODS

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

CO1: Understand terminologies related to robotics plan and motion

CO2: Apply mathematics for manipulator positioning and motion planning.

CO3: Plan trajectory of robot to reach the destination with controlled environment

CO4: Acquainted with methods of programing and various languages used in robotics

CO5: Awareness of AI and Machine learning in robotics

CO-PO 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. F. Bullo and S. L. Smith. Lecture notes on robotic planning and kinematics.
2. S. Thrun, W. Burgard, and D. Fox. Probabilistic Robotics. Intelligent Robotics and Autonomous Agents. The MIT Press, 2005.
3. H. Choset, K. Lynch, S. Hutchinson, G. Kantor, et al. Principles of Robot Motion, Theory, Algorithms, and Implementations. The MIT Press, 2005.
REFERENCE BOOKS:
1.S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. AsitavaGhoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
WEB RESOURCES:
https://archive.nptel.ac.in/courses/112/104/112104308/
https://onlinecourses.nptel.ac.in/noc22_me41/preview

INSTITUTEELECTIVE IV

MA607414-DISASTER MANAGEMENT						
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	

COURSE OBJECTIVES:

- To provide basic conceptual understanding of disasters.
- To understand approaches of Disaster Management.
- To build skills to respond to disaster.
- To impart knowledge of causes of various disaster and its impact.
- To understand the concept of Disaster Management Cycle and Framework

UNIT 1: DEFINITION AND TYPES OF DISASTER — **9**

Hazards and Disasters, Risk and Vulnerability in Disasters, Natural and Man-made disasters, earthquakes, floods drought, landside, land subsidence, cyclones, volcanoes, tsunami, avalanches, Global climate extremes. Man-made disasters: Terrorism, gas and radiations leaks, toxic waste Disposal, oil spills, forest fires.

UNIT 2: STUDY OF IMPORTANT DISASTERS — **9**

Earthquakes and its types, magnitude and intensity, seismic zones of India, major fault systems of India plate, flood types and its management, drought types and its management, landside and its Managements case studies of disasters in Sikkim (e.g) Earthquakes, Landside). Social Economics and Environmental impact of disasters.

UNIT 3: MITIGATION AND MANAGEMENT TECHNIQUES OF DISASTER — **9**

Basic principles of disasters management, Disaster Management cycle, Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems, Building design and Construction in highly seismic zones, retrofitting of buildings.

UNIT 4: TRAINING, AWARENESS PROGRAM AND PROJECT ON DISASTER MANAGEMENT — **9**

Training and drills for disaster preparedness, Awareness generation program, Usages of GIS and Remote sensing techniques in disaster management, Mini project on disaster risk assessment and Preparedness for disasters with reference to disasters in Sikkim and its surrounding areas.

UNIT 5: APPLICATIONS OF SCIENCE AND TECHNOLOGY FOR DISASTER MANAGEMENT & MITIGATION — **9**

Geo-informatics in Disaster Management, Disaster Communication System, Land Use Planning and Development Regulations, Structural and Non Structural Mitigation of Disasters, S&T Institutions for Disaster Management in India

TOTAL: 45 PERIODS

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

CO1: To understand the concepts of disaster management systems and it's various types of mode.

CO2: To acquire the knowledge onimportant disasters and its impact to the environment.

CO3: To Understand disasters, disaster preparedness and apply the mitigation measures.

CO4: To Understand role the of IT, remote sensing, GIS and GPS in risk reduction.

CO5: To explain the Applications of Science and Technology for Disaster Management & Mitigation.

CO-PO MAPPING

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

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

TEXT BOOKS:

1.Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)

2.Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth

Heineman.
3.Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.
REFERENCE BOOKS:
1. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication PVT. Ltd. New Delhi.
2.Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India LTD.
WEB RESOURCES:
https://nptel.ac.in/courses/124107010
https://onlinecourses.swayam2.ac.in/cec19_hs20/preview

MA607415- HUMAN RESOURCE MANAGEMENT					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand and appreciate the importance of the human resources vis-a-vis other resources of the organisation
- To familiarize the students with methods and techniques of HRM
- To equip them with the application of the HRM tools in real world business situations.
- To teach the basic principles of strategic human resource management—how an organization acquires, rewards, motivates, uses, and generally manages its people effectively.

UNIT 1: INTRODUCTION TO HRM **9**

Evolution of HRM, Objectives, Functions and Policies. Human resource planning: Uses and benefits, Man Power Inventory, Man Power Forecasting, Methods of Man Power Forecasting, job Description, Job Specification.

UNIT 2: RECRUITMENT & SELECTIONPROTOCOLS **9**

RECRUITMENT: Sources of Man power, Advertisement, Short Listing of Candidates calling Candidates for selection Process. SELECTION: Selection procedure – Written Test, Group Discussion. Interview – Different methods, advantages and limitations, Psychological testing – Advantages and limitations, Induction procedure, transfers, promotion, exit interview, (Tutorial on written test, Group Discussion, Interviews.

UNIT 3: COUNSELLING AND HUMAN RESOURCE ACCOUNTING **9**

Characteristics, Need, Function, Types, Suggestions for personnel development, communication function, communication process, effective communication. Human resource records, Advantages of HR accounting, Various methods of accounting.

