GOVERNMENT COLLEGE OF ENGINEERING, SALEM-11

Regulations 2018A
B.E. MECHANICAL ENGINEERING

Course Code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact Periods	Lecture	Tutorial/ Demo	Practical	Credits	CA	FE	Total
SEMESTER – I										
THEORY										
18MA101	Matrices and Calculus	BS	60	3	1	0	4	40	60	100
18PH102	Physics – Electromagnetism	BS	60	3	1	0	4	40	60	100
18EE103	Basics of Electrical Engineering	ES	60	3	1	0	4	40	60	100
18ME101	Engineering Graphics & Design	ES	60	1	0	4	3	40	60	100
PRACTICAL										
18PH103	Physics Laboratory	BS	45	0	0	3	1.5	60	40	100
18CY102	Chemistry laboratory	BS	45	0	0	3	1.5	60	40	100
18EE104	Basics of Electrical Engineering Laboratory	ES	30	0	0	2	1	60	40	100
18EN103	Professional Communication Laboratory	HS	30	0	0	2	1	60	40	100
18MC101	Induction Program -21 Days	MC					0			
Total				10	3	14	**20**	320	480	800
SEMESTER –II										
THEORY										
18EN101	Professional English	HS	30	2	0	0	2	40	60	100
18MA201	Differential Equations And Complex Variables	BS	60	3	1	0	4	40	60	100
18CY101	Chemistry	BS	60	3	1	0	4	40	60	100
18CS101	Fundamentals Of Problem Solving And C Programming	ES	45	3	0	0	3	40	60	100
PRACTICAL										
18EN102	Professional English Laboratory	HS	30	0	0	2	1	60	40	100
18CS102	Computer Practice Laboratory	ES	60	0	0	4	2	60	40	100
18ME102	Workshop Manufacturing Practices	ES	60	1	0	4	3	60	40	100
Total				12	2	10	**19**	280	420	700

Course Code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact Periods	Lecture	Tutorial/ Demo	Practical	Credits	CA	FE	Total
SEMESTER – III										
THEORY										
18PH202	Physics – Waves & Optics And Quantum Mechanics	BS	60	3	1	0	4	40	60	100
18MA204	Fourier Series and Transforms	BS	60	3	1	0	4	40	60	100
18ME301	Manufacturing Processes	PC	45	2	1	0	3	40	60	100
18ME302	Engineering Mechanics	PC	45	3	0	0	3	40	60	100
18ME303	Thermodynamics	PC	60	3	1	0	4	40	60	100
18EC308	Basic Electronics Engineering	ES	45	3	0	0	**3**	40	60	100
PRACTICAL										
18ME304	Manufacturing Technology Laboratory	PC	45	0	0	3	2	60	40	100
18EC309	Electronics Laboratory	ES	30	0	0	2	1	60	40	100
Total				17	4	5	**24**	320	480	800
SEMESTER –IV										
THEORY										
18ME401	Kinematics of Machinery	PC	60	3	1	0	4	40	60	100
18ME402	Applied Thermodynamics	PC	45	3	0	0	3	40	60	100
18ME403	Fluid Mechanics and Machinery	PC	60	3	1	0	4	40	60	100
18ME404	Strength of Materials	PC	45	3	0	0	3	40	60	100
18ME405	Materials Engineering	PC	45	3	0	0	3	40	60	100
18CYMC01	Environmental Science	MC	14	0	0	1	0	-	-	-
PRACTICAL										
18ME406	Strength of Materials and Fluid Mechanics Laboratory	PC	45	0	0	3	1.5	60	40	100
18ME407	Thermal Engineering Laboratory	PC	45	0	0	3	1.5	60	40	100
Total				15	2	7	**20**	280	420	700

Course Code	Name of the Course	Category	Contact Periods	Hours/Week Lecture	Tutorial/ Demo	Practical	Credits	Maximum Marks CA	FE	Total
SEMESTER – V										
THEORY										
18ME501	Heat and Mass Transfer	PC	60	3	1	0	4	40	60	100
18ME502	Instrumentation & Control	PC	45	3	0	0	3	40	60	100
18ME503	Metrology and Quality Control	PC	45	3	0	0	3	40	60	100
18ME504	Dynamics of Machinery	PC	45	3	0	0	3	40	60	100
18MEOE1X	Open Elective-I	OE	45	3	0	0	3	40	60	100
18MC301	Indian Constitution	MC	15	3	0	0	0	-	-	-
PRACTICAL										
18ME505	Heat Transfer and Refrigeration Laboratory	PC	45	0	0	3	1.5	60	40	100
18EN501	Communication Skills andLanguage Laboratory	HS	30	0	0	2	2	60	40	100
18ME506	Dynamics and Metrology Laboratory	PC	45	0	0	3	1.5	60	40	100
Total				18	1	8	**21**	320	480	800
SEMESTER –VI (Regular Stream)										
THEORY										
18MEPE1X	Program Elective- I	PE		3	0	0	3	40	60	100
18MEPE2X	Program Elective- II	PE		3	0	0	3	40	60	100
18MEPE3X	Program Elective- III	PE		3	0	0	3	40	60	100
18MEPE4X	Program Elective- IV	PE		3	0	0	3	40	60	100
18MEOE2X	Open Elective – II	OE		3	0	0	3	40	60	100
18MEOE3X	Open Elective – III	OE		3	0	0	3	40	60	100
18MEOE4X	Open Elective - IV	OE		3	0	0	3	40	60	100
PRACTICAL										
18ME605	Mini Project	PRO		0	0	6	1	60	40	100
Total				21	0	0	**22**	320	480	800
SEMESTER –VI (Protosem Stream)										
THEORY										
18MEPS11	Applied Design Thinking	PE		3	0	0	3	100	-	100
18MEPS12	Startup Fundamentals	PE		3	0	0	3	100	-	100
18MEPS13	Computational Hardware	PE		3	0	0	3	100	-	100
18MEPS14	Coding for Innovators	OE		3	0	0	3	100	-	100
18MEPS15	Industrial Design & Rapid Prototyping Techniques	OE		3	0	0	3	100	-	100
18MEPS16	Industrial Automation/ Data Life Cycle Management	OE		3	0	0	3	100	-	100
18MEPS17	Robotics /ML& MLOps	EEC		3	0	0	3	100	-	100
				21	0	0	**21**	700		700

SEMESTER –VII										
THEORY										
18ME701	Mechatronics	PC		3	0	0	3	40	60	100
18ME601	Computer Integrated Manufacturing	PC		3	0	0	3	40	60	100
18ME602	Finite Element Analysis	PC		3	0	0	3	40	60	100
18ME603	Design of Machine Elements	PC		3	1	0	4	40	60	100
PRACTICAL										
18ME702	Mechatronics & Simulation Laboratory	PC		0	0	3	1.5	60	40	100
18ME604	CAD /CAM Laboratory	PC		0	0	3	1.5	60	40	100
18ME605	Project-I	PRO		0	0	8	4	60	40	100
SEMESTER –VIII										
THEORY										
18MEPE5X	Program Elective- II	PE		3	0	0	3	40	60	100
18MEPE6X	Program Elective- II	PE		3	0	0	3	40	60	100
PRACTICAL										
18ME801	Project-II	PRO		0	0	12	10	80	120	200
Total							**16**	**160**	**240**	**400**
Grand Total							**163**			

PROFESSIONAL ELECTIVE COURSES

Code No.	Course	Hours/Week				Maximum Marks		
		Lecture	Tutorial	Practical	Credits	CA	FE	Total
Electives- I (VI SEMESTER)								
		L	**T**	**P**	**C**	**CA**	**FE**	**Total**
18MEPE11	Composite Materials	3	0	0	3	40	60	100
18MEPE12	Design of Transmission System	3	0	0	3	40	60	100
18MEPE13	Gas Dynamics & Jet Propulsion	3	0	0	3	40	60	100
18MEPE14	Renewable Energy System	3	0	0	3	40	60	100
18MEPE15	Metal Cutting & Tool Design	3	0	0	3	40	60	100
18MEPE16	Aeronautical Engineering	3	0	0	3	40	60	100
18MEPE17	Operations Research	3	0	0	3	40	60	100
Electives- II (VI SEMESTER)								
18MEPE21	Advanced Strength of Materials	3	0	0	3	40	60	100
18MEPE22	Internal Combustion Engines	3	0	0	3	40	60	100
18MEPE23	Power plant Engineering	3	0	0	3	40	60	100
18MEPE24	Machine Drawing	3	0	0	3	40	60	100
18MEPE25	Engineering System Analysis and Design	3	0	0	3	40	60	100
Electives-III (VII SEMESTER)								
18MEPE31	Applied Hydraulics and Pneumatics	3	0	0	3	40	60	100
18MEPE32	Professional Ethics and Human Values	3	0	0	3	40	60	100
18MEPE33	Maintenance Engineering	3	0	0	3	40	60	100
18MEPE34	Fuels and Combustion	3	0	0	3	40	60	100
18MEPE35	Rapid Product Development Technologies	3	0	0	3	40	60	100
18MEPE36	Refrigeration & Air Conditioning	3	0	0	3	40	60	100
Electives-IV (VII SEMESTER)								
18MEPE41	Marine Engineering	3	0	0	3	40	60	100
18MEPE42	Fracture Mechanics and Failure Analysis	3	0	0	3	40	60	100
18MEPE43	Automation in Manufacturing	3	0	0	3	40	60	100
18MEPE44	Fundamentals of Tribology	3	0	0	3	40	60	100
18MEPE45	Advanced Decision Modelling Technique	3	0	0	3	40	60	100
18MEPE46	Total Quality Management	3	0	0	3	40	60	100
Electives-V (VIII SEMESTER)								

18MEPE51	Advanced Mechanics of Solids	3	0	0	3	40	60	100
18MEPE52	Heat Transfer Problems in Electronics and Instrumentation	3	0	0	3	40	60	100
18MEPE53	Nuclear Engineering	3	0	0	3	40	60	100
18MEPE54	Analysis and Synthesis of Mechanism	3	0	0	3	40	60	100
18MEPE55	Thermal Turbo Machines	3	0	0	3	40	60	100
Electives-VI (VIII SEMESTER)								
18MEPE61	Cryogenic Engineering	3	0	0	3	40	60	100
18MEPE62	Introduction to Computational Fluid Dynamics	3	0	0	3	40	60	100
18MEPE63	Robotics	3	0	0	3	40	60	100
18MEPE64	Engineering System Modeling andSimulation	3	0	0	3	40	60	100
18MEPE65	Design of Production Tooling	3	0	0	3	40	60	100

LIST OF OPEN ELECTIVE COURSES

Code No.	Course	Hours/Week				Maximum Marks		
		Lecture	Tutorial	Practical	Credits	CA	FE	Total
		L	T	P	C	CA	FE	Total
18MEOE01	Design of Machine Elements and Machining	3	0	0	3	40	60	100
18MEOE02	Industrial Engineering	3	0	0	3	40	60	100
18MEOE03	Total Quality Management	3	0	0	3	40	60	100
18MEOE04	Principles of Management	3	0	0	3	40	60	100
18MEOE05	Professional Ethics and Human Values	3	0	0	3	40	60	100
18MEOE06	Robotics	3	0	0	3	40	60	100
18MEOE07	Robotic Process Automation	3	0	0	3	40	60	100

Definition of Credit

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credit

Structure of Undergraduate Engineering Program:

S.NO	Category	Breakup of Credits
1	Humanities and Social Sciences including Management courses	6
2	Basic Science Courses	27
3	Engineering Science courses including Workshop, Drawing,Basic of Electrical/Mechanical/Computer etc	20
4	Professional Core Courses	64
5	Professional Elective Courses relevant to chosen specialization/Branch	18
6	Open subjects- Electives from other Technical and / or Emerging subjects	12
7	Project Work, Seminar and Internship in Industry or elsewhere	16
8	Mandatory Courses (Environmental Sciences, Induction Program, Essence of Indian Traditional Knowledge)	---
	Total	**163**

SEMESTER I

18MA101 **MATRICES AND CALCULUS** **L T P C**
3 1 0 4

Course Objectives:

1. To know the use of matrix algebra needed by engineers for practical applications.
2. To understand effectively the geometrical application of differential calculus and Beta, Gamma functions.
3. To familiarize with partial differentiation concepts and its applications
4. To obtain the knowledge of multiple integration and their related applications.
5. To acquire the knowledge of vector differentiation and integration and its applications.

UNIT I MATRICES **9 + 3**

Symmetric, Skew Symmetric and Orthogonal Matrices – Characteristic equation of a Matrix – Eigen values and Eigen vectors – Properties – Cayley-Hamilton theorem (excluding proof) – Diagonalization of Matrices - Reduction of quadratic form to canonical form by orthogonal transformation.

UNIT II CALCULUS **9 + 3**

Curvature , Radius of Curvature (Cartesian coordinates) – Centre and Circle of curvature - Evolutes and Involutes-Definite integrals and their properties – Beta and Gamma functions and their properties.

UNIT III MULTIVARIABLE CALCULUS (DIFFERENTIATION) **9 + 3**

Partial derivatives – Euler's theorem for homogenous functions – Total Derivatives - Jacobians – Maxima, Minima and Saddle point- – Method of Lagrangian multipliers- Taylor's series.

UNIT IV MULTIVARIABLE CALCULUS (INTEGRATION) **9 + 3**

Multiple integrals- Double integrals – Change of order of integration in double integrals – Change of variables (Cartesian to Polar) – Application to Areas – Evaluation of Triple integrals – Application to volumes.

UNIT V VECTOR CALCULUS **9 + 3**

Vector differentiation-Gradient- Directional derivative - Divergence - Curl ,Vector integration-Line integration - work done – Surface and Volume integrals - Green's theorem , Gauss divergence and Stokes theorem (without proof) – Simple applications involving cubes and rectangular parallelopipeds.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : learn the fundamental knowledge of matrix theory.
CO2 : familiar with the concept of the differentiation and integration and its applications.
CO3 : acquire skills in applications of integral and vector calculus.

Text Books:

1. Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, (2015).
2. Veerarajan T., "Engineering mathematics for first year", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009

Reference Books:

1. James Stewart, "Essential Calculus", Cengage Learning, New Delhi, 2nd edition, 2013.
2. P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year B.E., B.Tech)", Nineth Edition, S. Chand & Co. Ltd. New Delhi, 2010.
3. Srimanta pal and Subath.C.Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi , 2015
4. Ewinkreyzig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2006.
5. Sivaramakrishnadas.P, Ruknmangadachari.E. "Engineering Mathematics", Pearson, Chennai & Delhi, 2nd edition, 2013.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

1- Faintly
2- Moderately
3- Strongly

18PH102 **PHYSICS – ELECTROMAGNETISM**

L	T	P	C
3	1	0	4

Course Objectives:

1. The concept of electrostatics, electric potential and their application.
2. The concept of dielectrics, laplace and poisons equation for electrostatic potential.
3. The concept of magnetostatics, magnetic fields in matter and their application.
4. The concept of Faraday's law, Ampere's Law, Maxwell's Equation and their application.
5. The concept of Electromagnetic waves, and Poynting vector.

UNIT I ELECTROSTATICS IN VACUUM 9 + 3

Electric field and electric flux density - Gauss's Law - applications of Gauss's law - electric field due to infinite line charge- infinite sheet of charge- uniformly charged sphere; Electric potential - potential due to a point charge- electric potential energy of a system of point charges - relationship between electric field and electric potential; Energy density in electrostatic fields.

UNIT II ELECTROSTATICS IN A LINEAR DIELECTRIC MEDIUM 9 + 3

Classification of materials based on conductivity ; Electric dipole - electrostatic field and potential of a dipole; Dielectrics - induced dipoles - polarization in dielectrics - dielectric constant and strength; Linear, isotropic, and homogeneous dielectrics; Capacitance - parallel plate capacitor - coaxial capacitor - spherical capacitor; Electric displacement; Laplace's and Poisson's equations for electrostatic potential.

UNIT III MAGNETOSTATICS AND MAGNETIC FIELDS IN MATTER 9 + 3

Biot-Savart's Law - magnetic induction at point *P* due to a straight filamentary conductor; Ampere's circuit law - applications of ampere's law: infinite line current - infinite sheet of current; Magnetization and associated bound currents - auxiliary Field H - Ampere's law in magnetized materials; Magnetic susceptibility and permeability; Classification of magnetic materials - diamagnetic, paramagnetic and ferromagnetic materials - hysteresis loop.

UNIT IV FARADAY'S LAW AND MAXWELL'S EQUATION 9 + 3

Faraday's law in terms of emf produced by changing magnetic flux; Lenz's law; Transformer emf; Motional emf ; Electromagnetic breaking and its applications; Self Inductance -self-inductance of a solenoid; Mutual Inductance - mutual Inductance of two tightly wound solenoids; Energy density in magnetic Fields; Displacement current - modified ampere's law; Maxwell's equation in vacuum and non-conducting medium.

UNIT V ELECTROMAGNETIC WAVES 9 + 3

The wave equation- plane electromagnetic waves in vacuum, their transverse nature and polarization; Polarization by reflection- Brewster's law; Relation between electric and magnetic fields of an electromagnetic wave; Energy carried by electromagnetic waves; Flow of energy and Poynting vector; Variation of intensity of electromagnetic wave with distance; Radiation pressure.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : understand the concepts of electrostatics, electrical potential, and their applications.
CO2 : interpret the concepts of dielectrics, laplace and poisons equation for electrostatic potential. .
CO3 : apply the concepts of magneto statics, magnetic fields in matter and their application.
CO4 : apply the concepts of faraday's law, ampere's law, maxwell's equation.
CO5 : interpret the concepts of electromagnetic waves and poynting vector.

Text Books:

1. Mathew N. O.Sadiku, 'Elements of Electromagnetics', Oxford University Press, Third Edition, 2001.
2. Halliday, Resnick, Walker, 'Fundamentals of Physics-Electricity and Magnetism', Wiley India Pvt.Ltd., 2011.
3. Gangadhar K.A, Ramanthan P.M, 'Field Theory', Khanna Publications, 2002.

Reference Books:

1. David J. Griffiths, 'Introduction to Electrodynamics', Prentice-Hall, Inc., 1999.
2. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions,Fifth edition, 2010.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	0	3	2	1	2	0	1	0	0	3	2	1	3
CO2	3	3	0	2	1	1	0	0	1	0	0	3	2	0	2
CO3	2	3	0	3	3	1	1	0	1	0	0	3	1	2	3
CO4	3	2	0	3	2	1	1	0	1	0	0	2	2	1	3
CO5	3	3	0	3	2	1	1	0	1	0	0	3	3	1	3

1- Faintly
2- Moderately
3- Strongly

18EE103	BASICS OF ELECTRICAL ENGINEERING	L	T	P	C
		3	1	0	4

Course Objectives:

1. To understand and analyze basic electric circuits
2. To Study the working principles of Electrical Machines and Transformers
3. To Study the working principles of power converters and Drives

UNIT I DC CIRCUITS **9 + 3**

Electrical Circuit Elements – Voltage and Current Sources- Source transformation techniques – Ohms law, Kirchhoff's laws –Analysis of simple circuits with DC excitation – Superposition, Thevenin and Norton's theorem. Star and Delta transformation. Time domain analysis of first order RL and RC Circuits.

UNIT II AC CIRCUITS **9 + 3**

Representation of Sinusoidal waveforms, peak, rms and average value. Real power, reactive power, apparent power and power factor. Analysis of single phase AC circuits consisting of R,L, C, RL, RC, RLC combinations (Series and Parallel) – Resonance in series Circuits (Study of phenomenon). Three phase circuits – relation between voltage and current in star and delta connections – Three phase balanced circuits.

UNIT III DC MACHINES AND TRANSFORMERS **9 + 3**

Construction and Principle of operation and speed control of separately excited DC motor – Characteristics of motors - Applications - Magnetic materials - BH characteristics – Single phase transformer – Equivalent circuit – Types of Losses in a transformer – No Load test and Load test – Regulation and Efficiency – Auto transformer – Three phase transformer connections - Uses of transformers - Applications.

UNIT IV AC MACHINES **9 + 3**

Construction and Principle of operation of Three phase induction motor – Torque slip characteristics – Starting and speed control methods – Loss components and efficiency. Construction and working of Single phase induction motor – Construction and Working of Synchronous generators and types — Applications of all machines.

UNIT V POWER CONVERTERS AND DRIVES **9 + 3**

Operation of three phase Converter and Inverter circuits – Working of Chopper and duty ratio control – Chopper control of separately excited DC motor – Stator voltage control of three phase induction motor drives - Rotor resistance control of three phase induction motor – Closed loop control of slip power recovery scheme.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : verify ohm's law and kirchoff's laws for simple electrical circuits.
CO2 : verify simple network theorems for electrical circuits.
CO3 : solve problems on ac circuits and analyze three phase ac circuits.
CO4 : understand the performance of dc machines and transformers.
CO5 : basic understanding of power electronic circuits and their application in speed control of ac and dc machines.

Text Books:

1. D.P.Kothari, I.J.Nagrath,, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
4. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, 1989

Reference Books:

1. Nagsarkar T K and Sukhija M S, "Basic Electrical Engineering", Oxford Press (2005).
2. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

3. E.Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
4. Mahmood Nahvi and Joseph A. Edminister, “Electric Circuits”, Schaum Outline Series, McGraw Hill, Sixth edition (2014).

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0
CO2	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0
CO3	3	3	0	2	1	1	1	0	0	0	0	0	0	0	0
CO4	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0
CO5	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

18ME101 **ENGINEERING GRAPHICS & DESIGN**

L	T	P	C
1	0	4	3

Course Objectives:

1. To impart knowledge on concepts, ideas and design of engineering products and to provide an exposure to CAD Modelling.
2. Standards of Engineering Drawing: Size, layout and folding of drawing sheets, lettering - Use of drafting instruments

UNIT I PROJECTION OF POINTS, LINES AND PLANE SURFACES **9 + 3**

General principles of orthographic projection- Projection of points, located in all quadrants – Projection of straight lines located in first quadrant – Determination of true lengths and true inclinations – Projection of polygonal surface and circular lamina inclined to both reference planes.

UNIT II PROJECTION OF SOLIDS **9 + 3**

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

UNIT III SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES **9 + 3**

Sectioning of above solids in simple vertical position by cutting planes inclined to one reference plane and perpendicular to other – solids inclined position with cutting planes parallel to one reference plane- Obtaining true shape of section. Development of lateral surfaces of simple and truncated solids – Prisms, pyramids cylinders and cones- Development of lateral surfaces of solids with square and cylindrical cutouts, perpendicular to the axis.

UNIT IV ISOMETRIC PROJECTION **9 + 3**

Principles of isometric projection –isometric scale - isometric projections of simple solids, truncated prisms, pyramids, cylinders and cones.

UNIT V PERSPECTIVE PROJECTION **9 + 3**

Perspective projection of prisms, pyramids and cylinders by visual ray and vanishing point methods.

Note: Study of drafting software – Auto CAD – Coordinate System (Absolute, relative and polar)
Creation of simple figures like polygon, Drawing a plan of residential building, Creation of 3-D
Models of simple objects and obtaining 2-D multi view drawing from 3-D model. (**Internal Assessment only)**

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : understand the conventions and the methods of engineering drawing.
CO2 : understand the fundamental concepts of theory of projection.
CO3 : understand the development of different surfaces.
CO4 : develop the relationships between 2d and 3d environments.
CO5 : demonstrate computer aided drafting.

Text Books:

1. Bhatt N.D, “Engineering Drawing”, Charotar publishing House, 2003
2. Natarajan, K.V, “A Text book of Engineering Graphics”, Dhanalakshmi Publishers, 2006.

Reference Books:

1. Gopalakrishnana K.R, “Engineering Drawing", Vol. I and II, Subhas Publications, 1999.
2. Dhananjay A. Jolhe, “Engineering Drawing with an Introduction to AutoCAD”, Tata McGraw Hill Publishing Company Limited, 2008.
3. Venugopal, K and Prabhu Raja, V., “Engineering Graphics”, New Age International (P) Ltd, 2008.
4. Gill, P.S, “Engineering Drawing-Geometrical Drawing”, S.K Kataria and Sons, 2008.
5. CAD Software Theory and User Manuals

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	0	0	0	0	0	0	0	0	0	0	1	1	2
CO2	0	0	2	0	0	0	0	0	0	0	0	0	1	2	1
CO3	0	0	0	2	1	0	0	0	0	0	0	0	2	1	1
CO4	0	1	1	0	0	0	0	0	0	3	0	0	1	2	1
CO5	1	2	0	1	1	0	0	0	0	0	0	2	2	1	3

1- Faintly
2- Moderately
3- Strongly

18PH103 **PHYSICS LABORATORY**

L	T	P	C
0	0	3	1.5

Course Objectives:

1. To handle different measuring instruments.
2. To understand the basic concepts of interference, diffraction, heat conduction and to measure the important parameters.

EXPERIMENTS:

1. Newton's rings – Determination of radius of curvature of a Plano convex lens.
2. Carey Foster's bridge – Determination of specific resistance of the material of the wire.
3. Poiseuille's flow – Determination of Coefficient of viscosity of a liquid.
4. Spectrometer – Grating – Normal incidence – Determination of Wavelength of Mercury lines.
5. Lee's disc – Determination of thermal conductivity of a Bad conductor.
6. Ultrasonic interferometer – Determination of velocity of Ultrasonic Waves in Liquid.
7. Non-uniform bending – Determination of young's modulus of the material of the Bar.
8. Determination of Band gap of a given semi conductor.
9. Determination of Wavelength of laser using grating and determination of particle size using Laser.
10. Determination of Acceptance angle and Numerical Aperture of fiber.

Total = 45 Periods

Course Outcomes:

After completing the laboratory course the students will be able to

CO1 : handle different measuring instruments and to measure different parameters.

CO2 : calculate the important parameters and to arrive at the final result based on the experimental measurements.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	1	1	2	0	3	0	1	2	1	0	3
CO2	3	3	2	3	1	1	2	0	3	0	1	2	1	0	3

1- Faintly
2- Moderately
3- Strongly

18CY102 **CHEMISTRY LABORATORY** **L T P C**
0 0 3 1.5

Course Objectives:

1. To gain practical knowledge by applying theoretical principles and performing the following experiments.

EXPERIMENTS:

1. Estimation of hardness of Water by EDTA
2. Estimation of Copper in brass by EDTA
3. Estimation of Alkalinity in water
4. Estimation of Chloride in water sample (Iodimetry)
5. Conductometric titration of Strong Acid and Strong Base
6. Conductometric titration of Mixture of acids and Strong base
7. Determination of strength of Iron by Potentiometric method
8. Estimation of Iron by Spectrophotometry
9. Determination of molecular weight and degree of Polymerisation by Viscometry.

Total = 45 Periods

Course Outcomes:

After completing the laboratory course the students will be able to

CO1 : know the applicability of the practical skill gained in various fields.

CO2 : know the composition of brass quantitatively and the molecular weight of polymers.

CO3 : understand the principle and applications of conductometric titrations, spectrometer and potentiometric titrations.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0
CO2	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0
CO3	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

18EE104 **BASICS OF ELECTRICAL ENGINEERING LABORATORY**

L	T	P	C
0	0	2	1

Course Objectives:

1. To gain practical knowledge by applying theoretical principles and performing the following experiments**.**

EXPERIMENTS:

1. Introductions to measuring instruments – voltmeter, ammeter, wattmeter, multimeter and Digital Storage Oscilloscope.
2. Resonance in RLC circuits, verification of laws in electrical circuits.
3. Measurement of phase difference between voltage and current
4. No load test on single phase transformer and equivalent test
5. Load Test on single phase transformer
6. Three phase transformer connections
7. Voltage - Current relations in three phase circuit and three phase power measurement
8. Demonstration of cut out section of machines
9. Swinburne's Test, Speed Control and Load test on DC motor
10. Direction change and load test on three phase induction motor
11. Alternator load test and regulation test
12. Demonstration of LT switchgear components
13. Demonstration of AC and DC drives

Total = 30 Periods

Course Outcomes:

After completing the laboratory course the students will be able to

CO1 : making electrical connections by wires of appropriate wires
CO2 : acquire exposure to common electrical components and measuring instruments.
CO3 : verify simple laws using electrical circuits.
CO4 : do experiment to understand the characteristics of transformers and electrical machines.
CO5 : understand the working of low tension switch gear components, ac and dc drives.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	0	1	1	0	1	1	0	0	0	0	0	0	0
CO2	3	2	0	1	1	0	0	0	0	0	0	0	0	0	0
CO3	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0
CO4	3	1	0	2	1	0	0	0	0	0	0	0	0	0	0
CO5	3	2	0	2	1	0	1	1	0	0	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

18EN103 PROFESSIONAL COMMUNICATION LABORATORY

L	T	P	C
0	0	2	1

Course Objectives:

1. To help students improve their reading skills.
2. To help students address an audience and present a topic.
3. To help students acquire speaking competency in English.
4. To help students strengthen their fluency in speaking.

METHODOLOGY – READING

1. Reading a story aloud with exact pronunciation, with intonation, and with expressing sense.
2. Reading poems for improving verbal skills, memory, and critical thinking.
3. Reading newspaper articles for strengthening the vocabulary and writing skills
4. Reading homophones with exact pronunciation for expressing different meanings.

METHODOLOGY – SPEAKING

1. Power point presentation – on general topics - for organising and structuring presentation.
2. Oral presentation -on basic technical ideas related to engineering.
3. Speaking on a given topic – current affairs, expressing opinion on social issues.
4. Describing a process – booking Ticket online, survey for starting a new office, sending an e-mail, etc.
5. Organising official events –compering, presenting welcome address, proposing vote of thanks.

Total = 30 Periods

Course Outcomes:

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

CO1 : read short passages fluently, avoiding mispronunciation, substitution, omission and transposition of word-pairs.
CO2 : vocalize words without the aid of pictures.
CO3 : develop a well-paced, expressive style of reading.
CO4 : make effective oral presentations on technical and general contexts.
CO5 : describe a process with coherence and cohesion.

Text Books:

1. Norman Whitby. Business Benchmark – Pre-Intermediate to Intermediate, Students book, Cambridge University Press, 2014.

Recommended Reading and Reference Sources:

1. Spoken English: A Self-Learning Guide. V.Sasikumar and P V Dhamija
2. English Conversation Practice: Grant Taylor Paperback 1976ly. Krishna Mohan, N P Singh
3. Discussions that Work. Penny Ur.CUP, 1981.
4. http://www.onestopenglish.com/skills/speaking/speaking-matters/
5. Speak Better Write Better English Paperback – November 2012 Norman Lewis, Goyal Publishers and Distributors.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	2	2	0	2	1	1	2	3	2	1	0	1	2
CO2	0	0	2	1	0	1	2	2	2	3	1	0	0	2	2
CO3	0	0	1	1	0	1	1	1	1	3	1	1	0	0	1
CO4	0	0	2	2	0	0	2	2	1	3	2	2	0	1	2
CO5	0	0	2	1	0	1	1	1	0	3	2	2	0	2	3

1- Faintly
2- Moderately
3- Strongly

SEMESTER II

18EN101 **PROFESSIONAL ENGLISH**

L	T	P	C
2	0	0	2

Course Objectives:

1. Master basic reading skills such as phonics, word recognition and meaningful division of sentences.
2. Read fast, decode accurately and remove oral reading errors that affect text meaning.
3. Acquire and develop writing skills for academic, social and professional purposes.
4. Gain skills in academic and functional writing tasks.

WRITING:

1. Word Formation with Prefix and Suffix, Synonyms and Antonyms, Tenses, Parts of Speech, Common Errors in English (Subject –Verb Agreement, Noun-Pronoun Agreement, Prepositions, Articles, Conditional statements, Redundancies, Clichés etc), Voices.
2. Email – Training Programme and related details, paper submission for seminars and conferences, Fixing an appointment, Arranging and Cancelling a meeting with team members, conference details, hotel accommodation, Reminder mails, Raising queries with team members, Congratulatory mails at work, arranging for a meeting with a foreign client, personal emails.
3. Letter Writing – Business and need based communication – Formats of official, personal and business letters, official leave and request applications (Bonafide certificate, course completion, conduct certificate, permission to arrange industrial visits) complaints, replies to queries from business customers, inviting dignitaries, accepting and declining invitations, Placing orders, cover letter for a job application with resume.
4. Technical Report Writing – status reports – Work Done in the Project, Feasibility Reports on Office Accommodation, Introduction of New Products, Sales Promotion, Customers Feedback, Starting a New Company, Event Reports- Seminars, Conferences, Meeting, Recommendations and Checklists.
5. Charts- interpreting pie charts, graphs etc.,

READING:

1. Understanding notices, messages, timetables, adverts, graphs, etc.- understanding meaning and purpose of short texts.
2. Gapped sentences – Meanings, collocations and meanings of individual words.
3. Reading passage with multiple choice questions – reading for gist and reading for specific Information – skimming for general idea of and meaning and contents of the whole text.
4. Short reading passage; gap-filling – Grammar, especially prepositions, articles, auxiliary verbs, modal verbs, pronouns, relative pronouns and adverbs.
5. Short reading passages; sentence matching – Scanning – ability to pick out specific information in a short text.

METHODOLOGY:

Objective Type:

1. Vocabulary of business communication.
2. Collocations related to technical and business.
3. Coherence in paragraphs – use of sequence clues.
4. Conversations and appropriate responses.
5. Tenses with time makers.
6. Verbal phrases
7. Description of objects in a sentence or two
8. Products and likely slogans
9. Tone, vocabulary, expressions in formal and informal letters.
10. Email writing- tone, vocabulary, expressions, mail ID., creation, CC, BCC.

DESCRIPTIVE WRITING:

1. Skimming and scanning to look for specific information.
2. Spotting Errors.
3. Email writing in different work place/ profession based contexts with hints.
4. Letter writing in different business based contexts with hints.
5. Report writing: feasibility report, progress in project reports, accident reports and event reports.

6. Checklists in business, office and profession based context.
7. Recommendations in business, office and profession based context.
8. Resume and Cover letter.
9. Mind mapping visuals on social and environmental issues – essay writing based on the given mind map visual.

Total = 30 Periods

Course Outcomes:

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

CO1 : read and summarize the main ideas, key details and inferred meanings from a passage.

CO2 : internalize the grammar items such as prepositions, articles, tenses, verbs, pronouns, and adverbs adjectives through contexts and apply them to spot errors.

CO3 : develop the ability to classify, check information and prepare reports.

CO4 : apply the academic and functional writing skills in new contexts.

CO5 : interpret pictorial representation of data and statistic.

Text Books:

1. Norman Whitby. Business Benchmark –Pre - Intermediate to Intermediate, Students Book, Cambridge University Press, 2014.

Recommended Reading and Reference Sources:

1. M. Ashraf Rizvi, Effective Technical Communication, McGraw Hill.
2. Farhathullah, T.M. Communication Skills for Technical Students.
3. Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice, Oxford University Press, New Delhi, 2004.
4. David F. Beer and David McMurray, Guide to Writing as an Engineer, John Willey. New York, 2004.
5. Collins Cobuild- Student's Grammar: Self-Study Edition with Answers (Collins Cobuild Grammar) paperback- 6 May 1991.
6. Essential English Grammar paperback Raymond Murphy CUP 2007.
7. Android App for Grammar: https://play.google.com/store/apps/details?id=com.zayaninfotech.english.grammar.
8. http://www.onestopenglish.com/grammar/
9. Speak Better Write Better English paperback – Nov 2012, Norman Lewis, Goyal Publishers and Distributors.
10. Essential English Grammar Paperback Raymond Murphy CUP 2007.
11. English Reading Comprehension 2014 RPH Editorial Board.
12. Proficiency in Reading Comprehension Simplifying the 'Passage' for you, 2008 Ajay Singh.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	2	1	0	1	2	2	2	3	1	1	0	1	2
CO2	0	0	1	2	0	0	1	1	1	3	2	1	0	1	2
CO3	0	0	2	1	0	0	2	2	2	3	1	2	0	0	2
CO4	0	0	2	1	0	1	2	1	1	3	1	2	0	2	3
CO5	0	0	1	2	0	1	0	1	1	3	2	1	0	1	3

1- Faintly
2- Moderately
3- Strongly

18MA201 DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES

L	T	P	C
3	1	0	4

Course Objectives:

1. To obtain the knowledge to solve second order differential equations with constant and Variable coefficients.
2. To familiarize with formation and solutions of first order partial differential equation.
3. To familiarize with the solutions of higher order partial differential equations.
4. To know about analytic functions with properties, construction of analytic functions and conformal transformations
5. To obtain the knowledge of Cauchy's integral theorems, calculus of residues and complex Integration around unit circle and semi-circle.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS OF HIGHER ORDER 9 + 3

Second order linear differential equations with constant and variable coefficients –Cauchy-Euler equation and Cauchy- Legendre's linear equation - Method of variation of parameters –Simultaneous first order linear equations with constant coefficients.

UNIT II PARTIAL DIFFERENTIAL EQUATIONS – FIRST ORDER 9 + 3

Formation of partial differential equations by elimination of arbitrary constants and functions –Solutions to first order partial differential equations – Standard types of first order linear and non-linear PDE- Lagrange's linear PDE.

UNIT III PARTIAL DIFFERENTIAL EQUATIONS – HIGHER ORDER 9 + 3

Solution to homogeneous and non-homogeneous linear partial differential equations of second and higher order by complementary function and particular integral method - Separation of variables method: simple problems in Cartesian coordinates, Laplace equation in Cartesian and polar coordinates, one dimensional diffusion equation, one dimensional wave equation.

UNIT IV COMPLEX DIFFERENTIATION 9 + 3

Functions of a complex variable – Analytic functions – Cauchy – Riemann equation and sufficient conditions (excluding proof) – Harmonic and orthogonal properties of analytic function –Construction of analytic functions – Conformal mappings: w= z+c, cz, 1/z, z2 and Bilinear transformations.

UNIT V COMPLEX INTEGRATION 9 + 3

Cauchy's integral theorem - Cauchy's integral formula – Taylor's and Laurent's theorems (Statements only) and expansions – Poles and Residues – Cauchy's Residue theorem – Contour integration: Circular and semi-circle contours with no poles on the real axis.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : learn the techniques of solving ordinary and partial differential equations of second and higher order that arise in engineering problems

CO2 : familiar with the concept of conformal and bilinear transformations.

CO3 : acquire the knowledge of contour integration over unit circle and semi-circle.

Text Books:

1. Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna publications, Delhi, 2015. Ltd., New Delhi, 2009
2. Veerarajan T., "Engineering mathematics for first year", Tata McGraw Hill Education Pvt.

Reference Books:

1. James Stewart, "Essential Calculus", Cengage Learning, New Delhi, 2nd edition, 2013.
2. P. Kandasamy, K. Thilagavathy and K. Gunavathy," Engineering Mathematics (For I year

B.E., B.Tech)", Nineth Edition, S. Chand & Co. Ltd. New Delhi, 2010.
3. Srimanta pal and Subath.C.Bhumia, "Engineering Mathematics", Oxford university publications, New Delhi, 2015
4. Ewinkreyzig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2006.
5. Sivaramakrishnadas.P, Ruknmangadachari.E. "Engineering Mathematics", Pearson, Chennai & Delhi, 2nd edition, 2013.

CO-PO MAPPING

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1

1- Faintly
2- Moderately
3- Strongly

18CY101 **CHEMISTRY** **L T P C**

3 1 0 4

Course Objectives: Technology is being increasingly based on the electronic, atomic and molecular level modifications. The course will enable the students to:

1. Analyze microscopic chemistry in terms of atomic and molecular orbitals.
2. Rationalize periodic properties of elements and the knowledge of acids and bases.
3. Analyze the stereo chemical aspects of organic molecules and chemical reactions that are used in the synthesis of organic molecules
4. Rationalize bulk properties and processes in thermodynamic aspects and its extension in electrochemical processes.
5. Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques

UNIT I MOLECULAR STRUCTURE 9 + 3

Formation of molecular orbitals of diatomic molecules - energy level diagrams of – H_2, He_2, N_2, O_2, CO and NO – bond order, bond length, bond energy, magnetic behaviour and relative stability;

Aromaticity- Huckel rule - concept of aromaticity - aromatic, non-aromatic and anti-aromatic molecules- Benzenoid, Non-benzenoid and Annulenes only;

Crystal field theory – Postulates- d-orbital splitting in octahedral and tetrahedral complexes- strong field and weak field ligands - spectrochemical series- high spin and low spin complexes- magnetic properties of complexes – crystal field stabilisation energy (CFSE) and its calculations for octahedral and tetrahedral complexes.

UNIT II PERIODIC PROPERTIES AND ACID-BASE CONCEPTS 9 + 3

Effective nuclear charge – shielding effect, penetration of orbitals - variations of s, p, d and f orbital energies of atoms –Aufbau principle - electronic configuration of elements – periodic properties - atomic and ionic size, ionization energy, electron affinity and electro negativity - anomalous properties of second period elements - diagonal relationship;

Acids and bases - Bronsted-Lowry concept - Lewis concept - pH and pKa – problems – HSAB - buffer solutions – types- mechanism of buffer action- Henderson–Hasselbalch equation- derivation and problems.

UNIT III STEREOCHEMISTRY AND ORGANIC REACTIONS 9 + 3

Stereoisomerism – geometrical isomerism – cis-trans and E-Z nomenclature – optical isomerism – symmetry, chirality, optical activity, enantiomer and diastereomers – absolute configuration - R-S notation - conformational analysis – Ethane, butane, cyclohexane;

Addition reaction – hydrogenation, halogenations - Markovnikov rule – Kharasch effect - hydration, hydro halogenation, hydroboration;

Aliphatic nucleophilic substitution reaction –SN_1, SN_2 and SN_i mechanism – electrophilic substitution reaction in benzene– mechanism - nitration, halogenations, suffocation, alkylation and acylation; Elimination reaction –E_1, E_2 and E_1CB- mechanism- Saytzeff rule – examples.

UNIT IV USE OF FREE ENERGY IN CHEMICAL EQUILIBRIA 9 + 3

Thermodynamic functions- internal energy, enthalpy, entropy and free energy- first and second law of thermodynamics - partial molar properties - Gibbs Duhem equation – variation of chemical potential with temperature and pressure – Third and Zeroth law of thermodynamics – definition only;

Free energy and EMF relation - single electrode potential - electrochemical series and its significance.- cell potential and its measurement (Poggendorff method only) - Nernst equation-derivation and problems-Standard cell potential and equilibrium constant relation- problems.

UNIT V SPECTROSCOPY TECHNIQUES AND APPLICATIONS 9 + 3

Beer-Lambert's law (problem) – UV visible spectroscopy: Principle, Chromophores, auxochrome, Electronic transitions and instrumentation (No applications);

IR spectroscopy: Principles – instrumentation and applications of IR in H_2O, CO_2 and NH_3;

Flame photometry – principle – instrumentation – estimation of sodium by flame photometer;

Atomic absorption spectroscopy - principles - instrumentation - estimation of nickel by atomic absorption spectroscopy.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : Understand in-depth knowledge of atomic and molecular orbitals based chemical aspects.
CO2 : Realize the nature of periodic properties of elements and the knowledge of acids and bases.
CO3 : Grasp the knowledge of 3d structural aspects of organic molecules and chemical reactions that are used in the synthesis of organic molecules.
CO4 : Substantiate the various processes involved in thermodynamic considerations and its involvement in electrochemical aspects.
CO5 : Aware of spectroscopic techniques in the field of molecular identification of materials.

Text Books:

1. P.R. Puri, L.R.Sharma and Madan S. Pathania,"Principle of physical chemistry" 47th Vishal Publishing Co, Jalandhar-8
2. C. N. Banwell and E. M. Mccash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2009.
3. Raj. K. Bansal - "A Text Book of Organic Chemistry" Revised 4th Ed.,(2005), New Age International Publishers Ltd., New Delhi.
4. P.S. Kalsi - "Stereochemistry conformation and Mechanism", 6th Ed., (2005), New Age International Publishers Ltd., New Delhi.
5. J.D. Lee - "A New Concise Inorganic Chemistry", 5th Edn., Oxford University Press, 2011.
6. Wahid Malik, G.D.Tuli and R.D.Madan, "Selected Topic in Inorganic Chemistry",S.Chand& Co., Ltd (2011).

Reference Books:

1. David.W.Ball, Physical Chemistry, Cengage Learning India Pvt. Ltd., New Delhi, 2009.
2. G.Aruldhas, Molecular structure and spectroscopy, second edition, PHI learning Pvt. Ltd., New Delhi, 2008.
3. Cotton and Wilkinson - "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons, New York- 2004.
4. James E. Huheey, Ellen A. Keiter and Richard L. Keiter - "Inorganic Chemistry-Principles of Structure and Reactivity", 4 thEdn., Pearson Education, 11th Impression, 2011.
5. F.A. Carey and R.J. Sund berg - "Advanced organic chemistry" Vol. I and II- 3rd Ed.,(1984), Plenum Publications.
6. Ernest. Eliel and Samuel H. Wilen - "Stereochemistry of Organic Compounds" - Wiley Student Ed., (2006). John Wiley and Sons Pvt. Ltd., Singapore.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	0	0	2	0	0	0	3	0	0	0	0	0	0	0
CO2	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0
CO3	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0
CO4	3	0	0	0	0	0	0	3	0	3	0	0	0	0	0
CO5	3	0	0	2	0	3	0	0	0	3	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

18CS101 FUNDAMENTALS OF PROBLEM SOLVING AND C PROGRAMMING

L	T	P	C
3	0	0	3

Course Objectives:

1. To express problem solving through programming.
2. To practice the basic concepts of C programming language.
3. To provide the basics knowledge about array and strings to solve simple applications.
4. To use pointers and functions in the simple applications.
5. To review the elementary knowledge of structures and unions.

UNIT I INTRODUCTION TO COMPUTER AND PROBLEM SOLVING 9 + 0

Problem formulation, Problem Solving methods, Need for logical analysis and thinking – Algorithm – Pseudo code – Flow Chart- Need for computer languages, Generation and Classification of Computers- Basic Organization of a Computer.

UNIT II C PROGRAMMING BASICS AND CONTROL STATEMENTS 9 + 0

C Character set- Identifies and Keywords- Data Type- Declarations-Expressions-Statements and Symbolic constants- Operators – Arithmetic Operators – Unary operators – Relational and Logical Operators – Assignment operators – Conditional operators- Managing Input and Output operations- Decision Making-Branching and Looping statements.

UNIT III ARRAYS AND STRINGS 9 + 0

Pre-processor directives-Storage classes-Arrays – Initialization – Declaration – one dimensional and two dimensional arrays. Strings - String operations – String handling functions-Simple programs-sorting-searching.

UNIT IV FUNCTIONS AND POINTERS 9 + 0

Function – Library functions and user-defined functions – Function prototypes and function definitions – Call by value –Call by reference – Recursion – Pointers - Definition – Initialization – Pointers arithmetic – Pointers and arrays.

UNIT V STRUCTURES, UNIONS AND FILE 9 + 0

Introduction – need for structure data type – structure definition – Structure declaration – Structure within a structure – Passing structures to functions – Array of structures – Pointers to structures-Union-basic file operation.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : formulate and apply logic to solve basic problems.
CO2 : write, compile and debug programs in c language.
CO3 : apply the concepts such as arrays, decision making and looping statements to solve real time applications.
CO4 : solve simple scientific and statistical problems using functions and pointers.
CO5 : write programs related to structures and unions for simple applications.

Text Books:

1. Anita Goel and Ajay Mittal, “Computer Fundamentals and Programming in C”, Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011. (Unit-I).
2. E.Balagurusamy, “Programming in ANSI C” fourth Edition, Tata McGraw-Hill, 2008. (Unit II-V).

Reference Books:

1. Byron S Gottfried, “Programming with C”, Schaum’s Outlines, Second Edition, Tata McGraw-Hill, 2006.
2. Kernighan,B.W and Ritchie,D.M, “The C Programming language”, Second Edition, Pearson Education, 2006.
3. Yashavant P. Kanetkar. “Let Us C”, BPB Publications, 2011.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3	3	2	2	1	1	1	3	3	3	2	0
CO2	3	3	3	3	3	2	2	1	1	1	3	3	3	2	0
CO3	3	3	3	3	3	2	2	1	1	1	3	3	3	1	0
CO4	3	3	3	3	3	2	2	1	1	1	3	3	3	1	0
CO5	3	3	3	3	3	2	2	1	1	1	3	3	3	1	0

1- Faintly
2- Moderately
3- Strongly

18EN102	**PROFESSIONAL ENGLISH LABORATORY**	**L T P C** **0 0 2 1**

Course Objectives:

1. To acquire and develop listening skills for academic, social and professional purposes.
2. To understand short conversations or monologues
3. To master basic reading skills such as phonics, word recognition, and fluency
4. Acquire and develop pre-intermediate level fluency in oral skills such as discourse management, grammar and vocabulary, pronunciation and interactive communication for academic, social and professional purposes.
5. Address an audience and present a topic.
6. Express an opinion and justify it.

METHODOLOGY - LISTENING

List of Audio files:

1. Job Responsibilities
2. Conversation between two employees on company culture
3. Emails
4. Description of gadgets
5. Interview with a leading industrialist
6. Office procedures – applying for permission, placing an order for office equipment,
7. Enquiries about orders and deliveries
8. Conversation between two people on general topics
9. Telephone Messages
10. Fixing and Cancelling appointments
11. Asking for directions
12. Rescheduling a travel plan
13. Tones : Rude and Polite
14. Conversation : Statements, Discussions, Debating, Accepting, Negotiating
15. Conferences ; Announcements about changes in schedules and sessions
16. Motivational Speech
17. TED Talk on Team Work
18. Describing charts and data
19. Presentation at an office
20. Short self-descriptions

METHODOLOGY: - Speaking

1. Self-Introduction – Personal information -Name, Home background, study details, area of interest, hobbies, strengths and weaknesses, projects and paper presentations if any, likes and dislikes in food, clothes, Special features of home town, Personal role models in life, goals and dreams, favorite inspirational quote.

2. Situational Role Play between Examiner and Candidate – Customer and Sales Manager, Hotel Manager and Organiser, Team Leader and Team member, Bank Manager and Candidate, Interviewer and Applicant, Car Driver and Client, Industrialist and Candidate, Receptionist and Appointment Seeker, New Employee and Manager, Employee and Employee, P.A. and Manager Schedule for training, Asking for directions, Seeking help with office equipment, Clarifying an error in the bill, Quality of Products, Buying a Product, Selling a Product, cancelling and fixing appointments, hotel accommodation, training facilities, dress code, conference facilities, faculty advisors and student, student and student, college Office personnel and student.

Total = 30 Periods

Course Outcomes:

At the end of the course, students will have acquired the following Listening and Speaking skills

CO1 : Infer, interpret and correlate routine, classroom-related conversation.

CO2 : Use a range of common vocabulary and context based idioms.

CO3 : Comprehend native speakers when they speak quickly to one another, although the student might still have trouble.

CO4 : Identify the most important words in a story/article.

CO5 : Summarize the main ideas, key details, and inferred meanings from listening passages of up to five minutes.

CO6 : Vocalize words without the aid of pictures

CO7 : Make effective self-introductions.

CO8 : Study options, compare and contrasts the options.

CO9 : Exercise a choice, justify it by giving examples and illustrations.

CO10 : Construct a situation and to participate in conversations.

Textbooks:

1. Norman Whit by. Business Benchmark -Pre - Intermediate to Intermediate, Students Book, Cambridge University Press, 2014.

Reference sources:

1. Spoken English: A Self-Learning Guide. V. Sasikumar and P V Dhamija.
2. English Conversation Practice: Grant Taylor Paperback 1976ely. Krishna Mohan, N P Singh.
3. Discussions that Work. Penny Ur. CUP, 1981.
4. http://www.onestopenglish.com/skills/speaking/speaking-matters/
5. Speak Better Write Better English Paperback - November 2012 Norman Lewis, Goyal Publishers and Distributors.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	1	1	0	1	1	2	1	3	1	2	0	1	3
CO2	0	0	1	2	0	1	1	2	2	3	1	1	0	1	2
CO3	0	0	1	1	0	0	1	2	1	3	2	1	0	0	1
CO4	0	0	2	2	0	1	2	3	1	3	1	2	0	1	3
CO5	0	0	1	1	0	0	1	1	1	3	2	1	0	1	3
CO6	0	0	1	1	0	1	1	2	0	3	1	2	0	0	2
CO7	0	0	2	1	0	0	2	3	0	3	2	1	0	1	2
CO8	0	0	2	2	0	0	2	2	1	3	2	0	0	1	3
CO9	0	0	2	1	0	2	1	2	1	3	0	1	0	0	2
CO10	0	0	1	1	0	1	1	1	2	3	1	2	0	0	2

1- Faintly
2- Moderately
3- Strongly

18CS102 **COMPUTER PRACTICE LABORATORY**

L	T	P	C
0	0	4	2

Course Objectives:

1. To provide basic knowledge of creating Word documents and also producing mail merge.
2. To make use of basic functions, formulas and charts in Spread sheet.
3. To implement problem solving techniques.
4. To promote the programming ability to develop applications for real world problems.

LIST OF EXERCISES

A. Word Processing

1. Document creation, Text manipulation with Scientific notations, Table creation, Table formatting and Conversion
2. Letter preparation using Mail merge and Draw flow Charts using tools

B. Spread Sheet

3. Chart - Line, XY, Bar and Pie.
4. Formula - formula editor, Sorting and Import and Export features.
5. Spread sheet - inclusion of object, Picture and graphics, protecting the document and sheet.

C. Simple C Programming

6. Program using Control statements.
7. Program using Looping.
8. Program using Array.
9. Program using String.
10. Program using Function.
11. Program using Structures.
12. Program using Pointers.
13. Program using Files.

*** For programming exercises Flow chart and pseudo code are essential**

Total = 60 Periods

Course Outcomes:

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

CO1 : demonstrate the basic mechanics of word documents and working knowledge of mail merge.
CO2 : demonstrate the use of basic functions and formulas in spread sheet.
CO3 : apply good programming methods for program development.
CO4 : implement c programs for simple applications.

CO/PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3	3	2	2	1	1	1	3	3	3	2	0
CO2	3	3	3	3	3	2	2	1	1	1	3	3	3	2	0
CO3	3	3	3	3	3	2	2	1	1	1	3	3	3	1	0
CO4	3	3	3	3	3	2	2	1	1	1	3	3	3	1	0

1- **Faintly**
2- **Moderately**
3- **Strongly**

18ME102 **WORKSHOP MANUFACTURING PRACTICES**

L	T	P	C
1	0	4	3

COURSE OBJECTIVES:

1. To provide an exposure of basic engineering practices to the student
2. To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering

LIST OF EXERCISES

1. Introduction to Safety measures and First aid.
2. Study of Lathe -Welding methods and equipment's- Casting process and tools- Sheet metal and fitting tools- Carpentry tools and joints.
3. Fitting: V-fitting, Square fitting, Curve fitting.
4. Lathe: Facing, turning, taper turning and knurling.
5. Welding: BUTT, LAP and T- joints.
6. Foundry: Green sand preparation- mould making practice.
7. Sheet metal: Cone, tray, cylinder.
8. Carpentry: CROSS, T and DOVETAIL joints.
9. Drilling: simple exercises.

Total = 60 Periods

COURSE OUTCOMES:

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

CO1 : prepare fitting of metal and wooden pieces using simple fitting and carpentry tools manually.
CO2 : prepare simple lap, butt and tee joints using arc welding equipment.
CO3 : prepare green sand moulding.
CO4 : prepare sheet metal components.
CO5 : prepare simple components using lathe and drilling machine.

REFERENCE BOOKS:

1. Bawa, H.S, "Work shop Practice", Tata McGraw Hill Publishing Company Limited, 2007.
2. Jeyachandran, K, Natarajan, K and Balasubramanian, S, "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3. Jeyapoovan, T, SaravanaPandian, M and Pranitha, S, "Engineering Practices Lab Manual", VikasPuplishing House Pvt. Ltd, 2006.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	2	2	1	1	0	1	1	0	0	1	1	1	2
CO2	1	1	2	2	1	1	0	1	1	0	0	1	1	1	2
CO3	1	1	2	2	1	1	0	1	1	0	0	1	1	1	2
CO4	1	1	2	2	1	1	0	1	1	0	0	1	1	1	2
CO5	1	1	2	2	1	1	0	1	1	0	0	1	1	1	2

1- Faintly
2- Moderately
3- Strongly

SEMESTER III

18PH202	PHYSICS – WAVES & OPTICS AND QUANTUM MECHANICS	L	T	P	C
		3	1	0	4

Course Objectives:

1. To make the students to understand Simple harmonic motion and Waves
2. To understand the Propagation of light
3. To get clear idea of wave optics
4. To understand the Principle and working of laser with applications
5. To know the basic concepts of quantum Mechanics and Matter Waves

UNIT I SIMPLE HARMONIC OSCILLATION AND WAVES **9 + 3**

Simple harmonic motion ; Damped Simple harmonic motion ; Forced vibrations – resonance; Wave motion- types and characteristics - velocity of a transverse wave along a stretched string -frequency of a vibrating string – harmonics and overtones - progressive waves & stationary waves – wave equation for progressive and Stationary waves.

UNIT II THE PROPAGATION OF LIGHT AND GEOMETRIC OPTICS **9 + 3**

Fermats Principle - laws of reflection and refraction ; Mirage effect ; Total internal reflection ; Matrix method - imaging by a spherical refracting surface - imaging by a coaxial optical system; Optical Instruments - simple and compound microscope - astronomical telescope.

UNIT III WAVE OPTICS **9 + 3**

Huygens Principle ; Principle of superposition ; Interference of Light – Youngs double slit experiment - Newtons rings - experimental arrangement to determine the wavelength of sodium light ; Michelson Interferometer ; Fraunhofer diffraction from a single slit ; Diffraction grating –determination of wavelength of light and dispersive power ; Polarisation - Polarisation by reflection - Brewsters Law.

UNIT IV LASERS **9 + 3**

Properties of Laser beams - monochromacity , coherence , directionality and brightness ; Einstiens theory of matter radiation interaction and A&B coeffiecients - amplification of light by population inversion - pumping methods ; Different types of laser - Ruby , Nd-YAG , He-Ne,CO_2 $laser$ - Energy level diagrams ; Applications of lasers in science ,engineering and medicine.

UNIT V QUANTUM MECHANICS **9 + 3**

Introduction - matter waves - Debroglie's equation - Davisson-Germer experiment-G.P.Thomson experiment; Time independent and dependent Schroedinger equation; Wave packet; Uncertainity Principle; Schroedinger equation for Particle in a one dimensional box; Physical Significance of wave function.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : understand simple harmonic oscillation and propagation of waves.
CO2 : apply matrix method to analyse system of reflecting and refracting surfaces.
CO3 : know various experimental techniques in wave optics.
CO4 : understand the concept of laser and its applications.
CO5 : gain knowledge in the basics of quantum mechanics.

Text Books:

1. Ajoy Ghatak,'Optics', Tata Mc Graw Hill Publishing Co.Ltd, Fourth Edition,2009
2. Gupta Kumar Sharma, 'Quantum Mechanics', Jai Prakash Nath & co, 25th Edition, 2005
3. Gaur R.K and Gupta S.L,'Engineering Physics', Dhanpat Rai Publishers,2009

Reference Books:

1. Palanisamy P.K,'Engineering Physics', Scitech Publications,2011
2. Rajendran V and Marikani A, 'Engineering Physics', PHI learning PVT, India, 2009

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	0	3	3	1	2	0	1	0	0	3	2	0	2
CO2	3	3	0	2	2	1	0	0	1	0	0	3	2	0	2
CO3	2	3	0	2	3	1	1	0	1	0	0	3	1	0	2
CO4	3	2	0	2	3	1	1	0	1	0	0	2	2	0	1
CO5	3	3	0	2	3	1	1	0	1	0	0	3	2	0	2

1- Faintly
2- Moderately
3- Strongly

18MA204 **FOURIER SERIES AND TRANSFORMS**

L	T	P	C
3	1	0	4

Course Objectives:

1. To impact analytical skills in the areas of boundary value problems and transform techniques.
2. To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
3. To familiarize with Fourier transform of a function and its sine and cosine transforms.
4. It serves as a prerequisite for post graduate and specialized studies and research.
5. To gain the skills to form difference equations and find its solution by using Z-transform method.

UNIT I FOURIER SERIES **9 + 3**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity – Harmonic Analysis.

UNIT II BOUNDARY VALUE PROBLEMS **9 + 3**

Classification of second order quasi linear partial differential equations – Solutions of one dimensional wave equation – One dimensional heat equation – Steady state solution of two-dimensional heat equation (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

UNIT III LAPLACE TRANSFORM **9 + 3**

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- solutions of linear ODE of second order with constant coefficient's using Laplace transformation techniques- statement and application of convolution theorem

UNIT IV FOURIER TRANSFORM **9 + 3**

Statement of Fourier integral theorem – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem - Parseval's Identity

UNIT V Z -TRANSFORM AND DIFFERENCE EQUATIONS **9 + 3**

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem -Formation of difference equations – Solution of difference equations using Z – transform technique.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : acquire the knowledge about fourier series
CO2 : learn the techniques of solving boundary value problems
CO3 : familiar with the transform techniques.

Text Books:

1. Veerarajan T, "Engineering Mathematics (For Semester III)", 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2. P.Kandasamy, K.Thilagavathy and K.Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company ltd., New Delhi, 1996.

Reference Books:

1. Grewal, B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
2. Wylie C. Ray and Barrett Louis, C., "Advanced Engineering Mathematics", Sixth Edition, McGraw-Hill, Inc., New York, 1995.
3. Andrews, L.A., and Shivamoggi B.K., "Integral Transforms for Engineers and Applied Mathematicians", MacMillan, New York, 1988.

4. Narayanan, S., Manicavachagom Pillai, T.K. and Ramaniah, G., “Advanced Mathematics for Engineering Students”, Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1

1- Faintly
2- Moderately
3- Strongly

18ME301	MANUFACTURING PROCESSES	L	T	P	C
		2	1	0	3

Course Objectives:

1. To make the students to familiarise with various manufacturing processes such as casting, welding, machining, metal forming, power metallurgy etc. involved in manufacturing of piston, connecting rod, crankshaft, engine block, front axle, frame, body, etc.

UNIT I CASTING **9 + 0**

Casting types, procedure to make sand mould, types of core making, moulding tools, machine moulding, special moulding processes – CO_2 moulding; shell moulding, investment moulding, permanent mould casting, pressure die casting, centrifugal casting, continuous casting, casting defects.

UNIT II WELDING **8 + 0**

Classification of welding processes. Principles of Oxy-acetylene gas welding. A.C metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, soldering and brazing.

UNIT III MACHINING **10 + 0**

General principles (with schematic diagrams only) of working and commonly performed operations in the following machines: Lathe, Shaper, Planer, Horizontal milling machine, Universal drilling machine, Cylindrical grinding machine, Capstan and Turret lathe. General principles and applications of the following processes: Abrasive jet machining, Ultrasonic machining, Electric discharge machining, Electro chemical machining.

UNIT IV FORMING AND SHAPING OF PLASTICS **9 + 0**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V METAL FORMING AND POWDER METALLURGY **9 + 0**

Principles and applications of the following processes: Forging, Rolling, Extrusion, Wire drawing and Spinning, Powder metallurgy – Principal steps involved advantages, disadvantages and limitations of powder metallurgy.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand various casting and moulding processes.
CO2 : familiar with welding processes
CO3 : able to learn various types of machining processes.
CO4 : gained knowledge about forming and shaping of plastics.
CO5 : understand various forming processes and principles of powder metallurgy.

Text Books:

1. Hajra Choudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2. NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1. SeropeKalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials",4/e, Pearson Education, Inc. 2007.
2. Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3. "H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.

4. Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	0	1	0	0	0	0	0	0	0	0	2	0	1
CO2	0	1	0	0	0	0	0	0	1	0	0	0	0	0	3
CO3	0	1	0	0	0	0	1	0	0	0	1	0	0	1	1
CO4	0	1	0	0	0	0	0	0	2	0	0	0	0	0	1
CO5	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1

1- Faintly
2- Moderately
3- Strongly

18ME302 **ENGINEERING MECHANICS**

L	T	P	C
3	0	0	3

Course Objectives:

1. To develop capacity to predict the effect of force and motion in the course of carrying out the design functions of engineering.
2. To analyze the force systems, friction and to study the dynamics of particles, impulse and momentum.

UNIT I STATICS OF PARTICLES **9 + 0**

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and triangular Law of forces – Vectorial representation of forces – Vector operations of forces -additions, subtraction, dot product, cross product – Coplanar Forces – rectangular components – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility .

UNIT II EQUILIBRIUM OF RIGID BODIES **9 + 0**

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

UNIT III PROPERTIES OF SURFACES AND SOLIDS **9 + 0**

Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its applications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections.

UNIT IV FRICTION **9 + 0**

Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack.

UNIT V KINETICS OF PARTICLES AND RIGID BODIES **9 + 0**

Equations of motion- Rectilinear motion-curvilinear motion- Relative motion- D'Alembert's Principle-work-Energy equation-Conservative forces and principle of conservation of energy-Impulse- momentum- Impact- Direct central impact and oblique central impact. Plane motion- Absolute motion- Relative motion- work and energy- impulse and momentum

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : illustrate the vectorial and scalar representation of forces and moments
CO2 : draw free body diagrams and write appropriate equilibrium equations firm free body diagram.
CO3 : evaluate the properties of surfaces and solids
CO4 : analyze the systems that involve frictional forces.
CO5 : apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems

Text Books:

1. A Textbook of Engineering Mechanics, R.K. Bansal, Laxmi Publications, 2010.
2. Engineering Mechanics, R.S. Khurmi, S.Chand Publishing, 2010.

Reference Books:

1. Engineering Mechanics, D.S. Bedi, Khanna Book Publishing Co. (P) Ltd.
2. Rajasekaran S and Sankarasubramanian G., "Fundamentals of Engineering Mechanics", Vikas Publishing House Pvt. Ltd., 2000
3. Palanichamy M.S. and Nagam S., "Engineering Mechanics – Statics & Dynamics", Tata McGraw-Hill, 2001
4. Engineering Mechanics, DP Sharma, Pearson

5. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, Vol II, - Dynamics, 9th Ed, Tata McGraw Hill, 2011.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	0	0	0	0	0	0	0	0	0	0	1	1	0
CO2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO4	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
CO5	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0

1- Faintly
2- Moderately
3- Strongly

18ME303 **THERMODYNAMICS**

L	T	P	C
3	1	0	4

(Use of standard thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables are permitted)

Course Objectives:

1. To understand the fundamentals of thermodynamics such as zeroth, first and second law concept.
2. To understand real and ideal gas behavior and thermodynamic relations.
3. To impart basic knowledge on psychrometry.

UNIT I BASIC CONCEPT AND FIRST LAW 9 + 3

Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems - closed, open and isolated. Property, state, path and process, quasi-static process, work, modes of work, Zeroth law of thermodynamics – concept of temperature and heat. Concept of ideal and real gases. First law of thermodynamics – application to closed and open systems, internal energy, specific heat capacities, enthalpy, steady flow process with reference to various thermal equipments.

UNIT II SECOND LAW, ENTROPY AND AVAILABILITY 9 + 3

Second law of thermodynamics – Kelvin's and Clausius statements of second law. Reversibility and irreversibility. Carnot cycle reversed Carnot cycle, efficiency, COP. Thermodynamic temperature scale, Clausius inequality, concept of entropy, entropy of ideal gas, and principle of increase of entropy – Carnot theorem, absolute entropy, and availability.

UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE 9 + 3

Properties of pure substances – Thermodynamic properties of pure substances in solid, liquid and vapour phases, phase rule, P-V, P-T, T-V, T-S, H-S diagrams, PVT surfaces, thermodynamic properties of steam. Calculations of work done and heat transfer in non-flow and flow processes. Standard Rankine cycle, Reheat and regenerative cycle.

UNIT IV IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS 9 + 3

Gas mixtures – Properties of ideal and real gases, equation of state, Avogadro's law, Vander Waal's equation of states, compressibility, and compressibility chart. Dalton's law of partial pressure, Exact differentials, Tds, relations, Maxwell relations, Clausius Clapeyron equations, Joule Thomson Coefficient.

UNIT V PSYCHROMETRY 9 + 3

Psychrometry and psychrometric charts, property calculations of air vapour mixtures. Psychrometric process - Sensible heat exchange processes. Latent heat exchange processes. Adiabatic mixing, evaporative cooling, problems.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : understand the concepts of zeroth, first and second law of thermodynamics.
CO2 : analyze the various work and heat interactions for different types of processes for closed and open systems.
CO3 : understand the properties of pure substance and concepts of rankine cycle.
CO4 : derive thermodynamic relations for ideal and real gases.
CO5 : understand the basic concepts of Psychrometry.

Text Books:

1. Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 1998.
2. Holman. J.P, "Thermodynamics", 3rd Ed. McGraw-Hill, 1995.
3. Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4. Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:

1. Cengel, "Thermodynamics- An Engineering Approach", 3rd Edition, Tata McGraw Hill,2003.
2. Merala C, Pother, Craig W and Somerton, "Thermodynamics for Engineers", Schaum Outline Series, Tata McGrawHill, New Delhi, 2004.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	3	1	2	1	1	1	0	0	0	0	0	1	2	1
CO2	2	1	1	2	3	1	1	0	0	0	0	0	1	3	1
CO3	2	1	3	1	2	1	1	0	0	0	0	0	2	1	3
CO4	1	2	2	1	3	1	1	0	0	0	0	0	2	1	2
CO5	1	2	1	3	1	2	1	0	0	0	0	0	1	2	1

1- Faintly
2- Moderately
3- Strongly

18EC308	BASIC ELECTRONICS ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the basics of electronic components and circuits.
2. To introduce the concepts of digital electronics and integrated circuits.

Unit I SEMICONDUCTOR DIODES AND APPLICATIONS **9 + 0**

Introduction to Resistors, Inductors, Capacitors and their colour codes, Semi-conductors, Characteristics of PN Junction Diode – Zener Effect – Zener Diode and its Characteristics, Photodiodes, LEDs. Half-wave rectifier, Full-wave rectifier, Full-wave rectifier with capacitor filter.

Unit II BIPOLAR JUNCTION TRANSISTOR **9 + 0**

Bipolar junction transistor – CB, CE, CC configurations and characteristics, CE amplifier, Concept of feedback, Negative feedback, voltage series feedback amplifier, Current series feedback amplifier.

Unit II DIGITAL ELECTRONICS **9 + 0**

Binary Number System, Logic gates: Basic gates and universal gates, Combinational logic circuit: Half adder, Full adder. Flip-Flops: SR, JK, D and T flip-flops.

Unit IV INTEGRATED CIRCUITS **9 + 0**

Introduction to Operational Amplifiers. Ideal OPAMP, Inverting and Non Inverting OPAMP circuits, OPAMP applications: voltage follower, addition, subtraction, integrator and differentiator. Digital to Analog converters – R-2R and weighted resistor types, Analog to Digital converters – Successive approximation and Flash types.

Unit V FUNDAMENTALS OF COMMUNICATION ENGINEERING **9 + 0**

Types of Signals: Analog and Digital Signals – Principle of Amplitude and Frequency Modulations. Communication Systems: Radio, TV, Microwave, Satellite and Optical Fibre. (Block Diagram Approach only).

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : to understand the concepts of electronic components and circuits.
CO2 : to understand the concepts of digital electronics.
CO3 : gain knowledge of integrated circuits.
CO4 : to understand the fundamentals concepts of communication engineering.

Text Books:

1. David A. Bell, “Electronic Devices and Circuits”, Oxford University Press, 5th Edition, 2008.
2. R.S. Sedha, “Applied Electronics” S. Chand & Co., 2006.

Reference Books:

1. D.P. Kothari, I. J. Nagrath, “Basic Electronics”, McGraw Hill Education (India) Private Limited, 2014.
2. Robert Boylestad and Louis Nashelsky, ―Electron Devices and Circuit Theory‖ Pearson Prentice Hall, 10th edition, July 2008.
3. Yang, ―Fundamentals of Semiconductor devices‖, McGraw Hill International Edition, 1978.
4. Mehta V K, “Principles of Electronics”, S.Chand & Company Ltd, (1994).

E-References:

1. https://www.elprocus.com/basic-electronic-books/
2. https://www.mheducation.co.in/engineering/electronics-engineering/basic-electronics

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	0	2	0	0	0	0	1	0	0	0	2	0	0
CO2	3	1	0	2	0	0	0	0	1	0	0	0	2	0	0
CO3	3	2	1	2	0	0	0	0	1	0	0	0	2	0	0
CO4	3	2	1	2	0	0	0	0	1	0	0	0	2	0	2

1- Faintly
2- Moderately
3- Strongly

18ME304 MANUFACTURING TECHNOLOGY LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

1. Study of different types of machine tools like lathe, drilling machine, shaper, grinding machine etc.,

EXPERIMENTS:

1. Eccentric turning
2. Multi starts thread cutting
3. Drilling and grooving
4. Counter boring
5. Counter sinking
6. Shaping the sides of a cubical blank
7. Groove cutting and V-cutting
8. Dovetail cutting
9. T -slot cutting
10. Spur gear cutting in milling machine
11. Helical Gear Cutting in milling machine
12. Contour milling using vertical milling machine
13. Surface Grinding of cubical block
14. Cylindrical Grinding of circular shaft

Total = 45 Periods

Course Outcomes:

After the successful completion of the practical session, the students will be able to:

CO1 : Acquire necessary skills to operate different machineries.

CO2 : Perform machining time calculation in machining jobs.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	0	2	3	0	0	1	0	0	0	2	2	2	1
CO2	3	2	3	2	0	0	0	1	0	0	0	0	1	1	2

1- Faintly
2- Moderately
3- Strongly

18EC309 **ELECTRONICS LABORATORY**

L	T	P	C
0	0	2	1

Course Objectives:

1. To understand the working of Semiconductor diodes and rectifiers.
2. To understand the Basics of digital electronics.
3. To understand the applications of Operational Amplifier.

EXPERIMENTS

1. Characteristics of PN Junction Diode
2. Characteristics of Zener Diode
3. Characteristics of Photodiode/LED
4. Half-Wave Rectifier and Full-Wave Rectifier
5. Full-Wave Rectifier with C Filter
6. Characteristics of CE Configuration of BJT
7. Study of Logic Gates (Basic gates, Universal gates)
8. Implementation of Half Adder
9. Implementation of Full Adder
10. Realization of JK, D and T Flip flops using NAND Gates
11. Inverting and Non inverting Operational amplifier
12. Operational amplifier applications (Any two)

Total = 30 Periods

Course Outcomes:

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

CO1 : study experimentally the characteristics of diodes, bjt.
CO2 : demonstrate functional verification of combinational logic circuits
CO3 : to demonstrate various applications of operational amplifier

Reference Books:

1. *Analog Electronic circuits Laboratory Manual. 2. David A. Bell, "Electronic Devices and Circuits",* 5thEdition, Oxford University Press,
2. B.Sasikala, S.Poornachandra Rao, "Handbook of experiments in Electronics and Communication Engineering", Vikas Publishing, 2007.
3. "David A Bell, "Laboratory Manual for Electronic Devices and Circuits", 4th edition, PHI, 2001.

E-References:

1. http://nptel.ac.in/courses/117105080/40
2. http://nptel.ac.in/courses/117108038/1

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	0	3	1	0	0	0	2	0	0	2	1	0	0
CO2	3	2	0	3	1	0	0	0	2	0	0	2	1	0	0
CO3	3	1	0	3	1	0	0	0	2	0	0	2	1	0	0

1- Faintly
2- Moderately
3- Strongly

SEMESTER IV

18ME401 **KINEMATICS OF MACHINERY**

L	T	P	C
3	1	0	4

Course Objectives:

1. To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
2. To understand the motion resulting from a specified set of linkages, design few linkage mechanisms and cam mechanisms for specified output motions.
3. To understand the basic concepts of toothed gearing and kinematics of gear trains and the effects of friction in motion transmission and in machine components.

UNIT I BASICS OF MECHANISMS **9 + 3**

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider crank chains-Limit positions- Mechanical advantage-Transmission angle- Description of some common mechanisms- Quick return mechanism, straight line generators- Universal Joint- Rocker Mechanisms.

UNIT II KINEMATIC ANALYSIS **9 + 3**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations- kinematic analysis of simple mechanisms- slider crank mechanism dynamics- Coincident points- Coriolis component of acceleration-introduction to linkage synthesis three Position graphical synthesis for motion and path generation.

UNIT III KINEMATICS OF CAM **9 + 3**

Classification of cams and followers- Terminology and definitions- Displacement diagrams-Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams- circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical and analytical disc cam profile synthesis for roller and flat face Followers.

UNIT IV GEARS AND GEARTRAINS **9 + 3**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V FRICTION IN MACHINE ELEMENTS **9 + 3**

Surface contacts- sliding and rolling friction- friction drives- bearings and lubrication friction Clutches- belt and rope drives- friction in brakes.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : demonstrate and understanding of the concepts of various mechanisms and pairs.
CO2 : synthesize simple mechanisms for function, path generation and motion generation.
CO3 : develop CAM profiles
CO4 : analyze gears and gear trains
CO5 : examine friction in machine elements

Text Books:

1. Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2. Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:

1. Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2. Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.
3. Erdman AG and Sandor G N, "Mechanism Design, Analysis and Synthesis", Vol.I, PHI Inc., 1997.

4. Ambekar A.G, “Mechanism and Machine Theory” Prentice Hall of India, New Delhi, 2007.
5. John Hannah and Stephens R C, “Mechanisms of Machines”, Viva Low Price Student Edition, New Delhi, 1999.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	1	0	0	0	0	0	0	0	3	2	0
CO2	2	2	1	1	1	0	0	0	0	0	0	0	3	2	0
CO3	3	2	2	1	1	0	0	0	0	0	0	0	2	2	0
CO4	3	2	2	2	1	0	0	0	0	0	0	0	3	2	0
CO5	2	1	2	1	1	0	0	0	0	0	0	0	2	3	0

1- Faintly
2- Moderately
3- Strongly

18ME402	**APPLIED THERMODYNAMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

(Use of standard thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables are permitted in the examination)

Course Objectives:

1. To integrate the concepts, laws and methodologies from the first course in thermodynamics into analysis of cyclic processes
2. To apply the thermodynamic concepts into various thermal application like IC engines, Steam Turbines, Compressors and Refrigeration and Air conditioning systems

UNIT I GAS POWER CYCLES **9 + 0**

Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure and air standard efficiency, Actual and theoretical PV diagram of Four stroke engines, Actual and theoretical PV diagram of two stroke engines.

UNIT II INTERNAL COMBUSTION ENGINES **9 + 0**

Classification of IC engine, IC engine components and functions. Valve timing diagram and port timing diagram. Comparison of two stroke and four stroke engines. Fuel supply systems, Ignition Systems, Performance calculation. Comparison of petrol and diesel engine. Fuels, Air-fuel ratio calculation, Knocking and Detonation. Lubrication system and cooling system. Exhaust gas analysis, pollution control norms.

UNIT III STEAM NOZZLES AND TURBINES **9 + 0**

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow. Impulse and reaction principles, compounding, velocity diagrams for simple and multistage turbines, speed regulations-governors and nozzle governors.

UNIT IV AIR COMPRESSOR **9 + 0**

Classification and working principle, work of compression with and without clearance. Volumetric efficiency, Isothermal efficiency and isentropic efficiency of reciprocating air compressors. Multistage air compressor and inter cooling – work of multistage air compressor, various types of compressors (Descriptive treatment only).

UNIT V REFRIGERATION AND AIR-CONDITIONING **9 + 0**

Vapour compression Refrigeration cycle – super heat, sub cooling, performance calculations. Working principle of vapour absorption system. Ammonia – water, Lithium bromide – water systems (Description only), Comparison between vapour compression and absorption systems. Psychrometry, Psychometric chart, Cooling load calculations. Concept of RSHF, GSHF, ESHF, Air conditioning systems.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : analyze the air standard cycles of internal combustion engines based on otto, diesel and dual cycles.

CO2 : get an insight of various components of internal combustion engines.
CO3 : apply thermodynamic concepts in steam nozzles and turbines
CO4 : get an insight of various types of air compressors.
CO5 : design refrigeration and air conditioning system for applications.

Text Books:

1. Rajput, R.K, “Thermal Engineering”, S. Chand Publishers, 2000.
2. Rudramoorthy, R, “Thermal Engineering”, Tata McGraw Hill, New Delhi, 2003.
3. Kothandaraman, C.P., Domkundwar,S. and Domkundwar , A.V, “A course in Thermal Engineering”, Dhanpat Rai and Sons, 5th Edition, 2002.
4. Sarkar B.K, “Thermal Engineering”, Tata McGraw Hill, 1998

Reference Books:

1. Holman. J.P., “Thermodynamics”, McGraw Hill, 1985.
2. Arora.C.P, “Refrigeration and Air Conditioning”, TMH, 1994.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	0	0	0	0	0	0	0	0	0	0	3	1	1
CO2	3	3	2	3	0	0	0	0	0	0	0	0	3	2	1
CO3	3	2	3	1	0	2	0	0	0	0	0	0	3	2	1
CO4	3	2	2	2	0	0	0	0	0	0	0	0	3	2	1
CO5	3	0	0	0	0	1	0	0	0	0	0	0	3	3	1

1- Faintly
2- Moderately
3- Strongly

18ME403 **FLUID MECHANICS AND MACHINERY**

L	T	P	C
3	1	0	4

Course Objectives:

1. To study the basics of fluid properties.
2. To study the kinematics and dynamics concept of the fluid flow.
3. To study the working and performance of turbine and pump.

UNIT I INTRODUCTION **9 + 3**

Definitions and units of measurement of physical quantities. Behavior of fluids - density, relative density, bulk modulus of elasticity, vapour pressure, surface tension, capillarity and viscosity. Fluid Statics: Concept of Hydrostatic Pressure, Manometers. Buoyancy and Archimedes' principle.

UNIT II FLUID KINEMATICS **9 + 3**

Classification of fluid flows, streamline, streak line, path line, stream function, velocity potential function, vorticity and circulation, flow net. Continuity equation and applications. Fluid Dynamics: Bernoulli's equation and its applications. Dimensional Analysis: Buckingham Π theorem, similarity laws and models.

UNIT III INCOMPRESSIBLE FLUID FLOW **9 + 3**

Viscous flow – Navier-Stokes equation. Shear stress, pressure gradient relationship. Laminar flow through circular pipes, Laminar flow between parallel plates. Turbulent flow through pipes. Friction factors in turbulent flow. Moody's friction factor chart. Flow through Pipes Series and Parallel pipes, Power transmission. Boundary Layer flows Boundary layer thickness, Boundary layer separation, Drag and Lift coefficients.

UNIT IV HYDRAULIC TURBINES **9 + 3**

Fluid Machines classification, Euler's equation for turbo machines. Working principles, velocity triangles, work done, specific speed, efficiency and performance curves of Pelton, Francis and Kaplan turbines.

UNIT V HYDRAULIC PUMPS **9 + 3**

Classification of pumps. Centrifugal pumps - working principle, velocity triangle, specific speed, efficiency and performance curves. Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps. Working principles of gear and vane pumps.

Total (45+15) = 60 Periods

Course Outcomes:

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

CO1 : understand the fundamental concepts of fluid mechanics
CO2 : apply the bernoulli equation to solve problems in fluid mechanics.
CO3 : understand the concepts of viscous flow and also have a knowledge in boundary layer concept.
CO4 : apply the principles of fluid mechanics to the design and operation of hydraulic pumps and turbines.

Text Books:

1. Bansal, R.K., "Fluid Mechanics and Hydraulic Machines", Laxmi Publication Pvt Ltd, 2007.
2. Kumar, D.S., "Fluid Mechanics and Fluid Power Engineering", S.K.Kataria Sons, 2009.
3. Subramanya, K., "Fluid Mechanics", Tata McGraw Hill publishing company Ltd, 2007.
4. Rajput, R.K., "Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2002.

Reference Books:

1. Streeter, V.L and Wyile, E.B., "Fluid Mechanics", Mc-Graw-Hill, 1999.
2. Som, S.K and Biswas, G, "Introduction to Fluid Mechanics and Fluid Machines", Tata McGraw Hill publishing company Ltd., New Delhi, 1998.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	0	0	0	0	0	1	0	0	0	0	2	2	1
CO2	2	3	0	1	0	0	0	1	0	0	0	0	3	2	1
CO3	3	1	0	1	0	0	0	0	0	0	0	1	2	2	1
CO4	2	2	3	3	0	0	0	1	0	0	0	0	2	3	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

18ME404 STRENGTH OF MATERIALS

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
2. To calculate the elastic deformation occurring in various simple geometries for different types of loading

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9 + 0

Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses-elastic constants and their relations- volumetric, linear and shear strains- principal stresses andprincipal planes- Mohr's circle. Deformation of simple compound bars-Relation between elastic constants-Thermal stresses.

UNIT II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAMS 9 + 0

Beams and types transverse loading on beams- shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads. Shear stress distribution of simple beams- circular, rectangular, "I" section, "T" section and channel sections.

UNIT III DEFLECTION OF BEAMS AND COLUMNS 9 + 0

Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Macaulay's method – Area moment method - Conjugate beam and strain energy – Maxwell's reciprocal theorems. Columns: End conditions-Equivalent length of a column-Euler's equation-Slenderness ratio-Rankine's formula for columns.

UNIT IV THIN CYLINDERS, SPHERES AND THICK CYLINDERS 9 + 0

Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure – Lame's theorem.

UNIT V TORSION AND SPRINGS 9 + 0

Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends. Torsion on springs-Wahl's factor of spring-Stresses in helical springs under torsion loads-Stiffness and deflection of springs under axial load.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand the concepts of stress and strain in simple and compound bars, the importance of principal stresses and principal planes
CO2 : understand the load transferring mechanism in beams and stress distribution due to shearing force and bending moment
CO3 : calculate the slope and deflection in beams using different methods.
CO4 : analyze and design thin and thick shells for the applied internal and external pressures.
CO5 : apply basic equation of simple torsion in designing of shafts and helical spring

Text Books:

1. Rajput, R.K, "Strength of Materials", S.Chand and Co, 3rd Edition, 2003.
2. Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2016.

Reference Books:

1. Strength of Materials, D.S. Bedi, Khanna Publishing House
2. Subramanian R., "Strength of Materials", Oxford University Press, Oxford Higher Education Series, 2010.
3. Mechanics of Materials, Punmia, Jain and Jain, Laxmi Publications
4. Strength of Materials (Mechanics of Solid), R.S. Khurmi, S.Chand Publications
5. Strength of Materials, Jindal U.C., Asian Books Pvt. Ltd., New Delhi, 2009

CO/PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
CO2	2	2	1	1	0	0	0	0	0	0	0	0	1	2	0
CO3	3	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO4	3	2	2	2	0	0	0	0	0	0	0	0	2	0	1
CO5	2	2	2	2	0	0	0	0	0	0	0	0	2	0	1

1- Faintly
2- Moderately
3- Strongly

18ME405	MATERIALS ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2. To learn basic principles in metallurgy and materials engineering.
3. To identity and select suitable engineering materials based on their applications

UNIT I FERROUS AND NON FERROUS METALS 9 + 0

Constitution of alloys – Solid solutions, substitution and interstitial – phase diagrams, Isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions, Iron – Iron carbide equilibrium diagram. Classification of steel and cast Iron microstructure, properties and application. Effect of alloying additions on steel (Mn, Si, Cr, Mo, V Tiand W) - stainless and tool steels – HSLA - maraging steels – Gray, White, Malleable, spheroid - Graphite - alloy cast irons , Copper alloys – Brass, Bronze and Cupronickel , Aluminium alloys, Bearing alloys.

UNIT II HEAT TREATMENT 9 + 0

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation and age hardening .Heat treatment of HSS tools, gears, springs and gauges.

UNIT III NON-METALLIC MATERIALS 9 + 0

Engineering Ceramics – Properties and applications of Al2O3, SiC, SiC, Si3, N4, PSZ Fracture and Defects of ceramics - Ceramic coating methods: Plasma spraying - APS and VPS, process principles, component preparation, deposition rates, coating materials. Chemical vapour deposition - deposition rates, carbon control of the substrate, industrial CVD, typical procedures, advantages and disadvantages, use of CVD coatings in metal cutting, wear mechanisms.– Fibre and particulate reinforced composites.

UNIT IV MECHANICAL PROPERTIES AND TESTING 9 + 0

Mechanical properties of engineering materials - Mechanisms of plastic deformation, slip and twinning – Creep, Fatigue and Fracture - Types of fracture – Testing of materials - tension, compression and shear loads - fatigue and creep tests – hardness and its effects – testing for hardness (Brinell, Vickers and Rockwell) - Impact test - Izod and Charpy.

UNIT V NON DESTRUCTIVE TESTING AND SURFACE ENGINEERING 9 + 0

Non Destructive Testing: Non Destructive Testing basic principles and testing method for radiographic Testing, Ultrasonic testing, Magnetic Particle Inspection and Liquid Penetrant Inspections Introduction to surface engineering Definition of surface engineering, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand the formation of materials and their classification based on atomic structure.

CO2 : describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry.

CO3 : understand the principles of various heat treatment processes in fabrication industry.

CO4 : describe various types of failure and select suitable techniques for failure analysis.

Text Books:

1. Kenneth G. Budinski and Michael K. Buinski, “Engineering Materials”, Prentice Hall of India Ltd, 2002.
2. Raghavan, V, “Materials Science and Engineering”, Prentice Hall of India (P) Ltd., 1999.
3. Aswani.K.G, “A Text Book of Material Science”, S.Chand and Co. Ltd., New Delhi, 2001.

4. Khanna O.P., “A Text Book of Materials Science and Metallurgy”, Dhanpat Rai Sons, 2004.

Reference Books:

1. William. D.Callsber, “Material Science and Engineering”, John Wiley and Sons, 1997.
2. Sydney.H.Avner, “Introduction to Physical Metallurgy” Mc Graw Hill Book Company, 1994.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	2	2	1	1	1	0	0	0	0	0	2	3	1
CO2	1	0	2	1	1	2	1	0	0	0	0	0	2	3	1
CO3	0	1	1	1	1	0	1	0	0	0	0	0	3	2	1
CO4	0	2	2	1	1	1	1	0	0	0	0	0	2	3	1

1- Faintly
2- Moderately
3- Strongly

18CYMC01 **ENVIRONMENTAL SCIENCE**

L	T	P	C
0	0	1	0

AIM

To impart awareness to the student that they are separate from the environment and should not control the environment.

Course Objectives:

1. They are part of the environment
2. To have an ancient wisdom drawn from Vedas
3. Activities based knowledge to preserve environment
4. Conservation of water and its optimization.

Curriculum

Environmental Awareness **6**

1. Group activity on water management
2. Group discussion on recycle of waste (4R's)
3. Slogan making contest.
4. Poster making event.
5. Expert lecture on environmental awareness.
6. Imparting knowledge on reduction of electricity usage

Environmental activities **8**

1. Identification and segregation of biodegradable and non-biodegradable waste
2. Campus cleaning activity
3. Plantation of trees in the college campus and local waste lands.
4. Identification of varieties of plants and their usage
5. Shutting down the fans and ACs of the campus for an hour
6. Field work on growing of kitchen garden for mess.

Total = 14 Periods

18ME406 **STRENGTH OF MATERIALS AND FLUID MECHANICS LABORATORY**

L	T	P	C
0	0	3	1.5

Course Objectives:

1. To analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.
2. To utilize appropriate materials in design considering engineering properties and sustainability.

STRENGTH OF MATERIAL LABORATORY EXERCISES

1. Double shear test on mild steel rod
2. Uniaxial tension test on mild steel rod
3. Torsion test on mild steel rod
4. Impact test on a metallic specimen
5. Brinell and Rockwell hardness tests on metallic specimen
6. Bending deflection test on beams

FLUID MECHANICS LABORATORY EXERCISES

1. Determination of friction factor of pipes
2. Performance characteristics of Kaplan turbine
3. Determination of the Coefficient of discharge of given Orifice meter
4. Determination of the Coefficient of discharge of given Mouthpiece
5. Determination of the Coefficient of discharge of given Venturi meter
6. Conducting experiments and drawing the characteristic curves of centrifugal pump
7. Conducting experiments and drawing the characteristic curves of reciprocating pump.

Total = 45 Periods

Course Outcomes:

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

CO1 : learn the various techniques of testing methods for materials.
CO2 : perform test and identify the different characteristics of materials.
CO3 : perform experiments on hydraulic machines to draw the performance characteristics.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	2	0	1	0	0	0	0	0	0	0	2	2	1
CO2	2	3	2	1	1	0	0	0	0	0	0	0	2	2	1
CO3	3	2	2	1	1	0	0	0	0	0	0	0	2	2	1

1- Faintly
2- Moderately
3- Strongly

18ME407 **THERMAL ENGINEERING LABORATORY** **L T P C**

0 0 3 1.5

Course Objectives:

1. To study the value timing-V diagram and performance of IC Engines
2. To Study the characteristics of fuels/Lubricates used in IC Engines

EXPERIMENTS:

1. Study of I.C. Engines, Components and Loading Devices
2. Study of Steam Generators and Turbines.
3. Valve Timing and Port Timing Diagrams.
4. Performance Test on 4-stroke Diesel Engine.
5. Heat Balance Test on 4-stroke Diesel Engine.
6. Morse Test on Multi cylinder Diesel Engine.
7. Retardation Test to find Frictional Power of a Diesel Engine.
8. Determination of Viscosity - Red Wood Viscometer.
9. Determination of Flash Point and Fire Point.

Total = 45 Periods

Course Outcomes:

After the successful completion of the practical session, the students will be able to:

CO1 : apply thermodynamic theory to real thermodynamic cycles

CO2 : understand the knowledge on testing the properties of fuels and lubricating oils

CO3 : demonstrate the performance of internal combustion engines

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	3	1	1	0	0	0	0	0	1	1	2
CO2	1	2	1	1	1	2	1	0	0	0	0	0	2	1	1
CO3	2	1	3	1	1	2	1	0	0	0	0	0	3	1	3

1- Faintly
2- Moderately
3- Strongly

SEMESTER V

18ME501 **HEAT AND MASS TRANSFER**

L	T	P	C
3	1	0	4

Course Objectives:

1. Understand the mechanisms of heat transfer under steady and transient conditions
2. Understand the concepts of heat transfer through extended surfaces.
3. Learn the thermal analysis and sizing of heat exchangers and to understand the basic concepts of mass transfer

UNIT I CONDUCTION **9 + 3**

Basic concepts, Mechanism of heat transfer, Fourier's law of conduction, general differential equation of heat conduction- Cartesian and cylindrical coordinates, one dimensional steady state heat conduction, conduction through plane wall, cylinders and spheres, composite geometries, contact resistance, conduction with heat generation, extended surface heat transfer, unsteady state heat conduction, lumped analysis and use of Heisler charts.