UNIT 4: INDUSTRIAL RELATIONS & INDUSTRIAL DISPUTES AND SETTLEMENT **9**

INDUSTRIAL RELATIONS: Indian trade union act, standing orders act, Indian factories act. INDUSTRIAL DISPUTES AND SETTLEMENT: Indian Industrial Disputes act, Industrial disputes settlement machinery. Works committee, Board of Conciliation, Voluntary Arbitration, Compulsory arbitration, Court of inquiry, Industrial tribunal, Adjudication.

UNIT 5: PRINCIPAL COMPENSATION & MANAGEMENT **9**

Financial Compensation- -Productivity and Morale - Job Evaluation - Productivity, Employee Morale and Motivation - Stress Management - Quality of Work Life.Facilitating Legislative Framework - Trade Unions - Managing Conflicts - Disciplinary Process - Collective Bargaining - Workers Participation in Management - Concept, Mechanisms and Experiences.

TOTAL: 45 PERIODS

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

CO1: Define and identify the basic concepts, functions and processes of human resourceManagement.

CO2: Describe the role, functions and functioning of human resource department of theorganizations.

CO3: Design and formulate various HRM processes such as Recruitment, Selection, Training, Development, Performance appraisals and Reward Systems, Compensation Plans and Ethical Behaviour.

CO4: Develop ways in which human resources management might diagnose a businessstrategy and then facilitate the internal change necessary to accomplish the strategy.

CO5: To Demonstrate principal compensation issues & management's various phases of Organization.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. Human Resources Management – Dr. K Ashwathappa – Tata mcgraw Hill – Edition 1999.
2. Management of Human Resources – CB Mamoria – Himalaya Publication House – 2003
3. Venkata Ratnam C. S. &Srivatsava B. K.,PERSONNEL MANAGEMENT AND HUMAN RESOURCES, Tata Mc-Graw Hill, newdelhi,,
4.Aswathappa, HUMAN RESOURCE MANGEMENT, Tata mcgraw Hill, newdelhi, 2010.
Reference books:
1.Garry dessler&varkkey, human resource management, pearson, new delhi, 2009
2.Pravin durai, human resource mangement, pearson, new delhi,2010
3.Alan Price, HUMAN RESOURCE MANAGEMENT, Cengage Learning, newdelhi, 2007
Web resources:
https://archive.nptel.ac.in/courses/110/105/110105069/
https://onlinecourses.nptel.ac.in/noc21_mg21/preview

MA607416- HAZARDOUS WASTE MANAGEMENT					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Understanding of problems of municipal waste, biomedical waste, hazardous waste, e-waste, industrial waste etc.
- Knowledge of legal, institutional and financial aspects of management of solid wastes.
- Become aware of Environment and health impacts solid waste mismanagement.
- Understand engineering, financial and technical options for waste management.

UNIT 1: SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK **9**

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes , plastics and fly ash – Financing waste management.

UNIT 2: WASTE CHARACTERIZATION AND SOURCE REDUCTION **9**

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse Practical: Composition of MSW, Determination of Physical and Chemical Properties of MSW

UNIT 3: STORAGE, COLLECTION AND TRANSPORT OF WASTES **9**

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport.

UNIT 4: WASTE PROCESSING TECHNOLOGIES **9**

Objectives of waste processing – material separation and processing technologies – biological &chemical conversion technologies – methods and controls of Composting - thermal conversion technologies, energy recovery – incineration – solidification & stabilization of hazardous wastes-treatment of biomedical wastes.

UNIT 5: WASTE DISPOSAL **9**

Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leach ate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation.

TOTAL: 45 PERIODS

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

CO1: To understand the basic definition of solid wastes–municipalwaste, biomedical waste, hazardous waste, e-waste.

CO2: To Describe the role and functioning of health and environmental issues related to solid waste management and source reduction.

CO3: To analyze integrated waste management; and waste minimization and concepts of industrial symbiosisand industrial ecology.

CO4: To Develop the waste processing cycles and to characterization of solid waste; analysis of hazardous waste.

CO5: To createsteps in solid waste management-waste reduction at source, collectiontechniques, materials and resource recovery/recycling, transport, optimization of solid waste.

CO-PO MAPPING

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

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

TEXT BOOKS:

1. George Techobanoglous et al, ‖Integrated Solid Waste Management‖, McGraw - Hill, 2014.

2. Manual on Municipal Solid waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi, 2000.

3. Techobanoglous Thiesen Ellasen; Solid Waste Engineering Principles and Management, McGraw - Hill 1997.

4.B. B. Sundaresan, A. D. Bhide – Solid Waste Management, Collection, Processing and Disposal, Mudrashilpa Offset Printers, 2001.

REFERENCE BOOKS:

1.R.E.Landrefh and P.A.Rebers,‖ Municipal Solid Wastes-Problems & Solutions‖ ,Lewis, 1997.

2. Blide A.D.& Sundaresan, B.B,‖Solid Waste Management in Developing Countries‖, INSDOC, 1993.

3.Georges E. Ekosse, Rogers W'O Okut-Uma, Pollution control & Waste management in Developing Countries, Commonwealth Publishers, New Delhi, 2000.

WEB RESOURCES:

1. https://archive.nptel.ac.in/courses/105/106/105106056/

https://archive.nptel.ac.in/content/storage2/courses/105106056/Introduction.pdf