UNIT II CONVECTIVE HEAT TRANSFER **9 + 3**

Dimensional analysis, boundary layer concept, basic governing equations, external flow-flow over plates, cylinders and spheres, internal flow- laminar and turbulent flow, combined laminar and turbulent flow, flow over bank of tubes, free convection-flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS **9 + 3**

Modes of boiling, Nusselt theory of condensation, correlations in boiling and condensation, types of heat exchangers, methods of analysis, LMTD and NTU method, overall heat transfer coefficient, fouling factors.

UNIT IV RADIATION **9 + 3**

Basic laws of radiation, view factor algebra, black body radiation, grey body radiation, radiation shields, electrical analogy using radiosity and irradiation, gaseous emission and absorption.

UNIT V MASS TRANSFER **9 + 3**

Basic concepts, Diffusion mass transfer-Fick's Law of diffusion, steady state molecular diffusion, convective mass transfer.

Total (45+15)= 60 Periods

Course Outcomes:

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

CO1 : analyze the basic concept of conduction, convection and radiation.
CO2 : analyze the extended surfaces and evaluate performance parameters
CO3 : design and analyze the performance of heat exchangers by using the method of LMTD and NTU
CO4 : understand the fundamental relationship between heat transfer and mass transfer.

Text Books:

1. Holman J.P, “Heat and Mass Transfer”, Tata McGraw Hill, 2000.
2. Sachdeva, R.C, “Fundamentals of Engineering Heat and Mass Transfer”, New Age International Publishers, New Delhi, 1995.
3. Bejan, A, “Heat Transfer”, John Wiley and Sons, 1995.
4. Ozisik, M.N, “Heat Transfer”, McGraw Hill Book Co., 1994.

Reference Books:

1. Yadav, R, “Heat and Mass Transfer”, Central Publishing House, Allahabad, 1995.
2. C.P.Kothandaraman,“Fundamentals of Heat and Mass Transfer”, New Age International Publishers, New Delhi,1998.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	3	3	1	0	1	0	0	0	0	0	3	3	0
CO2	3	3	3	2	2	0	1	0	0	0	0	0	3	3	0
CO3	1	3	3	3	2	0	1	0	0	0	0	0	3	3	0
CO4	2	1	3	1	0	0	0	0	0	0	0	0	3	2	0

1- Faintly
2- Moderately
3- Strongly

18ME502 **INSTRUMENTATION AND CONTROL**

L	T	P	C
3	0	0	3

Course Objectives:

1. To make the students aware of the modern sensors and advanced measurement systems
2. To select the correct system of instrumentation and sensing as per the industrial requirements.
3. To understand statistical signal processing
4. To provide adequate knowledge in the time response of systems and steady state error analysis.
5. To introduce stability analysis and design of compensators

UNIT I GENERAL CONCEPTS OF MEASUREMENT **9 + 0**

Measurement systems- Sensors and transducers- Classifications of Transducers -Static and Dynamic Characteristics –Sensors for displacement, position and proximity; velocity, motion, force, fluid pressure, liquid flow, liquid level, temperature, light sensors–Selection of sensors

UNIT II SIGNAL CONDITIONING **9 + 0**

Amplifier characteristics, wheat's stone bridge- Instrumentation sensor – integration and differentiation - sampling, A/D and D/A conversion, choppers, voltage to time conversion, voltage to freq. Conversion concept and methods.

UNIT III DATA ACQUISITION **9 + 0**

Real-time interfacing – Introduction - Elements of data acquisition and control - Overview of I/O process, Digital I/O, counters and timers, DMA, Software and hardware installation, Data acquisition interface requirements,- General configuration-single channel and multichannel data acquisition – Data Logging – Data conversion – Introduction To Digital Transmission system.

UNIT IV Time Response Analysis **9 + 0**

Response of systems for different time based input, Classification of feedback control system according to type; static error coefficients- generalized steady state errors steady state errors due to impulse, step, ramp and parabolic inputs.

UNIT V Frequency Domain Analysis **9 + 0**

Frequency response–Bode plot –Polar plot –Determination of closed loop response, open loop response-Correlation between frequency domain and time domain specifications-Effect of Lag, lead and lag-lead compensation on frequency response-Analysis

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : ability to apply common measurement characteristics and terms to select sensors to meet control and monitoring requirements.

CO2 : ability to design, build and test sensor interface circuits including amplifiers to process the measured variable into a useful signal in the presence of noise and environmental variations.

CO3 : ability to select, design appropriate signal processing to its instrumentation and control and their measurement

CO4 : ability to understand and apply basic science, theory control theory and apply them to control engineering problems.

CO5 : ability to aanalyse the performance of systems and components through the use of analytical techniques

Text Books:

1. John G. Webster, “Measurement, Instrumentation, and Sensors Handbook”, CRC Press. 1999.
2. Murthy, D.V.S., Transducers and Instrumentation, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010

Reference Books:

1. Patranabis, D, “Sensors and Transducers”, Wheeler Publishing Co, Ltd., New Delhi, 1997.
2. M. Gopal, ‘Control Systems, Principles and Design’, 4th Edition, Tata McGraw Hill, New Delhi, 2012
3. K.Ogata, Modern Control Engineering, 4th Edition, Prentice Hall, 2002

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0
CO2	0	0	2	2	0	0	0	0	0	0	0	0	2	0	0
CO3	0	0	0	0	2	0	1	0	0	0	0	1	0	0	1
CO4	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0
CO5	0	0	0	0	0	0	0	1	2	0	0	0	0	0	2

1- Faintly
2- Moderately
3- Strongly

18ME503	METROLOGY AND QUALITY CONTROL	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide knowledge on various Metrological equipments available to measure the dimension of the components
2. To provide knowledge on the correct procedure to be adopted to measure the dimension of the components.

UNIT I BASICS OF MEASUREMENT SYSTEM AND DEVICES 9 + 0

Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalized measurement system - mechanical loading - static characteristics of instruments - factors considered in selection of instruments - commonly used terms, error analysis and classification - sources of error. Principle of interferometry, laser interferometer.

UNIT II CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS 9 + 0

Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000 quality standards. Comparators - mechanical, electrical, optical and pneumatic.

UNIT III GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS 9 + 0

Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor‘s principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors, base pitch measurement.

UNIT IV STATISTICAL QUALITY CONTROL 9 + 0

Surface finish- terminology and measurements - Optical measuring instruments- Acceptance test for machines Statistical Quality Control - Control charts - Sampling plans.

UNIT V SIX SIGMA 9 + 0

Six sigma: define measure, analyse, improve and control phases. Analyse phase tools: Common Tools: Histogram, Box Plot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA, Multivariate analysis.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : upon completion of this course, the students can demonstrate different measurement technologies and use of them in industrial components

CO2 : evaluate quality of job, machine and instruments.

CO3 : perform calibration of measuring instruments

CO4 : differentiate the accuracy of instruments.

Text Books:

1. Gupta.I.C, ―A text book of Engineering Metrology‖, Dhanpat Rai publications, New Delhi, 2007
2. Beckwith.T.G,Roy D. Marangoni, John H. Lienhard, ―Mechanical Measurements‖, Prentice Hall, 2006
3 Jain.R.K, ―Mechanical and Industrial Measurements‖, Khanna Publishers, Delhi, 1999.

Reference Books:

1. Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2004.
2. Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.
3. Alan S Morris, ―Measurement and Instrumentation Principles‖, Butterworth, 2006.
4. De Feo J A and Barnard W W, ―Six Sigma: Break trough and Beyond‖, Tata McGraw-Hill, New Delhi, 2005.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	0	0	0	0	0	0	0	0	1	0	0
CO2	2	1	2	2	1	0	0	0	0	0	0	0	2	0	0
CO3	2	2	1	2	0	0	2	0	0	0	0	0	0	0	0
CO4	2	2	1	1	0	0	0	0	0	0	0	1	0	0	0

1- Faintly
2- Moderately
3- Strongly

18ME504 **DYNAMICS OF MACHINERY**

L	T	P	C
3	0	0	3

Course Objectives:

1. To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work
2. To facilitate students to understand the concept of balancing of rotating and reciprocating masses
3. To teach students concepts of linear vibration analyses of one and two degree-of-freedom rigid body systems
4. To teach students concepts of torsional vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects
5. To teach students about the concept of various types of governors

UNIT I FORCE ANALYSIS **9 + 0**

Rigid Body dynamics in general plane motion – Equations of motion - Dynamic force analysis - Inertia force and Inertia torque – D'Alemberts principle - The principle of superposition - Dynamic Analysis in Reciprocating Engines – Gas Forces - Equivalent masses - Bearing loads - Crank shaft Torque - Turning moment diagrams - Fly wheels –Engine shaking Forces - Cam dynamics - Unbalance, Spring, Surge and Windup.

UNIT II BALANCING **9 + 0**

Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines

UNIT III LONGITUDINAL AND TRANSVERSE VIBRATION **9 + 0**

Basic features of vibratory systems - idealized models - Basic elements and lumping of parameters - Degrees of freedom - Single degree of freedom - Free vibration - Equations of motion - Natural frequency of longitudinal and transverse (Free, Forced) vibrations - Types of Damping - Damped vibration (Free, Forced) - critical speed of simple shaft. Response to periodic forcing - Harmonic Forcing - Forcing caused by unbalance - Support motion – Force transmissibility and amplitude transmissibility – Vibration isolation.

UNIT IV TORSIONAL VIBRATION & VIBRATING MEASUREMENTS **9 + 0**

Torsional systems - Natural frequency of free torsional vibration – Single, two and three rotor systems – Torsionally Equivalent shaft - Introduction to multi-degree-of-freedom systems. Vibration instruments: vibrometer, accelerometer. Vibration Measuring Devices- Vibration exciters - FFT analyzer.

UNIT V GOVERNORS **9 + 0**

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors – Characteristics - Effect of friction - Controlling Force - other Governor mechanisms.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : apply basic principles of mechanisms in mechanical system
CO2 : perform static and dynamic analysis of simple mechanisms
CO3 : perform balancing of rotating and reciprocating masses
CO4 : model and analyse mechanical systems subjected to vibration
CO5 : study the various types of governors and its speed control mechanism

Text Books:

1. Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2. Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi

Reference Books:

1. Ballaney, P.L., "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2. Shigley, J.E. and Uiker, J.J., "Theory of Machines and Mechanisms", TMH ND, 1998.

3. Amithabha Ghosh, and Ashok Kumar Malik., “Theory of Mechanisms and Machines”, 2nd Ed., Affiliated East and West Press Limited, 1998.
4. Prof.Nakara, IIT-Delhi Reference Books

E-References:

1. www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of-machinery-ebook
2. http://nptel.ac.in/courses/112104114/

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	3	3	1	0	0	0	0	0	1	0	3	2	1
CO2	2	2	3	2	1	0	0	0	0	0	1	0	3	2	1
CO3	2	2	3	2	0	0	0	0	0	0	1	0	3	2	1
CO4	2	2	3	2	1	0	0	0	0	0	1	0	3	2	1
CO5	1	2	3	2	0	0	0	0	0	0	1	0	3	2	1

1- Faintly
2- Moderately
3- Strongly

18MC301	INDIAN CONSTITUTION	L	T	P	C
		2	0	0	0

Course Objectives:

1. Learn the salient features of the Indian Constitution.
2. To study the List the Fundamental Rights and Fundamental Duties.
3. To study the Present a systematic analysis of all dimensions of Indian Political System.
4. To study the Understand the power and functions of the Parliament, the Legislature and the Judiciary.

UNIT I

Union and its Territory – Citizenship-Fundamental Rights-Directive Principles of State Policy-Fundamental Duties

UNIT II

The Union-The States-The Union Territories-The Panchayats-The Municipalities

UNIT III

The Co-operative Societies-The scheduled and Tribal Areas-Relations between the Union and the States-Finance, Property, Contracts and Suits-Trade and Commerce within the territory of India

UNIT IV

Services under the Union, the States – Tribunals – Elections- Special Provisions -Relating to certain Classes

UNIT V

Languages-Emergency Provisions – Miscellaneous-Amendment of the Constitution

Total (15+0) = 15 Periods

Course Outcomes:

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

CO1	:	Understand the emergence and evolution of the Indian Constitution
CO2	:	Explain the key concepts of Indian Political System
CO3	:	Describe the role of constitution in a democratic society.
CO4	:	Present the structure and functions of the Central and State Governments, the Legislature and the Judiciary

Reference Books:

1. SubhashC.Kashyap, Our Constitution, National Book Trust, 2017.
2. Durga Das Basu, Introduction to the Constitution of India, Lexis Nexis, 2015
3. Granville Austin, The Indian Constitution: Cornerstone of a Nation, Oxford University Press, 1999.
4. M.V.Pylee, Constitutional History of India, S.Chand publishing, 2010.

18ME505 **HEAT TRANSFER AND REFRIGERATION LABORATORY**

L	T	P	C
0	0	3	1.5

Course Objectives:

1. To impart knowledge on conduction, convection and radiation heat transfer through experiments.
2. To study the performance of refrigeration cycle / components.

EXPERIMENTS:

HEAT TRANSFER

1. Thermal conductivity measurement by guarded plate method
2. Thermal conductivity of metal bar
3. Thermal conductivity of insulating powder
4. Thermal conductivity of pipe insulation using lagged pipe apparatus
5. Natural convection heat transfer from a vertical cylinder
6. Forced convection inside tube
7. Heat transfer from pin-fin (natural and forced convection modes)
8. Determination of Stefan-Boltzmann constant
9. Determination of emissivity of a grey surface
10. Effectiveness of Parallel/counter flow heat exchanger

REFRIGERATION AND AIR CONDITIONING

11. Determination of COP of a refrigeration system
12. Experiments on air-conditioning system
13. Performance test on single/two stage reciprocating air compressor.

Total = 45 Periods

Course Outcomes:

After the successful completion of the practical session, the students will be able to:

CO1 : demonstrate the conduction and convection heat transfer through experiments.
CO2 : evaluate heat transfer efficients for natural convection and Forced convention
CO3 : analyze heat exchanger performance using effectiveness method.
CO4 : calculate radiation heat exchange between black body and gray body surfaces.
CO5 : demonstrate the working principle of refrigeration and air-conditioning system

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	2	2	0	0	0	0	0	0	0	0	2	3	1
CO2	2	2	3	1	0	0	0	0	0	0	0	0	2	3	1
CO3	2	3	2	1	0	0	0	0	0	0	0	0	3	3	1
CO4	2	2	3	3	0	0	0	0	0	0	0	0	3	2	1
CO5	2	2	2	3	0	0	0	0	0	0	0	0	2	3	2

1- Faintly
2- Moderately
3- Strongly

18EN501 **COMMUNICATION SKILLS AND LANGUAGE LABORATORY** **L T P C**

0 0 2 2

Course Objectives:

1. Communicate effectively with interviewers
2. Express opinions, illustrate with examples, elucidate and conclude in group discussions
3. Write error free letters and prepare reports
4. Speak fluently and avoid pitfalls in pronunciation and grammatical errors

EXPERIMENTS:

1. **WRITING SKILLS**
   - Letter seeking permission to go on industrial visit
   - Letter of invitation
   - Letter of request for leave
   - Resume and Cover Letter
   - Report Writing – Progress in project work
2. **SPEAKING SKILLS**
   - Welcome Address and Vote of Thanks
   - Conversation Skills
   - Analysing and presenting business articles
   - Power Point Presentation
   - Group Discussion
3. **SOFT SKILLS**
   - Psychometric profile
   - Self-Introduction
   - Interview skills
   - Leadership traits

   Conducting a board meeting
4. **VERBAL ABILITIES**
   - Error Spotting
   - Listening Comprehension
   - Reading Comprehension
   - Rearranging Jumbled sentences
   - Vocabulary
5. **Lab Record**
   1. Group Discussion - Literature survey
   2. Group Discussion - Transcripts
   3. Group Discussion - Assessment forms
   4. InterviewSkills – Psychometric profile
   5. Interview Skills - Self-introduction
   6. Interview Skills – Resume and Cover Letter
   7. Interview Skills - Transcription of interview
   8. Interview Skills - Assessment sheet signed by interview panel
   9. Power Point Presentation
   10. Error spotting worksheet
   11. Jumbled sentences worksheet
   12. Reading comprehension worksheet
   13. Welcome Address
   14. Vote of Thanks
   15. Letter seeking permission to go on industrial visit
   16. Letter of request for leave
   17. Report Writing – Progress in project work
   18. Presentation of business articles - Transcription

Total = 30 Periods

Course Outcomes:

After the successful completion of the practical session, the students will be able to:

CO1 : write error free letters and prepare reports
CO2 : deliver welcome address and vote of thanks
CO3 : speak coherently with proper pronunciation and accent
CO4 : avoid common indianisms and grammatical errors
CO5 : improve repertoire of passive vocabulary
CO6 : answer questions posed by interviewers confidently
CO7 : participate in group discussion effectively
CO8 : undertake online psychometric and iq test to understand their strengths and weaknesses

References:

1. Anderson, P.V, Technical Communication, Thomason Wadsworth, Sixth Edition, New Delhi, 2007.
2. Prakash, P, Verbal and Non-Verbal Reasoning, Macmillan India Ltd., Second Edition, New Delhi, 2004.
3. John Seely, The Oxford Guide to Writing and Speaking, Oxford University Press, New Delhi, 2004.
4. Evans, D, Decision maker, Cambridge University Press, 1997.
5. Thorpe, E, and Thorpe, S, Objective English, Pearson Education, SecondEdition, New Delhi, 2007.
6. Turton, N.D and Heaton, J.B, Dictionary of Common Errors, Addision WesleyLongman Ltd., Indian reprint 1998.
7. Ready,Steaady, Go. Deepak Mehra, Jaico Publishing House, Delhi,2015
8. Business English Certificate Materials, Cambridge University Press.
9. http://www.learnmyself.com (Personality Test and IQ Test).
10. http://www.humanmetrics.com/cgi-win/jtypes2.asp

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	2	1	0	2	2	1	1	3	2	2	0	2	3
CO2	0	0	1	1	0	1	1	2	1	3	2	1	0	1	2
CO3	0	0	2	1	0	0	0	1	2	3	1	2	0	0	2
CO4	0	0	2	2	0	2	2	3	1	3	1	2	0	2	1
CO5	0	0	1	2	0	1	1	2	2	3	2	1	0	1	3
CO6	0	0	1	1	0	0	0	1	0	3	2	2	0	0	2
CO7	0	0	1	2	0	0	2	3	0	3	1	1	0	2	3
CO8	0	0	2	2	0	0	2	1	1	3	2	0	0	1	3

1- Faintly
2- Moderately
3- Strongly

18ME506 **DYNAMICS AND METROLOGY LABORATORY**

L	T	P	C
0	0	3	1.5

Course Objectives:

1. To be familiar With Different Measuring Equipment.
2. And Use Of these instruments in Industry For Quality Inspection
3. To know the need of accuracy in industry

EXPERIMENTS

1. Governors - Determination of sensitivity, effort, etc. for Watt, Porter, Proell, Hartnell governors
2. Cam - Study of jump phenomenon and drawing profile of the cam.
3. Motorized Gyroscope-Verification of laws -Determination of gyroscopic couple.
4. Whirling of shaft-Determination of critical speed of shaft with concentrated loads.
5. Determination of moment of inertia by oscillation method for connecting rod and flywheel.
6. Vibrating system - Spring mass system-Determination of damping co-efficient of single degree of freedom system.
7. Determination of transmissibility ratio - vibrating table.
8. Determination of torsional frequencies for compound pendulum and flywheel system with Lumped Moment of inertia.
9. Transverse vibration –free- Beam. Determination of natural frequency and deflection of beam.
10. Calibration of Vernier / Micrometer / Dial Gauge
11. Checking Dimensions of part using slip gauges
12. Measurements of Gear Tooth Dimensions
13. Measurement of Taper Angle using sine bar / tool makers microscope
14. Measurement of thread parameters
15. Checking the limits of dimensional tolerances using comparators (Mechanical / Pneumatic / Electrical)

Total = 45 Periods

Course Outcomes:

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

CO1 : ability to handle different measurement tools
CO2 : perform measurements in quality impulsion
CO3 : avoid errors in measurement
CO4 : understand balancing of equipment

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	3	2	2	3	0	0	0	0	0	0	0	3	1	2
CO2	0	2	0	3	1	1	0	0	0	0	0	0	1	2	3
CO3	3	1	0	0	0	2	0	0	0	0	0	0	2	3	1
CO4	2	3	0	1	3	1	0	0	0	0	0	0	3	2	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

SEMESTER VI

18ME601 COMPUTER INTEGRATED MANUFACTURING

L	T	P	C
3	0	0	3

Course Objectives:

1. To gain knowledge on how computers are integrated at various levels of planning and manufacturing.
2. To understand the flexible manufacturing system and to handle the product data and various software used for manufacturing

UNIT I INTRODUCTION 9 + 0

The meaning and origin of CIM- the changing manufacturing and management scene - External communication - islands of automation and software-dedicated and open systems-manufacturing automation protocol - product related activities of a company- marketing engineering - production planning - plant operations - physical distribution- business and financial management.

UNIT II GROUP TECHNOLOGY AND COMPUTER AIDED PROCESS PLANNING 9 + 0

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 III SHOP FLOOR CONTROL AND INTRODUCTION OF FMS 9 + 0

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.

UNIT IV CIM IMPLEMENTATION AND DATA COMMUNICATION 9 + 0

CIM and company strategy - system modeling tools -IDEF models - activity cycle diagram - CIM open system architecture (CIMOSA) - manufacturing enterprise wheel-CIM architecture - Product data management-CIM implementation software. Communication fundamentals- local area networks -topology - LAN implementations - network management and installations.

UNIT V OPEN SYSTEM AND DATABASE FOR CIM 9 + 0

Open systems-open system inter connection - manufacturing automations protocol and technical office protocol (MAP /TOP). Development of databases -database terminology- architecture of database systems-data modeling and data associations -relational data bases - database operators - advantages of data base and relational database.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : recognize the manufacturing activities interrelated with computers.
CO2 : understand the concept of group technology and the various approaches of computer aided process planning.
CO3 : explain the phases of shop floor control activities.
CO4 : apply the system modeling tools in cim
CO5 : explain the applications of database and system protocol

Text Books:

1. Mikell.P.Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Pearson Education, 2008.
2. Roger Hanman, “Computer Integrated Manufacturing”, Addison –Wesley, 1997.

Reference Books:

1. Ranky and Paul G., “Computer Integrated Manufacturing”, Prentice Hall International 1986.
2. David D.Bedworth, Mark R.Hendersan and Phillip M.Wolfe, “Computer Integrated Design and Manufacturing”, McGraw Hill Inc, 1998.
3. Kant Vajpayee S, “Principles of Computer Integrated Manufacturing”, Prentice Hall India,2003
4. Mikell. P.Groover and Emory ZimmersJr, “CAD/CAM”, Prentice Hall of India Pvt. Ltd, 1998
5. Yoremkoren, “Computer Integrated Manufacturing system”, McGraw-Hill, 1983.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	3	0	2	0	1	0	0	0	2	3	3	2	2
CO2	2	1	1	0	2	0	2	0	2	0	2	2	2	3	2
CO3	2	0	2	0	2	0	0	0	1	0	2	2	2	2	1
CO4	1	2	2	0	2	0	1	0	1	0	2	2	1	2	2
CO5	1	1	1	0	1	0	1	0	1	0	2	1	2	1	2

1- Faintly
2- Moderately
3- Strongly

18ME602 **FINITE ELEMENT ANALYSIS**

L	T	P	C
3	0	0	3

Course Objectives:

1. To equip the students with the basic concepts of Finite Element methods.
2. To make the students to formulate the physical design problems into FEA including domain discretization, polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems.
3. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills.
4. To familiarize the students in deriving FEA equations for 1D and 2D problems with different types of elements.
5. To make the students understand the need for FEA package and the procedure for solving problems

UNIT I INTRODUCTION **9 + 0**

Basics of FEM – history - Comparison with other methods - General steps of FEM - Applications and Advantages -Matrix approach- Application to the continuum – Discretization - Types of elements based on geometry- Node numbering, Half band width - Matrix algebra- Gaussian elimination - Classical techniques in FEM - Weighted residual methods –general weighted residual statement – weak formulation of the weighted residual statement – comparisons – piecewise continuous trial functions example of a bar finite element – functional and differential forms – principle of stationary total potential – Rayleigh Ritz method – piecewise continuous trial functions – application to bar element.

UNIT II ONE DIMENSIONAL FEA **9 + 0**

General form of total potential for 1-D applications – generic form of finite element equations – linear bar element – quadratic element –nodal approximation – development of shape functions – derivation of element stiffness matrices and vectors – assembly- example problems – extension to plane truss- development of element equations – assembly – element connectivity – global equations – solution methods –beam element – nodal approximation – shape functions – element matrices and vectors – assembly – solution – example solid mechanics problems - Temperature effects.

UNIT III TWO DIMENSIONAL FEA **9 + 0**

Introduction – approximation of geometry and field variable – 3 noded triangular elements – four noded rectangular elements – higher order elements – Interpolation polynomials- Linear, quadratic and cubic. Simplex complex and multiplex elements- 2D PASCAL's triangle - generalized coordinates approach to nodal approximations – difficulties – natural coordinates and coordinate transformations – CST elements - Shape functions and Nodal load vector - Strain displacement matrix and Jacobian for triangular and rectangular element – structural mechanics applications in 2-dimensions – elasticity equations – stress strain relations – plane problems of elasticity – element equations – assembly – example problems in plane stress, plane strain - axisymmetric element applications.

UNIT IV ISOPARAMETRIC FORMULATIONS **9 + 0**

Isoparametric elements – sub parametric and Super parametric elements - natural co-ordinate systems - Shape functions for isoparametric elements – One and two dimensions – Serendipity elements – axisymmetric applications - need for quadrature formula – transformations to natural coordinates – Gaussian quadrature Numerical integration and application to plane stress problems – Matrix solution techniques - Lagrange's interpolation- Higher order one dimensional elements - Quadratic and cubic element - Applying numerical integration: 1, 2 and 3 gauge point for 1D and 2D cases - example problems.

UNIT V HEAT TRANSFER AND FLUID FLOW APPLICATION **9 + 0**

One dimensional heat transfer element – Steady state heat transfer, 1D heat conduction governing Equations - Functional approach for heat conduction- Galerkin's approach for heat conduction - application to one-dimensional heat transfer problems- 1D heat transfer in thin fins problems - scalar variable problems in 2-

Dimensions – Applications to heat transfer in 2- Dimension – Incompressible fluid flow- Basic equations - solution procedure - Galerkin Approach - Problems in incompressible fluid flow.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : perform the mathematical formulation of the finite element method and apply the same to basic (linear) ordinary and partial differential equations.

CO2 : develop and solve stiffness equations for 1d fea using bar, truss and beam elements.

CO3 : develop and solve stiffness equations for 2d fea using cst and other plane elements.

CO4 : implement the finite element method efficiently in order to solve simple structural problems

CO5 : solve the basic 1d and 2d heat transfer and fluid flow problems.

Text Books:

1. Chandrupatla T. R &Belagundu A. D, "Introduction to Finite Elements in Engineering", 3rd Edition, Prentice Hall College Div, 1990.
2. Seshu, P, "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.

Reference Books:

1. Reddy. J.N., "An Introduction to the Finite Element Method", 3rd Edition, Tata McGraw-Hill, 2005.
2. Rao, S.S., "The Finite Element Method in Engineering", 3rd Edition, Butterworth Heinemann, 2004.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2002.
4. Bathe K.J, "Finite Element Procedures in Engineering Analysis", Prentice hall, 1981.
5. C.S. Desai and J.P. Abel, "Introduction to Finite Element Method", Affiliated East West Press, 1972.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	0	0	0	0	0	0	0	0	0	1	2	0
CO2	3	2	1	0	0	0	0	0	0	0	0	0	2	1	0
CO3	3	2	1	0	0	0	0	0	0	0	0	0	2	1	0
CO4	3	1	2	2	1	0	0	0	0	0	0	0	2	1	0
CO5	3	2	1	0	1	0	0	0	0	0	0	0	2	1	0

1- Faintly
2- Moderately
3- Strongly

18ME603 **DESIGN OF MACHINE ELEMENTS**

L	T	P	C
3	1	0	4

Course Objectives:

1. A strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components
2. An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3. An overview of codes, standards and design guidelines for different elements
4. An appreciation of parameter optimization and design iteration
5. An appreciation of the relationships between component level design and overall machine system design and performance

UNIT I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS 9 + 3

Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Design of curved beams – crane hook and 'C' frame - Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .

UNIT II DESIGN OF SHAFTS, COUPLINGS AND PIN JOINTS 9 + 3

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings – Design of pin joints like cotter and knuckle joints.

UNIT III DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS 9 + 3

Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures.

UNIT IV DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS 9 + 3

Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting Rods and crank shafts. Heat engines- Brief details about external combustion and internal combustion engines, Design of I.C engine cylinder, piston, connecting rod, crankshaft and flywheel.

UNIT V DESIGN OF BEARINGS, LEVERS, PRESSURE VESSELS AND PIPES 9 + 3

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings. Design of Levers - Design of pressure vessels and pipes

Total = (45+15) = 60 Periods

Course Outcomes:

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

CO1 : explain the influence of steady and variable stresses in machine component design.
CO2 : apply the concepts of design to shafts, keys and couplings.
CO3 : apply the concepts of design to temporary and permanent joints
CO4 : apply the concepts of design to various energy storing elements and engine components.
CO5 : design the various types of bearings and levers.

Textbooks:

1. Bhandari V.B, "Design of Machine Elements", Tata McGraw Hill Book Co, 2003
2. Md.Jalaludeen.S, "A text book of Machine Design", Anuradha Publications, 2006

Reference Books:

1. Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.

2. Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
3. Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4. PSG Tech, “Design Data Handbook”, M/s.DPV Printers, Coimbatore, 2009
5. R. L. Norton, Mechanical Design – An Integrated Approach, Prentice Hall, 1998
6. Md.Jalaludeen.S, “Design Data Handbook”, Anuradha Publications, 2006

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	0	0	0	0	0	0	0	0	3	2	0
CO2	3	2	2	1	0	0	0	0	0	0	0	0	2	2	0
CO3	3	2	2	2	0	0	0	0	0	0	0	0	2	2	0
CO4	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO5	3	3	2	1	0	0	0	0	0	0	0	0	3	2	0

1- Faintly
2- Moderately
3- Strongly

18ME604	CAD/CAM LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1. To train students in modeling the 3-D geometric information of machine components including assemblies, and automatically generate 2-D production drawings.
2. To improve visualization ability of machine components and assemblies before their actual fabrication through modeling.
3. To equip the students for implement CNC programs for milling and turning machining operations.
4. To create a computer aided manufacturing (CAM) model and generate the machining codes automatically using the CAM system.
5. To use full-scale CAD/CAM software systems designed for geometric modeling of machine components and automatic generation of manufacturing information

EXPERIMENTS:

A. CAD EXPERIMENTS

1. The students will be required to carry out the following exercises using software packages (e.g. 3D modeling package / Pro Engineer/ CATIA /I-Deas/ Solid Edge/Solid Works etc.)

CAD LAB

2. Introduction to advanced modeling software
3. Part Modeling of Screw Jack
4. Part Modeling of Flange Coupling
5. Part Modeling of Plummer Block
6. Part Modeling of Knuckle Joint
7. Creation of 3D assembly model of universal joint
8. Creation of 3D assembly model of connecting rod
9. Creation of 3D assembly model of crank shaft
10. Creation of 3D assembly model of Lathe Tailstock
11. Detailing of Lathe Tailstock
12. Surface Modeling /File import & Export/ STL file generation

B. CAM EXPERIMENTS

13. Tool path generation, Part programming, G & M codes development for machining operations, Physical interpretation of machining features and tool geometries

CAM LAB

14. Manual part programming- CNC Turning Centre
    Facing, Turning, Chamfering, Taper turning, Thread cutting
15. Manual part programming- CNC Turning Centre
    Facing, Turning, Chamfering, Taper turning, Grooving, Threading using canned cycles
16. Manual part programming- CNC Milling
    Linear and circular Profile, Pocket, Drill, Peck-Drill, Bore, Tap- Using canned cycles.
17. Part Program generation and tool path simulation for turning & Milling for Fanuc Control System using CAM software.
18. Demonstration on CNC Turning & Milling Machines

Total = 45 Periods

Course Outcomes:

After the successful completion of the practical session, the students will be able to:

CO1 : understand how cad technology can be leveraged in the design process and the basic and advanced features available with cad software

CO2 : design a part or assembly of parts using computer-aided design software.

CO3 : understand the cnc concepts and manual part programming using g and m codes.

CO4 : understand modern cnc control systems (fanuc, siemens etc.) and application of various cnc machines.

CO5 : prepare cnc part programming and perform manufacturing.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	0	1	3	0	0	0	0	1	0	1	1	1	1
CO2	2	0	0	0	3	0	0	0	0	0	0	0	1	3	2
CO3	2	1	0	0	3	0	0	0	0	0	0	0	1	2	3
CO4	2	1	0	0	3	0	0	0	0	0	0	0	1	2	3
CO5	2	2	0	1	2	0	0	0	0	0	0	0	1	2	3

1- **Faintly**
2- **Moderately**
3- **Strongly**

18ME605 **MINI PROJECT**

L	T	P	C
0	0	6	1

Course Objectives:

1. To get hands on training in the fabrication of one or more components of a complete working model, which is designed by them
2. To design and fabricate models

FABRICATION PROJECT GUIDELINES

a. Mechanical Assembly and Dismantling Models
b. Day-life Usage Project
c. New Scientific Invention
d. Implementation of Mechanical Principle

Total = 30 Periods

Course Outcomes:

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

CO1 : initiate the students to come out with innovative ideas for various applications.

CO2 : create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	1	0	2	1	2	1	3	1	1	3	3	2	2
CO2	2	2	3	1	3	2	2	1	2	1	0	3	1	2	3

1- Faintly
2- Moderately
3- Strongly

SEMESTER VII

18ME701	MECHATRONICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart knowledge about the elements and techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.

UNIT I INTRODUCTION TO MECHATRONICS 9 + 0

Definition and Introduction to Mechatronic Systems- Mechatronic Products and their functioning- Advanced applications in Mechatronics -Measurement systems- Control Systems- sequential controllers.

UNIT II PHYSICAL SYSTEM MODELING 9 + 0

General System Models- zero order-first order- second order-mechanical systems, electrical systems, thermal systems, electromechanical systems, hydro-mechanical systems, pneumatic systems-Basis of analogies in physical system models.

UNIT III ACTUATION SYSTEMS 9 + 0

Electric motors - Solenoids - Solid state switches - Stepper motors- Servo motors- Mechanical actuators-Hydraulic motors - Piezo actuators- Control systems - PID Controllers.- Artificial intelligence in Mechatronics – Adaptive and nonlinear control design- Neural networks and fuzzy systems.

UNIT IV PROGRAMMING LOGIC CONTROLLERS 9 + 0

Introduction to Programmable Logic Controllers – Basic Structure – Input / Output processing – Ladder logic programming – Mnemonics –relays and counters – Shift registers – Master and Jump controls – Data handling – Analog Input / Output – Case studies on PLC.

UNIT V MECHATRONICS SYSTEMS DESIGN 9 + 0

Stages in designing of Mechatronics systems – Traditional and Mechatronic design - Possible design solutions. Case studies: Data acquisition and control - Pick and place robot – automatic car park barrier systems – Engine management systems- Mechatronic control in automated manufacturing.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : students will be able to understand the basic elements underlying mechatronics systems and integrate them in the design of mechatronics systems.
CO2 : students will be able to develop a simulation model for simple physical systems and illustrate mechatronics design process.
CO3 : students will be capable of designing, interfacing and understand issues of implementation of different actuation in a mechatronics system for a set of specifications.
CO4 : students understand how to interface electromechanical systems to plcs.
CO5 : students will gain practical experience in applying knowledge gained in the course through a hands-on project.

Text Books:

1. Bolton, W, Mechatronics, Pearson Education, 6th Edition, 2015.
2. Ganesh S.Hegde, Mechatronics, Jones & Bartlett publishers, 1st Edition, 2010.

Reference Books:

1. Michael B. Histand and David G. Alciatore, Introduction to Mechatronics and Measurement Systems, McGraw Hill International Editions, 3rd Edition, 2007.
2. Bradley D. A., Dawson D., Buru N.C. and. Loader A.J, Mechatronics, Chapman and Hall, 1st Edition, 1993.
3. Dan Necsulesu, Mechatronics, Pearson Education Asia, 1st Edition, 2002

4. Brian Morriss, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, McGraw Hill International Edition, 1995.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0
CO2	0	0	2	0	1	0	0	0	0	0	0	0	0	2	0
CO3	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
CO4	0	0	0	0	2	0	0	0	0	0	3	0	0	2	1
CO5	0	0	0	2	0	0	0	0	0	0	0	3	0	0	3

1- Faintly
2- Moderately
3- Strongly

18ME702	MECHATRONICS AND SIMULATION LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1. To acquire adequate knowledge to design and simulate the basic electric, hydraulic and pneumatic, PLC systems.
2. To gain practical experience in interfacing Microcontroller, Computer and data acquisition system in real world problems
3. To design, set up, and conduct engineering experiments and analyze complex engineering problems

1. **MECHATRONICS LABORATORY**

   LIST OF EXPERIMENTS

   1. Design and testing of fluid power circuits to control
      (i) velocity (ii) direction and (iii) force of single and double acting actuators
   2. Simulation of basic Hydraulic, Pneumatic and Electric circuits using software.
   3. Circuits with multiple cylinder sequences in Electro pneumatic using PLC.
   4. Servo controller interfacing for open loop
   5. Servo controller interfacing for closed loop
   6. Stepper motor interfacing with 8051 Micro controller
      (i)full step resolution (ii) half step resolution
   7. Computerized data logging system with control for process variables like pressure flow and temperature.

2 **SIMULATION LABORATORY**

LIST OF EXPERIMENTS

Analysis of Mechanical Components – Use of FEA packages, like ANSYS/ NASTRON etc., Excesses shell include FEA analysis of

(i) Machine elements under static loads
(ii) Heat transfer in mechanical systems
(iii) Determination of natural frequency
(iv) Axi-Symmetric
(v) Non-linear systems

Total =45 Periods

COURSE OUTCOMES:

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

CO1 : select various control valves and use them in hydraulic and pneumatic circuit development.
CO2 : get adequate knowledge to simulate the basic electric, hydraulic and pneumatic system using simulation software.
CO3 : gain practical experience in data acquisition system and develop and evaluate alternate solutions to real world problems.
CO4 : use softwares as a tool for analyzing complex engineering problems.
CO5 : design, set up, and conduct engineering experiments and analyze the Results.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	3	0	0	0	0	0	0	0	0	0	0	1	1	1
CO2	0	0	1	2	0	0	0	0	0	0	0	0	1	2	2
CO3	0	0	1	0	0	0	1	2	0	0	0	0	2	1	3
CO4	0	0	0	3	0	0	0	0	0	0	2	3	2	1	3
CO5	0	0	0	0	0	0	0	0	2	1	2	0	2	2	3

1- Faintly
2- Moderately
3- Strongly

18ME703 **PROJECT – I**

L	T	P	C
0	0	10	4

COURSE OBJECTIVES:

1. The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.
2. It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester

GUIDELINE FOR REVIEW AND EVALUATION

1. The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners (Supervisors) constituted by the Head of the Department

Total = 75 Periods

COURSE OUTCOMES:

Upon completion of this course, Students will be able:

CO1 : to initiate and motivate the students to come out with innovative ideas for different applications.

CO2 : to create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.

CO3 : to create an environment to convert the design into manufacturing of prototype for useful industrial, agricultural and social applications.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	1	0	2	1	2	1	3	1	1	3	3	2	2
CO2	2	2	3	1	3	2	2	1	2	1	0	3	1	2	3
CO3	1	2	3	2	3	2	2	2	2	2	1	3	2	3	3

1- Faintly
2- Moderately
3- Strongly

SEMESTER VIII

18ME801 **PROJECT – II**

L	T	P	C
0	0	12	10

COURSE OBJECTIVES:

1. The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.

2. It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester.

GUIDELINE FOR REVIEW AND EVALUATION

1. The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners (Supervisors) constituted by the Head of the Department

Total = 90 Periods

COURSE OUTCOMES:

Upon completion of this course, Students will be able:

CO1 : to initiate and motivate the students to come out with innovative ideas for different applications.

CO2 : to create an environment to convert the ideas into design of prototype for useful industrial, agricultural and social applications.

CO3 : to create an environment to convert the design into manufacturing of prototype for useful industrial, agricultural and social applications.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	1	0	2	1	2	1	3	1	1	3	3	2	2
CO2	2	2	3	1	3	2	2	1	2	1	0	3	1	2	3
CO3	1	2	3	2	3	2	2	2	2	2	1	3	2	3	3

1- Faintly
2- Moderately
3- Strongly

PROFESSIONAL ELECTIVES COURSES

Electives – I (SEMESTER VI)

18MEPE11	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn about the benefits gained when combining different materials into a composite.
2. To make the students to understand different processing methods, issues, properties.
3. To practice the testing methods of different composite materials.

UNIT I INTRODUCTION TO COMPOSITES 9 + 0

Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement – particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers

UNIT II POLYMER MATRIX COMPOSITES 9 + 0

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings – woven fabrics – non woven random mats – various types of fibres. PMC processes - hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding - resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP). Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates.-applications of PMC in aerospace, automotive industries

UNIT III METAL MATRIX COMPOSITES 9 + 0

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding– stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface- measurement of interface properties- applications of MMC in aerospace, automotive industries

UNIT IV CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES 9 + 0

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics - need for CMC – ceramic matrix - various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing). applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.

UNIT V MECHANICS OF COMPOSITES 9 + 0

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : use different materials to design new composites
CO2 : apply different techniques to process different types of composites and know the limitations of each process
CO3 : derive mathematical techniques to predict the macroscopic properties of different laminates

Text Books:

1. Mathews F. L. and Rawlings R. D., “Composite Materials: Engineering and Science”, Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K. K., “Composite materials”, Springer – Verlag, Second Edition, 1998

Reference Books:

1. Clyne, T. W. and Withers, P. J., “Introduction to Metal Matrix Composites”, Cambridge University Press, 1993.
2. Strong, A.B., “Fundamentals of Composite Manufacturing”, SME, 1989.
3. Sharma, S.C., “Composite materials”, Narosa Publications, 2000.
4. Broutman, L.J. and Krock,R.M., “ Modern Composite Materials”, Addison-Wesley, 1967.
5. ASM Hand Book, “ Composites”, Vol.21, ASM International, 2001.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	3	2	0	2	0	0	0	0	0	0	2	0	1
CO2	1	2	3	2	1	0	0	0	0	0	0	0	0	2	0
CO3	3	1	1	2	3	1	0	0	0	0	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

18MEPE12	DESIGN OF TRANSMISSION SYSTEM	L	T	P	C
		3	0	0	3

Course Objectives:

1. To gain knowledge on the principles and procedures for the design of mechanical power transmission components.
2. To understand the standard procedures available for design of transmission elements.
3. To solve the problems for the real time applications of the systems

UNIT I DESIGN OF FLEXIBLE ELEMENTS **9 + 0**

Motor power capacity for various applications - Design of Flat belts and pulleys - Selection of V belts and sheaves – Selection of wire ropes and pulleys – Design of Transmission chains and Sprockets.

UNIT II SPUR AND HELICAL GEARS **9 + 0**

Gear materials - Design of straight tooth spur & helical gears based on speed ratios, number of teeth, Fatigue strength, Factor of safety, strength and wear considerations. Force analysis -Tooth stresses - Dynamic effects - Helical gears – Module - normal and transverse, Equivalent number of teeth - forces.

UNIT III BEVEL AND WORM GEARS **9 + 0**

Straight bevel gear: Gear materials - Tooth terminology, tooth forces and stresses, equivalent number of teeth, estimation of dimensions of straight bevel gears. Worm Gear: Gear materials - Tooth terminology, Thermal capacity, forces and stresses, efficiency, estimation of dimensions of worm gear pair.

UNIT IV GEAR BOXES **9 + 0**

Need - Design of sliding and constant mesh gear boxes: Speed selection - Geometric progression - Standard step ratio - Ray diagram, kinematic layout – Determination of number of teeth. Design of multi speed gear box for machine tool applications, Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.

UNIT V CLUTCHES, BRAKES AND CAMS **9 + 0**

Design of single and multi plate clutches, cone clutches, internal expanding rim clutches and Electromagnetic clutches. Design of brakes: External shoe brakes - Single and Double Shoe, Internal expanding shoe brakes and Band brakes. Design of Cams: Types- Pressure angle and under cutting, determination of base circle -forces and surface stresses.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : appreciate the functions of various transmission elements and their assemblies

CO2 : design different transmission components according to the requirement as per standards using data books.

CO3 : apply the appropriate calculation procedures for the various systems designing

Text Books:

1. Joseph Shigley,CharlesMischke, Richard Budynas and Keith Nisbett “Mechanical Engineering Design”, 10th Edition, Tata McGraw-Hill, 2014.
2. Sundararajamoorthy T. V and Shanmugam .N, “Machine Design”, 9th edition, Anuradha Publications, Chennai, 2003.

Reference Books:

1. Bhandari V, “Design of Machine Elements”, 15th Reprint, Tata McGraw-Hill Book Co, 2014.
2. Prabhu. T.J., “Design of Transmission Elements”, Mani Offset, Chennai, 2003.
   Md. Jalaludeen , Machine Design, Volume II, Design of Transmission Systems, 4th edition, Anuradha Publications, 2014.
3. GitinMaitra,L. Prasad “Handbook of Mechanical Design”, 2nd Edition, Tata McGraw-Hill,2001.

4. C.S.Sharma, KamleshPurohit, “Design of Machine Elements”, Prentice Hall of India,Pvt. Ltd., 2003.
5. Bernard Hamrock, Steven Schmid, Bo Jacobson, “Fundamentals of Machine Elements”,2nd Edition, Tata McGraw Hill, 2006.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	2	1	1	0	1	0	0	0	0	0	0	1	0
CO2	2	3	2	1	1	0	0	0	0	0	0	0	0	2	1
CO3	2	1	3	2	1	0	2	0	0	0	0	0	0	2	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

18MEPE13	GAS DYNAMICS & JET PROPULSION	L	T	P	C
		3	0	0	3

Course Objectives:

1. To learn the concepts of gas dynamics and various flows
2. To acquire the knowledge about the flow through ducts and their phenomena
3. To get the concepts of jet and space propulsion

UNIT I BASIC CONCEPTS AND ISENTROPIC FLOWS **9 + 0**

Energy and momentum equations of compressible fluid flows - Stagnation states, Mach waves and Mach cone - Effect of Mach number on compressibility - Isentropic flow through variable area ducts - Nozzle and Diffusers - Use of Gas tables.

UNIT II FLOW THROUGH DUCTS **9 + 0**

Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) - Variation of flow properties - Use of tables and charts - Generalized gas dynamics.

UNIT III NORMAL AND OBLIQUE SHOCKS **9 + 0**

Governing equations - Variation of flow parameters across the normal and oblique shocks - Prandtl – Meyer relations - Use of table and charts - Applications.

UNIT IV JET PROPULSION **9 + 0**

Theory of jet propulsion - Thrust equation - Thrust power and propulsive efficiency - Operation principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines – Aircraft combustors.

UNIT V SPACE PROPULSION **9 + 0**

Types of rocket engines - Propellants - Ignition and combustion - Theory of rocket propulsion – Performance study - Staging - Terminal and characteristic velocity - Applications - Space flights.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : explain basic concepts of gas dynamics and describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas

CO2 : analyze the concepts of flow through ducts and the shock flow.

CO3 : describe the basic concepts of jet and space propulsion

Text Books:

1. Yahya, S.M, “Fundamentals of Compressible Flow”, New Age International (P) Limited, New Delhi, 1996.
2. Ganesan, V, “Gas Turbines”, Tata McGraw Hill Publishing Co., New Delhi, 1999.

Reference Books:

1. Hill, P and Peterson, C, “Mechanics and Thermodynamics of Propulsion”, Addison -Wesley Publishing Company, 1992.
2. Zucrow, N.J, “Principles of Jet Propulsion and Gas Turbines”, John Wiley, New York, 1970.
3. Cohen,H, Rogers, G.E.C and Saravanamuttoo, “Gas Turbine Theory”, Longman Group Ltd., 1980.
4 Zucrow, N.J, “Aircraft and Missile Propulsion”, Vol. I and II, John Wiley, 1975.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0
CO2	2	2	1	3	2	0	1	0	0	0	0	0	1	0	1
CO3	2	1	1	2	0	0	1	0	0	0	0	0	1	0	1

1- Faintly
2- Moderately
3- Strongly

18MEPE14 **RENEWABLE ENERGY SYSTEM**

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the principles and applications of solar and wind energy.
2. To learn the biomass energy and the conversion tecnologies.
3. To gain knowledge on wave and tidal energy and their appliations.

UNIT I SOLAR ENERGY **9 + 0**

Devices for thermal collectors and storage-Thermal applications-Solar thermal power plant-Solar Photo voltaic Conversion-Solar cell-PV application.

UNIT II WIND ENERGY **9 + 0**

Principles of wind Energy Conversion-Site Selection Considerations-Wind Energy Conversion system-Advantages and Disadvantages of WECS-Wind Energy Collectors Interconnected System Environmental Aspects.

UNIT III BIO ENERGY **9 + 0**

Biomass Conversion Technologies-Types of Bio gas plants-Bio gas from plant wastes-Site selection Problems related to Bio gas plants-Alternative liquid fuels-Advantages and Disadvantages of Biological Conversion of Solar Energy.

UNIT IV ENERGY FROM THE OCEANS **9 + 0**

Ocean thermal Electric Conversion-Energy fromTides-Layout of Tidal power house-Tidal power plants-Single and Double basin Arrangement wave-Energy Conversion devices-Hybrid System.

UNIT V GEOTHERMAL ENERGY AND FUEL CELLS **9 + 0**

Hot Dry Rock Resources systems-Advantages and Disadvantages-Applications of Geothermal Energy-Fuel Cells-Classifications-Advantages and disadvantages-Applications of Fuel cells

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : acquire awareness about non-conventional sources of energy technologies.
CO2 : understand various renewable energy technologies and systems.
CO3 : impart the knowledge of storage technologies for the autonomous renewable energy sources.

Text Books:

1. Suhas P. Sukhatme, “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., 2007.
2. G.D. Rai, “Non-Conventional Energy Sources”, Khanna publishers, 2008.

Reference Books:

1. Godfrey Boyle, “Renewable Energy”, Power for a Sustainable future, Oxford University Press,1996.
2. G.N. Tiwari, “Solar Energy – Fundamentals Design, Modelling and Applications”, Navosa Publishing House, 2002.
3. Johnson Gavy L, “Wind Energy Systems”, Prentice Hall, 1985.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	1	0	1	0	2	0	1	0	0	0	1	0	0
CO2	1	1	1	1	0	0	1	0	1	0	1	0	0	0	1
CO3	2	1	2	1	0	0	0	0	0	0	0	1	2	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE15	**METAL CUTTING & TOOL DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To provide students with fundamental knowledge and principles in material removal processes.
2. To demonstrate the fundamentals of machining processes and machine tools.
3. To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.

UNIT I MECHANICS OF METAL CUTTING 9 + 0

Chip formation- Shear Zone- Shear Plane angle: Different Theories. Friction in Metal Cutting- Chip Flow Velocity- Shear Strain. Measurement of cutting forces- Dynamometer Requirements. Classification of Cutting Force Dynamometers. Heat in metal cutting - Heat Sources in Metal Cutting Temperature in Chip Formation- Temperature Distribution- Factors Effecting the Temperature-Work Material, Cutting Variables, Tool Geometry, Cutting Fluid.

UNIT II FAILURE OF CUTTING TOOLS 9 + 0

Tool Wear and Tool Life- Premature failure- Gradual Wear. Crater Wear. Flank Wear, Grooving Wear, Chip notching - Wear Mechanisms in Metal Cutting, Abrasive, Diffusion, Adhesion, and Oxidation Wear - Tool Life, Taylor's Tool Life Equation. Cutting Conditions for Limiting Tool Life Conditions. TV-he Tool Life Plots. Cutting Rate- Tool Life Characteristics Curve. Tool wear measurement – Optical Methods; Flank Wear, Crater Wear Measurement. Radioactive Methods - Augur Electron Spectroscopy (AES)

UNIT III TOOL GEOMETRY 9 + 0

Tool Nomenclature -Basic Tool Angles, Effect of Basic Angles. Tool Nomenclature Systems; British System, ISO System. Geometrical Relationship of True Rake Angle, Angle of Inclination. Design of single point tool - Tool Strength and Rigidity- Design of Form Tools- Types of Form Tools- Circular Form Tool- Profile Design- Geometrical and Analytical Method- Flat Form Tool Design- Grinding the Form Tool. Profile for a Tapered Surface- Tangential Type of Form Tool.

UNIT IV DESIGN OF DRILL BIT AND MILLING CUTTER 9 + 0

Twist Drill Construction- Drill Diameter- Flute Angle - Web Thickness and Chisel Edge- Land Width Margin- Shape of Flute Section - Flute Length- Shank. Geometry of the Cutting Edge, Rake Angle, Relief Angle, Angle of Inclination. Design of milling cutter- Types of Milling Cutters and its design -Profile Sharpened- Form Relieved Milling Cutters

UNIT V DESIGN OF BROACHING AND REAMING TOOL 9 + 0

Design of broach- Design Elements of Broach- Number of Teeth, Tooth, Pitch and Chip space- Rear Pilot Length of Broach- Strength of Broach - Reamer Design- Length- Flutes- Rake Angle and Relief Angle - Grinding of Reamer. Thread cutting tools -Thread Cutting Dies- Thread Rolling Tools- Design of Thread Cutting Taps.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : identify the various force acting and its measuring method on metal cutting

CO2 : find the various causes of failure of tool

CO3 : design the drill bit and milling cutter for the machining processes

Text Books:

1. B.J.Ranganth, “Metal Cutting and Tool Design” Vikas publishing
2. Bhattacharya. A., “Metal Cutting Theory and practice”, Central Book Publishers, India, 1984.

Reference Books:

1. Boothroid D.G. & Knight W.A., "Fundamentals of machining and machine tools", Marcel Dekker, New York, 1989.
2. Shaw.M.C. "Metal cutting principles", oxford Clare don press, 1984.
3. Graham T.Smith "Cutting Tool Technology" Industrial Handbook , Springer

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1	0	0	0	0	0	0	0	0	1	0	0
CO2	2	3	2	2	3	1	0	0	0	0	0	0	0	1	1
CO3	2	2	3	1	0	0	0	0	0	0	0	0	0	2	1

1- Faintly
2- Moderately
3- Strongly

18MEPE16 **AERONAUTICAL ENGINEERING**

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the fundamentals of aerospace engineering
2. To learn about the concepts of aero foil
3. To provide an understanding of flight instruments
4. To provide an understanding of aero propellers
5. To learn about the basics about aerodynamics

UNIT I INTRODUCTION **9 + 0**

The atmosphere-characteristics of troposphere, stratosphere, thermosphere, and ionosphere- pressure, temperature and density variations in the atmosphere. Application of dimensional analysis – aerodynamic force – model study and similitude. 2D aero foils -Nomenclature and classification- pressure distribution in inviscid and real flows- momentum and circulation theory of aerofoil- characteristics.

UNIT II CONCEPT OF AERO FOIL **9 + 0**

3D or Finite aero foils – effect of releasing the wingtips- wing tip vortices- replacement of finite wing by horse shoe vertex system, lifting line theory-wing load distribution – aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and from drag- changes in finite wing plan shape.

UNIT III AERO PROPELLERS **9 + 0**

Propellers – momentum and blade element theories –propeller coefficients and charts. Aircraft performance-straight and level flight –power required and power available graphs for propeller and jet aircraft.

UNIT IV GLIDING AND CLIMBING **9 + 0**

Rate of climb-service and absolute ceilings-gliding angle and speed of flattest glide takeoff and landing performance – length of runway required- aircraft ground run- circling flight – radius of tightest turn-jet and rocket assisted take –off high lift devices-range and endurance of airplanes-charts for piston and jet engine aircrafts.

UNIT V AERODYNAMICS **9 + 0**

Basics of aerodynamics- Fundamentals of potential flows from subsonic to supersonic speeds- Viscous flows including laminar and turbulent boundary layers- Aerodynamic models of airfoils and wings.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : identify, formulate and solve aerospace engineering problems
CO2 : perform analysis of flight dynamics of aircrafts
CO3 : provided an understanding of flight instruments
CO4 : provided an understanding of aero propellers
CO5 : learned about the basics about aerodynamics

Text Books:

1. Anderson , Fundamentals of Aerodynamics, McGraw-Hill, 2010
2. A.C. Kermode Mechanics of flight, Prentice Hall, 2007

Reference Books:

1. Kuethe, A.M., and Chow, C.Y., “Foundations of Aerodynamics”, John Wiley & Sons, 1982.
2. Hill, Mechanics and thermodynamics of propulsion
3. J.J.Bertin, “Aerodynamics for Engineers”, Prentice-Hall, 1988.
4. EHJ Pallett, Aircraft Instruments and Integrated systems, Longman,1992
5. Houghton and brock, Aerodynamics for Engineering Student, Hodder & Stoughton,1977

E-REFERENCES:

Nptel.ac.in / courses /downloads

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	2	0	0	0	0	0	0	0	0	0	2	1	0
CO2	2	2	1	1	0	0	0	0	0	0	0	0	2	1	0
CO3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
CO4	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1
CO5	3	1	1	0	0	0	0	0	0	0	0	0	1	0	0

1- Faintly
2- Moderately
3- Strongly

18MEPE17 **OPERATIONS RESEARCH**

	L	T	P	C
	3	0	0	3

Course Objectives:

1. Build the capabilities to analyze different industrial/business situations involving limited resources.
2. Develop the skills to build own formulations/expand existing formulations, to critically evaluate the impact of model assumptions.
3. Strengthen the ability to choose an appropriate solution technique for a given formulation.
4. Finding the optimal solution for any practical situation which is subjected with some constraints.
5. Enhance the skills on managerial science.

UNIT I LINEAR MODELS **9 + 0**

The phases of operations research study - Formation of linear programming model - Graphical method - Simplex algorithm - Big M method – Two phase method - Dual simplex method.

UNIT II TRANSPORTATION AND ASSIGNMENT MODELS **9 + 0**

Transportation models - Optimal solution by North West Corner method - Least Cost Method - Vogel's Approximation Method - optimality test - MODI method - Assignment problem formulation - Hungarian method - Unbalanced and maximization assignment problems.

UNIT III NETWORK MODELS **9 + 0**

Construction of project networks - Network optimization algorithms - Shortest route models, Minimal spanning tree models, Maximum flow models - CPM and PERT networks - Critical path scheduling.

UNIT IV REPLACEMENT AND SEQUENCING MODELS **9 + 0**

Replacement of items that deteriorate with time: value of money change with time, not change with time - Optimum replacement policy - Individual and group replacement - Sequencing problems – Problems with *n* jobs with *2* machines, *n* jobs with *3* machines, *n* jobs with *k* machines, *2* jobs with *k* machines.

UNIT V QUEUING THEORY AND SIMULATION **9 + 0**

Queuing systems and structures - Notations and parameters - Queuing models (Model I, Model II, Model III, Model IV) - Simulation- Random number generation - Application of simulation for queuing and maintenance.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : identify and develop mathematical models from the real situations.

CO2 : understand the mathematical tools that are needed to solve optimization problems.

CO3 : use mathematical software to solve the proposed models.

CO4 : propose recommendations to the decision-making processes in engineering/ management.

Text Books:

1. Taha, H.A, "Operations Research", 7th Edition, Prentice Hall of India, 2002.
2. Hira and Gupta, "Introduction to Operations Research", S. Chand and Co, 2002.

Reference Books:

1. Bhaskar, S, "Operations Research", Anuradha Publishers, Tamil Nadu, 1999.
2. Hillier and Lieberman, "Operations Research", Holden Day, 1986.

3. Sharma J.K, “Operations Research”, Macmillan, 2007.
4. Philip and Ravindran, “Operational Research”, John Wiley, 1992.

CO-PO MAPPING

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CO2	2	2	1	1	3	0	0	0	0	0	0	0	0	1	0
CO3	1	2	2	2	3	0	0	0	0	0	0	0	2	1	0
CO4	1	2	1	2	1	0	0	0	0	0	0	0	1	1	1

1- Faintly
2- Moderately
3- Strongly

Elective – II (VI SEMESTER)

18MEPE21	**ADVANCED STRENGTH OF MATERIALS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To provide basic knowledge in mechanics of materials to solve real engineering problems and design engineering systems
2. To determine the Mechanical behavior of the body by determining the stresses, strains produced by the application of load.
3. To apply fundamental concepts related to deformation, moment of inertia, load carrying capacity, shear forces, bending moments, torsional moments, column and struts, principal stresses and strains.

UNIT I ELASTICITY **9 + 0**

Stress – Strain relation and General equation of elasticity in cartesian- polar and spherical coordinates- differential equation of equilibrium – compact ability –boundary conditions- representations of three dimensional stress of a tension –generalized Hooke's law – St.Vennant's principle – Plane strain- plane stress – Airy's stress function. Shear Centre- Location of shear centre for various sections – shear flow.

UNIT II UNSYMMETRICAL BENDING **9 + 0**

Stresses and deflection in beams subjected to unsymmetrical loading – Kern of a section. Curved flexural members - circumferential and radial stresses – deflection and radial curved beam with re-strained ends – closed ring subjected to concentrated load and uniform load – chain link and crane hooks.

UNIT III THICK CYLINDERS AND ROTATING DISKS **9 + 0**

Thick walled cylinder subjected to internal and external pressures – Shrink fit joints – Stresses due to rotation – Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness – allowable speed. – Rotating shafts and cylinders.

UNIT IV TORSION OF NON CIRCULAR SECTIONS **9 + 0**

Torsion of rectangular cross section – St.Vennant Theory – elastic membrane analogy – Prandtl's stress function – Torsional stresses in hollow thin walled tubes.

UNIT V STRESSES IN FLAT PLATES **9 + 0**

Stresses in circular and rectangular plates due to various types of loading and end conditions – Buckling of plates. Theory of contact stresses – methods of computing contact stresses – deflection of bodies in point and line contact – applications.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : understand the concepts of stress and strain at a point as well as the stress-strain relationships for homogenous, isotropic materials.

CO2 : calculate the stresses and strains in axially-loaded members, circular torsion members, and members subject to flexural loadings.

CO3 : calculate the stresses and strains associated with thin-wall spherical and cylindrical pressure vessels.

Text Books:

1. Arthur P.Boresi and Richard J.Schmidt, "Advanced Mechanics of Materials", 6th Edition, John Wiley &Sons-Inc., 2003.
2. Arthur P.Boresi and Omar M.Siseborttom- "Advanced Mechanics of Materials", John Wiley International Education, 1985.

Reference Books:

1. Robert D.Cook and Wareen.C.Yound, "Advanced Mechanics of Materials", 2nd Edition, Macmilon Publishers Company, 1985
2. Srinath.L.S, "Advanced Mechanics of Solids", Tata McGraw Hill Publishing Company Limited, 2003
3. KrishnaRaju- N and Gururaja-D.R., "Advanced Mechanics of Solids and Structures", Narosa Publishing House, 1997.
4. U.C.Jindal, "Advanced Topics of Strength of materials", Galgotia Publications, 1st Edition, 1997

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	0	0	0	1	0	2	0	0	3	2	1
CO2	2	3	3	1	0	0	0	0	0	0	0	0	3	2	1
CO3	2	3	3	2	0	0	0	1	0	0	0	0	2	3	1

1- Faintly
2- Moderately
3- Strongly

18MEPE22	INTERNAL COMBUSTION ENGINES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To Acquire the knowledge of engine components and fuel air cycles.
2. To understand the working of engine auxiliary systems.
3. To learn the combustion aspects of CI and SI Engines and the alternate fuels

UNIT I COMPONENTS OF IC ENGINES AND PERFORMANCE 9 + 0

Classification of Internal combustion Engine, Function and operation of Two stroke and Four stroke engines, Comparison of SI and CI and two stroke and four stroke engines, Effects of supercharging and supercharging Types - centrifugal, roots, vane, Types of scavenging process- Design and Performance data, Efficiency, Specific fuel consumption, IMEP determination -Simple calculations - Performance characteristics, Heat balance calculations, Fuel air cycles and their significance, Comparison of air-standard and fuel air cycles.

UNIT II ENGINE AUXILIARY SYSTEMS 9 + 0

Desirable air- fuel ratios for starting, warm up, acceleration, idling and normal operation, Necessity of Carburetors and their function and types, Function and classification of injection systems, Injection pump, governor and nozzle types, Description of construction and function of Electronic injection system and MPFI systems, Energy requirement of ignition system, need, Types - Battery and Magneto ignition types, Ignition timing and engine parameters, Engine oil properties, lubrication system types - mist, wet sump and dry sump lubrication systems, Types of cooling systems - Direct and Indirect - Coolant and antifreeze solutions.

UNIT III COMBUSTION IN SI ENGINES 9 + 0

Homogeneous and heterogeneous mixture, Combustion in spark ignition engines, Stages of combustion in spark ignition engines, Flame front propagation, Factors influencing flame speed, Rate of pressure rise, Phenomenon of knock in SI engines, Effect of engine variables on knock, Combustion chambers for SI engines - Smooth engine operation, High power output and thermal efficiency, Stratified charge engine.

UNIT IV COMBUSTION IN CI ENGINES 9 + 0

Combustion in CI engine, Stages of combustion in CI engines, Factors affecting the delay period - compression ratio, engine speed, output, atomization and duration of injection, quality of fuel, intake temperature, intake pressure, Phenomenon of knock in CI engines, Comparison of knock in SI and CI engines, Air motion - Swirl - Squish.

UNIT V ALTERNATE FUELS AND EMISSION 9 + 0

Alternate Fuels -Alcohol, Methanol, Ethanol, Gaseous fuel - Hydrogen, CNG, LPG, Biodiesel -production, advantages & disadvantages. Air pollution due to IC engines, Hydrocarbon emission and their reasons, Formation of oxides of nitrogen, CO, Particulates, aldehydes, sulphur, lead and phosphorus emissions, catalytic converter, exhaust gas recirculation, Flame ionization detector, NDIR, smoke types - measuring device. Emission standards.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : describe and explain different types of reciprocating internal combustion engines (ice), their typical design features and performance characteristics.

CO2 : describe and analyze the power cycle of internal combustion engines using ideal gas cycles, air cycles, and fuel-air cycles. compute indicated power and thermal efficiency.

CO3 : explain the characteristic of homogeneous combustion in si-engines and spray combustion in ci-engines.

Text Books:

1. Ganesan.V, "Internal Combustion Engines" , Tata McGraw-Hill, New Delhi,2009
2. Ramalingam.K.K, "Internal Combustion Engines- Theory and practice ",SciTech publications India Pvt. Ltd., Chennai, 2010

Reference Books:

1. Thipse.S.S, "internal Combustion Engines", Jaico Publication House., 2010.
2. Thipse.S.S, "Alternate Fuels", Jaico Publication House., 2010.
3. Mathur.M.L and Sharma.R.P, "A course in internal Combustion Engines", Dhanpat Rai & Sons, New Delhi, 2010.
4. Heywood.J.B, "Internal Combustion Engine Fundamentals", McGraw Hill International, New York, 2008
5. Domkundwar.V.M, "A course in internal Combustion Engines", Dhanpat Rai & Sons, 2010.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	2	1	0	0	0	0	0	0	0	0	3	2	1
CO2	3	3	2	2	0	0	0	0	0	0	0	0	2	3	1
CO3	3	2	1	2	0	0	0	0	0	0	0	0	3	2	1

1- Faintly
2- Moderately
3- Strongly

18MEPE23 **POWER PLANT ENGINEERING**

L	T	P	C
3	0	0	3

Course Objectives:

1. To learn about the various processes involved in the conventional power plants
2. To study about the instruments and testing methods used in thermal power plants
3. To learn the basic knowledge of different types of diesel, gas and nuclear power plants

UNIT I STEAM POWER PLANT **9 + 0**

Layout of steam power plant – boilers - Modern high pressure and supercritical boilers -- Preparation and handling of coal - Pulverizer - Dust collector - Ash removal; Stokers - Different types - Pulverized fuel burning ; Draught - Different types - Chimney design - Selection of blowers, Cooling towers - Different types - Analysis of pollution from thermal power plants - Waste heat recovery, Fluidized bed boilers.

UNIT II INSTRUMENTATION, TESTING OF BOILERS, POWER PLANT ECONOMICS **9 + 0**

CO_2 recorders - Automatic controls for feed water, steam, fuel, air supply and combustion, Boiler testing and trails - Inspection and safety regulations. Economics of power plant - Actual load curves, fixed costs – Operating costs - Variable load operation.

UNIT III HYDRO ELECTRIC POWER PLANT **9 + 0**

Layout of hydel power plant- classification –working – components – layout of pumped storage power plant. Solar power plant- classification – components –working principle.

UNIT IV DIESEL AND GAS POWER PLANT **9 + 0**

Layout of Diesel power plant- Important components – performance analysis – Layout of gas power plant – classification of gas turbine cycles – components – relative thermal efficiencies of different cycles. Wind mill: layout –components - working.

UNIT V NUCLEAR, MHD POWER GENERATION AND WIND MILL **9 + 0**

Elementary treatment - Nuclear fission, chain reaction - Pressurized water reactors, boiling water reactors, gas cooled reactors - Fast breeder reactors, MHD power cycle principles

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : select the suitability of site for a power plant.
CO2 : calculate performance of thermal power plant.
CO3 : able to find the suitable types of power plant in any location

Text Books:

1. Arora, S.C and Domkundwar, S, "A Course in Power Plant Engineering", Dhanpat Rai and Sons, TMH, 1998.
2. Nag P.K, "Power Plant Engineering", Tata McGraw Hill Publishing Co. Ltd., 1998

Reference Books:

1. Bernhardt G. Askrotzki and William A. Vopat, "Power Station Engineering and Economy", Tata McGraw Hill Publishing Co. Ltd., 1972.
2. Frederick T. Mores, "Power Plant Engineering", Affiliated East-West Press Private Ltd., 1953.
3. Nagpal, G.R, "Power Plant Engineering", Khanna Publishers, 1998.
4. Joel Weisman and Roy Eckart, "Modern Power Plant Engineering", Prentice Hall International Inc., 1985.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	1	1	1	0	0	0	0	0	0	0	0	2	1	3
CO2	3	3	2	2	0	0	0	0	0	0	0	0	3	3	1
CO3	3	2	2	1	0	0	0	0	0	0	0	0	3	2	3

1- Faintly
2- Moderately
3- Strongly

18MEPE24	MACHINE DRAWING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide the fundamental concepts of machine drawing elaborating on how to concretize the idea of new structure such as a machine element.
2. Study the conventions and rules to be followed by engineers for making accurate drawings
3. Understand the basic dimensioning practices that have to be followed in the preparation of drawings

UNIT I SECTIONAL VIEWS **9 + 0**

Review of sectioning – Conventions showing the section – symbolic representation of cutting plane- types of section – full section, half section, offset section, revolved section, broken section, removed section – section lining.

UNIT II LIMITS, FITS AND TOLERANCES **9 + 0**

Limits, Fits and Tolerances- Indication of tolerances on linear dimension of drawings - General aspects, Nominal size and basic dimensions, Definitions, Basis of fit or limit system- Classifications of fits – Selection of fits – examples Systems of specifying tolerances, Designation of holes, Shafts and fits, Commonly used holes and shafts.

UNIT III SURFACE TEXTURE **9 + 0**

Conventional representation of surface finish - Roughness number symbol, Symbols of Machine elements and welded joints - Surface texture – importance – controlled and uncontrolled surfaces.

UNIT IV KEYS, SCREW THREADS AND THREADED FASTENERS **9 + 0**

Types of fasteners – temporary fasteners – keys – classification of keys – Heavy duty keys – light duty keys. Screw thread – Nomenclature – different types of thread profiles – threads in sections – threaded fasteners – bolts – nuts – through bolt – tap bolt, stud bolt – set screw – cap screws – machine screws – foundation bolts.

UNIT V MANUAL DRAWING PRACTICE **9 + 0**

Assembly and detailed drawings of Sleeve & Cotter joint - Knuckle joint - Foot step bearing - Plummer Block - Universal Coupling - Simple Eccentric - Protected type flanged coupling - Union joint, Gland & Stuffing Box, Expansion joint.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : understand the principles and requirements of production drawings.
CO2 : understand the various symbols used in drawing.
CO3 : assemble and disassemble the various mechanical components and joints.

Text Books:

1. Geometrical and Machine Drawing, N.D. Bhatt, Cheroter book stalls, Anand, West Railway
2. Machine drawing – P.S. Gill S.K. Kataria& Sons Delhi.
3. Machine drawing – T.Jones.

Reference Books:

1. Mechanical Draughtsmanship, G.L. Tamta, DhanpatRai& Sons, Delhi
2. Engineering Drawing, D.N. Ghose, DhanpatRai& Sons, Delhi

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	0	0	0	0	1	0	0	1	1	1	1	1
CO2	2	1	1	0	0	0	0	1	0	0	1	1	1	1	1
CO3	1	1	1	0	0	0	0	1	0	0	1	1	2	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE25 **ENGINEERING SYSTEM ANALYSIS AND DESIGN**

L	T	P	C
3	0	0	3

Course Objectives:

1. Analyze the asymptotic performance of Manual and automated systems.
2. Ability to understand the principles of systems documentation.
3. Demonstrate a familiarity with Systems flowcharts and structured charts.
4. Apply important Planning considerations for advance development.
5. Understand the basic concepts and implement the Object Oriented Analysis and design.

UNIT I SYSTEM DEFINITION AND CONCEPTS **9 + 0**

Characteristics and types of system, Manual and automated systems Real-life Business sub-systems: Production, Marketing, Personal, Material, and Finance. Systems models types of models: Systems environment and boundaries, Real-time and distributed systems, Basic principles of successful systems.

UNIT II SYSTEMS ANALYST **9 + 0**

Role and need of systems analyst, Qualifications and responsibilities, Systems Analyst and agent of change, Introduction to systems development life cycle (SDLC), Various phases of development: Analysis, Design, Development, Implementation, Maintenance Systems documentation considerations: Principles of systems documentation, Types of documentation and their importance, Enforcing documentation discipline in an organization.

UNIT III SYSTEMS DESIGN AND PROCESS MODELING **9 + 0**

Logical and physical design, Design representation, Systems flowcharts and structured charts, Data flow diagrams, Common diagramming conventions and guidelines using DFD and ERD diagrams. Data Modeling and systems analysis, Designing the internals: Program and Process design, Designing Distributed Systems.

UNIT IV SYSTEM IMPLEMENTATION AND MAINTENANCE **9 + 0**

Planning considerations, Conversion methods, producers and controls, System acceptance Criteria, System evaluation and performance, Testing and validation, Systems quality Control and assurance, Maintenance activities and issues. Threat to computer system and control measures, Disaster recovery and contingency planning.

UNIT V OBJECT ORIENTED ANALYSIS AND DESIGN **9 + 0**

Introduction to Object Oriented Analysis and design life cycle, object modeling: Class Diagrams, Dynamic modeling: state diagram, Dynamic modeling: sequence diagramming.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : gather data to analyse and specify the requirements of a system.
CO2 : design system components and environments.
CO3 : build general and detailed models that assist programmers in implementing a system.
CO4 : design a database for storing data and a user interface for data input and output, as well as controls to protect the system and its data.
CO5 : able to analyse object modeling and dynamics modeling.

Text Books:

1. Analysis and design of information systems – James A.Senn, McGraw-Hill Education, 2008
2. System analysis and design –Perry Edwards , McGraw-Hill Companies, 1993

Reference Books:

1. System Analysis and Design Methods, Whitten, Bentaly and Barlow, Galgotia Publication.
2. System Analysis and Design Elias M. Award, Galgotia Publication
3. Modern System Analysis and Design, Jeffrey A. Hofer Joey F. George Joseph S. Valacich Addison Weseley.

CO-PO MAPPING

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CO1	1	2	2	1	2	0	0	0	0	0	0	0	2	1	0
CO2	0	1	3	2	1	0	0	0	0	0	0	0	2	3	0
CO3	1	2	2	1	1	0	0	0	0	0	0	0	2	3	0
CO4	1	2	3	2	1	0	0	0	0	0	0	0	1	3	0
CO5	0	2	2	2	0	0	0	0	0	0	0	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

Electives – III (VII SEMESTER)

18MEPE31	**APPLIED HYDRAULICS AND PNEUMATICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries.
2. To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
3. To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.

UNIT I FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS 9 + 0

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – 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 criteria of Linear and Rotary – Fixed and Variable displacement pumps.

UNIT II HYDRAULIC ACTUATORS AND CONTROL COMPONENTS 9 + 0

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 – Accessories : Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols.

UNIT III HYDRAULIC CIRCUITS AND SYSTEMS 9 + 0

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 IV PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS 9 + 0

Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V TROUBLE SHOOTING AND APPLICATIONS 9 + 0

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : explain the Fluid power and operation of different types of pumps.
CO2 : summarize the features and functions of Hydraulic motors, actuators and Flow control valves
CO3 : explain the different types of Hydraulic circuits and systems
CO4 : explain the working of different pneumatic circuits and systems
CO5 : summarize the various trouble shooting methods and applications of hydraulic and pneumatic systems.

Text Books:

1. Anthony Esposito, "Fluid Power with Applications", Pearson Education, 2005.

2. Majumdar S.R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGrawHill, 2001.

Reference Books:

1. Anthony Lal, “Oil hydraulics in the service of industry”, Allied publishers, 1982.
2. Dudelyt, A. Pease and John T. Pippenger, “Basic Fluid Power”, Prentice Hall, 1987.
3. Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 1995
4. Michael J, Prinches and Ashby J. G, “Power Hydraulics”, Prentice Hall, 1989.
5. Shanmuga sundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	0	0	0	0	0	0	0	0	0	1	1	1
CO2	0	2	2	1	0	0	0	0	0	0	0	0	1	1	1
CO3	1	2	3	0	0	1	0	0	0	0	0	0	1	2	1
CO4	1	1	3	2	2	0	0	0	0	0	0	0	2	1	1
CO5	1	1	2	0	0	0	0	0	0	0	0	0	1	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE32 PROFESSIONAL ETHICS AND HUMAN VALUES

L	T	P	C
3	0	0	3

Course Objectives:

1. To create awareness on Engineering Ethics and providing basic knowledge about engineering Ethics, Variety of moral issues and Professional Ideals.
2. To provide basic familiarity about Engineers as responsible Experimenters, Codes of Ethics, Industrial Standards.
3. To inculcate knowledge and exposure on Safety and Risk, Risk Benefit Analysis.

UNIT I HUMAN VALUES 9 + 0

Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for Others – Living Peacefully – caring – Sharing – Honesty – Courage – Valuing Time – Co-operation – Commitment – Empathy – Self-Confidence – Character – Spirituality.

UNIT II ENGINEERING ETHICS 9 + 0

Senses of 'Engineering Ethics' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy – Models of Professional Roles - theories about right action – Self-interest- customs and religion - uses of ethical theories.

UNIT III ENGINEERING AS SOCIAL EXPERIMENTATION 9 + 0

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law – the challenger case study.

UNIT IV SAFETY, RESPONSIBILITIES AND RIGHTS 9 + 0

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - the three mile island and Chernobyl case studies. Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest – occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination.

UNIT V GLOBAL ISSUES 9 + 0

Multinational corporations - Environmental ethics - computer ethics - weapons development - engineers as managers consulting engineers-engineers as expert witnesses and advisors -moral leadership-sample code of Ethics like ASME,ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of electronics and telecommunication engineers (IETE),India.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand the importance of ethics and values in life and society.
CO2 : understood the core values that shape the ethical behavior of an engineer.
CO3 : exposed awareness on professional ethics and human values.

Text Books:

1. Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 2005.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

Reference Books:

1. Tripathi A N, "Human values" , New Age international Pvt. Ltd., New Delhi, 2002.
2. Charles D. Fleddermann, "Engineering Ethics", Pearson Education / Prentice Hall, New Jersey, 2004.
3. Charles E Harris, Michael S. Protchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Wadsworth Thompson Learning, United States, 2000.
4. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, 2003.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	3	2	3	0	0	0	0	0	0	3
CO2	0	0	0	0	0	3	2	3	0	0	0	0	0	0	3
CO3	0	0	0	0	0	3	2	3	0	0	0	0	0	0	3

1- Faintly
2- Moderately
3- Strongly

18MEPE33	MAINTENANCE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide the students with the fundamental concepts.
2. The necessary Knowledge and the basic skills related to systems reliability and systems maintenance function are learned.
3. The course intends to expose the students to the concept of reliability and to help them learn the techniques of estimating reliability and related characteristics of components/ systems
4. It exposes them to the necessary engineering techniques used for analyzing, planning and controlling maintenance systems

UNIT I INTRODUCTION **9 + 0**

Need of Maintenance Management- Maintenance Policies- Strategies and options in Maintenance management- Maintenance forms/actions and their inter relationships-Maintenance Organizations- factors determining effectiveness-objectives of organization design- types of organization. Types of maintenance – corrective-planned preventive and predictive maintenance- Factors affecting maintenance- opportunistic maintenance. Maintainability- Factors affecting Maintainability- Maintainability design criteria-operating and down time categories- Availability- types of Availability- approaches to increase equipment Availability.

UNIT II MAINTENANCE PLANNING AND CONTROL **9 + 0**

Establishing a Maintenance Plan-Preliminary considerations-Systematic method of Maintenance Plan and schedule planning and schedule of Plant shut downs- Maintenance practices on production machines- Lathe, Drilling, Milling, Welding, Shaper- Machine Reconditioning- Spare Parts Management-Capacity utilization, cost reduction approach to spares- reliability and quality of spares- spare parts procurement- and inventory control of spare parts.

UNIT III RELIABILITY **9 + 0**

Definition and basic concepts- Failure data- failure modes and reliability in terms of hazard rate and failure density Function-Hazard models and bath tub curve-applicability of Weibull distribution- Reliability calculations for series, parallel and parallel-series Systems-Reliability calculations for maintained and stand-by systems. Reliability Centred Maintenance.

UNIT IV COMPUTER AIDED MAINTENANCE MANAGEMENT **9 + 0**

Introduction -Definition- Basic components of CMMS- Uses of Computers in Maintenance -CMMS effectiveness - Approach towards Computerization- selection of computer system- Master files-Maintenance files- Maintenance Module- classification records- Preventive and repair planning module- codification for Break down- job sequencing files/records.

UNIT V CONDITION MONITORING **9 + 0**

Condition monitoring Techniques- Visual monitoring- Leak detection-wear monitoring-Crack monitoring- Noise and sound Monitoring-Temperature monitoring-Vibration monitoring-Signature analysis-Shock monitoring-Lubricant-Analysis-Methodology-Equipments-Applications.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : understand the maintenance principles, functions and practices adapted in industries.
CO2 : know the different categories of maintenance.
CO3 : gain knowledge about the instruments used for condition monitoring.
CO4 : provide in depth knowledge in Maintenance management systems
CO5 : provide the details of various Replacement and Inspection decision models for maximizing profit and minimizing downtime

Text Books:

1. S.K.Shrivastava, "Industrial Maintenance Management", S. Chand and Co, 2000.
2. Bhattacharya, "Installation, Servicing and Maintenance", S. Chand and Co, 1995.

Reference Books:

1. ADS Carter and Macmilan, "Mechanical Reliability Engineering", *Macmillan* Education Ltd., 1991.
2. Roy Billington, Allen, R.N and Pitman, "Reliability Evaluation of Engineering Systems", Pitman, London, 1983.
3. Gopal Krishnan, P and Banerji, A.K, "Maintenance & Spare Parts Management", Prentice-Hall of India Pvt Ltd, 1995.
4. Grant Ireson, W and Clyde, F, "Hand Book of Reliability Engineering & Management", McGraw Hill, 1998.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	0	1	2	1	3	0	2	1	0	0	3	1	1	1
CO2	2	0	0	3	1	2	0	1	2	0	0	1	2	1	1
CO3	2	0	2	2	3	2	0	2	1	0	2	1	2	1	1
CO4	1	0	0	2	2	1	0	0	0	0	3	2	3	2	1
CO5	1	0	3	0	2	0	3	0	2	0	1	1	1	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE34 **FUELS AND COMBUSTION**

L	T	P	C
3	0	0	3

Course Objectives:

1. Ability to characterize the fuels.
2. Understanding of thermodynamics and kinetics of combustion.
3. Understand and analyse the combustion mechanisms of various fuels.

UNIT I CHARACTERIZATION **9 + 0**

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels – Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation.

UNIT II SOLID FUELS & LIQUID FUELS **9 + 0**

Solid Fuels-Types - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry. Renewable Solid Fuels - Biomass - Agro Fuels – Manufactured Solid Fuels. Liquid Fuels-Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number etc., - Alcohols - Tar Sand Oil - Liquefaction of Solid Fuels.

UNIT III GASEOUS FUELS **9 + 0**

Classification - Composition & Properties - Estimation of Calorific Value – Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas- Stripped Natural Gas – Foul & Sweet Natural Gas - Liquefied Petroleum Gas - Liquefied natural gas - Compressed natural gas - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas.

UNIT IV COMBUSTION **9 + 0**

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions- Calculations - Rapid Methods - Combustion Processes – Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion Explosive Combustion.

UNIT V COMBUSTION EQUIPMENT'S **9 + 0**

Coal Burning Equipment's - Types - Pulverized Coal Firing - Fluidized Bed Firing – Fixed Bed & Recycled Bed - Cyclone Firing - Spreader Stokers - Vibrating Grate Stokers - Sprinkler Stokers, Traveling Grate Stokers. Oil Burners - Vaporizing Burners, Atomizing Burners. Gas Burners - Atmospheric Gas Burners - Air Aspiration Gas Burners – Burners.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : analyse the characterization of the fuel.
CO2 : determination of Flash and Fire point of various fuel blends.
CO3 : understand the various alternative fuel options available for conventional fuels.

Text Books:

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
2. Bhatt, Vora Stoichiometry, 2nd Edition, Tata McGraw Hill, 1984.

Reference Books:

1. Blokh AG,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
2. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966.
3. Sharma SP, Mohan Chander, Fuels & Combustion, Tata McGraw Hill, 1984.
4. Shaha AK (2003), Combustion Engineering & Fuel Technology, Oxford and IBH Publications, New York.
5. Kenneth K Kou (2002), Principles of Combustion, Wiley & Sons Publications, New York.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	3	3	0	1	0	0	0	0	0	0	1	1	0
CO2	2	2	3	1	0	1	0	0	0	0	0	0	1	2	0
CO3	2	1	3	2	0	1	0	0	0	0	0	0	1	1	0

1- **Faintly**
2- **Moderately**
3- **Strongly**

18MEPE35	RAPID PRODUCT DEVELOPMENT TECHNOLOGIES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand advanced techniques in RPT
2. To familiarize the students with recent developments in RPT
3. To learn Precision machining techniques

UNIT I INTRODUCTION **9 + 0**

Need for time compression in product development- Product development – conceptual design – development – detail design – prototype – tooling -History of RP systems- Survey of applications- Growth of RP industry- classification of RP systems

UNIT II STEREO LITHOGRAPHY SYSTEMS **9 + 0**

Stereo lithography systems – Principle – process parameters – process details – machine details- Applications. Selective laser sintering – Principle – process parameters – process details – machine details- Applications-Direct Metal Laser Sintering (DMLS) system – Principle – process parameters – process details – machine details- Applications.

UNIT III FUSED DEPOSITION MODELING **9 + 0**

Fusion Deposition Modelling – Principle – process parameters – process details – machine details- Applications. Laminated Object Manufacturing – Principle – process parameters – process details – machine details- Applications.

UNIT IV SOLID GROUND CURING AND CONCEPT MODELERS **9 + 0**

Solid Ground Curing – Principle – process parameters – process details – machine details- Applications. 3-Dimensional printers – Principle – process parameters – process details – machine details- Applications- and other concept modelers like thermo jet printers- Sander’s model maker- JP system 5- Object Quadra system. Laser Engineering Net Shaping (LENS)- Ballistic Particle Manufacturing (BPM) -Principle.

UNIT V RAPID TOOLING AND SOFTWARES **9 + 0**

Introduction to rapid tooling – direct and indirect method- Indirect Rapid Tooling - Silicone rubber tooling- Aluminium filled epoxy tooling- Spray metal tooling- etc. Direct Rapid Tooling - Direct AIM- Quick cast process- Copper polyamide- Rapid Tool- DMILS- ProMetal- Sand casting tooling- Laminate tooling- soft tooling vs hard tooling. Software for RP – STL files- Magics- Mimics. Application of Rapid prototyping in Medical field.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : generating a good understanding of RP history, its development and applications.

CO2 : expose the students to different types of Rapid prototyping processes, materials used in RP systems and reverse engineering

CO3 : develop creativity in design of RPT product.

Text Books:

1. Pham D.T. & Dimov.S. S, “Rapid manufacturing”, Springer Verlag, London, 2001.
2. Paul F Jacobs, “Rapid Prototyping and manufacturing – Fundamentals of Stereo lithographic”, Society of Manufacturing Engineering, Dearborn, USA 1992.

Reference Books:

1. Terry wohlers, “Wohlers Report 2007”, Wohlers Associates, USA 2007.
2. “Rapid Prototyping and Tooling”, Industrial Design Centre, IIT Mumbai, 1998.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	3	0	3	1	1	0	0	0	0	0	3	2	2
CO2	2	3	2	0	3	1	1	0	0	0	0	0	2	1	2
CO3	2	2	1	0	3	1	1	0	0	0	0	0	2	1	2

1- Faintly
2- Moderately
3- Strongly

18MEPE36	REFRIGERATION & AIR CONDITIONING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the underlying principles of operations in various Refrigeration & Air conditioning systems
2. To familiarize the components of the refrigerating systems
3. To know the applications of refrigeration and air conditioning systems
4. To provide knowledge on cooling load calculation and the system design aspects
5. To know the wide range of applications of refrigeration and air conditioning systems

UNIT I INTRODUCTION **8 + 0**

Thermodynamics of refrigeration- reversed Carnot cycle- heat pump and refrigeration machines, Limitations of reversed Carnot cycle - Unit of Refrigeration and C.O.P.– Ideal cycles- Refrigerants Desirable properties – Classification – Nomenclature – ODP & GWP.

UNIT II VAPOUR COMPRESSION REFRIGERATION SYSTEM **10 + 0**

Vapour compression cycle: p-h and T-s diagrams - deviations from theoretical cycle - sub cooling and super heating- effects of condenser and evaporator pressure on COP- multi pressure system - low temperature refrigeration - Cascade systems - problems. Equipments: Type of Compressors, Condensers, Expansion devices, Evaporators.

UNIT III OTHER REFRIGERATION SYSTEMS **8 + 0**

Working principles of Vapour absorption systems and adsorption cooling systems - Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems.

UNIT IV PSYCHROMETRIC PROPERTIES AND PROCESSES **10 + 0**

Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychometric chart; Psychometric of air-conditioning processes, mixing of air streams.

UNIT V AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION **9 + 0**

Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load; Classifications, Layout of plants; Air distribution system; Filters; Air Conditioning Systems with Controls: Temperature, Pressure and Humidity sensors, Actuators & Safety controls.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : students understood the basic concepts of refrigeration and properties of refrigerants
CO2 : knowledge about the simple and multiple vapour compression systems has been acquired by the students
CO3 : students have understood the other refrigeration systems and their applications
CO4 : the Knowledge about the psychometric processes and the use of charts in problem solving have been practiced by the students
CO5 : students can able to demonstrate the operations in different Refrigeration & Air Conditioning systems and also able to design Refrigeration & Air conditioning systems

Text Books:

1. Arora, C.P., “Refrigeration and Air Conditioning”, 3rd edition, McGraw Hill, New Delhi, 2010
2. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010

Reference Books:

1. Roy J. Dossat, “Principles of Refrigeration”, 4th edition, Pearson Education Asia, 2009.
2. Stoecker, W.F. and Jones J. W., “Refrigeration and Air Conditioning”, McGraw Hill, New Delhi, 1986.
3. Ballaney P. L, Refrigeration and Air-Conditioning, Khanna Publishers, New Delhi, 2014
4. Manohar Prasad, Refrigeration and Air-Conditioning, New Age International, 2011
5. ASHRAE Hand book, Fundamentals, 2010

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	0	0	0	0	0	0	0	0	2	1	0
CO2	2	2	1	3	0	0	0	0	0	0	0	0	2	1	0
CO3	2	2	1	2	0	0	0	0	0	0	0	0	1	1	0
CO4	2	1	1	2	0	0	0	0	0	0	0	0	1	1	0
CO5	1	1	1	3	0	0	0	0	0	0	0	0	2	1	0

1- Faintly
2- Moderately
3- Strongly

Electives – IV (VII SEMESTER)

18MEPE41	MARINE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:
1. To create an institution which provides an platform.
2. Naval architects and all those who seek professional avenues in fields related to the maritime industry are trained.
3. Learning that professional edge to succeed is better.
4. We endeavor to fulfill our vision of providing the maritime professionals with all the possibilities to make shipping safer, cleaner and environmentally adaptive.

UNIT I SHIP SYSTEMS **9 + 0**

Ship system formulations, main propulsion system requirements, and main propulsion system trade-off studies, arrangement of machinery, piping diagrams, and auxiliary systems.

UNIT II I.C ENGINE CHARACTERISTICS **9 + 0**

Characteristics of internal combustion engines, marine uses for such engines. Marine steam generators, selection and design of boilers. Main propulsion steam engines. Main propulsion steam turbines. Main propulsion gas turbines. Electric propulsion drives.

UNIT III VIBRATIONS ANALYSIS **9 + 0**

Propeller shafting and shafting system vibration analysis. Pumps, blowers, compressors, ejectors, condensers, heat exchangers, distilling plants. Hull machinery design considerations and machinery installations, machinery foundation designs, hydrostatic power transmission equipment and systems.

UNIT IV ENVIRONMENTAL SYSTEM **9 + 0**

Machinery for environmental control and waste treatment. Electric generating plants, switchboards and panels, lighting and power distribution, power equipment, lighting fixtures. Electronics navigation and radio communication. Automation systems. Safety considerations.

UNIT V NUCLEAR APPLICATION **9 + 0**

Fundamentals of pressurized-water nuclear steam supply systems for use in marine propulsion, reactor design considerations, nuclear fuels, reactor coolants, reactor control, shielding, safety, health physics, and economics.

Total (45+0)= 45 Periods

Course Outcomes:

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

CO1 : understand the Marine Engineering principles, functions and practices.

CO2 : develop knowledge of reducing vibration and environmental pollution.

Text Books:

1. Grover T K, “Marine Engineering”, Anmol Publications Pvt Ltd, 2008.
2. Harrington and Roy, L, “Marine Engineering”, The Society of Naval Architects and Marine Engineers, 1991.

Reference Books:

1. Cameron, I.R., “Nuclear Fission Reactors”, Plenum Press, 1998.
2. Henke and Russell, W., “Introduction to Fluid Power Circuits and Systems”, Addison-Wesley, 1970.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	2	3	0	0	0	0	0	0	1	1	2	1	1
CO2	1	2	2	2	0	2	3	0	2	0	1	2	2	1	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

18MEPE42	FRACTURE MECHANICS AND FAILURE ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Identify and explain the types of fractures of engineered materials and their characteristic features.
2. Understand the differences in the classification of fracture mechanics and how their corresponding parameters can be utilized to determine conditions under which engineering materials will be liable to fail catastrophically in service.
3. Understand and explain the mechanisms of fracture; and learn how to carry out engineering failure analysis.

UNIT I BASIC CONCEPTS IN FRACTURE MECHANICS 9 + 0

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation, Brittle fracture: Griffith's theory, Ductile fracture, Probabilistic aspects of fracture mechanics – Microstructure.

UNIT II MECHANICS OF FRACTURE- STATIC LOADING 9 + 0

Elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation – plastic zone size – Dugdaale model – J integral and its relation to crack opening displacement. Strain energy release and stress intensity factor. Evaluation of fracture Toughness of different materials: size effect & control.

UNIT III FAILURE ANALYSIS OF FATIGUE FRACTURE 9 + 0

Fundamental sources of failures- Deficiency in design, Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment. Micro structural analysis of fatigue failures, some case studies in analysis of fatigue failures.

UNIT IV FAILURE ANALYSIS OF CREEP RUPTURE 9 + 0

Fracture at elevated temperature: Time dependent mechanical behaviour, stress rupture, Micro Structural changes during creep, Mechanism of creep deformation and Creep deformation maps, Prediction of time to rupture, Creep-fatigue interaction. Some case studies in analysis of creep failures.

UNIT V FAILURE ANALYSIS OF CORROSION AND WEAR 9 + 0

A different environment. Types of wear, Role of friction, Interaction of corrosion and wear. Analysis of wear failure.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : Ability to design structure to prevent failure from the internal defect that unit within the structure.
CO2 : Ability to design structure to prevent fatigue and creep.
CO3 : Ability to define different deformation and related theories.
CO4 : Ability to analyse the corrosion and wear failure and system methods to prevent corrosion and wear
CO5 : Ability to analyse fatigue failures

Text Books:

1. Hertz berg R W, "Deformation and fracture mechanics of Engineering Materials" Second Edition John Wiley sons inc, New York 1983.
2. Knott. J.F, "Fundamentals of Fracture Mechanics" Butterworth London, 1973.

Reference Books:

1. Evalds H L and RJH Warnhil, "Fracture Mechanics", Edward Arnold Ltd, Baltimore,1984.
2. Campbell J E, Underwood J H, and Gerberich W., "Applications of Fracture Mechanics for the selection of Materials ", American Society for Metals, Metals Park Ohio, 1982.
3. Fracture Mechanics Metals Handbook, ninth edition, vol. 8 437-491, American Society of Metals Metal Park Ohio, 1985.

4. Kare Hellan, “Introduction of Fracture Mechanics”, McGraw-Hill Book Company, 1985.
5. Prashant Kumar, “Elements of Fracture Mechanics”, Wheeler Publishing, 1999.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	3	3	2	1	0	0	0	0	0	0	0	1	2	1
CO2	1	3	2	2	1	0	0	0	0	0	0	0	1	2	2
CO3	1	3	2	3	1	0	0	0	0	0	0	0	2	1	1
CO4	2	2	1	2	3	0	0	0	0	0	0	0	1	2	1
CO5	1	3	0	2	3	0	0	0	0	0	0	0	1	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE43 **AUTOMATION IN MANUFACTURING**

L	T	P	C
3	0	0	3

Course Objectives:

1. To get the knowledge of various elements of manufacturing automation
2. To study various techniques of automatic material handling in a manufacturing organization.
3. To identify suitable automation hardware for the given application
4. To incorporate application of electronics and computer engineering in mechanical engineering for enhancing manufacturing automation
5. To develop CNC programs to manufacture industrial components

UNIT I Introduction to automation **9 + 0**

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system - Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Manufacturing Support System - Automation in Manufacturing Systems - Reasons for Automating- Automation Principles and Strategies-Automation Migration Strategy

UNIT II Detroit-Type Automation **9 + 0**

Automated Flow lines, Methods of Work part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Computer Simulation of Automated Flow Lines.

UNIT III Control Technologies in Automation **9 + 0**

Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules, SCADA System and RTU. man-machine interface

UNIT IV Numerical Control Machines **9 + 0**

NC components, NC coordinate systems, Point to point, line and contouring systems, open and close loop control system, Steps in NC manufacturing, Role of NC/CNC technology in modern manufacturing, Features of CNC system, components and tooling of machining centre and CNC turning centre, Automatic tool changer, Feedback devices: Encoders and linear scale, Features of DNC and adaptive control systems.

UNIT V CNC Programming **9 + 0**

Part programming fundamentals, Manual Part Programming, APT Programming, Geometric & motion commands, Post processor commands, Safety measures in CNC programming.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : the student shall be able to understand the effect of manufacturing automation strategies
CO2 : knowledge of industrial automation by transfer lines and automated assembly lines.
CO3 : ability to understand the electronic control systems in metal machining and other manufacturing processes.
CO4 : identify different CNC components, systems and controls CNC machines
CO5 : ability to write CNC programming to solve complex machining process

Text Books:

1. M.P.Grover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education. 5^{th} edition, 2009.

Reference Books:

1. Computer Numerical Control (CNC) Machines Paperback – 1, P. Radhakrishnan , New Central Book Agency; 1st edition, 2013
2. Steve F Krar, "Computer Numerical Control Simplified", Industrial Press, 2001.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	1	2	1	1	2	2	0	0	0	1	1	1	2	2
CO2	1	2	2	1	1	2	1	0	0	0	1	1	1	2	2
CO3	1	2	2	2	2	2	1	0	0	0	1	1	1	2	2
CO4	0	1	1	1	3	2	2	0	0	0	1	1	1	2	2
CO5	0	1	1	1	3	2	2	0	0	0	1	1	1	2	2

1- Faintly
2- Moderately
3- Strongly

18MEPE44 **FUNDAMENTALS OF TRIBOLOGY**

L	T	P	C
3	0	0	3

Course Objectives:

1. To provide broad based understanding of the interdisciplinary subject 'tribology' and its technological significance.
2. To understand the nature of engineering surfaces, their topography and learn about surface characterisation techniques.
3. To learn about consequences of wear, wear mechanisms, wear theories and analysis of wear problems.

UNIT I SURFACES AND FRICTION **9 + 0**

Topography of Engineering surfaces- Contact between surfaces - Sources of sliding Friction- Adhesion-Ploughing- Energy dissipation mechanisms Friction Characteristics of metals - Friction of non-metals. Friction of lamellar solids - friction of Ceramic materials and polymers - Rolling Friction - Source of Rolling Friction - Stick slip motion – Measurement of Friction.

UNIT II WEAR **9 + 0**

Types of wear - Simple theory of Sliding Wear Mechanism of sliding wear of metals - Abrasive wear - Materials for Adhesive and Abrasive wear situations - Corrosive wear - Surface Fatigue wear situations - Brittle Fracture - wear - Wear of Ceramics and Polymers - Wear Measurements.

UNIT III LUBRICANTS AND LUBRICATION TYPES **9 + 0**

Types and properties of Lubricants - Testing methods - Hydrodynamic Lubrication - Elasto- hydrodynamic lubrication- Boundary Lubrication - Solid Lubrication- Hydrostatic Lubrication.

UNIT IV FILM LUBRICATION THEORY **9 + 0**

Fluid film in simple shear - Viscous flow between very close parallel plates - Shear stress variation Reynolds Equation for film Lubrication - High speed unloaded journal bearings - Loaded journal bearings - Reaction torque on the bearings - Virtual Co-efficient of friction - The Sommer field diagram.

UNIT V SURFACE ENGINEERING AND MATERIALS FOR BEARINGS **9 + 0**

Surface modifications - Transformation Hardening, surface fusion - Thermo chemical processes - Surface coatings - Plating and anodizing - Fusion Processes - Vapour Phase processes - Materials for rolling Element bearings - Materials for fluid film bearings - Materials for marginally lubricated and dry bearings.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand the surface phenomena related to relative motion, the nature of friction, and mechanisms of wear.
CO2 : introduce and expose students to the field and fundamentals in tribology and its applications.
CO3 : ability to identify different types of sliding & rolling friction, Wear and related theories.
CO4 : ability to distinguish among the different lubricant regime
CO5 : ability to select materials for bearing

Text Books:

1. A. Harnoy. "Bearing Design in Machinery "Marcel Dekker Inc, New York, 2003.
2. B.C. Majumdar ; A.H.Wheeler "Introduction to Tribology of Bearings"

Reference Books:

1. M. M. Khonsari & E. R. Booser, "Applied Tribology", John Willey &Sons, New York, 2001
2. E. P. Bowden and Tabor.D., "Friction and Lubrication ", Heinemann Educational Books Ltd., 1974.
3. A. Cameron, "Basic Lubrication theory", Longman, U.K.., 1981.
4. M. J. Neale (Editor), "Tribology Handbook", Newnes. Butterworth-Heinemann, U.K., 1995.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	3	3	1	1	2	0	0	0	0	0	1	2	1
CO2	0	1	2	2	1	1	1	0	0	0	0	0	1	1	1
CO3	1	2	2	2	1	1	0	0	0	0	0	0	2	1	1
CO4	0	1	2	2	1	0	0	0	0	0	0	0	2	1	1
CO5	0	2	2	2	0	0	0	0	0	0	0	0	1	2	1

1- Faintly
2- Moderately
3- Strongly

18MEPE45	ADVANCED DECISION MODELLING TECHNIQUE	L	T	P	C
		3	0	0	3

Course Objectives:

1. Consider the role of decision modelling in economic evaluation to guide decision making.
2. Use the basic building blocks of decision analysis such as joint and conditional probabilities and expected values.
3. Implement the principles of conceptual modelling as a way of planning a model.

UNIT I DECISION MAKING AND QUANTITATIVE TECHNIQUES 9 + 0

Forecasting methods & Time Series Analysis, Stochastic process introduction, Decision Analysis: Decision Trees& Utility Theory, Decision Making under uncertainty, Decision Making under risk, Decision Making under certainty, Decision Making under conflict (Game Theory).

UNIT II LINEAR PROGRAMMING FORMULATION AND SOLUTION 9 + 0

Linear Programming, Graphical & Simplex method, Dual simplex, Sensitivity Analysis & Duality, Integer Linear Programming, Transportation, Transhipment & Assignment Models.

UNIT III MULTI-CRITERIA DECISION MAKING TOOLS 9 + 0

Multi-criteria Decision making, Linear Goal Programming, Scoring Models, Fuzzy outranking, AHP (Analytic Hierarchy Process} concepts & applications, ANP (Analytic Network Process) an Introduction.

UNIT IV INVENTORY AND QUEUING MANAGEMENT 9 + 0

Inventory models (static, dynamic, probabilistic & stochastic), Waiting Line / Queuing models steady state operation(M/M/1), Simulation concepts & applications for inventory & Queuing situations, Network models; shortest route, maximal flow problem.

UNIT V ADVANCE QUANTITATIVE METHODS 9 + 0

PERT& CPM Techniques & Applications, Glimpses of Meta-heuristics, Tabu, Simulated Annealing & Genetic algorithm, Markov chains & Decision Processes, Sequencing, Dynamic Programming, Nonlinear Programming (Quadratic & Geometric Programming).

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : apply the discussed techniques to solve basic problems.
CO2 : understand Structure real life problems, build and analyze a model.
CO3 : implement key generic analytic steps in decision analysis such as evidence identification and basic synthesis, sensitivity analysis and reporting results.
CO4 : think critically about the structure of decision models in particular situations and apply these appropriately
CO5 : Understand when and how the techniques can be applied in business

Text Books:

1. Charles A. Gallagher Hugh. J.Watson , 1985, Quantitative Methods for Business Decisions, McGraw Hill.
2. Nobbert Lloyd Enrick, 1979, Management Operations Research, Holt Rinchart and Winston.

Reference Books:

1. Ronald L. Rardin, 1998, Optimization in Operations Research, Prentice Hall, Upper saddle-River New Jersey.
2. Hadley.G, 1972, Linear Programming, Addison Wesley Publication Company.
3. Wisniewski MIK, 2004, Quantitative Methods for Decision Makers, Macmillan India Ltd.
4. Thomas L. Saaty, 2005, Theory and applications of the analytic network process: Decision making within benefits, opportunities, costs and risks, RWS Publications, Pittsburgh.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	2	2	1	2	0	1	2	1	0	2
CO2	2	1	1	0	0	1	1	0	0	0	0	0	1	0	2
CO3	2	1	1	1	1	0	0	0	0	0	0	0	2	0	1
CO4	2	1	1	1	0	1	1	1	0	0	1	1	2	0	1
CO5	2	1	1	1	0	1	1	1	0	0	0	0	2	0	1

1- Faintly
2- Moderately
3- Strongly

18MEPE46	**TOTAL QUALITY MANAGEMENT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. Understand the philosophy and core values of Total Quality Management (TQM)
2. Explain the salient contributions of Quality Gurus like Deming, Juran and Crosby.
3. Determine the voice of the customer and convert into quality terms to enhance the economic performance and long-term business success of an organization.

UNIT I INTRODUCTION **9 + 0**

Definition of Quality - Dimensions of Quality - Quality planning - Quality costs, Analysis techniques for quality costs - Basic concepts of total quality management (TQM) - Historical review - Principles of TQM - Leadership - Role of senior management - Quality council, Quality statements - Strategic planning - Deming philosophy - Barriers to TQM implementation.

UNIT II TQM PRINCIPLES **9 + 0**

Customer satisfaction - Customer perception of quality, Customer complaints, Service quality, Customer Retention, Employee involvement - Motivation, Empowerment, Teams, Recognition and reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen - Supplier Partnership, Sourcing, Supplier selection, Supplier rating, Relationship development - Performance measures, Basic concepts, Strategy.

UNIT III STATISTICAL PROCESS CONTROL (SPC) **9 + 0**

The seven tools of quality, Statistical fundamentals – Measures of central tendency and dispersion, Population and sample, Normal curve - Control charts for variables and attributes, Process capability - Concept of six sigma, new seven Management tools.

UNIT IV TQM TOOLS **9 + 0**

Benchmarking – Reasons to benchmark, Benchmarking process, Quality function deployment (QFD) process – House of quality, Benefits - Taguchi quality loss function - Total productive maintenance (TPM) concept, Improvement needs - FMEA – Stages of FMEA.

UNIT V QUALITY MANAGEMENT SYSTEMS **9 + 0**

Need for ISO 9000 and other quality systems, ISO 9001:2008 quality system – Elements, Implementation of quality system, Documentation, Quality auditing, TS 16949:2002.

Total (45 + 0) = 45 Periods

Course Outcomes:

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

CO1 : Identify customer needs and convert those as quality index that will be used as inputs in TQM methodologies.
CO2 : Measure the performance quality i.e. cost of poor quality, process effectiveness and efficiency to identify areas for improvement.
CO3 : Determine the set of performance indicators that will align people with the objectives of an organization.
CO4 : Apply various TQM tools as a means to improve quality
CO5 : Explain ISO standards & quality systems, procedure for implementation, documentation and auditing

Text Books:

1. Dale H. Besterfiled et al., “Total Quality Management”, Pearson Education Asia, 1999.
2. Feigenbaum.A.V. “Total Quality Management”, McGraw Hill, 1991.

Reference Books:

1. Oakland.J.S, "Total Quality Management", Butterworth – Hcinemann Ltd., Oxford. 1989.
2. Narayana V and Sreenivasan, N.S, "Quality Management – Concepts and Tasks", New Age International, 1996.
3. James R.Evans and William M.Lidsay, "The Management and Control of Quality", 5th Edition, South-Western, 2002.
4. Zeiri, "Total Quality Management for Engineers", Wood Head Publishers, 1991.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	2	1	0	0	1	3	1	1	1	2
CO2	0	0	1	2	0	1	1	0	0	0	1	2	0	1	1
CO3	0	0	0	0	3	0	1	1	0	0	2	0	1	2	2
CO4	0	2	0	0	3	0	0	0	2	2	3	0	0	1	1
CO5	0	0	2	1	2	0	0	0	2	0	3	0	0	1	1

1- Faintly
2- Moderately
3- Strongly

Electives – V (VIII SEMESTER)

18MEPE51 **ADVANCED MECHANICS OF SOLIDS**

L	T	P	C
3	0	0	3

Course Objectives:

1. Know the concepts of stress and strain.
2. Analyze the beam of different cross sections for shear force, bending moment, slope and deflection.
3. Understand the concepts necessary to design the structural elements and pressure vessels.
4. To gain knowledge of different types of stresses, Strains and deformation induced in Mechanical Components due to external loads.

UNIT I ELASTICITY **9 + 0**

Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium-compatibility-boundary conditions-representation of three-dimensional stress of a tension generalized hook's law - St. Venant's principle - plane stress - Airy's stress function. Energy methods.

UNIT II SHEAR CENTER AND UNSYMMETRICAL BENDING **9 + 0**

Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.

UNIT III STRESSES IN FLAT PLATES AND CURVED MEMBERS **9 + 0**

Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions.

UNIT IV TORSION OF NON-CIRCULAR SECTIONS **9 + 0**

Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes.

UNIT V STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES **9 + 0**

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress- deflection of bodies in point and line contact applications.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : apply concepts of stress and strain analyses in advanced mechanics of solids problems.
CO2 : use the procedures in theory of elasticity at a basic and advanced level.
CO3 : solve general bending problems.
CO4 : apply energy methods in structural mechanics problems
CO5 : gain understanding into the effects of various types of loading on structures.

Text Books:

1. Arthur P Boresi, Richard J. Schmidt, “Advanced mechanics of materials”, John Wiley, 2002.
2. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill.

Reference Books:

1. Allan F. Bower, “Applied Mechanics of Solids”, CRC press – Special Indian Edition -2012, 2010
2. G H Ryder Strength of Materials Macmillan, India Ltd, 2007.
3. Srinath. L.S., “Advanced Mechanics of solids”, Tata McGraw Hill, 1992.
4. Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Mc-Millan pub. Co., 1985.
5. K. Baskar and T.K. Varadan, “Theory of Isotropic/Orthotropic Elasticity”, Ane Books Pvt. Ltd., New Delhi, 2009

E-References:

1. NPTEL Videos/Tutorials

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	1	2	1	2	0	0	0	0	0	1	1	1
CO2	2	1	3	1	1	3	1	0	0	0	0	0	2	3	1
CO3	3	1	2	1	2	1	1	0	0	0	0	0	3	1	2
CO4	1	2	1	2	1	1	1	0	0	0	0	0	1	1	2
CO5	3	1	3	1	1	1	1	0	0	0	0	0	1	1	1

1- Faintly
2- Moderately
3- Strongly

18MEPE52 **HEAT TRANSFER PROBLEMS IN ELECTRONICS AND INSTRUMENTATION**

L	T	P	C
3	0	0	3

Course Objectives:

1. To understand the underlying principles of heat transfer
2. To learn the conduction heat transfer in electronic equipments
3. To familiarize with the convection heat transfer in electronic applications
4. To acquire the knowledge in the radiation heat transfer in electronic instruments
5. To understand the principles of thermal Design of Electronic Equipments

UNIT I INTRODUCTION **9 + 0**

Basics of Electronic and instrumentations, basics of thermodynamics and heat transfer, Components of Electronic Systems, Thermal management in electronic devices - Packaging Trends. Electronic packaging and interconnection technology.

UNIT II CONDUCTION HEAT TRANSFER IN ELECTRONIC EQUIPMENT **9 + 0**

Thermal Conductivity, Thermal Resistances, Conductivity in Solids, Conductivity in Fluids, Conduction—Steady State, Conduction in Simple Geometries, Conduction through a Plane Wall, Conduction through Cylinders and Spheres. Conduction—Transient, Lumped Capacitance Method, Conduction in Extended Surfaces. Fin Efficiency, Fin Optimization, Fin Surface Efficiency, Thermal Contact Resistance in Electronic Equipment, Discrete Heat Sources and Thermal Spreading.

UNIT III CONVECTION HEAT TRANSFER IN ELECTRONIC EQUIPMENT **9 + 0**

Convection Heat Transfer in Electronic Equipment. Natural Convection in Electronic Devices, Overall Heat Transfer Coefficient. Liquid Cooling Systems, Coolant Selection, Pressure Drop and Pump Requirements. Air Cooling System, Induced or Draft Cooling, Selection of Fans and Blowers.

UNIT IV RADIATION HEAT TRANSFER IN ELECTRONIC EQUIPMENT **9 + 0**

The Electromagnetic Spectrum, Radiation Equations , Stefan-Boltzmann Law, Surface Characteristics, Emittance, Emittance Factor, Emittance from Extended Surface, Absorptance, Reflectance, Specular Reflectance, Heat Transfer with Phase Change. Combined Modes of Heat Transfer for Electronic Equipment, Radiation and Convection in Parallel.

UNIT V INTRODUCTION TO THERMAL DESIGN OF ELECTRONIC EQUIPMENT **9 + 0**

Analysis of Thermal Failure of Electronic Components. Analysis of Thermal Stresses and Strain, Effect of PCB Bending Stiffness on Wire Stresses, Vibration Fatigue in Lead Wires and Solder Joints. Electronics Cooling Methods in Industry. Heat Sinks, Heat Pipes, Heat Pipes in Electronics Cooling, Thermoelectric Cooling, Immersion Cooling, Cooling Techniques for High Density Electronics.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : students understood the basic concepts of heat and mass transfer principles
CO2 : knowledge about the concept of conduction heat transfer in electronic and instrumentation
CO3 : students have understood the convective heat transfer in the electronic appliances
CO4 : the Knowledge about the radiation heat transfer in electronic instruments
CO5 : students can able to design the thermal systems in electronic equipments

Text Books:

1. Heat transfer Dr. A.S. Padalkar, NiraliPrakashan, Pune 2012
2. Heat & mass transfer, D.S. Kumar, S.K. Kataria& Sons, 2010

Reference Books:

1. Heat transfer B.L. Singhal, Techmax, publication, Pune 2010
2. Heat & mass transfer,Mills and Ganesan, Pearson Publication, New Delhi 2010

E-References:

1. nptel.ac.in/ courses/downloads

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	2	1	1	1	0	0	0	0	0	1	1	1
CO2	2	1	1	2	3	1	1	0	0	0	0	0	1	2	2
CO3	3	1	1	2	1	2	1	0	0	0	0	0	1	1	2
CO4	1	1	1	1	2	2	1	0	0	0	0	0	1	3	1
CO5	1	0	3	2	1	1	1	0	0	0	0	0	2	3	1

1- Faintly
2- Moderately
3- Strongly

18MEPE53	NUCLEAR ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To teach students fundamental physics about nuclear processes and a heat transfer techniques from nuclear energy
2. To introduce students about the nuclear fuels with its properties and also extraction process of nuclear fuels.
3. To teach about the characteristics of spent fuel and reprocessing of solvent extraction
4. To teach about the nuclear reactor product
5. To teach about the safety aspects to be used in nuclear process and disposal of nuclear waste

UNIT I NUCLEAR REACTIONS **9 + 0**

Mechanism of Nuclear Fission - Nuclides - Radioactivity – Decay Chains - Neutron Reactions - the Fission Process - Reactors - Types of Fast Breeding Reactor - Design and Construction of Nuclear reactors - Heat Transfer Techniques in Nuclear Reactors - Reactor Shielding.

UNIT II REACTOR MATERIALS **9 + 0**

Nuclear Fuel Cycles - Characteristics of Nuclear Fuels - Uranium - Production and Purification of Uranium - Conversion to UF4 and UF6 - Other Fuels like Zirconium, Thorium - Beryllium.

UNIT III REPROCESSIG **9 + 0**

Nuclear Fuel Cycles - Spent Fuel Characteristics - Role of Solvent Extraction in Reprocessing - Solvent Extraction Equipment.

UNIT IV NUCLEAR REACTOR **9 + 0**

Nuclear reactors: types of fast breeding reactors-design and construction of fast breeding reactors-heat transfer techniques in nuclear reactors-reactor shielding. Fusion reactors.

UNIT V SAFETY AND DISPOSAL **9 + 0**

Safety and disposal: Nuclear plant safety-safety systems-changes and consequences of accident-criteria for safety-nuclear waste-types of waste and its disposal-radiation hazards and their prevention-weapons proliferation.

Total (45 +0) = 45 Periods

Course Outcomes:

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

CO1 : learn about the fundamental knowledge about nuclear reactions
CO2 : learn about the various nuclear fuels and its properties.
CO3 : study about the processing of nuclear fuel cycles
CO4 : learn about the function of nuclear reactor
CO5 : study about safe disposal of nuclear wastes.

Text Books:

1. Thomas J.Cannoly, “Fundamentals of nuclear Engineering” John Wiley 1978.
2. Glasstone, S and Sesonske, A, “Nuclear Reactor Engineering”, 3rd Edition, Von Nostrand, 1981.
3. Lamarsh, J.R., “Introduction to Nuclear Reactor Theory”, Wesley, 1966.

Reference Books:

1. Winterton, R.H.S., “Thermal Design of Nuclear Reactors”, Pergamon Press, 1981.
2. Jelly N A, “Nuclear Engineering”, Cambridge University Press, 2005.
3. Duderstadt, J.J and Hamiition, L.J, “Nuclear Reactor Analysis”, John Wiley, 1976.
4. Walter, A.E and Reynolds, A.B, “Fast Breeder Reactor”, Pergamon Press, 1981.

E- Reference

1. http://nptel.ac.in/courses/112101007/

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	2	1	1	1	1	0	0	0	0	0	1	1	1
CO2	1	1	2	1	2	1	2	0	0	0	0	0	2	3	3
CO3	1	1	1	1	1	1	1	0	0	0	0	0	1	2	1
CO4	3	1	1	1	1	2	1	0	0	0	0	0	3	1	1
CO5	1	1	2	1	1	1	1	0	0	0	0	0	1	3	1

1- Faintly
2- Moderately
3- Strongly

18MEPE54 **ANALYSIS AND SYNTHESIS OF MECHANISM**

L	T	P	C
3	0	0	3

Course Objectives:

1. To Study of kinematics of various mechanisms and kinematic synthesis of linkages.
2. To Study of various graphical constructions of acceleration analysis.
3. To Study Static and dynamic force analysis of linkages.
4. To Study Kinematic analysis and kinematic synthesis of spatial mechanisms
5. To Study about the spatial mechanisms and robotics

UNIT I KINEMATIC ANALYSIS OF MECHANISMS **9 + 0**

Review of Fundamentals of Kinematics - Mobility Analysis - Classifications of Mechanisms - Kinematic Inversion - Grashoff's law - Mechanical Advantage - Transmission Angle - Position Analysis - Vector Loop Equations for four bar, Slider Crank, Six bar linkages - Analytical and Graphical methods for velocity and acceleration analysis - Four bar linkage jerk analysis. Plane complex mechanism.

UNIT II KINEMATIC SYNTHESIS OF LINKAGES **9 + 0**

Type, Number and Dimensional Synthesis - Function Generation - Path Generation and Motion Generation. - Graphical Methods: Two Position, Three Position and Four Position synthesis of four bar Mechanism, Slider crank Mechanism, Precision positions Over lay Method. Analytical Methods: Blotch's Synthesis - Freudestien's Method - Coupler curve Synthesis - Cognate linkages - The Roberts - Chebyshev theorem.

UNIT III PATH CURVATURE THEORY **9 + 0**

Fixed and moving centrodes. - Hartmann's Construction - Inflection Points, The Inflection Circle - The Euler - Savary Equation - The collination axis and Bobiller's theorem - Conjugate points and inverse motion - The Cubic Stationary curvature - Ball's Point.

UNIT IV DYNAMICS OF MECHANISMS **9 + 0**

Static force analysis - Inertia force analysis - Combined static and inertia force Analysis - Shaking force - Introduction to force and moment balancing of linkages.

UNIT V SPATIAL MECHANISMS AND ROBOTICS **9 + 0**

Introduction: Mobility of mechanisms - Description of spatial motions - Kinematic analysis of spatial mechanism - Kinematic synthesis of spatial mechanisms: position, velocity and acceleration analysis. Eulerian Angles - Introduction to Robotic Manipulators - Topological arrangements of robotic arms - Kinematic analysis of spatial mechanism - Denavit - Hartenberg Parameters, Forward and inverse kinematics of robotic manipulators.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : analysis the kinematics of mechanisms
CO2 : synthesis the kinematics of linkages
CO3 : acquire knowledge about the theory of path curvature
CO4 : learned the dynamics of mechanisms
CO5 : design the robotics arms and manipulators

Text Books:

1. Rao.J.S and Dukkipatti.R.V, “Mechanisms and Machine Theory”, 2nd Edition, New Age international (P) Ltd., 2007
2. Shigley.J.E and Uicker J.J, “Theory of Machines and Mechanisms”, McGraw Hill, 1995.

Reference Books:

1. Norton.R. L, “Design of Machinery”, McGraw Hill, 2010.

2. Sandor.G.N and Erdman A. G, “Mechanism Design, Analysis and Synthesis”, Vol: I and Vol: II, Prentice Hall, Digitized 2007.
3. Hamilton.HMabie and Charles F. Reinhofz, “Mechanisms and Dynamics of Machinery”, John Wiley & Sons, Digitized 2007.
4. AmitabhaGhose and Ashok Kumar Malik, “Theory of Mechanisms and Machines”, EWLP, Delhi, 1999.

E-References:

1. Nptel.ac.in / courses / downloads

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	1	2	1	1	0	0	0	0	0	1	2	1
CO2	2	1	3	1	1	1	1	0	0	0	0	0	1	2	1
CO3	1	3	1	1	1	2	1	0	0	0	0	0	1	1	3
CO4	1	2	1	1	1	2	3	0	0	0	0	0	2	1	1
CO5	1	1	1	1	2	1	1	0	0	0	0	0	3	1	2

1- Faintly
2- Moderately
3- Strongly

18MEPE55 **THERMAL TURBO MACHINES** **L T P C**

3 0 0 3

Course Objectives:

1. To understand the various systems, principles, operations and applications of different types of turbo machinery components.

UNIT I INTRODUCTION TO TURBO MACHINES 9 + 0

Turbines, Pumps, Compressors, Fans and Blowers – Stages of Turbo machines – Energy transfer between fluid and rotor – Stage velocity triangles Thermal Turbo machines – Classification – General energy equation – Modified to turbo machines – compression and expansion process – Velocity triangles – Work – T-S and H-S diagram, Total – to – Total and Total – to – Static efficiencies. Dimensional analysis – Non dimensional parameters of compressible flow Turbo machines – Similarity laws, applications and limitations.

UNIT II CENTRIFUGAL FANS AND COMPRESSOR 9 + 0

Definition, selection and classifications -Types of blading design-velocity triangles - Stage Parameters – Flow analysis in impeller blades -Design parameter- Volute and Diffusers – Efficiencies and Losses – Fan noises – Causes and remedial measures. Centrifugal Compressors: - Constructional details – Stage velocity triangles — Stage work – Stage pressure rise – Stage efficiency – Degree of reaction – Slip factor – H-S diagram – Efficiencies – Performance characteristics.

UNIT III AXIAL FANS AND COMPRESSOR 9 + 0

Definition and classifications – Stage parameters – Types of fan stages-performance characteristics. Cascade of blades – Cascade tunnel - Blade geometry-Cascade variables-Energy transfer and loss in terms of lift and drag - Axial Flow Compressors: definition and classifications – Constructional details – Stage velocity triangles – Stage work – Stage pressure rise – H-S diagram – Stage efficiencies and losses- Degree of reaction – Radial equilibrium-Surging and Stalling – Performance characteristics.

UNIT IV AXIAL FLOW TURBINES 9 + 0

Construction details -90^0 IFR turbine- Stage work – Stage Velocity triangles – Stage pressure rise – Impulse and reaction stage – Effect of degree of reaction – H-S diagram – Efficiencies and Losses -Performance characteristics.

UNIT V RADIAL FLOW TURBINES AND WIND TURBINES 9 + 0

Constructional details — Stage velocity triangles – H-S diagram – Stage efficiencies and losses -Performance characteristics. Wind turbines: definition and classifications – Constructional details -Horizontal axis wind turbine-Power developed – Axial thrust – Efficiency.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : understand the Basic Concept of Compressors, Turbines, Fans and Blowers
CO2 : analyze the velocity triangles of Centrifugal fans and Compressors.
CO3 : analyze the construction details and performance of axial fans and compressor.
CO4 : analyze the design variations of axial flow turbines.
CO5 : study the construction features and performance analysis of radial flow turbine and wind turbine

Text Books:

1. Yahya, S.M., "Turbines, Compressors and Fans", Tata McGraw Hill Publishing Company, 1996.
2. Dixon S.L, "Fluid Mechanics, Thermodynamics of Turbo Machines", 2nd Edition, Pergamon press, 1990.
3. Kadambi V and Manohar Prasad, "An Introduction to Energy Conversion - Vol. III Turbo Machines", Wiley Eastern India Ltd, 1977.

Reference Books:
1. Bruneck, Fans, Pergamom Press, 1973.
2. Earl Logan, Jr., Hand book of Turbomachinery, Marcel Dekker Inc., 1992.
3. Shepherd, D.H., Principles of Turbomachinery, Macmillan, 1969.
4. Stepanpff, A.J., Blowers and Pumps, John Wiley and Sons Inc. 1965.
5. Ganesan, V., Gas Turbines, Tata McGraw Hill Pub. Co., 1999.
7. Rangwala A S, “Structural Dynamics of Turbo-Machines”, New Age International,2005.
8. Astashev VK, Babitsky VI and Kolovsky MZ, “Dynamics and Control of Machines”, Springer Pub, 2000

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	1	1	3	1	1	0	0	0	0	0	1	2	2
CO2	1	3	1	1	2	1	1	0	0	0	0	0	1	1	3
CO3	2	1	3	1	1	2	1	0	0	0	0	0	1	1	2
CO4	2	1	1	1	3	1	1	0	0	0	0	0	1	1	2
CO5	2	1	1	3	1	2	1	0	0	0	0	0	2	3	1

1- Faintly
2- Moderately
3- Strongly

Electives – VI (VIII SEMESTER)

18MEPE61	**CRYOGENIC ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:
1. To provide the knowledge of evolution of low temperature science
2. To provide knowledge on the properties of materials at low temperature
3. To familiarize with various gas liquefaction systems and to provide design aspects of cryogenic storage and transfer lines
4. To learn information concerning low temperature processes and techniques
5. To be familiar with the applications of low temperature technology

UNIT I INTRODUCTION **9 + 0**

Liquefaction systems ideal system, Joule Thomson expansion, Adiabatic expansion, LindeHampson Cycle, Claude & Cascaded System, Magnetic Cooling, Stirling Cycle Cryo Coolers.

UNIT II GAS LIQUEFACTION SYSTEMS **9 + 0**

Introduction-Production of low Temperatures-General Liquefaction systems- Liquefaction systems for Neon. Hydrogen and Helium –Critical components of Liquefaction systems.

UNIT III CRYOGENIC REFRIGERATION SYSTEMS **9 + 0**

Ideal Refrigeration systems- Refrigeration using liquids and gases as refrigerant- Refrigerators using solids as working media.

UNIT IV CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS **9 + 0**

Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems.

UNIT V CRYOGENIC FLUID STORAGE AND TRANSFER SYSTEMS **9 + 0**

Pressure flow-level and temperature measurements. Types of heat exchangers used in cryogenic systems (only description with figure) Cryo pumping Applications.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : Know about properties of material at cryogenic temperatures.
CO2 : know about various liquefaction systems.
CO3 : get ideas on cryogenic refrigeration systems, cryogenic instrumentation and cryogenic heat exchangers.
CO4 : learned about the cryogenic fluid storage and transfer systems.
CO5 : acquire knowledge about the cryogenic fluid storage and transfer systems.

Text Books:
1. J. H. Boll Jr, Cryogenic Engineering
2. R. B. Scott, Cryogenic Engineering, Van Nostrand Co., 1959

Reference Books:
1. Klaus D. Timmerhaus and Thomas M.Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989.
2. Randal F.Barron, Cryogenic systems, McGraw Hill, 1986.

E-References:
1. nptel.ac.in / courses / downloads

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0
CO2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2
CO3	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0
CO4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1
CO5	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

18MEPE62 INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

Course Objectives:

1. To introduce numerical modeling and its role in the field of heat transfer and fluid flow.
2. To enable the students to understand the various discretization methods and solving methodologies.
3. To create confidence to solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.

UNIT I GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 9 + 0

Classification, Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II CONDUCTION HEAT TRANSFER 9 + 0

Steady one-dimensional conduction, two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III INCOMPRESSIBLE FLUID FLOW 9 + 0

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, simple Procedure of Patankar and Spalding, Computation of Boundary layer flow, Finite difference approach.

UNIT IV CONVECTION HEAT TRANSFER AND FEM 9 + 0

Steady One-Dimensional and Two-Dimensional Convection – Diffusion, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady heat conduction by FEM – Incompressible flow – Simulation by FEM.

UNIT V TURBULENCE MODELS 9 + 0

Algebraic Models – One equation model, K - £ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

Total(45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand and be able to numerically solve the governing equations for fluid flow.
CO2 : solve computational problems related to fluid flows and heat transfer.
CO3 Solve the problems related to incompressible fluid flow.
CO4 : interpret the knowledge, capability of analyzing and solving heat convection problem.
CO5 : understand and apply turbulence models to engineering fluid flow problems.

Text Books:

1. Ghoshdasdidar, P.S, “Computer Simulation of flow and heat transfer”, Tata McGraw-Hill Publishing Company Ltd., 1998.
2. Muralidhar, K.andSundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 1995.

Reference Books:

1. Bose, T.X., “Numerical Fluid Dynamics”, Narosa Publishing House, 1997
2. Fletcher, C.A.J. “Computational Techniques for Fluid Dynamics 2-Specific Techniques for Different Flow Categories”, Springer and Verlag, 1987
3. Taylor, C and Hughes, J.B, “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.
4. Subas, V, Patankar, “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0
CO3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
CO4	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
CO5	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0

1- Faintly
2- Moderately
3- Strongly

18MEPE63	**ROBOTICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To explore concepts of Robot technologies that is playing vital role in manufacture.
2. Describe various Robot technology applications.
3. Develop an understanding of Robot Kinematics and dynamics.
4. Explain and summarize Robot End effectors and Sensors.
5. Explore conceptual understanding of Robot programming.

UNIT I INTRODUCTION 9 + 0

Robot - definition - robot anatomy - co-ordinate systems - work envelope - types and classification - specifications – joint notations – types of joints - speed of motion - pay load - robot parts and their functions - need for robots in Indian scenario.

UNIT II ROBOT DRIVE SYSTEMS AND END EFFECTORS 9 + 0

Drives - hydraulic, pneumatic, mechanical and electrical - servo motors - stepper motors - salient features, application – end effectors – types: tools - grippers - mechanical grippers - pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, multiple grippers.

UNIT III SENSORS AND MACHINE VISION 9 + 0

Requirements of sensors – principles, types and applications of following types of sensors proximity (inductive, Hall effect, capacitive, ultrasonic and optical) – range (Triangulation, structured light approach, laser range) – speed, position (resolvers, optical encoders, pneumatic) – force – torque – touch sensors (binary, analog sensor) - introduction to machine vision -functions - image processing and analysis.

UNIT IV ROBOT KINEMATICS AND ROBOT PROGRAMMING 9 + 0

Forward kinematics and reverse kinematics of manipulators - two, three degrees of freedom (in 2 dimensional) – homogeneous transformation matrix - simple problems - lead through programming, robot programming languages - VAL programming –motion commands - sensor commands - end effecter commands - simple programs for loading, unloading and palletizing operations.

UNIT V APPLICATIONS, IMPLEMENTATION AND ROBOT ECONOMICS 9 + 0

Robot cell design – types - Application of robots in processing - assembly - inspection - material handling - loading -unloading - automobile - implementation of robots in industries - safety considerations for robot operations – economic analysis of robots - pay back method and rate of return method.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : understand the basic concepts, parts of robots and types of robots.
CO2 : understand the potential applications of robots in industries as part of automation tool
CO3 : familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots.
CO4 : discuss about the various applications of robots, justification, implementation and safety of robot
CO5 : select an appropriate robot for a particular application.

Text Books:

1. Mikell. P. Groover, 'Industrial Robotics Technology', Programming and Applications, McGraw Hill Co,1995.
2. Fu.K.S. Gonzalz.R.C., and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co.,1987.

Reference Books:

1. Richard D.Klafter, Thomas A.Chmielewski and MichealNegin, "Robotic engineering –An Integrated Approach",Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 2005.

2. Janakiraman.P.A. “Robotics and Image Processing”, Tata McGraw-Hill, 1995.
3. YoramKoren, “Robotics for Engineers”, McGraw-Hill Book Co., 1992.
4. A.K.Gupta and S.K.Arora, “Industrial Automation and Robotics”, Laxmi Publications Pvt ltd, 2007.
5. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., ‘Robotics control, sensing, vision and intelligence’, McGraw Hill Book co, 1987.
6. Craig. J. J. ‘Introduction to Robotics mechanics and control’,Addison- Wesley, 1999.
7. Ray Asfahl. C., ‘Robots and Manufacturing Automation’, John Wiley & Sons Inc., 1985.

E-References:

1. NPTEL Videos/Tutorials

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0
CO2	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
CO3	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0
CO4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3
CO5	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

18MEPE64 ENGINEERING SYSTEM MODELING AND SIMULATION

L	T	P	C
3	0	0	3

Course Objectives:

1. Outline the fundamentals of system simulation
2. Identify the different types of techniques to generate Random numbers
3. Outline random number and variate generation.
4. The ability to analyze a system and to make use of the information to improve the performance

UNIT I INTRODUCTION **9 + 0**

Static physical models, dynamic physical models, static mathematical models, dynamic mathematical models, principles used in modeling. System studies, a corporate model: Environment segment, production segment, management segment. Types of system study.

UNIT II MATHEMATICAL AND STATISTICAL MODELS **9 + 0**

Probability concepts, Queuing Models, Methods for generating random variables and Validation of random numbers.

UNIT III DESIGN OF SIMULATION EXPERIMENTS **9 + 0**

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation validation.

UNIT IV SIMULATION LANGUAGES **9 + 0**

Input modeling: data collection, identifying the distribution with data, parameter estimation, goodness of fit test, fitting a non-stationary Poisson process, selecting input models without data, multivariate and time series input models. Verification and validation of simulation models, model building, verification and validation, verification of simulation models, calibration and validation of models.

UNIT V CASE STUDIES **9 + 0**

Development of simulation models using simulation language studied for systems like queuing systems, Production systems, Inventory systems, maintenance and replacement systems and Investment analysis.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : modeling any given system with rationality.
CO2 : predicting the behavior through fine grained analysis.
CO3 : simulate the life cycle analysis, and drives over issues like model verification and validation.
CO4 : design simulation models for various case studies like inventory, traffic flow networks,etc.
CO5 : practice on simulation tools and impart knowledge on building simulation systems.

Text Books:

1. Geoffrey Gordon, “System Simulation”, 2nd Edition, Prentice Hall, India, 2002.
2. Narsingh Deo, “System Simulation with Digital Computer, “Prentice Hall, India, 2001.

Reference Books:

1. Jerry Banks and John S.Carson, Barry L. Nelson, David M.Nicol, “Discrete Event System Simulation”, 3rd Edition, Prentice Hall, India, 2002.
2. Thomas J. Schriber, Simulation using GPSS, John Wiley, 1991.
3. Shannon, R.E. Systems simulation, The art and science, Prentice Hall, 1975.

E-References:

1. NPTEL Videos/Tutorials

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0
CO2	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0
CO3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
CO4	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0
CO5	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0

1- Faintly
2- Moderately
3- Strongly

18MEPE65	DESIGN OF PRODUCTION TOOLING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Describe tool design methods and punch and die manufacturing techniques
2. Select material for cutting tools and gages; classify various cutting tools and gages and identify their nomenclature
3. Describe the principles of clamping, drill jigs and computer aided jig design
4. Design fixtures for milling, boring, lathe, grinding, welding; identify fixtures and cutting tools for NC machine tools
5. Explain the principles of dies and moulds design

UNIT I DESIGN OF CUTTING TOOLS **9 + 0**

Tool materials, design of single point cutting tool, form tool, drill, reamer, broach & plain milling cutter.

UNIT II METAL CUTTING **9 + 0**

Theory of metal cutting – design of tool holders for single point tools – Boring bars – selection of tools for machining applications – economics of machining.

UNIT III DESIGN OF FIXTURES **9 + 0**

Standard work holding devices – principles of location and clamping – clamping methods and elements – quick-acting clamps – design & sketching of milling fixtures for simple components – Turning, Grinding, Welding fixtures. Inspection fixtures and design of gauges.

UNIT IV DESIGN OF DRILL JIGS **9 + 0**

Drill bushings – types of jigs: Plate, Leaf, Turn over & Box Jigs – design & sketching of drill jigs for machining simple components.

UNIT V PRESS TOOLS **9 + 0**

Power presses – die cutting operations – centre of pressure – scrap strip lay out for blanking – press tonnage calculations – Progressive & Compound dies – die design for simple components. Drawing dies – blank development – estimation of drawing force – blank holders & blank holding pressure – design & sketching of drawing dies for simple components – Bending dies & Combination tools.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : identify the various cutting tools for different machining processes.
CO2 : select suitable tools for metal machining
CO3 : identify suitable fixures for various components.
CO4 : ability to design jigs for machining components.
CO5 : the students can able to design jigs, fixtures and press tools

Text Books:

1. Cyril Donaldson, Lecain and Goold: Tool Design – Tata McGraw Hill publications
2. A Bhattacharyya: Metal Cutting – Theory and Practice – Central Book Agency Kolkata

Reference Books:

1. ASTME: Fundamentals of Tool Design – Prentice Hall
2. F W Wilson: Hand Book of Fixture Design - McGraw Hill publications.
3. Edward G Hoffman, “Jigs and Fixture Design”, Thomson – Delmar Learning, Singapore 2004.
4. Joshi P H, “Jigs and Fixtures”, Tata McGraw Hill Publishing Company Limited, New Delhi 2004.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0
CO3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3
CO4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
CO5	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0

1- Faintly
2- Moderately
3- Strongly

18MEOE01 DESIGN OF MACHINE ELEMENTS AND MACHINING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To familiarize the various steps involved in the design process
2. To understand the basic concepts of machining techniques
3. To know the factors influencing the processes and their applications

UNIT I STRESSES IN MACHINE ELEMENTS 9 + 0

Stress in simple machine members- axial, bending, torsional, bearing stress, Hertz contact stress; combined stresses, principle stresses, Theories of failure, factor of safety, stress concentration, preferred numbers.

UNIT II DESIGN OF SHAFTS AND WELDED JOINTS 9 + 0

Design of shaft members subjected to simple and combined stresses - Welded joints- Types of welding symbols, design of welded joints subjected to various load -Design of Riveted joints

UNIT III DESIGN OF MACHINE ELEMENTS 9 + 0

Springs: Design of helical springs- stresses and deflection - design procedure. Bearings: Need for bearing, Types, sliding and rolling contact bearings, hydro- dynamic and hydro static bearings- Life of bearings – Selection of bearings-Problems.

UNIT IV METAL CUTTING 9 + 0

Theory of metal cutting: Introduction, mechanics of metal cutting, orthogonal and oblique cutting, merchants equation, chip formation, heat generation, cutting fluids, cutting tool life, recent developments and applications (Dry machining and high speed machining)

UNIT V MACHINE TOOLS AND SURFACE FINISHING PROCESSES 9 + 0

Tools and machine tools: Cutting tool materials, cutting tool nomenclature, introduction to machine tools, lathe, shaper, planning, milling, drilling and boring machines, working principle, operations, work holding devices. Surface finishing processes**:** Introduction to Grinding honing, lapping processes and machines. Introduction to CAD/CAM/CIM.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : analyze the stresses induced in a machine element.
CO2 : understand the design concept of joints under various loading.
CO3 : identify the process parameters associated with various machining processes.

TEXT BOOKS:

1. Rao P N, "Manufacturing Technology" Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2006
2. HMT, "Production Technology" Tata McGraw-Hill Co., New Delhi, 1998
3. Robert L Mott, "Machine Elements in Mechanical Design", Macmillan Publishing Co., London. UK, 1992.
4. Shighley and Mische, "Mechanical Engineering Design" McGraw Hill, 1992.

REFERENCE BOOKS:

1. Milton C Shaw, "Metal Cutting Principles", Clarendon Press, Oxford, 1999.
2. James Brown, "Advanced Machining Technology Handbook", McGraw- Hill Book Company, New York, 1988.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	3	3	3	0	0	0	1	0	0	0	0	3	3	0
CO2	1	3	3	0	0	0	0	0	0	0	0	0	3	3	0
CO3	0	2	0	2	0	0	0	0	0	0	0	0	1	3	0

1- Faintly
2- Moderately
3- Strongly

18MEOE02 **INDUSTRIAL ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. Assume professional, technical, managerial and leadership roles in the industrial organizations.
2. Apply knowledge through discovery, synthesis, and integration for the betterment of the organization.
3. Apply engineering principles to the work environment.
4. Use quality tools to foresee and solve issues in the industrial situations.
5. Work collaboratively.

UNIT I FORECASTING AND INVENTORY **9 + 0**

Characteristics and Principles, Qualitative methods - Delphi technique, Market Research, Intrinsic method - Time-series analysis, Moving averages, Exponential smoothing - The Bon Jenkins method, Extrinsic methods - Regression models, Measurement of forecast errors. Inventory models - Classification of inventory systems – EOQ models and purchase discounts - ABC and other classification methods - Applications

UNIT II FACILITIES PLANNING **9 + 0**

Facilities planning - An overview, Facilities planning and engineering economic analysis - Facilities location problems – Types of layouts - Computerized layout planning - Warehouse management, Value added management, Management system audit - Role of KAIZEN, TQM, QC and POKA YOKE in facilities planning.

UNIT III JIT AND MODERN MANUFACTURING PRINCIPLES **9 + 0**

Introduction - Elements of Just In Time (JIT), Pull versus Push method, Kanban system - Single Minute Exchange of Die (SMED) - Continuous improvement - Optimized production technology - Business process reengineering (BPR), Lean manufacturing concepts – Implementation of Six Sigma concepts - Cellular manufacturing - Concurrent engineering - Agile manufacturing - Rapid manufacturing.

UNIT IV AGGREGATE PLANNING AND SUPPLY CHAIN MANAGEMENT **9 + 0**

Approaches to aggregate planning - Development of master production schedule - Capacity planning - Materials requirements planning (MRP-I), Manufacturing resources planning (MRP-II), Enterprises resources planning (ERP) - Supply chain management (SCM) – Supply chain and “Keiretsu”.

UNIT V SCHEDULING AND CONTROLLING **9 + 0**

Objectives in scheduling - Major steps involved - Production control in repetitive, batch and job shop manufacturing environment - Allocation of units for a single resource, allocation of multiple resources - Resource balancing - Flexible manufacturing system - Concepts, advantages and limitation.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : apply knowledge of mathematics, science, and engineering in the direction to improve the productivity of industries.
CO2 : design a system to meet desired needs within realistic constraints.
CO3 : function in multidisciplinary teams.
CO4 : use the techniques, skills, and modern engineering tools in manufacturing practice.

TEXT BOOKS:

1. Dilworth B. James, “Operations Management Design, Planning and control for Manufacturing and Services”, McGraw Hill Inc., New York, 1992.
2. Samson Eilon, “Elements of Production Planning and Control”, Universal Book Corpn.1984.

REFERENCE BOOKS:

1. Tomkins, J.A and White, J.A, “Facilities Planning”, John Wiley and Sons, 1984.
2. Vollman T.E, “Manufacturing Planning and Control systems”, Galgotia Publications, 2002.
3. Elwood S. Buffa, and Rakesh K.Sarin, “Modern Production and Operations Management”, 8th Edition. John Wiley and Sons, 2000.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO2	1	2	3	1	0	0	0	0	0	0	0	0	1	2	1
CO3	0	0	0	0	0	0	0	0	3	0	0	1	0	0	2
CO4	0	2	2	0	3	1	0	0	0	0	0	0	1	2	3

1- **Faintly**
2- **Moderately**
3- **Strongly**

18MEOE03 **TOTAL QUALITY MANAGEMENT**

L	T	P	C
3	0	0	3

Course Objectives:

1. Understand the philosophy and core values of Total Quality Management (TQM)
2. Explain the salient contributions of Quality Gurus like Deming, Juran and Crosby.
3. Determine the voice of the customer and convert into quality terms to enhance the economic performance and long-term business success of an organization.

UNIT I INTRODUCTION **9 + 0**

Definition of Quality - Dimensions of Quality - Quality planning - Quality costs, Analysis techniques for quality costs - Basic concepts of total quality management (TQM) - Historical review - Principles of TQM - Leadership - Role of senior management - Quality council, Quality statements - Strategic planning - Deming philosophy - Barriers to TQM implementation.

UNIT II TQM PRINCIPLES **9 + 0**

Customer satisfaction - Customer perception of quality, Customer complaints, Service quality, Customer Retention, Employee involvement - Motivation, Empowerment, Teams, Recognition and reward, Performance appraisal - Continuous process improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen - Supplier Partnership, Sourcing, Supplier selection, Supplier rating, Relationship development - Performance measures, Basic concepts, Strategy.

UNIT III STATISTICAL PROCESS CONTROL (SPC) **9 + 0**

The seven tools of quality, Statistical fundamentals – Measures of central tendency and dispersion, Population and sample, Normal curve - Control charts for variables and attributes, Process capability - Concept of six sigma, new seven Management tools.

UNIT IV TQM TOOLS **9 + 0**

Benchmarking – Reasons to benchmark, Benchmarking process, Quality function deployment (QFD) process – House of quality, Benefits - Taguchi quality loss function - Total productive maintenance (TPM) concept, Improvement needs - FMEA – Stages of FMEA.

UNIT V QUALITY MANAGEMENT SYSTEMS **9 + 0**

Need for ISO 9000 and other quality systems, ISO 9001:2008 quality system – Elements, Implementation of quality system, Documentation, Quality auditing, TS 16949:2002.

Total (45 + 0) = 45 Periods

Course Outcomes:

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

CO1 : Identify customer needs and convert those as quality index that will be used as inputs in TQM methodologies.

CO2 : Measure the performance quality i.e. cost of poor quality, process effectiveness and efficiency to identify areas for improvement.

CO3 : Determine the set of performance indicators that will align people with the objectives of an organization.

CO4 : Apply various TQM tools as a means to improve quality

CO5 : Explain ISO standards & quality systems, procedure for implementation, documentation and auditing

Text Books:

1. Dale H. Besterfiled et al., "Total Quality Management", Pearson Education Asia, 1999.
2. Feigenbaum.A.V. "Total Quality Management", McGraw Hill, 1991.

Reference Books:

1. Oakland.J.S, "Total Quality Management", Butterworth – Hcinemann Ltd., Oxford. 1989.

2. Narayana V and Sreenivasan, N.S, “Quality Management – Concepts and Tasks”, New Age International, 1996.
3. James R.Evans and William M.Lidsay, “The Management and Control of Quality”, 5th Edition, South-Western, 2002.
4. Zeiri, “Total Quality Management for Engineers”, Wood Head Publishers, 1991.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	2	1	0	0	1	3	1	1	1	2
CO2	0	0	1	2	0	1	1	0	0	0	1	2	0	1	1
CO3	0	0	0	0	3	0	1	1	0	0	2	0	1	2	2
CO4	0	2	0	0	3	0	0	0	2	2	3	0	0	1	1
CO5	0	0	2	1	2	0	0	0	2	0	3	0	0	1	1

1- Faintly
2- Moderately
3- Strongly

18MEOE04 **PRINCIPLES OF MANAGEMENT**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the term management basic features of management, principles usages in all walks of life and industrial growth.
2. Knowledge on the principles of management is essential for all kinds of people in all kinds of organizations. After studying this course, students will be able to have a clear understanding of the managerial functions like planning, organizing, staffing, leading and controlling.
3. Students will also gain some basic knowledge in international aspect of management.

UNIT I MANAGEMENT AN INTRODUCTION AND OVERVIEW **9 + 0**

Definitions of management – features of management – Management thoughts – different schools of management – Scientific management – Arts or Science, Management Vs administration – Principles of Management.

UNIT II FUNCTIONS OF MANAGEMENT **9 + 0**

Role of managers. Functions approach to management, Management functions, Management levels –, reconciling functions and role, responsibility of managers – towards subordinates, peers, supervisors, customers, government, company, creditors, shareholders, competitors etc..

UNIT III MANAGERIAL PLANNING AND DECISION MAKING **9 + 0**

Planning fundamentals, objectives. Management by objectives – Changes in objectives – goal distortions – major types of planing, policies and objectives, procedures – methods, rules, programmes and schedule, projects, budgets – importance of decision making, types of decisions, decision making process – decision theory – quantitative techniques – decision making conditions – Operation Research (OR), Definition, successful areas of operation research – Decision tree.

UNIT IV ORGANIZATION **9 + 0**

Organization: Basic concepts – organization as a structure – as a process – as a group properties of modern organization – typology, importance of organization – business /industrial organization – sole trading, partnership company, co – operative , public enterprise line (military), line and staff, functional , matrix committee based organization - departmentalization – need, bases of departmentation – career planning and management.

UNIT V STAFFING, CONTROLLING AND COMMUNICATION **9 + 0**

Nature and purpose of staffing – man power planning, aims and objectives of HR recruitment, selection and training sources of recruitment, process of recruitment, training methods – performance appraisal methods – communication – importance process – barriers to communications. How to remove obstacles of effective communication – controlling – definition – Characteristics of control – types of control – requirements of effective control – direct and preventive control repairing, control techniques.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the basic concepts of management
CO2 : explain the contributions and functions, types of business organization
CO3 : list the various types of leadership and evaluate the motivation theories and techniques.
CO4 : select forecasting models for future demands and to make decision in the management processes.

TEXT BOOKS:

1. Herald knootz and Heinz weihrich, ―Essentials of Management‖, McGraw-Hill Publishing Company, Singapore International Edition, 2007
2. Joseph L, Massie, ―Essentials of Management‖, Prentice Hall of India Pvt., Ltd (Pearson) Fourth Edition, 2003.

REFERENCE BOOKS:

1. Stephen A. Robbins & David A. Decenzo & Mary Coulter, "Fundamentals of Management" 7th Edition, Pearson Education, 2011.
2. Robert Kreitner & Mamata Mohapatra, "Management", Biztantra, 2008.
3. Harold Koontz & Heinz Weihrich "Essentials of management" Tata Mc Graw Hill, 1998.
4. Tripathy PC & Reddy PN, "Principles of Management", Tata McGraw Hill, 1999.

E-REFERENCES:

1. Nptel.ac.in / courses / downloads

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	0	0	0	0	1	0	3	0	1	3
CO2	0	0	0	0	0	1	0	2	1	0	0	2	0	1	2
CO3	0	0	0	1	0	0	0	0	3	2	0	2	0	1	3
CO4	0	0	0	0	0	1	1	0	2	0	0	1	0	1	2

1- Faintly
2- Moderately
3- Strongly

18MEOE05 PROFESSIONAL ETHICS AND HUMAN VALUES

L	T	P	C
3	0	0	3

Course Objectives:

1. To create awareness on Engineering Ethics and providing basic knowledge about engineering Ethics, Variety of moral issues and Professional Ideals.
2. To provide basic familiarity about Engineers as responsible Experimenters, Codes of Ethics, Industrial Standards.
3. To inculcate knowledge and exposure on Safety and Risk, Risk Benefit Analysis.

UNIT I HUMAN VALUES 9 + 0

Morals, Values and Ethics – Integrity – Work Ethic – Service Learning – Civic Virtue – Respect for Others – Living Peacefully – caring – Sharing – Honesty – Courage – Valuing Time – Co-operation – Commitment – Empathy – Self-Confidence – Character – Spirituality.

UNIT II ENGINEERING ETHICS 9 + 0

Senses of 'Engineering Ethics' - variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy – Models of Professional Roles - theories about right action – Self-interest- customs and religion - uses of ethical theories.

UNIT III ENGINEERING AS SOCIAL EXPERIMENTATION 9 + 0

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law – the challenger case study.

UNIT IV SAFETY, RESPONSIBILITIES AND RIGHTS 9 + 0

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - the three mile island and Chernobyl case studies. Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest – occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination.

UNIT V GLOBAL ISSUES 9 + 0

Multinational corporations - Environmental ethics - computer ethics - weapons development - engineers as managers consulting engineers-engineers as expert witnesses and advisors -moral leadership-sample code of Ethics like ASME,ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of electronics and telecommunication engineers (IETE),India.

Total (45+0) = 45 Periods

Course Outcomes:

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

CO1 : understand the importance of ethics and values in life and society.
CO2 : understood the core values that shape the ethical behavior of an engineer.
CO3 : exposed awareness on professional ethics and human values.

Text Books:

1. Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw-Hill, New York 2005.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

Reference Books:

1. Tripathi A N, "Human values" , New Age international Pvt. Ltd., New Delhi, 2002.
2. Charles D. Fleddermann, "Engineering Ethics", Pearson Education / Prentice Hall, New Jersey, 2004.
3. Charles E Harris, Michael S. Protchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Wadsworth Thompson Learning, United States, 2000.
4. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, New Delhi, 2003.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	0	2	1	3	0	0	1	0	1	1	0
CO2	0	0	0	0	0	0	2	3	0	0	0	0	1	0	0
CO3	0	0	0	0	0	1	1	3	0	0	0	0	1	0	3

1- **Faintly**
2- **Moderately**
3- **Strongly**

18MEOE06	ROBOTICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To explore concepts of Robot technologies that is playing vital role in manufacture.
2. Describe various Robot technology applications.
3. Develop an understanding of Robot Kinematics and dynamics.
4. Explain and summarize Robot End effectors and Sensors.
5. Explore conceptual understanding of Robot programming.

UNIT I INTRODUCTION 9 + 0

Robot - definition - robot anatomy - co-ordinate systems - work envelope - types and classification - specifications – joint notations – types of joints - speed of motion - pay load - robot parts and their functions - need for robots in Indian scenario.

UNIT II ROBOT DRIVE SYSTEMS AND END EFFECTORS 9 + 0

Drives - hydraulic, pneumatic, mechanical and electrical - servo motors - stepper motors - salient features, application – end effectors – types: tools - grippers - mechanical grippers - pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, multiple grippers.

UNIT III SENSORS AND MACHINE VISION 9 + 0

Requirements of sensors – principles, types and applications of following types of sensors proximity (inductive, Hall effect, capacitive, ultrasonic and optical) – range (Triangulation, structured light approach, laser range) – speed, position (resolvers, optical encoders, pneumatic) – force – torque – touch sensors (binary, analog sensor) - introduction to machine vision -functions - image processing and analysis.

UNIT IV ROBOT KINEMATICS AND ROBOT PROGRAMMING 9 + 0

Forward kinematics and reverse kinematics of manipulators - two, three degrees of freedom (in 2 dimensional) – homogeneous transformation matrix - simple problems - lead through programming, robot programming languages - VAL programming –motion commands - sensor commands - end effecter commands - simple programs for loading, unloading and palletizing operations.

UNIT V APPLICATIONS, IMPLEMENTATION AND ROBOT ECONOMICS 9 + 0

Robot cell design – types - Application of robots in processing - assembly - inspection - material handling - loading -unloading - automobile - implementation of robots in industries - safety considerations for robot operations – economic analysis of robots - pay back method and rate of return method.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : understand the basic concepts, parts of robots and types of robots.
CO2 : understand the potential applications of robots in industries as part of automation tool
CO3 : familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots.
CO4 : discuss about the various applications of robots, justification, implementation and safety of robot
CO5 : select an appropriate robot for a particular application.

Text Books:

1. Mikell. P. Groover, 'Industrial Robotics Technology', Programming and Applications, McGraw Hill Co,1995.
2. Fu.K.S. Gonzalz.R.C., and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book Co.,1987.

Reference Books:

1. Richard D.Klafter, Thomas A.Chmielewski and MichealNegin, "Robotic engineering –An Integrated Approach",Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 2005.

2. Janakiraman.P.A. "Robotics and Image Processing", Tata McGraw-Hill, 1995.
3. YoramKoren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
4. A.K.Gupta and S.K.Arora, "Industrial Automation and Robotics", Laxmi Publications Pvt ltd, 2007.
5. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., 'Robotics control, sensing, vision and intelligence', McGraw Hill Book co, 1987.
6. Craig. J. J. 'Introduction to Robotics mechanics and control',Addison- Wesley, 1999.
7. Ray Asfahl. C., 'Robots and Manufacturing Automation', John Wiley & Sons Inc., 1985.

E-References:
1. NPTEL Videos/Tutorials

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	0	1	0	0	0	0	0	0	0	2	3	1
CO2	0	0	2	0	3	0	1	0	0	0	0	0	1	3	1
CO3	1	2	0	0	2	0	0	0	0	0	1	2	1	2	1
CO4	0	0	0	0	0	3	0	0	0	0	0	0	1	1	1
CO5	0	0	0	0	2	0	0	0	0	0	0	2	1	1	1

1- Faintly
2- Moderately
3- Strongly

18MEOE07 **ROBOTIC PROCESS AUTOMATION**

L	T	P	C
3	0	0	3

Course Objectives:

1. To study the various parts of robots and fields of robotics.
2. To study the various kinematics and inverse kinematics of robots.
3. To study the Euler, Lagrangian formulation of Robot dynamics.
4. To study the trajectory planning for robot.
5. To study the control of robots for some specific applications.

UNIT I BASIC CONCEPTS **9 + 0**

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.

UNIT II POWER SOURCES AND SENSORS **9 + 0**

Hydraulic, pneumatic and electric drives – determination of HP of motor and gearing ratio – variable speed arrangements – path determination – micro machines in robotics – machine vision – ranging – laser – acoustic – magnetic, fiber optic and tactile sensors.

UNIT III MANIPULATORS, ACTUATORS AND GRIPPERS **9 + 0**

Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – U various types of grippers – design considerations.

UNIT IV KINEMATICS AND PATH PLANNING **9 + 0**

Solution of inverse kinematics problem – multiple solution jacobian work envelop – hill Climbing Techniques – robot programming languages

UNIT V CASE STUDIES **9 + 0**

Mutiple robots – machine interface – robots in manufacturing and non- manufacturing applications – robot cell design – selection of robot.

Total (45+0) =45 Periods

Course Outcomes:

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

CO1 : explain the basic concepts of working of robot.
CO2 : analyze the function of sensors in the robot.
CO3 : analyze the working of manipulates, actuators and grippers.
CO4 : write program to use a robot for a typical application.
CO5 : use Robots in different applications.

Text Books:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., “Industrial Robotics”, Mc Graw-Hill Singapore, 1996.
2. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.

Reference Books:

1. Deb. S.R.,“Robotics Technology and flexible Automation”, John Wiley, USA 1992.
2. Klafter R.D., Chimielewski T.A., Negin M., “Robotic Engineering – An integrated approach”, Prentice Hall of India, New Delhi, 1994.
3. Mc Kerrow P.J. “Introduction to Robotics”, Addison Wesley, USA, 1991.
4. Issac Asimov “Robot”, Ballantine Books, New York, 1986.
5. Barry Leatham – Jones, “Elements of industrial Robotics” PITMAN Publishing, 1987.
6. Mikell P.Groover, Mitchell Weiss, Roger N.Nagel Nicholas G.Odrey, “Industrial Robotics Technology, Programming and Applications “, McGraw Hill Book Company 1986.
7. Fu K.S. Gonzaleaz R.C. and Lee C.S.G., “Robotics Control Sensing, Vision and Intelligence” McGraw Hill International Editions, 1987.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	0	0	0	0	2	0	0	0	0	0	0	0	2	2	0
CO2	0	3	1	1	1	0	0	0	0	0	0	0	1	3	0
CO3	0	3	2	1	1	0	0	0	0	0	0	0	1	3	0
CO4	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0
CO5	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0

1- Faintly
2- Moderately
3- Strongly

PROTOSEM COURSES SYLLABUS

18MEPS11	APPLIED DESIGN THINKING		Semester			VI
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	The course enables product innovators and early-stage startup founders to learn the customer development process
2	To familiarize with the tools & techniques & validate the inherent risks by linking their progress to customer-motivation, customer-commitment & customer-acceptance.
3	To learn the system thinking concepts by reverse engineering technique.

Unit I	DESIGN THINKING PRINCIPLES	9	0	0	9

Exploring Human – Centered Design – Understanding the innovation process, discovering areas of opportunity, interviewing &empathy –building techniques, Mitigate validate risk with FIR(Forge Innovation Rubric) – Case Studies.

Unit II	CUSTOMER-CENTRIC INNOVATION	9	0	0	9

Importance of customer-centric innovation – Problem Validation and Customer Discovery – Understanding problem significance and problem incidence- Customer Validation. Target user, User persona & user stories. Activity : Customer development process – Customer interviews and field visit.

Unit III	APPLIED DESIGN THINKING TOOLS	9	0	0	9

Concept of Minimum Usable Prototype(MUP) – MUP challenge brief – Designing & Crafting the value proposition – Designing and Testing Value Proposition: Design a compelling value proposition: Process, tools and techniques of Value Proposition Design.

Unit IV	CONCEPT GENERATION	9	0	0	9

Solution Exploration, Concepts Generation and MUP design – Conceptualize the solution concept: explore, iterate and learn; build the right prototype: Assess capability, usability and feasibility. Systematic concept generation; evaluation technology alternatives and the solution concepts.

Unit V	SYSTEM THINKING & REVERSE ENGINEERING	9	0	0	9

System Thinking, Understanding Systems, Examples and Understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components – Re-Engineering a complex system.

Total = 45 Periods

Text Books:

1	Steve Blank, (2013), The four steps to epiphany: Successful strategies for products that win, Wiley.
2	Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, Trish Papadakos, (2014), Value
3	Proposition Design: How to Create Products and Services Customers Want, Wiley
4	Donella H. Meadows, (2015), “Thinking in Systems -A Primer”, Sustainability Institute.
5	Tim Brown,(2012) “Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation”, Harper Business.

Reference Books:	
1	https://www.ideou.com/pages/design-thinking#process
2	https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations-49f253c a8624
3	https://blog.forgeforward.in/product-innovation-rubric-adf5ebdfd356
4	https://blog.forgeforward.in/evaluating-product-innovations-e8178e58b86e
5	https://blog.forgeforward.in/user-guide-for-product-innovation-rubric-857181b253dd 6
6	https://blog.forgeforward.in/startup-failure-is-like-true-lie-7812cdfe9b85

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Define & treat various hypotheses to mitigate the inherent risks in product innovations	L1: Remembering
CO2	Design the solution concept based on the proposed value by exploring various alternate solutions to achieve value-price fit.	L6: Creating
CO3	Develop skills in empathizing, critical thinking, analyzing, storytelling & pitching.	L3: Applying
CO4	Apply system thinking to reverse engineer a product/prototype and understand its internal correlations.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1	1	1	1	1	1	1	2	2	3
CO2	2	2	3	2	2	1	1	1	1	1	1	1	3	3	2
CO3	1	2	2	1	1	3	1	1	3	3	1	1	1	1	1
CO4	2	3	3	3	3	2	2	1	2	2	1	1	3	3	3
AVG	**1.75**	**2.5**	**2.5**	**2.25**	**2**	**1.75**	**1.25**	**1**	**1.75**	**1.75**	**1**	**1**	**2.25**	**2.25**	**2.25**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS12	STARTUP FUNDAMENTALS			Semester			VI
PREREQUISITES		Category			Credit		3
		Hours/Week		L	T	P	TH
				3	0	0	3

Course Learning Objectives	
1	Learn the science of to transforming an innovative idea into high-growth enterprises.
2	To understand the basic concepts of IPR, and develop a patent draft for a potential IP

Unit	Title	L	T	P	TH
Unit I	ENTREPRENEURIAL MINDSET & METHOD	9	0	0	9
Introduction to Innovation-led, tech-powered entrepreneurship - Understand from research the attributes of an expert entrepreneur - Effectuation principles - Dealing with the unknowns - Case studies of startup failures.					
Unit II	IDEA TO ENTERPRISE	9	0	0	9
Design and Planning of Product Concept - Business Model - Business Planning - Building Proof of Product and Value Testing - Target Market and Revenue Planning					
Unit III	MINIMUM VIABLE BUSINESS	9	0	0	9
Framework for Minimum Viable Business - Disruptive Innovation - Theory of Disruption - Competitive advantage - Building proof of viable business model - Demystifying Scalability - Funding Opportunities					
Unit IV	INTELLECTUAL PROPERTY	9	0	0	9
Introduction and the need for Intellectual Property Rights - IPR Genesis and Development - Copyright - Trademark - Trade Secret - Geographical Indicators - Industrial Designs - Types of Patent – Sample Patent Application - IPR in INDIA; Global trends - Patent fees					
Unit V	PRIOR ART SEARCH AND PATENT DRAFTING	9	0	0	9
Prior Art Search - IP Licensing – IP Commercialization - IP Infringement- Case Study on Apple vs Samsung, Case study on basmati rice. The invention as a concept - Keywords formation - Structure of patent - Key attributes in patent drafting - Drafting provisional specifications - Drafting complete specifications - Draft claims - Case studies on patent drafting					
					Total = 45 Periods

Text Books:	
1	Steven Blank and Bob Dorf, (2012), The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch
2	Dr Saras Sarasvathy, (2008), Effectuation: Elements of Entrepreneurial Expertise, New Horizons in Entrepreneurship series.
3	Elizabeth Verkey, (2005), Law of Patents, Eastern Book Company
4	Prabuddha Ganguli, (2017), Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education; 1st edition

Reference Books:	
1	WIPO Intellectual Property Handbook https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
2	https://assets.entrepreneur.com/static/20220301113822-Marketing.pdf
3	https://www.deluxe.com/blog/startup-fundamentals-guide/
4	https://www.forbes.com/sites/allbusiness/2018/07/15/35-step-guide-entrepreneurs-starting-a-business/?sh=69a6031e184b

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop an entrepreneurial mindset to identify, assess, shape & act on opportunities.	L3: Applying
CO2	Demonstrate the potential of an innovative idea to create economic value, as a startup	L2: Understanding
CO3	Understand the scientific process to explore a viable business model	L2: Understanding
CO4	Demonstrate knowledge on the fundamental concepts of Intellectual Property	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	2	1	2	2	2	3	3	1	1	2
CO2	2	2	3	1	1	1	1	2	2	1	3	2	2	2	2
CO3	1	2	2	2	1	1	1	1	1	1	3	2	1	1	1
CO4	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1
AVG	**1.25**	**1.75**	**2**	**1.25**	**1**	**1.25**	**1**	**2**	**1.5**	**1.25**	**2.5**	**2**	**1.25**	**1.25**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS13	COMPUTATIONAL HARDWARE				Semester		VI
PREREQUISITES			**Category**	**PE**	**Credit**		**3**
			Hours/Week	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	To learn basic concepts of Embedded Systems by familiarizing the functionalities of embedded platforms with development boards.
2	To understand the core concepts of GPIO Pins, Functionality of peripherals, Selection of I/O devices , Usage of Internal functions, and Communication protocols.
3	To familiarize the current technologies and protocols used in the Internet of Things (IoT) and to learn the Cloud services.

Unit I	BASICS OF EMBEDDED SYSTEM	9	0	0	9

Embedded Platform: Architecture and working - Factors for Microcontroller/Microprocessor selection. Arduino - Boards and schematics – Tool chain - Setup and Configuration - Input/Output Configurations and Access - Libraries - Digital I/O - ADC - Analog I/O - Timers, Interrupts - Pulse Width Modulation - Display: 7-segment , LCD , OLED.

Unit II	BASICS OF RASPBERRY PI	9	0	0	9

Raspberry Pi: Raspberry pi Board - Processor - Setup and Configuration - Installing Python IDLE using Command Terminal - General Purpose I/O Pins - Protocol Pins - GPIO Access - Pulse Width Modulation - Network Libraries - Web services - Twitter APIs - Twitter Bot - Interfacing pi with camera modules.

Unit III	SENSORS AND ACTUATORS	9	0	0	9

Interfacing of Sensors and Actuators - Sensors: Introduction, Characteristics: Analog - Potentiometer, Temperature Sensor, Soil Moisture Sensor, LDR - Digital - PIR Sensor, Smoke Sensor, Infrared - Sensor, Ultra- Sonic Sensor. Actuators - Introduction, Characteristics and working with relay, DC motors, Servo motor, Stepper motor and its drivers.

Unit IV	COMMUNICATION PROTOCOLS	9	0	0	9

Protocols - Wired: RS232 Standard - UART, SPI, I2C - Comparative study of wired protocols - Implementation of wired Serial Communication protocols Wireless: Standards - Bluetooth, RF - Comparative study of wireless protocols - Implementation of wireless Serial Communication protocols.

Unit V	INTERNET OF THINGS	9	0	0	9

Definition and Architecture of IoT, Building blocks of IoT, Programming with IoT protocols - MQTT, CoAP - Connecting embedded target board to Web, Basics networking in IoT: creating a web page - Creating a server on target board - Controlling I/O peripherals from the webpage, Embedded Application Development, Creating communication between different nodes - Cloud platforms for IoT, Cloud data logging and monitoring, Interfacing with web services.

Total = 45 Periods

Text Books:

1	Raj Kamal, “ Embedded Systems - SoC, IoT, AI and Real-Time Systems”, 4th Edition, McGraw Hill, 2020.
2	Mohit Arora, “Embedded System Design”, 1st Edition, Learning Bytes Publishing, 2016.
3	Elecia White, “Making Embedded Systems”, 1st Edition, Shroff/ O’ Reilly, 2012.
4	Jack Ganssle, “ The Firmware Handbook”, 1st Edition, Newnes, 2004.

Reference Books:	
1	https://juniorfall.files.wordpress.com/2011/11/arduino-cookbook.pdf
2	https://drive.google.com/file/d/13s0m3lHPEFP2f2aCuVNRWeBZNKXWKTW5/view?ts=6231cab 3
3	https://ptolemy.berkeley.edu/books/leeseshia/releases/LeeSeshia_DigitalV2_2.pdf 4.
4	https://www.riverpublishers.com/pdf/ebook/RP9788793519046.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand and implement the functions & Capabilities of embedded platforms for easy prototyping.	L2: Understanding
CO2	Identify the type of sensors and actuators for required applications.	L3: Applying
CO3	Develop communication between devices using different protocols.	L3: Applying
CO4	Develop IoT based systems with wireless network connections and accessing devices over cloud.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	2	2	2	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
AVG	**3**	**2.25**	**2.75**	**2**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS14	CODING FOR INNOVATORS				Semester		VI
PREREQUISITES			Category			Credit	3
			Hours/Week	L	T	P	TH
				3	0	0	3

Course Learning Objectives	
1	To learn and express creativity using coding skills.
2	To gain knowledge of Python programming with hands-on experience.
3	To demonstrate a problem solving using OOPs concepts.
4	To learn basics of Linux by familiarizing the concepts of management and file structure.
5	To practise full stack development using cloud platform.

Unit I	PROGRAMMING PARADIGMS	9	0	0	9
Need for programming - Outside box thinking to solve problems - Need for algorithms and data structures - Flowcharts & Algorithms - Memory Allocation - Conditions and loops - Creating effective functions - Case studies - Visual Programming - Types of programming languages & paradigms - Getting started with development - Build & test an algorithm - best practices					
Unit II	**BASIC OF PROGRAMMING**	**9**	**0**	**0**	**9**
Introduction to Python: statements, variables, functions, operators, modules, conditional statements, loop statements, Lists: list operations, traversing a list, slicing a list - Text Handling: Strings, string functions, conversion functions, Dictionaries - File Operations: File open, close, read, copy, word frequency, creating word histograms from text file.					
Unit III	**OOPS 5**	**9**	**0**	**0**	**9**
OOPS- Why OOPS- verticals- implementation in python - Classes and Objects, Methods, Constructors and Destructors, Inheritance, Polymorphism, Abstraction, Encapsulation.					
Unit IV	**SOFTWARE DEVELOPMENT TO DELIVERY**	**9**	**0**	**0**	**9**
Software Engineering - Life Cycle (Tools), Agile Methodologies - Framework - Why Frameworks - Software Testing(Tool Based) - Data Structures - Database Management System - A case study to experiment from Development to Deployment(D2D) - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs AWS- Anaconda					
Unit V	**OPERATING SYSTEMS**	**9**	**0**	**0**	**9**
Introduction to Linux - Process Management - Process Scheduling - Memory Management - Storage Management - System calls - File System Structure - Multithreading - Multicore Programming - Deadlock Handling - Disk Structure - Disk Management - Dockers - Kubernetes					
Total = 45 Periods					

Text Books:	
1	Zed A. Shaw, “Learn Python 3 the Hard Way”, 3rd edition, Addison-Wesley Professional, 2013.
2	Silberschatz Abraham, “Operating System Concepts”, 9th edition, John Wiley & Sons Inc (Sea) Pte Ltd, 2016.
3	Paul Barry, "Head-First Python", 2nd edition, O'Reilly Media, Inc, 2016.
4	Anton Spraul, “Think Like a Programmer”, 1st edition, No Starch Press, 2012.

E-References :	
1	https://www.geeksforgeeks.org/python-programming-language/
2	https://www.guru99.com/python-tutorials.html
3	https://www.tutorialspoint.com/python/python_tutorial.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the aspects of programming protocols	L2: Understanding
CO2	Develop optimized code for real-world problems	L3: Applying
CO3	Build full-stack development to deployment	L3: Applying
CO4	Demonstrate problem solving and continuous development	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	0	0	0	0	0	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	1	3	0	0	0	0	0	0	0	3	2	2
CO4	2	3	2	1	2	0	0	0	0	0	0	3	2	1	1
AVG	**2.5**	**2.5**	**2.5**	**1.25**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**1.5**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS15	INDUSTRIAL DESIGN AND RAPID PROTOTYPING TECHNIQUES			Semester		VI
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	Learn to design a UI/UX design and develop an android application.
2	Provide working CAD model for prototype development.
3	Knowledge in hardware, 3D Printers and Laser cutters.
4	Acquire basic knowledge in designing electrical circuits and fabrication of electronic devices.

Unit I	**UI / UX**	**9**	**0**	**0**	**9**

Fundamental concepts in UI & UX - Tools - Fundamentals of design principles - Psychology and Human Factors for User Interface Design - Layout and composition for Web, Mobile and Devices - Typography - Information architecture - Colour theory - Design process flow, wireframes, best practices in the industry -User engagement ethics - Design alternatives

Unit II	**APP DEVELOPMENT**	**9**	**0**	**0**	**9**

SDLC - Introduction to App Development - Types of Apps - web Development - understanding Stack - Frontend - backend - Working with Databases - Introduction to API - Introduction to Cloud services - Cloud environment Setup- Reading and writing data to cloud - Embedding ML models to Apps - Deploying application.

Unit III	**INDUSTRIAL DESIGN**	**9**	**0**	**0**	**9**

Introduction to Industrial Design - Points, lines, and planes - Sketching and concept generation - Sketch to CAD - Introduction to CAD tools - Types of 3D modeling - Basic 3D Modeling Tools - Part creation - Assembly - Product design and rendering basics - Dimensioning & Tolerancing

Unit IV	**MECHANICAL RAPID PROTOTYPING**	**9**	**0**	**0**	**9**

Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - **Mechanical Prototyping:** 3DPrinting and classification - Laser Cutting and engraving - RD Works - Additive manufacturing

Unit V	**ELECTRICAL RAPID PROTOTYPING**	**9**	**0**	**0**	**9**

Electronic Prototyping: Basics of electronic circuit design - lumped circuits - Electronic Prototyping - Working with simulation tool - simple PCB design with EDA

Total = 45 Periods

Text Books:

1	Peter Fiell, Charlotte Fiell, Industrial Design A-Z, TASCHEN America Llc(2003)
2	Samar Malik, Autodesk Fusion 360 - The Master Guide.
3	Steve Krug, Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability, Pearson,3rd edition (2014)

E - References:	
1	https://www.adobe.com/products/xd/learn/get-started.html
2	https://developer.android.com/guide
3	https://help.autodesk.com/view/fusion360/ENU/courses/
4	https://help.prusa3d.com/en/category/prusaslicer_204

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Create quick UI/UX prototypes for customer needs	L6: Creating
CO2	Develop web application to test product traction / product feature	L3: Applying
CO3	Develop 3D models for prototyping various product ideas	L3: Applying
CO4	Built prototypes using Tools and Techniques in a quick iterative methodology	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	0	0	0	1	1	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	1	1	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
CO4	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
AVG	**2.75**	**2.25**	**3**	**2**	**3**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2.75**	**1.75**	**1.75**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS16	INDUSTRIAL AUTOMATION DATA LIFE CYCLE MANAGEMENT			Semester		VI
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	Acquire conceptual knowledge in Industrial Controllers by scaling of on-board devices and embedded board interfacing with various I/O peripherals.
2	Learn PLC by working on internal features and also interfacing with Sensors and actuators along HMI concept using SCADA and standard communication protocols.
3	To work with FPGA boards and RT controllers for reprogrammable embedded applications using LabVIEW
4	Understand the concepts and design electronics circuits

Unit I	INDUSTRIAL CONTROLLERS - I	9	0	0	9

Industrial Controllers - Introduction to RIO Controllers - Platform - Connection and Configuring controllers - Accessing onboard devices - Module SOM - Interfacing with Input and Output devices - Interfacing protocol based Analog and Digital sensors - Acquiring and Data Logging from sensors - Interfacing Actuators: Relay, DC Motor, Servo Motor - Creating standalone applications.

Unit II	INDUSTRIAL CONTROLLERS - II	9	0	0	9

Industrial Controllers - II - PLC - Introduction - Mode of Operation - IEC 61131 Programming languages for PLC - Programming & sequence control - Instruction set - Scan Time - Timers - Counters - Interfacing with Input/Output devices - Interfacing with Sensors - Interfacing with Actuators - Interfacing with Human Machine Interface - Commissioning and operational safety of PLC – SCADA.

Unit III	INDUSTRIAL COMMUNICATION PROTOCOLS	9	0	0	9

Serial Communication Protocols - I2C, SPI - Serial Field bus protocols CAN, PROFIBUS - Ethernet, HTTP, TCP/UDI, WiF, Cloud data logging. Multi-sensor communication, Data parsing between Embedded platforms. Comparative study of Industrial communication protocols - Implementation of Industrial Communication protocols.

Unit IV	FPGA AND RT CONTROLLER PROGRAMMING	9	0	0	9

Introduction to FPGA - Architecture - Operations in FPGA programming - FPGA Programming in LabVIEW and implementation in myRIO - Introduction to RT controllers - Architecture - Programming RT Controllers - Creating standalone applications.

Unit V	INDUSTRIAL CIRCUIT BOARD DESIGN	9	0	0	9

Designing basics circuits and to simulate in environment setup - Component selection - Creating libraries - Schematic design - Design rules, supply & communication track rules - Component and footprint editor - Understanding component package types - Test point creation for measurement - PCB Layout, placement rules - Footprint, 3D models, BoMs - Generating GERBER and output documentation.

Total = 45 Periods

Text Books:	
1	Ed Doering, NI myRIO Project Essential Guide, National Instruments, 2016.
2	Willian Bolton, Programmable Logic Controllers, 6th edition, Newnes Publications, 2015
3	Richard Zurawski, Industrial Communication Technology Handbook, Second edition, CRC Press, 2014
4	Simon Monk, Make Your Own PCBs with EAGLE, McGraw Hill Education, 2014.
References Books:	
1	Jeffrey Travis, Jim Kring, LabVIEW for Everyone: Graphical Programming Made Easy and Fun, 3rd edition, Prentice Hall
2	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, Fourth edition, Pearson Education, 2016
3	Michael J. Hamill, Industrial Communications and Control Protocols, PDH centre, 2016
4	Ema Design Automation, The Hitchhiker's Guide to PCB Design, First edition, Blurb Publishers, December 2021

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the usage of controllers in an industrial environment	L2: Understanding
CO2	Build Real-Time systems for Industrial embedded monitoring and controlling deterministic applications	L3: Applying
CO3	Communicate between devices at different levels using industrial protocols	L3: Applying
CO4	Understand the process involved in PCB design using EDA tools and fabricate it	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	3	2.25	2.75	1.75	3	0	0	0	0	0	0	0	3	2.75	2.5

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS17	ROBOTICS/ML&MLOps			Semester		VI
PREREQUISITES		**Category**	**EE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	Learn the fundamentals of ROS
2	Understand the requirements and choose the right sensors and actuators for the application development
3	Create Bot in the virtual environment and simulate it to know the functionalities of the system developed
4	Learn the basics of Robotics Vision System
5	Integrate ROS and Computer Vision to build systems for various use cases

Unit I	**INTRODUCTION TO ROBOT KINEMATICS**	**9**	**0**	**0**	**9**

Introduction to Robotics - Transformations - Forward Kinematics - Kinematics equations - Link transformations - Inverse Kinematics - Kinematic analysis - Numerical Inverse Kinematic Solutions - Analytical Inverse Kinematic Solutions

Unit II	**SELECTION OF SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**

Introduction - Sensors & Actuators - Types - Selection criteria - Design considerations: Motor sizing - Selection of motors based on torque and speed characteristics - Hardware Interface & Assembly

Unit III	**INTRODUCTION TO ROBOT OPERATING SYSTEM**	**9**	**0**	**0**	**9**

Introduction to ROS framework and prerequisites - Understanding communications in ROS - ROS Ecosystem - Introduction to ROS programming - ROS nodes, topics, messages - ROS services - ROS Tools and Utilities - URDF , Rviz - Simulation - Gazebo - ROS Motion

Unit IV	**INTRODUCTION TO ROBOTICS VISION SYSTEM**	**9**	**0**	**0**	**9**

Image basics - Image Processing - Histograms - Gray scale, Color, Equalization - Smoothing and blurring/filtering - Averaging, Gaussian, Median, Bilateral - Thresholding - Simple, Adaptive, Otsu - Gradients and Edge detection - Laplacian, Sobel, Canny - Contours - Camera calibration

Unit V	**INTEGRATION OF ROS AND COMPUTER VISION**	**9**	**0**	**0**	**9**

Introduction - Installation - CV Bridge - Image publisher node - Image subscriber node - Nodes building and launching - Building real world applications

Total = 45 Periods

Text Books:

1	Introduction to Robotics: Mechanics and Control by John J Craig, Pearson Publishers.
2	Robot Operating System (ROS) for Absolute Beginners by Lentin Joseph, A press; Publishers (2018).
3	Learning OpenCV by Gary Bradski, Adrian Kaehler, O'Reilly Media, Inc.

Reference Books:	
1	https://www.intechopen.com/chapters/379
2	https://www.plantengineering.com/articles/eight-selection-criteria-for-actuation-components/
3	https://www.controleng.com/articles/tips-on-sensor-selection/
4	https://www.toptal.com/robotics/introduction-to-robot-operating-system
5	https://www.thomasnet.com/articles/automation-electronics/machine-vision-systems/
6	https://automaticaddison.com/working-with-ros-and-opencv-in-ros-noetic/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand kinematics considerations of robot	L2: Understanding
CO2	Selection of sensors and actuators according to application	L3: Applying
CO3	Utilize the ROS environment to simulate and communicate between robot	L3: Applying
CO4	Develop algorithms to extract features and data from image	L3: Applying
CO5	Utilize the open CV for robotic applications	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	0	0	0	0	0	0	0	3	3	2
CO2	3	3	2	1	2	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	3	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	**3**	**2.5**	**2.75**	**1.5**	**2.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

PROFESSIONAL ELECTIVE COURSES – VERTICALS

VERTICAL 1 – CLEAN AND GREEN ENERGY TECHNOLOGY

18MEHO101	**HYDROGEN AND FUEL CELL TECHNOLOGIES**					
		CATEGORY	**PE**	**Credit**		**C**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES

1	To study in detail on the hydrogen production methodologies, possible applications and various storage options
2	To understand the working principle of atypical fuel cell, its types and to elaboration its thermodynamics and kinetics
3	To study the cost effectiveness and eco-friendliness of Fuel Cells

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
Hydrogen–physical and chemical properties, salient characteristics, Production of hydrogen – steam reforming–water electrolysis–gasification–biological hydrogen production–photo dissociation– direct thermal or catalytic splitting of water.					
UNITII	**HYDROGENSTORAGE**	**9**	**0**	**0**	**9**
Hydrogenstorageoptions–compressedgas–liquidhydrogen–Hydride–chemicalStorage– comparisons, safety and management of hydrogen.					
UNITIII	**FUELCELLS**	**9**	**0**	**0**	**9**
History–principle-working-thermodynamicsandkineticsoffuelcellprocess–performance evaluation of fuel cell–comparison on battery Vs fuel cell.					
UNITIV	**FUELCELL–TYPES**	**9**	**0**	**0**	**9**
Types of fuel cells–AFC, PAFC,SOFC, MCFC, DMFC, PEMFC– Relative merit sand demerits.					
UNITV	**APPLICATIONOFFUELCELLANDECONOMICS**	**9**	**0**	**0**	**9**
Fuel cell usage for domestic power systems, large scale power generation, Auto mobile, Space, Economic and environmental analysison usage of Hydrogen and Fuel cell, Future trendsin fuel cells.					
Total (45L) = 45Periods					

REFERENCE BOOKS:

1	ViswanathanB.andAuliceScibioh.M,FuelCells–Principlesand Applications,UniversitiesPress,2006
2	RebeccaL.andBusby,HydrogenandFuelCells:AComprehensiveGuide,Penn WellCorporation,Oklahoma,2005
3	BentSorensen(Sorensen),HydrogenandFuelCells:EmergingTechnologies andApplications,Elsevier,UK2005
4	KordeschK.AndG.Simader,FuelCellandtheirApplications,Wiley-Vch,Germany1996
5	HartA.B.andG.J.Womack,FuelCells:TheoryandApplication,PrenticeHall,NewYorkLtd., London1989
6	JeremyRifkin,TheHydrogenEconomy,PenguinGroup,USA2002
7	BarclayF.J.,FuelCells,EnginesandHydrogen,Wiley,2009

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe and analyze the techniques of Hydrogen generation	Analyze
CO2	Describe and classify various options for Hydrogen storage	Analyze
CO3	Explain the principal operations of fuel cell, its thermodynamics and kinetics	Understand
CO4	Comprehendthedifferenttypesoffuelcellscomparetheirmeritsanddemerits	Understand
CO5	Identify the potential application of a fuel cells for domestic ,automotive, spacecraft power generations and evaluate the techno-economics of a fuel cells	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	0	1	0	0	0	0	0	0	0	1	1
CO2	3	2	0	0	1	0	0	0	0	0	0	0	1	1
CO3	3	2	1	1	1	0	1	0	0	0	0	0	1	1
CO4	3	3	1	2	1	1	1	0	0	0	0	0	1	1
CO5	3	2	1	1	2	2	1	0	0	0	0	1	1	1
Avg	**3**	**2.2**	**0.6**	**0.8**	**1.2**	**1.5**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO102	THERMAL MANAGEMENT OF ELECTRIC VEHICLE BATTERY SYSTEMS				
	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES

1	To know Thermal Management of Electric Vehicle Battery Systems
2	To recognize the applications of PC Min Thermal Management
3	To investigate the Thermal be haviorsin Electric Vehicle Battery Systems through Simulation and Experimental
4	To calculate the Energy and Exergy Analyses of Battery TMSs
5	ToobtainsolutionsforcaseStudiesonThermalManagementSolutionsofElectricbatteries

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction, Current Battery Technologies: Lead Acid Batteries, Nickel Cadmium Batteries, Nickel Metal Hydride Batteries, Lithium-Ion Batteries, Battery Environmental Impact, Battery Management Systems, Safety Management/Fault Diagnosis/Thermal Management.					
UNITII	**PHASECHANGEMATERIALSFORTHERMALMANAGEMENT SYSTEMS**	**9**	**0**	**0**	**9**
Basic Properties and Types of PCMs, Organic PCMs, Inorganic PCMs ,Measurement of Thermal Properties of PCMs ,Heat Transfer Enhancements, Environmental Impact of Phase Change Materials, Applications of PCMs.					
UNIT III	**SIMULATION AND EXPERIMENTAL NVESTIGATION OF BATTERY TMS**	**9**	**0**	**0**	**9**
numerical Model Development for Cell and Sub modules, Cell and Module Level Experimentation Set Up and Procedure, Vehicle Level Experimentation Set Up and Procedure, Illustrative, Simulation and Experimentations on the liquid battery TMS using PCMs					
UNITIV	**ENERGYANDEXERGYANALYSESOFBATTERYTMS**	**9**	**0**	**0**	**9**
TMS Comparison, Mode ling of Major TMS Components ,Energy and Exergy Analyses, Illustrative Example: Liquid Battery Thermal Management Systems					
UNITV	**CASE STUDIESONTHERMALMANAGEMENT SOLUTIONSOF ELECTRIC BATTERIES**	**9**	**0**	**0**	**9**
Case Study1:Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium- Ion Battery. CaseStudy2: Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles					
Total (45L) = 45Periods					

REFERENCE BOOKS:

1	IbrahimDinçer,HalilS.Hamut,NaderJavani,ThermalManagement ofElectricVehicle BatterySystems,C,2017
2	Halil S.Hamut,NaderJavani,IbrahimDinçer,Thermal Management ofElectricVehicle BatterySystems,Wiley,2016
3	WeixiangShen,RuiXiong,AdvancedBatteryManagementTechnologiesforElectric Vehicles,JohnWileyandsons,Firstedition2019
4	ChitraA.,SanjeevikumarPadmanaban,JensBoHolm-Nielsen,ArtificialIntelligentTechniques

	forElectricandHybridElectricVehicles,JohnWileyandsons,Firstedition2020
5	BrunoScrosati, JurgenGarche,WernerTillmetz,AdvancesinBatteryTechnologiesfor ElectricVehicles,WoodheadPublishing,2015

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describeandanalyzethetechniquesofthermalmanagementofelectricvehiclebatterysystems	Analyze
CO2	Describe and classify various applications of PC Min thermal management	Understand
CO3	Investigate the thermal behaviour sin electric vehicle battery systems through simulation and experimental.	Analyze
CO4	Calculate the energy and exergy analyses of battery TMSS	Analyze
CO5	Identifythesolutionsforcasestudiesonthermalmanagementsolutionsofelectricbatteries	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	0	2	0	1	0	0	0	0	0	1	0	0
CO2	3	2	1	0	1	0	1	0	0	0	1	0	2	0	0
CO3	3	2	2	3	1	0	1	0	0	0	1	0	2	0	0
CO4	3	2	1	2	1	1	0	0	0	0	1	0	2	0	0
CO5	3	3	0	0	1	2	1	1	1	1	1	0	2	0	0
Avg	**2.8**	**2.2**	**0.8**	**1**	**1.2**	**0.6**	**0.8**	**0.2**	**0.01**	**0.01**	**0.04**	**0.0**	**1.8**	**0.0**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO103	ELECTRIC AND HYBRID VEHICLE TECHNOLOGY				
	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES

1	To introduce the concept of hybrid and electric drive trains
2	Toelaborateonthetypesandutilizationofhybridandelectricdrivetrains
3	To exposeon different types of AC and DC drives for electric vehicles
4	To understand and utilize different types of energy storage systems
5	To introduce concept of energy management strategies and drive sizing

UNIT I	INTRODUCTION	9	0	0	9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles

UNIT II	HYBRID ELECTRIC DRIVE TRAINS	9	0	0	9

Basic concept of hybridtraction, introduction to various hybrid drive-train to pologies, power flow controlin hybriddrive-traintopologies,fuel efficien cyanalysis.ElectricDrive-trains:Basicconceptofelectrictraction, introduction to various electric drive-traintopologies, power flow control in electricdrive-train.

UNIT III	CONTROLOFAC&DCDRIVES	9	0	0	9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control– DC Motor drives, Induction Motor drives, Permanent MagnetMotordrive,and SwitchReluctanceMotordrives, drivesystem efficiency

UNIT IV	ENERGYSTORAGE AND DRIVE SIZING	9	0	0	9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and it sanalysis, Hybridization of different energy storage devices, Sizing the drive system: Matching the electric machine and the internalcombustionengine(ICE),Sizingthepropulsionmotor,sizingthepowerelectronics,selectionof appropriate energy storage technology

UNIT V	ENERGY MANAGEMENTSTRATEGIES	9	0	0	9

EnergyManagementStrategies:Introductiontoenergymanagementstrategiesusedinhybridandelectricvehicles,classificationandcomparisonofenergymanagementstrategies,implementationissues

Total(45L) = 45 Periods

REFERENCE BOOKS:

1	IqbalHussein,ElectricandHybridVehicles:DesignFundamentals,CRC press,2003
2	JamesLarminie,johnlowry,ElectricVehicleTechnologyExplained,Wiley,2003
3	MehrdadEhsani, YimiGao, SebastianE. Gay,AliEmadi, ModernElectric,HybridElectric andfuelcellvehicles: Fundamentals,theoryanddesign, CRC press,2004
4	Randd.A.J,Woods,R&dellrmbatteriesforelectricvehicles,johnwiley&Sons,1998

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Characterize and configure hybrid drive trains requirement for a vehicle	Understand
CO2	Design and apply appropriate hybrid and electric drive train sina vehicle	Create
CO3	Design and install suitable AC and DC drives for electric vehicles	Create
CO4	Arrive at a suitable energy storage system for a hybrid/electric vehicle	Understand
CO5	Apply energy management strategiestoen sure better economy and efficiency	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	0	1	1	1	0	0	0	0	0	0	0	1
CO2	3	2	2	0	1	1	0	1	1	0	0	0	0	0	2
CO3	3	1	3	1	2	1	1	2	0	1	0	0	0	0	2
CO4	2	3	1	1	1	1	1	1	0	1	2	0	0	1	1
CO5	3	2	0	0	1	1	1	0	0	2	1	2	0	1	1
Avg	**2.8**	**2**	**1.6**	**0.4**	**1.2**	**1**	**1**	**0.8**	**0.2**	**0.8**	**0.6**	**0.4**	**0.0**	**0.4**	**1.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO104	ALTERNATE FUELS FORICENGINES					
		CATEGORY	PE	Credit		C
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To expose potential alternate fuels and their characteristics
2	Touseappropriatesyntheticfuelsandfueladditivesforbettercombustioncharacteristics
3	To utilize alcohol fuels effectively for low emissions
4	ToelaborateontheutilizationofBio-DieselanditstypesasasuitablefuelinCIengines
5	To utilize different gaseousfuelsandpredicttheirperformanceandcombustioncharacteristics

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Availability, Need, Suitability,Properties,MeritsandDemeritsofPotentialAlternativeFuels– Alcohols, Bio- Diesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards Fuel standards–ASTM&EN

UNIT II	**SPECIAL AND SYNTHETIC FUELS**	**9**	**0**	**0**	**9**

Different synthetic fuels, Merits and demerits, Dual, Bi-fuel and Pilot inject defuel systems, Fuel additives– types and their effect on performance and emission characteristics of engines,Ethers–asfuelandfueladditives,propertiesandcharacteristics

UNIT III	**ALCOHOL FUELS**	**9**	**0**	**0**	**9**

Alcohols–Properties, Production methods and usage in engines. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols

UNIT IV	**BIO-DIESEL FUELS**	**9**	**0**	**0**	**9**

Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils–Blending,preheating,Transesterificationandemulsification–Performance,combustion and emission Characteristics in diesel engines

UNIT V	**GASEOUS FUELS**	**9**	**0**	**0**	**9**

Biogas, Natural gas, LPG, Hydrogen–Properties, problems, storage and safety spects. Methods of utilization in engines. Issues &limitation in Gaseous fuels

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	KeithOwenandtrevoreoley,AutomotiveFuelsHandbook,SAE publications,1990
2	PundirB.P,I.C.EnginesCombustionandEmission,2010, Narosapublishinghouse
3	PundirB.P,EngineCombustionandEmission,2011, Narosapublishinghouse, Keith
4	Richardl.Bechtold,AutomotiveFuelsguidebook, SAE publications,1997

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Analyze potential alternate fuels and their characteristics	Analyze
CO2	Useappropriatesyntheticfuelsandfueladditivesforbettercombustioncharacteristics	Understand
CO3	Describethepropertiesofalcoholfuelandestimatetheperformanceofalcoholfuelsand its emissions	Understand
CO4	Explainthepropertiesandcombustionandemissioncharacteristicsofbio-diesel	Understand
CO5	Explain different gaseous fuels and predicttheir performance and combustion characteristics	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	0	1	1	1	0	0	0	0	0	0	3	2
CO2	3	2	1	1	0	1	0	0	0	0	1	0	2	2
CO3	2	3	2	1	1	0	1	0	0	1	0	0	2	2
CO4	2	1	1	1	1	1	1	0	1	0	2	0	0	2
CO5	1	0	0	0	0	2	0	0	0	2	1	0	0	0
Avg	**2.2**	**1.8**	**0.8**	**0.8**	**0.6**	**1**	**0.4**	**0.0**	**0.2**	**0.6**	**0.8**	**0.0**	**1.4**	**1.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

18MEHO105	ADVANCED ENERGY STORAGE TECHNOLOGIES					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	Tounderstandthevarioustypesofenergystoragetechnologiesanditsapplications
2	Tostudythevariousmodelingtechniquesofenergystoragesystemsusing TRNSYS
3	To learn the concepts and types of batteries
4	Tomakethestudentstogetunderstandtheconceptsof HydrogenandBiogasstorage
5	To provide the insight son Fly wheel and compressed energy storage systems

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
Necessityofenergystorage–typesofenergystorage–comparisonofenergystoragetechnologies–Applications					
UNIT II	**THERMAL STORAGE SYSTEM**	**9**	**0**	**0**	**9**
Thermal storage–Types–Modelling of thermal storage units–Simple water and rock bed storage system– pressurized water storage system–Modelling of phase change storage system–Simple units, packed bed storage units					
UNIT III	**ELECTRICAL ENERGY STORAGE**	**9**	**0**	**0**	**9**
Fundamentalconceptofbatteries–measuringofbatteryperformance,charginganddischargingofa battery,storagedensity,energydensity,andsafetyissues.Typesofbatteries–LeadAcid,Nickel–Cadmium,Zinc Manganese di oxide and Lithium Battery					
UNIT IV	**HYDROGEN AND BIOGAS STORAGE**	**9**	**0**	**0**	**9**
Hydrogenstorage options–compressed gas–liquid hydrogen–MetalHydrides,chemicalStorage,Biogas storage-comparisons.Safety and management of hydrogen and Bio gas storage- Applications					
UNIT V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**9**	**0**	**0**	**9**
Flywheel,Supercapacitors,Principles&Methods–Applications,CompressedairEnergystorage,ConceptofHybridStorage–Applications					
					Total(45L) = 45 Periods

REFERENCE BOOKS:

1	IbrahimDincerandMark A.Rosen, ThermalEnergyStorageSystemsand Applications, JohnWiley&Sons2002
2	JamesLarminieandAndrewDicks,FuelcellsystemsExplained,Wileypublications,2003
3	LuisaF.Cabeza,AdvancesinThermalEnergyStorageSystems:Methodsand Applications,ElsevierWoodheadPublishing,2015
4	RobertHuggins,EnergyStorage:Fundamentals,MaterialsandApplications,2ndedition, Springer,2015
5	Ru-shiliu,Leizhang,Xueliangsun,electrochemicaltechnologiesforenergystorageand conversion,Wileypublications,2012

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Identify the energy storage technologies for suitable applications	Analyze
CO2	Analyze the energy storage systems	Analyze
CO3	Recognize the concept sand types of batteries	Understand
CO4	Diagnose the principle of operations of Hydrogen and Bio gas storage	Understand
CO5	Analyze the concepts of Fly wheel and compressed energy storage systems	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	0	0	1	1	0	1	0	0	0	0	3	1
CO2	2	3	1	1	1	0	1	0	1	0	0	0	0	0
CO3	3	2	0	1	0	0	1	1	0	0	1	0	3	0
CO4	3	1	2	1	1	2	1	0	0	2	0	0	1	1
CO5	2	3	1	1	0	0	0	0	1	0	0	0	0	1
Avg	**2.6**	**2.2**	**0.8**	**0.8**	**0.6**	**0.6**	**0.6**	**0.4**	**0.4**	**0.4**	**0.2**	**0.0**	**1.4**	**0.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

18MEHO106	SOLAR POWER PLANTS					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	Toexplainconceptofvariouspowercyclesinvolvedinthesolarpowerplants
2	To learn and study the solar adiation and various solar power plants
3	To outline the variety of solar systems used to collect solar energy
4	To learn electrical performance of PV power plants
5	To summarize basic economics of solar power plants

UNITI	**INTRODUCTION**	**9**	**0**	**0**	**9**
PowerPlantScenario-Classification,BasicPrinciplesandFeatures-Comparisonandselection Criteria					
UNITII	**SOLARPOWERCYCLES**	**9**	**0**	**0**	**9**
Vapourcycles–Organiccycles–CombinedCycles–BinaryCycles–StirlingCycle–BraytonCycle– Ericsson Cycle					
UNIT III	**SOLAR THERMAL POWER PLANTS**	**9**	**0**	**0**	**9**
Collector, Receiver, Energy Transfer Power cycles-Tower, Trough and Dish Systems- Concentrating Dish Systems - Solar Chimneys – Hybrid Systems					
UNIT IV	**SOLAR PV POWER PLANTS**	**9**	**0**	**0**	**9**
InternationalPVPowerProgrammes-PhotovoltaicPowerSystems-SystemIntegration–EnergyStorage - Power Electronics - Stand-Alone Systems - Grid-Connected Systems –Electrical Performance.					
UNIT V	**ECONOMICS OF POWER PLANTS**	**9**	**0**	**0**	**9**
Methods of fixing power tariff –Simple Methods to Calculate the Plant Economy –Life Cycle Cost - Payback Period - Economic Analysis for the Selection of Alternative Decisions and the future of the Power Plants					
					Total(45L): 45Periods

REFERENCE BOOKS:

1	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, NewYork,2006
2	Kosuke Kurokawa (Ed.), Eergyfrom the Desert –Feasibilityofverylarge-scale photovoltaicpowergenerationsystems,JamesandJames2003
3	SukhatmeS.P.,SolarEnergy,TataMcGrawHillsPvtCo.,3rdEdition,2008
4	C.J.Winter, R.L.Sizmann, L.L.Vant-Hull, SolarPowerPlants, Springer-Verlag Berlinand Heidelberg GmbH&Co.K,2001

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describetheconceptofvariouspowercyclesinvolvedinthesolarpowerplantswerelearnt	Understand
CO2	Analyze different cycle for solar power generation	Analyze
CO3	Describetheconstructionandworkingofcomponentsolarthermalpowerplant	Understand
CO4	Explain PV system and its Integration	Understand
CO5	Fix power tariff and analyze economical aspects of power plant	Analyze

COURSE ARTICULATION MATRIX													
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1	0	1	2	1	0	0	0	0	0	2	2
CO2	3	2	1	1	2	0	1	0	0	0	0	0	2	2
CO3	2	1	0	0	1	0	1	0	0	0	0	0	1	0
CO4	3	2	1	2	0	0	0	1	0	0	0	0	1	0
CO5	1	2	0	0	2	0	0	0	0	0	0	0	1	0
Avg	**2.4**	**1.6**	**0.6**	**0.6**	**1.2**	**0.4**	**0.6**	**0.2**	**0**	**0**	**0**	**0**	**1.4**	**0.8**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)														

18MEHO107	MATERIALS FOR SOLAR DEVICES					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To comprehend the materials that has been implicated in various forms of solar energy sources and its storages
2	To educate the structure-property relationship and appreciate enovel developments in the materials
3	To explain the concept and the diverse materials used for solar devices
4	To explicate in depth knowledge of about solar cells, thermal energy storage and electrical energy storages
5	To gather idea of system balance and analysis with reference toitscost

UNITI	**MATERIALSFORSOLAR COLLECTORS**	**9**	**0**	**0**	**9**
Collector Materials for Low, Medium and High Temperature Applications-Glazing Materials, Optical Materials–Absorber Coatings, Insulations, Use of Plastics–Reliability and Durability of Solar Collectors– Environmental Degradation of Low- Cost Solar Collectors					
UNIT II	**MATERIALS FOR SOLAR CELLS**	**9**	**0**	**0**	**9**
Crystalline Structure – Fundamental Principles of Energy Bands–Types of Semiconductors – Doping and influence of impuritieson energy levels—Structure of Silicon solar cell–Fabrication and Optimization of solar cells– Amorphous silicon solar cells					
UNIT III	**NOVEL AND THIN FILM SOLAR CELLS**	**9**	**0**	**0**	**9**
Cadmium Telluride, Galium-Arsenic, GaInP/GaAs/Ge-Thin Film, Single Crystalline, Polycrystalline Materials-Multi Junction and Tandem Junction Solar Cells – Conversion Efficiency of Solar Cells–Organic solar cells.					
UNIT IV	**ENERGY STORAGE MATERIALS**	**9**	**0**	**0**	**9**
Thermal Storage Concepts-Materials for Sensible and Latent Heat Energy Storage. Chemical storage Concepts – Rechargeable Batteries–Types, Operating range, Comparison and suitability for various applications-Super Capacitors.					
UNIT V	**MATERIALS AND COST ANALYSIS**	**9**	**0**	**0**	**9**
Functionalrequirementsofothermaterialsforcomponentslike Invertors,ChargeControllers, Wires,Pipes,Valves,etc.andidentificationofsuitablematerials-SimpleCostAnalysisfor alternatives election of materials-Case studies.					
Total (45L) = 45 Periods					

REFERENCE BOOKS:

1	Ibrahim Dincer and Marc A Rosan,Thermal Energy Storage: Systems and Applications, JohnWiley,2003.
2	Sukhatme and Nayak, Solar Energy: Principles of Thermal Collection & Storage,Tata McGrawHill,2008
3	Nelson,J, The Physics of Solar Cells, Imperial College Press, 2003
4	Jef Poortmans and VladimirArkhipov, Thin Film Solar Cells, JohnWiley and Sons,2008.
5	ThomasMarkvart, SolarElectricity, JohnWiley and Sons,2007

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describethefundamentalprinciplesofmaterialsbestsuitedformakingsolarcollectors,their reliability, characteristics and possibility of using plastics.	Understand
CO2	Explorethematerialsforsolarcells,principles,dopingandfabricationandoptimizationsofsolar cells.	Analyze
CO3	Explorethenovelmaterialsforthefabricationofsolarcell,theirefficiencyandorganic solar cells.	Analyze
CO4	Explain the concept and the diverse materials used for solar energy devices for diverse applications.	Understand
CO5	Describetherequirementsofsystembalanceandanalysiswithreferencetoitscost.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	0	0	0	0	1	0	0	0	0	1	1	1
CO2	3	2	1	0	0	0	1	0	0	0	0	0	1	1	2
CO3	2	3	0	0	1	0	0	0	0	0	0	0	2	2	2
CO4	2	1	0	0	2	1	0	0	1	0	0	0	1	1	1
CO5	3	2	0	1	0	0	1	0	0	0	0	1	1	1	2
Avg	**2.6**	**2**	**1**	**1**	**1.5**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**1.2**	**1.2**	**1.6**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO108	DESIGN OF SOLAR AND WIND SYSTEMS					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	To learn and study the radiation principles with respective solar energy estimation.
2	TounderstandPVtechnologyprinciplesandtechniquesofvarioussolarcells/materialsforenergy conversion
3	To understand the fundamentals of wind energy and its conversion system.
4	Tounderstandtheaerodynamicsandtypesofloads,generatorsinwindturbines
5	To learn and study the radiation principles with respective solar energy estimation.

UNITI	**SOLAR RADIATION AND COLLECTORS**	**9**	**0**	**0**	**9**
Sun angles–Radiation-extra-terrestrial characteristics -estimation on horizontal and tilted surfaces - flat plate collector thermal analysis –evacuated tubular collectors-concentrator collectors–classification-design and performance parameters - compound parabolic concentrators - parabolic trough concentrators -Heliostats.					
UNIT II	**SOLAR THERMAL TECHNOLOGIES**	**9**	**0**	**0**	**9**
Principle of working, types, design and operation of-Solar heating and cooling systems– Thermal Energy storage systems – Solar Desalination – Solar cooker: domestic, community – Solar Pond – Solar drying.					
UNIT III	**SOLAR PV SYSTEM DESIGN**	**9**	**0**	**0**	**9**
Solar cells - p-njunction- Solar cell array system analysis and performance prediction-solar cell array design concepts-PVsystemdesign-designprocessandoptimization–detailedarraydesign-storageautonomy-voltage regulation-centralized and decentralized SPV systems – hybrid and grid connected system.					
UNIT IV	**WIND ENERGY FUNDAMENTALS AND WIND MEASUREMENTS**	**9**	**0**	**0**	**9**
Wind Energy Basics, Wind Speed sand scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Instrumentation for wind measurements, wind data analysis, tabulation, Betz's Limit, Turbulence Analysis.					
UNIT V	**AERODYNAMIC THEORY AND WIND TURBINES**	**9**	**0**	**0**	**9**
Air foil terminology, Bladeelementtheory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor& Blade), Types of loads, Sources of loads Vertical Axis, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generat or Drive systems.					
					Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Sukhatme S.P., Nayak.J.P,'SolarEnergy –PrincipleofThermalStorageand collection", TataMcGrawHill,2008.
2	SolarEnergyInternational,"Photovoltaic – Designand InstallationManual" –New SocietyPublishers,2006.
3	DuffieA.andBeckannW.A.,"SolarEngineeringofThermalProcesses,JohnWiley,1991.
4	JohnDSorensenandJensNSorensen, "WindEnergySystems", WoodheadPublishing

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Classify and describe solar radiation and collectors.	Understand
CO2	Describe the principle and design the solar heating, cooling and other solar applications.	Understand
CO3	Explain the principle, working, design optimization of PV system for different applications.	Understand
CO4	Describe the basics and measurements of wind energy.	Understand
CO5	Explain the aerodynamic constructional details of wind turbine.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	0	0	0	0	0	0	0	0	0	3	1	0
CO2	3	1	2	1	0	0	0	0	0	0	0	0	3	2	0
CO3	3	2	2	0	1	0	0	0	0	1	0	0	3	2	2
CO4	3	2	0	1	0	1	0	0	0	0	0	0	3	2	0
CO5	3	2	0	0	1	1	0	0	0	0	0	0	3	2	0
Avg	**3**	**1.8**	**1**	**0.6**	**0.5**	**0.4**	**0**	**0**	**0**	**0.2**	**0**	**0**	**3**	**1.8**	**0.4**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO109	FIRE ENGINEERING AND EXPLOSION CONTROL					
		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES

1	Tounderstandandlearnthefundamentalsoffire,explosionandtheoryofcombustion.
2	To know various classes of fires & types of fire extinguishers
3	To understand and learn various fire protection systems, components and their working
4	To understand the various fire-resistant materials and to design fire protection of building
5	To understand the principles of explosion protection systems

UNITI	FIREANDEXPLOSIONS	9	0	0	9

Fire properties of solid, liquid and gases - fire spread -toxicity of products of combustion – theory of combustion and explosion –vapour clouds– flash fire– jetfires– pool fires-auto-ignition–boiling liquid expanding vapour explosion – Flix borough, Mexico disaster, Bombay Victoria dock ship explosions.

UNIT II	FIRE PREVENTION AND PROTECTION	9	0	0	9

Sources of ignition– fire triangle – principles of fire extinguishing – active and passive fire protection systems– various classes offires– A,B, C,D,E –types of fire extinguishers– fire stoppers– hydrant pipes – hoses -fire alarms and sirens – foam generators – escape from fire rescue operations–fire drills–notice- first aid for burns.

UNIT III	FIRE PREVENTION AND PROTECTION	9	0	0	9

Sprinkler-hydrants-standpipes–specialfiresuppressionsystemslikedelugeandemulsifier,selectioncriteria of the above installations, reliability, maintenance, evaluation and standards –alarmand detection systems, suppression systems – CO2system, foam system– smoke venting-firefighting systems.

UNIT IV	BUILDING FIRE SAFETY	9	0	0	9

Objectives of fire safe building design, Fire load, fire resistant material and fire testing–structural fire protection–structural integrity–concept of egress design–with calculations-fire certificates–fire safety requirements for high rise buildings–snookers.

UNIT V	EXPLOSION PROTECTING SYSTEMS	9	0	0	9

Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment,FlameArrestors,isolation,suppression,venting,explosionreliefoflargeenclosure- explosion venting-inert gases, suppression system based on carbon dioxide (CO_2)and halons-hazards in LPG, Ammonia(NH_3), Sulphur dioxide(SO_2),chlorine(Cl_2).

Total (45L) = 45 Periods

REFERENCE BOOKS:

1	Gupta,R.S.,“HandBookofFire Technology”OrientLongman,Bombay1977.
2	“AccidentPreventionmanualforindustrialoperations”N.S.C.,Chicago,1982.
3	DinkoTuhtar,“Fireandexplosionprotection”.
4	“DavisDanieletal,“HandBookoffiretechnology”.
5	FirefightershazardousmaterialsreferencebookFirePreventioninFactories”,anNostrandReinHold,New York,1991.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Describe the fundamentals of fire, explosion and theory of combustion.	Understand
CO2	Classify the fire, class of fire and equipment for fire extinguishing.	Understand
CO3	Explainvariousindustrialfireprotectionsystemscomponentsandtheirworking.	Understand
CO4	Design the building with fire protection and concepts of their design.	Create
CO5	Describe the explosion protection system for various application.	Understand

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	0	1	0	1	0	0	0	0	0	0	2	0	0
CO2	3	2	0	0	0	1	2	0	0	0	0	0	2	0	0
CO3	3	2	0	1	2	1	2	0	0	0	0	0	2	0	0
CO4	2	1	3	2	0	1	2	0	0	0	1	0	2	0	0
CO5	3	2	0	1	2	2	1	0	0	0	1	0	2	0	0
Avg	**2.8**	**1.8**	**3**	**1.25**	**2**	**1.2**	**1.75**	**0**	**0**	**0**	**1**	**1**	**2**	**0**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO110	ENERGY MANAGEMENT AND ENVIRONMENTAL BENEFITS					
	CATEGORY	**PE**	**Credit**			**3**
	Hours/Week	**L**	**T**	**P**		**TH**
		3	**0**	**0**		**3**

COURSE OBJECTIVES	
1	To create a warenesson the energy scenario of India with respect to world
2	To learn the methodology adopted for an energy audit
3	To appreciate the concepts adopted in project management
4	Tostudythedifferenttechniquesadoptedforfinancialappraisalofaproject
5	To Comprehend the impact of energy on environment

UNITI	**ENERGYSCENARIO**	**9**	**0**	**0**	**9**
Comparison of energy scenario – India and World (energy sources, generation mix, consumption pattern, T&D losses, energy demand, percapitaenergy consumption)– energy pricing–energy security-energy conservation and its importance, Energy Conservation Act 2001.					
UNIT II	**ENERGY MANAGEMENT**	**9**	**0**	**0**	**9**
Energy audit-need–types– methodology– barriers-analysis on energy costing and sharing bench marking- fuel and energy substitution–billing parameters in TANGEDCO–demand side management-instruments for energy audit–energy monitoring and targeting- CUSUM energy labeling.					
UNIT III	**PROJECT MANAGEMENT**	**9**	**0**	**0**	**9**
Four Basic Elements of Project Management- Project Management Life Cycle- Stepsin Project Management- Project Definition and Scope, Technical Design, Financing, Contracting, Implementation Techniques (Gantt chart, CPM and PERT) and Performance Monitoring.					
UNIT IV	**FINANCIAL MANAGEMENT**	**9**	**0**	**0**	**9**
Investment appraisal for energy conservation projects - Financial analysis techniques, Simple payback period, Returnoninvestment,Netpresentvalue,Internalrateofreturn-Cashflows,Riskandsensitivityanalysis:microandmacrofactors.					
UNIT V	**ENERGY AND ENVIRONMENT**	**9**	**0**	**0**	**9**
Greenhouse effect and the carbon cycle - current evidence and future effects of climate change – Global Environmental Concerns– United Nations Frame work Convention on Climate Change (UNFCCC),Kyoto Protocol, Conference of Parties (COP), Emissions trading (ET), Joint Implementation (JI), Clean Development Mechanism (CDM),Proto type Carbon Fund(PCF), sustainable development.					
Total (45L) = 45 Periods					

REFERENCE BOOKS:	
1	Energy Manager Training Manual (4Volumes) available at http://www.em- ea.org/gbook1.asp, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government ofIndia.2004.
2	L.C.Witte,P.S.Schmidt,D.R.Brown,"IndustrialEnergyManagementandUtilisation"HemispherePubl,Washington,1988.
3	W.C.turner,"EnergyManagementHandbook"Wiley,NewYork,1982.

4	W.R.MurphyandG.McKay“EnergyManagement”Butterworths,London1987.
5	Eastop.T.D&Croft D.R,Energy Efficiency for Engineers andTechnologists,.LogmanScientific &Technical,ISBN-0-582-03184,1990.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the importance of energy conservation and suggest measures for improving percapita energy consumption.	Understand
CO2	Analyses the energy sharing and cost sharing pattern of fuel susedin industries.	Analyze
CO3	Apply Gantt Chart, CP M and PERT in energy conservation projects.	Apply
CO4	Evaluatethetechno-economicsofaprojectadoptingdiscountingandnon-discountingcashflow techniques.	Evaluate
CO5	Assess the sources of additional revenue generation for energy conservation projects adopting	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	0	1	0	0	0	1	1	0	0	2	2
CO2	3	2	0	0	0	1	0	0	0	0	0	2	0	2	0
CO3	3	1	1	1	0	1	0	0	0	0	0	0	0	2	3
CO4	3	2	0	0	0	0	1	0	0	0	0	1	0	0	2
CO5	2	1	0	0	1	2	1	0	0	0	0	0	0	0	0
Avg	**2.8**	**1.6**	**1**	**1**	**1**	**1.25**	**1**	**0**	**1**	**1**	**1**	**1.5**	**0**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

VERTICAL 2 - COMPUTATIONAL ENGINEERING

18MEHO201	**NUMERICAL METHODS IN MECHANICAL ENGINEERING**						
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

COURSE OBJECTIVES:

1.	Upon completion of this course, the students will understand and systematize numerical solution techniques for the partial differential equations governing the physics of mechanical engineering problems.
2.	Numerical Methods use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations.
3.	This course is designed to give an overview of numerical methods of interest to scientists and mechanical engineers.

UNIT I	**ERRORS**	**9**	**0**	**0**	**9**
Errors: Introduction, Types of errors, Rules for estimate errors, Error propagation, Error in the approximation of function. Roots of Equation - Bracketing Method: Bisection Methd, False position method - Open method: Newton-Raphson's method for Single root, multiple roots, Iterative method for Non-linear equations - Roots of polynomial: Muller's Method, limited to TWO Iterations.					
UNIT II	**LINEAR ALGEBRAIC EQUATION**	**9**	**0**	**0**	**9**
Linear Algebraic Equation - Gauss Elimination Method. Pitfalls and improving techniques - LU decomposition method, Gauss-Jacobi and Gauss-Seidel Iteration method. Curve Fitting & Interpolation- Least Square Regression – Linear regression, Parabolic regression - Interpolation–Interpolating polynomial, Lagrange's interpolating polynomial, Divided Difference Formula					
UNIT III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**9**	**0**	**0**	**9**
Numerical Differentiation and Integration - Newton-Cote's Integration of equation: Trapezoidal rule, Simpson's rules - Integration of Equation: Gauss Quadrature methods. - Numerical differentiation: For Equally spaced Data: Forward difference Formula, Central difference Formula, Backward difference Formula, - For unequally spaced Data: Divided difference Formula.					
UNIT IV	**ORDINARY DIFFERENTIAL EQUATION**	**9**	**0**	**0**	**9**
Ordinary Differential Equation - Taylor's series method, Picard's Method, Euler's Method, Runge-Kutta 4th Order method - Boundary value Problem-Finite Difference Method -- Eigen value problem: Eigen value problem based on Power method.					
UNIT V	**PARTIAL DIFFERENTIAL EQUATION**	**9**	**0**	**0**	**9**
Partial Differential Equation - Finite Difference–Elliptical equation, Liebmann's method to Solve Laplace's and Poisson's Equations - Finite Difference- Parabolic Equation - Implicit Method- Crank-Nicolson method (Derivation Only)					
					Total (45L) = 45 Periods

TEXT BOOKS:

1.	B. S. Grewal and J. S. Grewal, "Numerical methods in Engineering and Science," 6 th Edition, Khanna publishers, New Delhi, 2004.

2.	D. G. Luenberger, "Linear and Nonlinear Programming," Springer, 3rd Edition, 2008.
REFERENCES:	
1.	K. E. Atkinson, "An Introduction to Numerical Analysis," Wiley, 2nd Edition, 1989.
2.	S. D. Conte and C. de Boor, Elementary Numerical Analysis, Third Edition, Tata McGraw-Hill Education, 2005.
3.	F.B. Hildebrand, Introduction to Numerical Analysis, Second (Revised) Edition, Courier Dover Publications, 1987.
4.	E. Kreyszig, Advanced Engineering Mathematics, Tenth Ed., John Wiley and Sons, 2010
5.	R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition (second Indian Reprint 2012), Brooks/Cole, 2011.
6.	L.N. Trefethen, David Bau III, Numerical Linear Algebra, SIAM, 1997.
7.	A.Quarteroni, R. Sacco, and F. Saleri. Numerical Mathematics, Springer-Verlag, New York, 2000.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Apply various methods to find roots of equations.	Apply
CO2	Implement different methods to solve simultaneous equations and apply the methods of Regression and interpolation.	Apply& Evaluate
CO3	Implement various numerical methods for differentiation and Integration.	Apply
CO4	Apply various methods to solve engineering problems with Ordinary differential equations.	Apply
CO5	Solve Partial differential equations involved in Engineering Problems.	Apply

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO2	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO3	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO4	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
CO5	3	3	1	2	1	0	0	0	0	0	0	0	2	1	0
Avg	**3**	**3**	**1**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO202	ADVANCED FLUID MECHANICS					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1. Enhanced understanding of fluid mechanics, including the equations of motion in differential form and turbulence.

		L	T	P	TH
UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Eulerian and Lagrangian Description of Fluid Motion, Lines of Flow Visualization and Acceleration of Flow, Angular Deformation of Fluid Elements, Linear and Volumetric Deformation; Perspectives from Mass Conservation, Continuity Education in Integral Form Stream Function and Velocity Potential.

UNIT II	**VISCOUS FLUID FLOW**	**9**	**0**	**0**	**9**

Euler Equation for Inviscid Flow, Bernoulli's Equation, Examples of Bernoulli's Equation, Reynolds Transport Equation, Reynolds Transport Theorem Mass and Linear Momentum Conservation, Reynolds transport theorem arbitrarily moving control volume, Reynolds transport theorem angular momentum conservation, Introduction to traction vector and stress tensor, Cauchy/Navier equation, Navier Stokes equation.

UNIT III	**FLUID DYNAMICS**	**9**	**0**	**0**	**9**

Lubrication Theory, Thin Film Dynamics, Stokes Flow past a Sphere.

UNIT IV	**TURBULENCE**	**9**	**0**	**0**	**9**

Introduction to Turbulence, Statistical Treatment of Turbulence and Near - Wall Velocity Profiles, Introduction to Boundary Layer Theory, Similarity Solution of Boundary Layer Equation, Momentum Integral Method, Application of Momentum Integral Method and Boundary Layer Separation, Potential Flow.

UNIT V	**COMPRESSIBLE FLOWS**	**9**	**0**	**0**	**9**

Stagnation properties, Compressible Flows - variable area- Normal Shock- Converging Nozzle- Converging Diverging Nozzle- Compressible Flow with Friction.

Total (45L) = 45 Periods

TEXT BOOKS:

1. Rouse, H. (1957), “Advanced Fluid Mechanics”, John Wiley & Sons, N York
2. Mohanty A.K. (1994), “Fluid Mechanics”, Prentice Hall of India, N Delhi

REFERENCES:

1. Wand D.J., and Harleman D.R. (91964) “Fluid Dynamics”, Addison Wesley.
2. Schlichting, H.: (1976) “Boundary Layer theory”, International Text – Butterworth
3. Lamb, H.R. (1945) “Hydrodynamics”, Rover Publications
4. White, F.M. (1980) “Viscous Fluid Flow”, McGraw Hill Pub. Co, N York
5. Yalin, M.S.(1971), “Theory of Hydraulic Models”, McMillan Co., 1971.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Explain the fundamental concepts of fluid flow.	Understand
CO2	Apply the Bernoulli to solve problems related to Viscous fluid flow.	Apply
CO3	Device the concepts of fluid dynamics in various geometry.	Create
CO4	Depict the turbulence of fluid flow.	Analyze
CO5	Interpret the knowledge for Compressible Flows in various geometrical configuration.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO2	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO3	3	3	2	3	3	0	0	0	0	0	0	1	2	2	0
CO4	3	3	2	3	0	0	0	0	0	0	0	1	2	2	0
CO5	3	3	2	3	3	0	0	0	0	0	0	1	2	2	0
Avg	**3**	**3**	**2**	**3**	**1.2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO203	FUNDAMENTALS OF BIO-MECHANICS					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
1.Basic knowledge of physics and biology which includes kinetics &kinematics.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Explain the principles of mechanics.
2.	Discuss the mechanics of physiological systems.
3.	Explain the mechanics of joints.
4.	Illustrate the mathematical models used in the analysis of biomechanical systems

UNIT I	**INTRODUCTION TO MECHANICS**	**9**	**0**	**0**	**9**

Introduction – Scalars and vectors, Statics – Force types, Resolution and composition of forces, Moments of force and couple, Resultant force determination, parallel forces in space, equilibrium of coplanar forces, Dynamics - Basic principles – Linear motion, Newton's laws of motion, Impulse and Momentum, Work and Energy. Kinetics – Velocity and acceleration, Kinematics – Link segment models, Force transducers, Force plates, Introduction to Constitutive equations – Constitutive equations of Non-viscous fluid, Newtonian Viscous fluid and Hookean Elastic solid

UNIT II	**BIO-FLUID MECHANICS**	**9**	**0**	**0**	**9**

Intrinsic fluid properties – Density, Viscosity, Compressibility and Surface Tension, Viscometers – Capillary, Coaxial cylinder and cone and plate, Rheological properties of blood, Pressure-flow relationship for Non-Newtonian Fluids, Fluid mechanics in straight tube – Steady Laminar flow, Turbulent flow, Flow development, Viscous and Turbulent Sheer Stress, Effect of pulsatility, Boundary Layer Separation, Structure of blood vessels, Material properties and modeling of Blood vessels, Heart – Cardiac muscle characterization, Native heart valves – Mechanical properties and valve dynamics, Prosthetic heart valve fluid dynamics.

UNIT III	**BIO-SOLID MECHANICS**	**9**	**0**	**0**	**9**

Constitutive equation of viscoelasticity – Maxwell & Voight models, anisotropy, Hard Tissues – Structure, blood circulation, elasticity and strength, viscoelastic properties, functional adaptation, Soft Tissues – Structure, functions, material properties and modeling of Soft Tissues – Cartilage, Tendons and Ligaments Skeletal Muscle – Muscle action, Hill's models, mathematical modeling, Bone fracture mechanics, Implants for bone fracture

UNIT IV	**BIO-MECHANICS OF JOINTS**	**9**	**0**	**0**	**9**

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, Free body diagrams, Structure of joints, Types of joints, Biomechanical analysis of elbow, shoulder, spinal column, hip, knee and ankle, Lubrication of synovial joints, Gait analysis, Motion analysis using video.

UNIT V	**MODELING AND ERGONOMICS**	**9**	**0**	**0**	**9**

Introduction to Finite Element Analysis, finite element analysis of lumbar spine; Ergonomics – Musculoskeletal disorders, Ergonomic principles contributing to good workplace design, Design of a Computer work station, Whole body vibrations, Hand transmitted vibrations.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues", Springer-Verlag, 1998.
2.	Subrata Pal, "Textbook of Biomechanics", Viva Books Private Limited, 2009.

REFERENCES:	
1.	Krishna B. Chandran, Ajit P. Yoganathan and Stanley E. Rittgers, "Biofluid Mechanics: The Human Circulation", Taylor and Francis, 2007.
2.	Sheraz S. Malik and Shahbaz S. Malik, "Orthopaedic Biomechanics Made Easy", Cambridge University Press, 2015.
3.	Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids, Analysis and Design", Springer Science Business Media, 2004.
4.	Shrawan Kumar, "Biomechanics in Ergonomics", Second Edition, CRC Press 2007.
5.	Neil J. Mansfeild, "Human Response to Vibration", CRC Press, 2005.
6.	Carl J. Payton, "Biomechanical Evaluation of movement in sports and Exercise", 2008
7.	NPTEL: Mechanical Engineering - NOC:Biomechanics of Joints and Orthopaedic Implants

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the fundamentals of mechanics and its application in human system.	Understand
CO2	Understand the principles of bio-fluid dynamics and its application in human system.	Understand
CO3	Understand the fundamentals of bio-solid mechanics.	Understand
CO4	Analyze the biomechanics of different human joints and also the forces at a skeletal joint for various static and dynamic human activities.	Analyze
CO5	Give Examples of computational mathematical modelling applied in Bio-mechanics.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO2	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO3	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO4	2	2	2	2	0	0	0	0	0	0	1	0	2	2	0
CO5	2	2	2	2	2	0	0	0	0	0	1	0	2	2	0
Avg	**2**	**2**	**2**	**2**	**0.4**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO204	INTRODUCTION TO MACHINE LEARNING					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
Machine learning is a mathematical discipline, and students will benefit from a good background in probability, linear algebra and calculus, programming, and experience is essential.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Understand a wide variety of learning algorithms.
2.	Understand how to evaluate models generated from data.
3.	Apply the algorithms to a real problem.
4.	Optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Introduction: Basic definition-types of learning-designing a learning system-perspective and issues in machine learning-hypothesis space and inductive bias- evaluation-cross-validation.

UNIT II	**CONCEPT LEARNING AND THE GENERAL-TO-SPECIFIC ORDERING**	**9**	**0**	**0**	**9**

Introduction-a concept task, concept learning as search-find S: finding a maximally specific hypothesis- version spaces and the candidate elimination algorithm-remarks on version spaces and candidate elimination-inductive bias.

UNIT III	**DECISION TREE LEARNING**	**9**	**0**	**0**	**9**

Introduction-decision tree representation-appropriate problems for decision tree learning-the basic decision tree learning algorithm-hypothesis space search in decision tree learning-inductive bias in decision tree learning-issues in decision tree learning.

UNIT IV	**ARTIFICIAL NEURAL NETWORKS**	**9**	**0**	**0**	**9**

Introduction-neural network representation-appropriate problems for neural network learning- perceptrons-multilayer networks and the back propagation algorithm-remarks on the back propagation algorithm-an illustrative example: face recognition, advanced topics in artificial neural networks.

UNIT V	**LEARNING SYSTEM**	**9**	**0**	**0**	**9**

Probability and Bayes learning, bayes optimal classifier, gibbs algorithm, Naïve bayes classifier, instance-based learning - K nearest neighbour learning - locally weighted regression, Computational learning theory-PAC learning model -Sample complexity-VC Dimension -Ensemble learning, analytical learning-learning with perfect domain theories: prolog –EBG.

Total (45L) = 45 Periods

REFERENCES:

1.	Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
2.	Introduction to Machine Learning Edition 2, by Ethem Alpaydin
3.	T. Hastie, R. Tibshirani, and J. Friedman. The Elements of Statistical Learning. Springer 2011. (Available for download on the authors' web-page: http://statweb.stanford.edu/ ~tibs/ElemStat Learn/)
4.	Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012. (Electronic copy available through the Bodleian library.)
5.	Christopher M. Bishop. Pattern Recognition and Machine Learning, Springer 2007.
6.	S. Haykin. Neural networks and learning machines. Pearson 2008.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.	Understand
CO2	Have an understanding of the strengths and weaknesses of many popular machine learning approaches.	Understand
CO3	Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.	Understand
CO4	Be able to design and implement Artificial Neural Networks algorithms in a range of real-world applications.	Create
CO5	Be able to design and implement various machine learning algorithms in a range of real-world applications.	Create

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	1	3	0	0	0	0	0	0	1	2	2	0
CO2	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
CO3	2	2	0	1	3	0	0	0	0	0	0	1	2	2	0
CO4	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
CO5	2	2	0	1	3	0	3	0	0	0	0	1	2	2	0
Avg	**2**	**2**	**0**	**1**	**3**	**0**	**1.8**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO205	DESIGN OPTIMIZATION & DESIGN THEORY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**C**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	The primary objective of this course is for students to gain knowledge to translate practical engineering design problems into mathematical optimization problems that can be solved using numerical methods for optimization

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of the objective function, design constraints, and classification of optimization problems. Single and multivariable optimization techniques					
UNIT II	**DESIGN OPTIMIZATION TECHNIQUE**	**9**	**0**	**0**	**9**
The technique of unconstrained minimization. The golden section, Random, Pattern, and Gradient search methods, interpolation methods, and equality and inequality constraints.					
UNIT III	**PROGRAMME**	**9**	**0**	**0**	**9**
Direct methods and indirect methods using penalty function, Lagrange multipliers, Geometric programming, stochastic programming, Genetic algorithms					
UNIT IV	**ENGINEERING APPLICATION**	**9**	**0**	**0**	**9**
Engineering applications, structural-design application axial and transverse loaded members for minimum cost, maximum weight. Design of shafts and torsion members, design optimization of springs.					
UNIT V	**DYNAMICS APPLICATION**	**9**	**0**	**0**	**9**
Dynamics applications for a two-degree freedom system. Vibration absorbers. Application in mechanisms.					
					Total (45L) = 45 Periods

TEXT BOOKS:

1.	S. S. Rao, Engineering Optimization: Theory and Practice, 4th edition, John Wiley & Sons, 2009. ISBN: 0470183527.
2.	Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, New Delhi, 2005

REFERENCES:

1.	R.C. Johnson, “Optimum Design of Mechanical Elements”, Willey, New York, 1980
2.	Kalyanmoy Deb, “Evolutionary multi-objective optimization, Willey, New York.
3.	S. S. Stricker, “Optimising performance of energy systems” Battelle Press, New York, 1985.
4.	J. S. Arora, “Introduction to Optimum Design”, McGraw Hill, New York, 1989.
5.	L.C.W. Dixon, “Non-Linear Optimisation - Theory and Algorithms”, Birkhauser, Boston, 1980.
6.	R.J. Duffin, E.L. Peterson and C.Zener “Geometric Programming-Theory and Applications”, Willey, New York, 1967.
7.	G.B.Dantzig “Linear Programming and Extensions Princeton University Press”, Princeton, N. J., 1963
8.	R. Bellman “Dynamic Programming-Princeton” University Press, Princeton, N.J. 1957.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Demonstrate an understanding of how design optimization fits into the overall engineering design process.	Create
CO2	Formulate practical engineering design problems as well-posed optimization problems.	Create
CO3	Determine the advantages and disadvantages of applying different optimization techniques for a specific problem.	Analyze
CO4	Model and analyze multi-objective and multi-disciplinary optimization problems.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	1	0	0	0	0	0	0	2	2	2	0
CO2	2	2	3	3	1	0	0	0	0	0	0	2	2	2	0
CO3	2	2	2	3	1	0	0	0	0	0	0	2	2	2	0
CO4	2	2	2	3	1	0	0	0	0	0	0	2	2	2	0
Avg	**2**	**2**	**2.5**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO206	ADVANCED FINITE ELEMENT METHODS				
PREREQUISITES		CATEGORY	PE	Credit	C
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To develop a thorough understanding of the advanced finite element analysis techniques.
2.	An ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.
3.	To understand and solve the Finite Element 1-D structural and 2-D structural problems.
4.	To develop and understand the dynamic problems in structures
5.	To gain the knowledge of FEM for heat transfer analysis and flow analysis

UNIT I	INTRODUCTION	9	0	0	9

Classification of problems – Dimensionality, time dependence, Boundary value problems, Initial value problems, Linear/Non-linearetc., Historical Perspective of FEM and applicability to mechanical engineering design problems. Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions, Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss- Legendre scheme of numerical integration, Nodal degrees of freedom. Compatibility conditions, Assembly and boundary considerations.

UNIT II	ONE DIMENSIONAL PROBLEMS	9	0	0	9

Structural problems with one dimensional geometry. Formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method. Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies with emphasis on boundary conditions and introduction to contact problems. Beams and Frames: Review of bending of beams, higher order continuity (C0 and C1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.

UNIT III	TWO DIMENSIONAL PROBLEMS	9	0	0	9

Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, sub parametric, Isoparametric and super parametric elements. General considerations in finite element analysis of two-dimension problems. Introduction plate bending elements and shell elements.

UNIT IV	DYNAMIC ANALYSIS	9	0	0	9

FE formulation in dynamic problems in structures using Lagragian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion and introduction to the solution procedures. Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.

UNIT V	FEM IN HEAT TRANSFER & FLUID MECHANICS	9	0	0	9

Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Design case studies.

Total (45L) = 45 Periods

REFERENCES:	
1.	K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
2.	J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998
3.	Cook and Robert Davis etal, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley and Sons, 2001.
4.	Segerlind L.J, "Applied Finite Element Analysis", 2nd Edition, John Wiley, 1984.
5.	O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford,

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concept of the finite element method for solving design problems.	Understand
CO2	Formulate and solve manually problems in 1-D structural systems involving bars, trusses, beams and frames.	Apply
CO3	Develop 2-D FE formulations involving triangular, quadrilateral elements, and higher-order elements	Create
CO4	Apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis	Evaluate
CO5	Apply the knowledge of FEM for heat transfer analysis and flow analysis	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	1	0	0	0	1	1	0	0	0	1	2	0
CO2	3	1	3	3	3	0	0	1	1	0	0	0	0	0	3
CO3	3	1	3	3	2	0	0	1	1	0	0	0	0	0	0
CO4	3	2	3	3	2	0	2	2	1	0	0	0	1	2	0
CO5	3	1	1	1	1	0	0	0	1	0	0	0	1	1	0
Avg	**3.0**	**1.2**	**2.6**	**2.2**	**1.6**	**0.0**	**0.4**	**1.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.6**	**1.0**	**0.6**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO207	ADVANCED COMPUTATIONAL FLUID DYNAMICS (CFD)					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Knowledge of undergraduate heat transfer and fluid mechanics, basic computational fluid dynamics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	The primary objective of the course is to teach fundamentals of computational method for solving non-linear partial differential equations (PDE) primarily in complex geometry. The emphasis of the course is to teach CFD techniques for solving incompressible and compressible N-S equation in primitive variables, grid generation in complex geometry, transformation of N-S equation in curvilinear coordinate system and introduction to turbulence modelling.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Brief introduction of boundary layer flow, incompressible and compressible flows, finite difference and finite volume method, example of parabolic and hyperbolic systems and time discretization technique, explicit and implicit methods, upwind and central difference schemes, stability, dissipation and dispersion errors

UNIT II	**SOLUTION OF SIMULTANEOUS EQUATIONS**	**9**	**0**	**0**	**9**

Point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, SOR), CGS, Bi-CGSTAB and GMRES (m) matrix solvers, different acceleration techniques.

UNIT III	**INCOMPRESSIBLE FLOW**	**9**	**0**	**0**	**9**

Higher order upwind schemes: second order convective schemes, QUICK. Solution of NS equations: Solution of incompressible N-S equation (Explicit time stepping, Semi–explicit time stepping). SMAC method for staggered grid: Predictor - Corrector step, discretization of N-S and continuity equations, Pressure correction Poisson's equation, boundary conditions (no-slip, moving wall, slip boundary and inflow conditions), outflow (zero gradient/Orlanski) boundary conditions for unsteady flows, algorithm for the SMAC method, stability considerations for SMAC method.

UNIT IV	**FDE IN COMPLEX GEOMETRIES**	**9**	**0**	**0**	**9**

Transformation of governing equation in ξ $\eta-$ plane, transformation of Laplace equation, introduction to geometrical parameters and the accuracy of the solution, basic facts about transformation, grid transformation on complex geometries. N-S equations in transformed plane, matrices and Jacobians

UNIT V	**COMPRESSIBLE FLOW**	**9**	**0**	**0**	**9**

N-S and energy equations, properties of Euler equation, linearization. Solution of Euler equation: Explicit and implicit treatment such as Lax-Wendroff, MacCormark, Beam and Warming schemes, Upwind schemes for Euler equation: Steger and Warming, Van Leer's flux splitting, Roe's approximate Riemann solver, TVD schemes. Solution of N-S equations: MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Computational Fluid Flow and Heat Transfer, Second Edition by K. Muralidhar, T. Sundararajan (Narosa), 2011.
2.	Computational Fluid Dynamics by Chung T. J., Cambridge University Press, 2003.
3.	Computational Fluid Dynamics by Tapan K. Sengupta, University Press, 2005.
4.	Numerical Computation of Internal and External Flows by Hirch C., Elesvier 2007.

REFERENCES:	
1.	K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
2.	J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998
3.	Cook and Robert Davis et.al, “Concepts and Applications of Finite Element Analysis”, 4th Edition, John Wiley and Sons, 2001.
4.	Segerlind L.J, “Applied Finite Element Analysis”, 2nd Edition, John Wiley, 1984.
5.	O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford,

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand and be able to numerically solve the incompressible and compressible flows.	Understand
CO2	Solve computational problems related to iterative methods.	Evaluate
CO3	Solve the problems related to incompressible fluid flow.	Evaluate
CO4	Interpret the knowledge, capability of analyzing and solving FDE in complex geometries problem.	Apply
CO5	Solve the problems related to compressible fluid flow.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO2	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
CO3	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
CO4	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO5	2	2	1	3	2	0	0	0	0	0	0	0	2	2	0
Avg	**2**	**2**	**1**	**2.2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO208	SMART MATERIALS AND STRUCTURES				
PREREQUISITES	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

COURSE OBJECTIVES:

1. Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis

UNIT I	SMART STRUCTURES	9	0	0	9

Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor. Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

UNIT II	SHAPE MEMORY ALLOY	9	0	0	9

Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others.

UNIT III	VIBRATION ABSORBERS	9	0	0	9

series and Parallel Damped Vibrations (OverView), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice. 13Hours

UNIT IV	MEMS	9	0	0	9

Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

UNIT V	DEVICES	9	0	0	9

Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.

Total (45L) = 45 Periods

TEXT BOOKS:

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817). 3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCES:

1. Electro ceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley &Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).

3.	Piezoelectric Actuators and Transonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4.	Handbook of Giant Magneto strictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5.	Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the behavior and applicability of various smart materials	Understand
CO2	Design simple models for smart structures & materials	Create
CO3	Perform simulations of smart structures & materials application	Analyse
CO4	Conduct experiments to verify the predictions	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO2	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO3	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
CO4	2	2	1	1	2	0	0	0	0	0	0	0	2	2	0
Avg	**2**	**2**	**1**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO209	DESIGN OF PRESSURE VESSELS						
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

COURSE OBJECTIVES:

1.	To study about the various types of stresses act in the pressure vessels
2.	To design components of pressure vessel using codes and standards.
3.	To study the design the supportive members of pressure vessels.
4.	To study about design considerations of pressure vessels.
5	To study about the design of pipes related to design of pressure vessels.

UNIT I	**STRESSES IN PRESSURE VESSELS**	**9**	**0**	**0**	**9**

Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor. Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

UNIT II	**DESIGN OF VESSELS USING CODES**	**9**	**0**	**0**	**9**

General theory of membrane stresses in vessel under internal pressure and its application to shells (Cylindrical, Conical and Spherical) and end closures. Bending of circular plates and determination of stresses in simply supported and clamped circular plate. Thermal stresses, Stress concentration in plate having circular hole due to bi-axial loading, Excessive elastic deformation, Plastic instability, Brittle rupture and creep. Theory of reinforced opening and reinforcement limits, design of composite analysis, wind and seismic load consideration in the design of pressure vessel.

UNIT III	**SUPPORTS FOR VERTICAL & HORIZONTAL VESSELS**	**9**	**0**	**0**	**9**

Introduction to ASME codes 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 IV	**OTHER DESIGN CONSIDERATIONS**	**9**	**0**	**0**	**9**

Buckling phenomenon, Elastic Buckling of circular ring and cylinders under external pressure, Collapse of thick-walled cylinders or tubes under external pressure, Effect of supports on Elastic Buckling of Cylinders, Design of circumferential stiffeners, and buckling under combined External pressure and Axial loading. Fatigue, shock, high pressure, high temperature, irradiation, corrosion, and other hostile environments; High strength, light weight pressure vessels, Vessels resistant to external high pressures found in undersea exploration, offshore drilling, and mineral mining.

UNIT V	**PIPING DESIGN**	**9**	**0**	**0**	**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 (45L) = 45 Periods

TEXT BOOKS:

1.	Dennis Moss "Pressure Vessel Design Manual"
2.	Henry H Bednar, "Pressure vessel Design Hand book", CBS publishers and distributors.

REFERENCES:	
1.	Harvey J F, “Pressure vessel design”, CBS, publication.
2.	Brownell L. E & Young. E. D, “Process equipment design”, Wiley Eastern Ltd., India.
3.	Stanley M Wales, “Chemical Process Equipment, Selection and Design”, Butterworths,
4.	Series in Chemical Engineering, 1988. 6. J. Phillip Ellenberger “Pressure Vessels: ASME Code Simplified”.
5.	“ASME Pressure Vessel and Boiler Code”, Section VIII Div. 1, 2, and 3.
6.	“American standard code for pressure piping”, B 31.1.
7.	Smith P, “Fundamentals of Piping Design”, Elsevier.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Determine stresses in pressure vessels	Evaluate
CO2	Design pressure vessels using ASME codes	Create
CO3	Design support members of pressure vessels	Create
CO4	Apply other design considerations for pressure vessels	Apply
CO5	Design of pressurized fluid piping	Create

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	2	0	0	0	0	0	0	0	0	3	3	0
CO2	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
CO3	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
CO4	3	1	1	1	0	0	0	0	0	0	0	0	3	3	0
CO5	2	3	3	3	0	0	0	0	0	0	0	0	3	3	0
Avg	**2**	**2.4**	**2.4**	**2.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3**	**3**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO210	MECHANICAL VIBRATIONS					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:	
1.	To understand the Fundamentals of Vibration and its practical applications.
2.	To understand the characteristics of free and forced vibration.
3.	To understand the Single and Multi DOF of vibration system.
4.	To understand the working principle and operations of various vibration measuring instruments
5	To understand about the vibration analysis methods.

UNIT I	FUNDAMENTALS OF VIBRATIONS	9	0	0	9
Basic concepts of vibration – causes and effects of vibrations – vibration parameters – spring, mass, damper models. Motion – periodic, non-periodic, harmonic, non-harmonic. Degree of freedom, static equilibrium position, vibration classification – steps involved in vibration analysis.					
UNIT II	FREE VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS	9	0	0	9
Free undamped single DOF vibration system – Longitudinal, transverse, torsional vibration system – Methods for formulation of differential equations by newton, energy, lagrangian and Rayleigh's method. Viscous damped system – under damped, critically damped, over damped – logarithmic decrement – Coulomb's damping; combined viscous and coulomb's damping.					
UNIT III	FORCED VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS	9	0	0	9
Forced Single DOF system – Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) – vibration isolation – force transmissibility – motion transmissibility, typical isolators & mounts – Rotor dynamics, critical speed of single rotor, undamped and damped.					
UNIT IV	VIBRATION OF MULTI DEGREE OF FREEDOM SYSTEMS	9	0	0	9
Free undamped Multi Degree of Freedom vibration system – Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix - Eigen values and Eigen vectors for linear system and torsional two degree of freedom; Holzer method for linear and torsional unbalanced system; Two rotors, three rotors and geared system; Dunkerley's and Rayleigh's method for transverse vibratory system.					
UNIT V	VIBRATION MEASURING INSTRUMENTS AND VIBRATION ANALYSIS	9	0	0	9
Vibration Analysis Overview - Experimental Methods in Vibration Analysis. -Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes.					
					Total (45L) = 45 Periods

TEXT BOOKS:	
1.	Mechanical Vibration by V.P.Singh
2.	Singiresu S. Rao, "Mechanical Vibrations", Pearson Education Incorporated, 2017.

REFERENCES:	
1.	Benson H. Tongue, “Principles of Vibrations”, Oxford University, 2007.
2.	Grover. G.K., edited by Nigam. S. P., “Mechanical Vibrations”, Nem Chand and Bros., 2014.
3.	David A. Bies and Colin H. Hansen, “Engineering Noise Control – Theory and Practice”, Spon Press, 2009.
4.	Julian Happian-Smith – “An Introduction to Modern Vehicle Design”, Butterworth-Heinemann, 2001.
5.	William T. Thomson, “Theory of Vibration with Applications”, Taylor and Francis, 2003.
6.	Balakumar Balachandran and Edward B. Magrab, “Fundamentals of Vibrations”, 1st Editon, Cengage Learning, 2009
7.	Grover. G.T., “Mechanical Vibrations”, Nem Chand and Bros., 2009
8.	NPTEL :: Mechanical Engineering - NOC:Introduction to Mechanical Vibration

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Determine stresses in pressure vessels	Evaluate
CO2	Design pressure vessels using ASME codes	Create
CO3	Design support members of pressure vessels	Create
CO4	Apply other design considerations for pressure vessels	Apply
CO5	Design of pressurized fluid piping	Create

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	0	0	0	0	0	0	0	0	2	2	0
CO2	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO3	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO4	3	3	2	2	0	0	0	0	0	0	0	0	2	2	0
CO5	1	1	2	2	0	0	0	0	0	0	0	0	2	2	0
Avg	**2.2**	**2.4**	**2**	**1.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2**	**2**	**0.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

VERTICALS -3 PRODUCT AND PROCESS DEVELOPMENT

18MEHO301	**PRECISION ENGINEERING**					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	Explain the need and progress of precision engineering.
2.	To know about the principle and working of different methods of precision machining.
3.	To understand about micromachining.
4.	To know about Laser devices and machine vision.
5.	To understand about SEM and 3D surface topography.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Introduction to Precision Engineering, Need for precision manufacturing, Four Classes of Achievable Machining Accuracy – Normal, Precision, High-precision, Ultraprecision Processes and Nanotechnology					
UNIT II	**PRECISION MACHINING**	**9**	**0**	**0**	**9**
Overview of Micro- and Nano-machining, Conventional micro machining techniques - micro turning, micro-milling, micro-grinding, Ultra-precision diamond turning, SPDT Single point diamond turning.					
UNIT III	**MICRO MACHINING**	**9**	**0**	**0**	**9**
Micro electrical discharge machining, Photochemical machining, Electro chemical micromachining, Laser beam micromachining, Electron beam micromachining, Focused Ion Beam micromachining, etc					
UNIT IV	**LASER AND OPTICS**	**9**	**0**	**0**	**9**
Micro electrical discharge machining, Photochemical machining, Electro chemical micromachining, Laser beam micromachining, Electron beam micromachining, Focused Ion Beam micromachining.					
UNIT V	**MEASUREMENT AND CHARACTERISATION**	**9**	**0**	**0**	**9**
Measurement of Typical Nanofeatures, Surface metrology - 3D surface topography - Need, Measurement – Chromatic confocal Microscopy, Interferometry, Non-optical Scanning Microscopy – Scanning electron Microscopes, Scanning probe microscopes, Parameters for characterizing 3D surface topography.					
Total (45L) = 45 Periods					

TEXT BOOKS:

1.	Jain, V.K., Introduction to micromachining, Narosa publishers, 2018
2.	Venktesh V.C., Sudin Izman, Precision Engineering, Tata Mc.Graw Hill Publishing Company, New Delhi 2007.

REFERENCES:

1.	David Dornfeld, Dae-Eun Lee, Precision Manufacturing, Springer, 2008
2.	Kevin Harding, “Handbook of Optical Dimensional Metrology, Series: Series in Optics and optoelectronics”, Taylor & Francis, 2013
3.	Murty, R.L., Precision Engineering in Manufacturing, New Age publishers, 2005.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Impart knowledge progress of precision engineering	Understand
CO2	Identify principle and working of different methods of precision machining	Understand
CO3	Apply knowledge on micromachining	Apply
CO4	Define the uses of Laser devices and machine vision	Remember
CO5	Apply knowledge on Surface metrology	Apply

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	0	1	0	0	1	0	0	0	0	2	1	2	2
CO2	1	3	1	1	0	0	1	0	0	0	0	2	0	1	1
CO3	3	3	1	1	2	0	1	0	0	0	0	3	0	1	3
CO4	3	2	1	2	2	0	1	0	0	0	0	3	2	1	3
CO5	2	3	0	3	1	0	1	0	0	0	0	3	0	1	2
Avg	**2.2**	**2.6**	**0.6**	**1.6**	**1.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**0.6**	**1.2**	**2.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO302	ADVANCED MATERIALS TECHNOLOGY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To understand knowledge of crack and failure of metals
2.	To know different types of coatings
3.	Apply knowledge of composites
4.	To understand properties of modern alloys
5.	To know about advanced aerospace alloys

UNIT I	**REVIEW OF MECHANICAL BEHAVIOUR OF MATERIALS**	**9**	**0**	**0**	**9**
Plastic deformation in poly phase alloys – Strengthening mechanism –Griffith's theory of failure modes- brittle and ductile fractures- damping property of materials- fracture toughness –initiation and propagation of fatigue cracks – Creep mechanism –Hydrogen embrittlement of metals					
UNIT II	**SURFACE MODIFICATION OF MATERIALS**	**9**	**0**	**0**	**9**
Mechanical surface treatment and coating –Case hardening and hard facing –thermal spraying –Vapour deposition –Ion implantation- diffusion coating –electroplating and electroforming –conversion coating –Ceramic and organic coating –Diamond coating – Advanced surface modification of steels					
UNIT III	**ADVANCED HEAT TREATMENT OF MATERIALS**	**9**	**0**	**0**	**9**
Composite- Types- Natural composites- Metal matrix composites- Ceramic matrix composites- Applications					
UNIT IV	**MODERN MATERIALS AND ALLOYS**	**9**	**0**	**0**	**9**
Super alloys Hastelloy, Inconel, Invar, and Monel and uses.–Refractory materials - Fireclay refractories. High alumina refractories, Silica brick, Magnesite refractories Ceramic and their applications - Low melting alloys Mercury, Cadmium, Zinc, Lead– Shape memory alloys -Copper –Aluminium-Nickel and Nickel -Titanium					
UNIT V	**APPLICATION OF ADVANCED MATERIALS**	**9**	**0**	**0**	**9**
Ti and Ni based alloys for gas turbine applications –Maraging (Low carbon and high Nickel) and cryogenic steels –Newer materials and their treatment for automobile applications – Materials for aerospace (AL6061,AL 7075), Marine(AH36, DH36, and EH36)and nuclear systems					
Total (45L) = 45 Periods					

TEXT BOOKS:

1.	Dowling, ''Mechanical Behaviour Of Materials, Engineering Method Of Determination, Fracture",Mcgraw Hill,1999
2.	Dieter, 'Engineering Design, A materials And Processing Approach'', Third Edition, Mcgraw Hill,1999

REFERENCES:

1.	P.Rama Rao, "Advances In Materials And Their Applications", Willey Eastern Ltd.,1993.
2.	Serope Kalpakjian, "Manufacturing Engineering And Technology' Third Edition, Addison Wisley Publishing Co.,1995.

3.	Kennith G .Budinski, ‘’Surface Engineering For Wear Resistance’’, Prentice Hall,1998.
4.	Dieter, ‘’Mechanical Metallurgy’ ’Mcgraw Hill, 1989
5.	D.R.Gabe, ‘Principles Of Metal Surface Treatment And Protection’, Pergamon Press1978.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Impartknowledge of crack and failure of metals	Understand
CO2	Identify the different types of coatings	Understand
CO3	Applyknowledge of composites	Apply
CO4	Definethe properties of modern alloys	Remember
CO5	Provide information of advanced aerospace alloys	Remember

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	0	1	0	0	1	0	0	0	0	2	1	2	2
CO2	1	3	1	1	0	0	1	0	0	0	0	2	0	1	1
CO3	3	3	1	1	2	0	1	0	0	0	0	3	0	1	3
CO4	3	2	1	2	2	0	1	0	0	0	0	3	2	1	3
CO5	2	3	0	3	1	0	1	0	0	0	0	3	0	1	2
Avg	**2.2**	**2.6**	**0.6**	**1.6**	**1.0**	**0.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**0.6**	**1.2**	**2.2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO303	ADDITIVE MANUFACTURING						
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**	
1. Manufacturing technology, Drafting software		**Hours/Week**	**L**	**T**	**P**	**TH**	
2. Engineering Materials			**3**	**0**	**0**	**3**	

COURSE OBJECTIVES:

1.	To introduce the development of Additive Manufacturing (AM), various business opportunities and applications
2.	To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
3.	To be acquainted with vat polymerization and material extrusion processes.
4.	To be familiar with powder bed fusion and direct energy deposition.
5.	To gain knowledge on applications of binder jetting, material jetting and laminated object manufacturing processes

UNIT I	INTRODUCTION	9	0	0	9

Overview – Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Benefits. Applications: Building Printing-Bio Printing- Food Printing-Printing Electronics. Business Opportunities and Future Directions - Intellectual Property.

UNIT II	DESIGN FOR ADDITIVE MANUFACTURING (DFAM)	9	0	0	9

Concepts and Objectives- AM Unique Capabilities: Part Consolidation-Topology Optimization Light weight Structure - DFAM for Part Quality Improvement. Data Processing - CAD Model Preparation -Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation-Customized Design and Fabrication for Medical Applications- Case Studies.

UNIT III	VAT POLYMERIZATION AND MATERIAL EXTRUSION	9	0	0	9

Photo polymerization: Stereo lithography Apparatus (SLA)- Materials -Process -Advantages Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Extrusion Based System: Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations.

UNIT IV	POWDER BED FUSION AND DIRECT ENERGY DEPOSITION	9	0	0	9

Powder Bed Fusion: Selective Laser Sintering (SLS): Process – Powder Fusion Mechanism –Process Parameters – Typical Materials and Application. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process - Advantages and Applications.

Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters - Materials -Benefits -Applications.

UNIT V	OTHER ADDITIVE MANUFACTURING PROCESSES	9	0	0	9

Binder Jetting: Three -Dimensional Printing - Materials -Process - Benefits and Limitations. Material Jetting: Multi-jet Modeling- Materials - Process - Benefits. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2015, ISBN: 978-1-56990-582-1.
2.	Ian Gibson, David W. Rosen and Brent Stucker “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, 2nd edition, Springer., United States, 2015, ISBN13: 978-1493921126.

REFERENCES:	
1.	Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.
2.	Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing”, Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN: 9783446425521.
3.	Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer., United States, 2006, ISBN: 978-1-4614-9842-1.
4.	Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press., United States, 2011, ISBN: 9780849334092.
5.	Milan Brandt, “Laser Additive Manufacturing: Materials, Design, Technologies, and Applications”, Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the development of AM technology and how AM technology propagated into various businesses and developing opportunities.	Remember
CO2	Acquire knowledge on process of transforming a concept into the final product in AM technology.	Understand
CO3	Elaborate the vat polymerization and material extrusion processes and its applications.	Apply
CO4	Acquire knowledge on process and applications of powder bed fusion and direct energy deposition.	Apply
CO5	Evaluate the advantages, limitations, applications of binder jetting, material jetting and laminated object manufacturing processes.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	0	0	0	0	0	1	2	0	1	0	2	1	1	1
CO2	2	1	1	1	1	0	2	1	0	1	0	2	1	2	1
CO3	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
CO4	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
CO5	2	1	0	0	0	0	1	0	0	1	0	2	1	1	1
Avg	**2.0**	**0.8**	**0.2**	**0.2**	**0.2**	**0.0**	**1.2**	**0.6**	**0.0**	**1.0**	**0.0**	**2.0**	**1.0**	**1.2**	**1.0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO304	NON DESTRUCTIVE TESTING AND FAILURE ANALYSIS					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To develop the fundamental knowledge about non-destructive and destructive analysis, in order to control the quality in manufacturing and production engineering components.

UNIT I	INTRODUCTION AND SURFACE NDT	9	0	0	9

Non destructive testing– Comparison with destructive testing, importance, scope and difficulties. Visual Inspection: Tools, applications and limitations. Liquid penetrant Inspection - Principles, properties required for a good penetrant and developers. Magnetic particle inspection - Principles, advantage and limitations.

UNIT II	RADIOGRAPHY AND ACOUSTIC EMISSION	9	0	0	9

Radiography- basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety. Acoustic emission testing- procedures and its importance.

UNIT III	EDDY CURRENT AND ULTRASONIC TESTING	9	0	0	9

Eddy current testing – principle, application, limitation; Ultrasonic testing – basic properties of sound beam, transducers, inspection methods, flaw characterization techniques, immersion testing, advantage and limitations.

UNIT IV	LEAK TESTING AND THERMOGRAPHY	9	0	0	9

Leak testing, Holography and Thermography – principles, procedures and applications; Comparison and selection of Non destructive testing methods; Defects in casting, forging, rolling and welding.

UNIT V	FAILURE ANALYSIS METHODOLOGY	9	0	0	9

Failure analysis methodology, tools and techniques of failure analysis, failure data retrieval, procedural steps for investigation of a failure analysis; types of failure and techniques for failure analysis.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Baldev Raj, “Practical Non-Destructive Testing”, Narosa Publishing House, 1997.
2.	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).
3.	Peter J Shull, “Nondestructive Evaluation- Theory, Techniques and Applications” Marcel Dekker, Inc, USA 2002, ISBN: 0-8247-8872-9.

REFERENCES:

1	George E Dieter, “Mechanical Metallurgy”, McGraw Hill Book Company
2	B.Hull and V.John. “Non-Destructive Testing”, McMillan
3	A.K Das, “Metallurgy of failure analysis”, TMH, 1992

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Understand the concept of destructive and Non-destructive testing methods.	Understand
CO2	Explain the working principle and application of die penetrant test and magnetic particle inspection.	Remember
CO3	Understand the working principle of eddy current inspection, Ultrasonic testing and applications.	Understand
CO4	Apply radiographic techniques for testing and acoustic emission testing.	Apply
CO5	Define tools and techniques of failure analysis, procedural steps for investigation of failure.	Remember

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	1	0	0	0	0	0	0	0	0	2	2	0
CO2	2	2	1	3	0	0	0	0	0	0	0	0	2	2	0
CO3	2	2	1	3	1	0	0	0	0	0	0	0	2	2	0
CO4	2	2	1	3	1	0	0	0	0	0	0	0	2	2	0
CO5	2	2	1	3	3	0	0	0	0	0	0	0	2	2	0
Avg	**1.8**	**2**	**1**	**2.6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO305	PRODUCT LIFE CYCLE MANAGEMENT					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To study about the history, concepts and terminology in PLM
2.	To learn the functions and features of PLM/PDM
3.	To develop different modules offered in commercial PLM/PDM tools
4.	To demonstrate PLM/PDM approaches for industrial applications
5.	To use PLM/PDM with legacy data bases, Coax& ERP systems

UNIT I	**HISTORY, CONCEPTS AND TERMINOLOGY OF PLM**	**9**	**0**	**0**	**9**

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications

UNIT II	**PLM/PDM FUNCTIONS AND FEATURES**	**9**	**0**	**0**	**9**

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration

UNIT III	**DETAILS OF MODULES IN A PDM/PLM SOFTWARE**	**9**	**0**	**0**	**9**

Case studies based on top few commercial PLM/PDM tools – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.-Architecture of PLM software- selection criterion of software for particular application - Brand name to be removed

UNIT IV	**ROLE OF PLM IN INDUSTRIES**	**9**	**0**	**0**	**9**

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance- process compliance and process automation

UNIT V	**BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE**	**9**	**0**	**0**	**9**

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Product Lifecycle Management for a Global Market, Springer; 2014 edition (29 September 2016),ISBN-10 : 3662516330
2.	Product Life Cycles and Product Management, Praeger Publishers Inc (27 March 1989)ISBN-10 : 0899303196

REFERENCES:

1.	AnttiSaaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher, 2008 (3rd Edition)
2.	IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.

3.	J ohn Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007
4.	John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
5.	Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Summarize the history, concepts and terminology of PLM	Remember
CO2	Develop the functions and features of PLM/PDM	Create
CO3	Discuss different modules offered in commercial PLM/PDM tools.	Evaluate
CO4	Interpret the implement PLM/PDM approaches for industrial applications.	Analyze
CO5	Integrate PLM/PDM with legacy data bases, cax& ERP systems	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	0	0	0	0	0	0	0	0	2	2	1	1	0
CO2	1	1	0	0	0	0	0	0	0	0	2	2	1	1	0
CO3	1	1	0	0	1	0	0	0	0	0	2	2	1	1	0
CO4	1	1	0	0	2	0	0	0	2	0	2	2	1	1	0
CO5	1	1	0	0	3	0	0	0	2	0	2	2	1	1	0
Avg	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0.8**	**0**	**2**	**2**	**1**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO306	ERGONOMICS IN DESIGN					
PREREQUISITES		CATEGORY	PE	Credit		3
		Horus/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	Accurately recognize and evaluate hazards (ergonomic in nature) Accurately recognize and evaluate hazards (ergonomic in nature) which are likely to cause occupational illnesses or injuries.
2.	To introduce students about the essentials of Static and dynamic anthropometry and Posture and job relation
3.	Apply the knowledge, skills, and abilities obtained in through subject into an industrial based problem.

UNIT I	**INTRODUCING ERGONOMICS AND DISCIPLINE APPROACH: ERGONOMICS/ HUMAN FACTORS**	**9**	**0**	**0**	**9**
Design today- Human aid to lifestyle, Journey, Fitting task to man their contractual structure, Domain, Philosophy and Objective, Mutual task comfort: two way dialogue, communication model, Ergonomics/ human Factors fundamentals, Physiology (work physiology) and stress					
UNIT II	**HUMAN PHYSICAL DIMENSION CONCERN AND POSTURE AND MOVEMENT**	**9**	**0**	**0**	**9**
Human body- structure and function, anthropometrics, Anthropometry: body growth and somatotypes, Static and dynamic anthropometry, Stand Posture- erect, Anthropometry landmark: Sitting postures, Anthropometry: squatting and cross-legged postures, Anthropometric measuring techniques, Statistical treatment of data and percentile calculations Human body- structure and function, Posture and job relation, Posture and body supportive devices, Chair characteristics, Vertical work surface, Horizontal work surface, Movement, Work Counter.					
UNIT III	**BEHAVIOUR AND PERCEPTION AND VISUAL ISSUES, ENVIRONMENTS FACTORS**	**9**	**0**	**0**	**9**
Communication and cognitive issues, Psycho-social behaviour aspects, behaviour and stereotype, Information processing and perception, Cognitive aspects and mental workload, Human error and risk perception; Visual performance, Visual displays, Environmental factors influencing human performance.					
UNIT IV	**ERGONOMIC DESIGN PROCESS, PERFORMANCE SUPPORT AND DESIGN INTERVENTION**	**9**	**0**	**0**	**9**
Ergonomics design methodology, Ergonomics criteria/check while designing, Design process involving ergonomics check, Some checklists for task easiness. Occupational safety and stress at workplace in view to reduce the potential fatigue, errors, discomforts and unsafe acts, Workstation design, Furniture support, Vertical arm reach and design application possibility, Humanising design: Design and human compatibility, comfort and adaptability aspects.					
UNIT V	**OFFICE FURNITURE GUIDELINES FOR FIT AND FUNCTION, DESIGN ERGONOMICS IN INDIA AND UNIVERSAL DESIGN CONSIDERATIONS**	**9**	**0**	**0**	**9**
Office Furniture Guidelines for Fit and Function Anticipate Actions, Chairs, Desk and Work surfaces, Storage and Files, Accessories Resources for Designing Ergonomic Products. Design Ergonomics in India: scope for exploration. Universal Design Considerations Wheelchairs Crutches, Canes, and Walkers Knobs, Handles, and Controls Access Ramps and Stairs, Resources on Universal Design.					
					Total (45L) = 45Periods

TEXT BOOKS:

1.	Bridger, RS: Introduction to Ergonomics, 2nd Edition, Taylor &Francis, 2003.
2.	Dul, J. and Weerdmeester, B. Ergonomics for beginners, a quick reference guide, Taylor & Francis, 1993.

REFERENCES:	
1.	Green, W.S. and Jordan, P .W, Human Factors in Product Design, Taylor & rancis, 1999.
2.	D. Chakrabarti, Indian Anthropometric Dimensions for ergonomic design practice, National Institute of Design, Ahmedabad, 1997
3.	G. Salvendy (edit), Handbook of Human Factors and ergonomics, John Wiley & Sons,Inc., 1998.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Learn about the basics of Human aid to lifestyle, Physiology and stress	Understand
CO2	Learn about the anthropometry: body growth and somatotypes, further about Vertical work surface, Horizontal work surface can also be obtained.	Remember
CO3	Study about the communication and cognitive issues, it promotes about environmental factors influencing human performance.	Understand
CO4	Learn about the Ergonomics design methodology and gives fathom notion on Occupational safety and stress at workplace	Apply
CO5	Study about Office furniture guidelines for fit and function and universal design considerations	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO2	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO3	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO4	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
CO5	1	0	0	0	0	3	2	2	0	0	0	2	1	2	1
Avg	**1**	**0**	**0**	**0**	**0**	**3**	**2**	**2**	**0**	**0**	**0**	**2**	**1**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO307	SURFACE ENGINEERING					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To teach students fundamental about surface properties in engineering applications and Wear modes
2.	To introduce students about the essentials of electroplating and Other plating processes
3.	To teach about the thin film for wear application, Coating specifications.
4.	To teach about the special surfacing processes
5.	To teach about the hard facing processes and applications

UNIT I	**BASICS OF SURFACE ENGINEERING**	**9**	**0**	**0**	**9**
Importance of surfaces and wear surface properties in engineering applications, Current status of surface engineering. Wear modes; Categories of wear, Low stress, High stress and Gouging abrasion, Cavitation, Slurry erosion, Impingement erosion, Fretting wear, Adhesive wear, Seizure, Galling, Oxidative wear, Spalling, Impact wear brinelling.					
UNIT II	**PLATING PROCESSES**	**9**	**0**	**0**	**9**
Fundamentals of electroplating, Electro deposition from plating baths, Electroless plating, Mentalliding, Selective plating, Hard anodizing, Other plating processes, Applicability of plating for wear resistance.					
UNIT III	**THIN FILM COATINGS**	**9**	**0**	**0**	**9**
Thermal evaporation, PVD and CVD, Sputter coating, Ion plating, Thin film for wear application, Coating specifications.					
UNIT IV	**SPECIAL SURFACING PROCESSES**	**9**	**0**	**0**	**9**
Rebuilding and surface cements, Wear tiles, Electrospark deposition coatings, Fused carbide cloth ceramic coatings, Wear sleeves, Wear plates.					
UNIT V	**HARD FACING PROCESSES AND APPLICATIONS**	**9**	**0**	**0**	**9**
Shielded metal arc welding, Gas tungsten arc welding, Gas metal arc welding, Flux coaxed are welding, Submerged arc welding, Plasma arc welding oxyacetylene welding, Furnace fusing, Thermal spray processes and their applications, Hardfacing transformation, Fusion alloys, Non fusion materials. Hardfacing in new designs, Hardfacing for repairs, Hardfacing with fusion processes, Nonfusion deposits, Weldability considerations, Finishing considerations.					
					Total (45L) = 45Periods

TEXT BOOKS:

1.	Budinski, K.G., Surface Engineering for Wear Resistance, Prentice Hall (1988).
2.	Mathews, A., Advanced Surface Coatings: A Hand book of Surface Engineering, Spinger (1991)

REFERENCES:

1.	Hocking, M.G., Metallic and Ceramic Coatings, John Wiley (1989)
2.	Strafford, K.N., Datta, P.K., and Gray, J.S., Surface Engineering Practice, Processes, Fundamentals and Applications in Corrosion and Wear, Ellis Harwood (1990).

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		Bloom Taxonomy Mapped
CO1	Learn about the basics and Current status of surface engineering. Wear modes	Understand
CO2	Learn about the Fundamentals of electroplating and Other plating processes	Understand
CO3	Study about the Thermal evaporation and wear application, Coating specifications.	Remember
CO4	Learn about the rebuilding and surface cements, Wear sleeves, Wear plates	Understand
CO5	Study about Shielded metal arc welding, Gas tungsten arc welding and Nonfusion deposits, Weldability considerations, Finishing considerations.	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO2	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO3	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO4	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
CO5	1	1	2	0	1	0	0	0	0	0	0	0	2	1	0
Avg	**1**	**1**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO308	INDUSTRIAL LAYOUT DESIGN AND SAFETY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1. Knowledge in basic manufacturing systems.		**Hours/Week**	**L**	**T**	**P**	**TH**
2. Knowledge in operations research			**3**	**0**	**0**	**3**
3. Knowledge in safety regulations.						

COURSE OBJECTIVES:

1.	To get the basics of process layout & product layout
2.	To explore the layout planning by computer applications following different algorithms.
3.	To imbibe knowledge on safety management functions and its techniques.
4.	To introduce knowledge on accident reporting & investigation procedure.
5.	To assimilate knowledge on workplace hazards & its control

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Objectives of a good plant layout, principles of a good layout, Classification of Layout, Advantages and Limitations of different layouts, Layout design procedures, Overview of the plant layout. Process layout & Product layout: Selection, specification, Implementation and follow up, comparison of product and process layout.					
UNIT II	**COMPUTERIZED LAYOUT PLANNING**	**9**	**0**	**0**	**9**
Heuristics for Plant layout – ALDEP, CORELAP, CRAFT, Group Layout, Fixed position layout- Quadratic assignment model. Branch and bound method, Evaluation of layout.					
UNIT III	**SAFETY REGULATIONS**	**9**	**0**	**0**	**9**
Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer, Safety committee, Overview of factories act 1948 – ISO-45001.					
UNIT IV	**SAFETY HARAZDS IN MACHINES**	**9**	**0**	**0**	**9**
Machine Guarding, Guarding of hazards, Machine Guarding types and its application – Safety in welding and Gas cutting – Safety in Manual and Mechanical material handling- Safety in use of electricity					
UNIT V	**CHEMICAL AND FIRE HAZARDS**	**9**	**0**	**0**	**9**
Toxicity- TLV- Types of Chemical Hazards-Occupational diseases caused by dust, fumes, gases, smoke and solvent hazards- control measures Fire triangle- Types of fire - first aid fire fighting equipment – flammability limit- LPG safety - Hazard identification and Risk Analysis, case studies					
Total (45L) = 45Periods					

TEXT BOOKS:

1.	James M Moore-Plant Layout Design, Mac Millan Co.1962 LCCCN61-5204.
2.	Krishnan N.V. "Safety Management in Industry" Jaico Publishing House, Bombay, 1997

REFERENCES:

1.	James Apple, "Plant Layout & Material Handling", The Ronalt Press Co., New Delhi, 1998.
2.	Pannerselvam. R, "Production and Operations Management", PHI, 2017

3.	Sunderesh Heragu-Facilities Design, PWS Publishing Company, ISBN-0-534-95183.
4.	Heinrich H.W. “Industrial Accident Prevention” McGraw-Hill Company, New York, 1980.
5.	Blake R.B., “Industrial Safety” Prentice Hall, Inc., New Jersey, 1973
6.	John Ridley, “Safety at Work”, Butterworth & Co., London, 1983.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Able to get the basics of layout design procedure and selection of appropriate layout for industries.	Create
CO2	The students will be able to plan and design plant and production layouts through basic strategies and with computer application	Create
CO3	Apply principles of safety management, its functions and technique in any organization.	Apply
CO4	Apply machine guarding principles in industrial applications.	Apply
CO5	Realize chemical hazards, toxicity, fire and explosion in the work place and involve to take various control measures to prevent hazards	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	2	1	2	3	2	1	1	2	2	2	2	3	2	2
CO2	0	1	2	3	0	1	0	1	2	0	2	0	1	2	1
CO3	0	2	2	1	3	1	1	1	1	0	1	2	2	3	2
CO4	0	2	1	1	2	0	0	1	1	1	2	0	2	1	1
CO5	1	2	2	1	2	0	0	1	1	1	2	1	3	2	1
Avg	**0.4**	**1.8**	**1.6**	**1.6**	**2.0**	**0.8**	**0.4**	**1.0**	**1.4**	**0.8**	**1.8**	**1.0**	**2.2**	**1.0**	**1.4**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

18MEHO309	DIGITAL MANUFACTURING AND IOT					
PREREQUISITES		CATEGORY	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

COURSE OBJECTIVES:

1.	To study the various aspects of digital manufacturing.
2.	To inculcate the importance of DM in Product Lifecycle Management and Supply chain Management
3.	To formulate of smart manufacturing systems in the digital work environment
4.	To interpret IOT to support the digital manufacturing
5.	To elaborate the significance of digital twin

UNIT I	INTRODUCTION	9	0	0	9

Introduction – Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

UNIT II	DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT	9	0	0	9

Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM

UNIT III	SMART FACTORY	9	0	0	9

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cybersecurity

UNIT IV	INDUSTRY 4.0	9	0	0	9

Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine to Machine communication – Case Studies.

UNIT V	STUDY OF DIGITAL TWIN	9	0	0	9

Basic Concepts – Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins

Total (45L) = 45Periods

TEXT BOOKS:

1.	Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.
2.	Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.

REFERENCES:

1.	Lihui Wang and Andrew YehChing Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009.
2.	Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019.

3.	Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing The Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2017
4.	Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018.
5.	Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Impart knowledge to use various elements in the digital manufacturing.	Understand
CO2	Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.	Analyze
CO3	Select the proper procedure of validating practical work through digital validation in Factories.	Apply
CO4	Implementation the concepts of iot and its role in digital manufacturing.	Apply
CO5	Analyse and optimize various practical manufacturing process through digital twin.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO2	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO3	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO4	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
CO5	1	1	0	0	0	0	2	0	0	0	2	2	2	2	2
Avg	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**2**	**2**	**2**	**2**

3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)

18MEHO310	SMART MOBILITY AND INTELLIGENT VEHICLES					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles
2.	To learn Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, LIDAR Sensor Technology and Systems and other sensors for automobile vision system
3.	To learn Basic Control System Theory applied to Autonomous Automobiles
4.	To produce overall impact of automating like various driving functions, connecting the automobile to sources of information that assist with a task
5.	To allow the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants through connected car & autonomous vehicle technology

UNIT I	**INTRODUCTION TO AUTOMATED, CONNECTED AND INTELLIGENT VEHICLES**	**9**	**0**	**0**	**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 II	**SENSOR TECHNOLOGY FOR SMART MOBILITY**	**9**	**0**	**0**	**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 III	**CONNECTED AUTONOMOUS VEHICLE**	**9**	**0**	**0**	**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 IV	**VEHICLE WIRELESS TECHNOLOGY AND NETWORKING**	**9**	**0**	**0**	**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 V	**CONNECTED CAR AND AUTONOMOUS VEHICLE TECHNOLOGY**	**9**	**0**	**0**	**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 (45L) = 45Periods					

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

REFERENCES:	
1.	Tom Denton, “Automobile Electrical and Electronic systems, Roultedge”, Taylor & Francis Group, 5th Edition, 2018.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Recognize the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles	Understand
CO2	Select the concept of remote sensing and the types of sensor technology needed to implement remote sensing	Understand
CO3	Familiar with the concept of fully autonomous vehicles	Understand
CO4	Apply the basic concepts of wireless communications and wireless data networks	Apply
CO5	Analyse the concept of the connected vehicle and its role in automated vehicles	Analyse

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO2	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO3	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO4	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
CO5	2	2	2	0	2	1	0	0	0	0	1	2	2	2	0
Avg	**2**	**2**	**2**	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**2**	**0**
3/2/1 – indicates strength of correlation (3 – high, 2- medium, 1- low)															

GOVERNMENT COLLEGE OF ENGINEERING, SALEM

REGULATION 2018 A - VERTICALS FOR MINOR DEGREE

VERTICAL - I	VERTICAL - II	VERTICAL - III	VERTICAL - IV	VERTICAL - V	VERTICAL - VI
Civil Engineering	**Computer Science and Engineering**	**Electronics and Communication Engineering**	**Electrical and Electronics Engineering**	**Mechanical Engineering**	**Metallurgical Engineering**
18CEM01 Construction Materials	18CSM01 Programming in C++	18ECM01 Electron Devices	18EEM01 – Network Analysis and Synthesis	18MEM01 Engineering Thermodynamics	18MTM01 Advanced Physical Metallurgy
18CEM02 Building Construction & Equipment	18CSM02 Advanced Data Structures and Algorithms	18ECM02 Digital Electronics	18EEM02 – Signals and Systems	18MEM02 Fluid Mechanics and Machinery	18MTM02 Metallurgical Thermodynamics and kinetics
18CEM03 Concrete Technology	18CSM03 Computer Organization and Design	18ECM03 Electronic Circuits (EC-I & EC-II, LIC)	18EEM03 – Linear and Digital Electronics Circuits	18MEM03 Manufacturing Processes	18MTM03 Mechanical Behaviour of Materials
18CEM04 Environmental Engineering	18CSM04 Advanced Operating Systems	18ECM04 Signal Processing	18EEM04 – Microprocessor and Microcontrollers	18MEM04 Materials Engineering	18MTM04 Rate Processing in Metallurgy
18CEM05 Basics of Transportation Engineering	18CSM05 Data Communication and Computer Networks	18ECM05 Microprocessors and Microcontrollers	18EEM05 – Control Systems	18MEM05 Kinematics of Machinery	18MTM05 Corrosion and Surface Engineering
18CEM06 Repair and Rehabilitation Structures	18CSM06 Programming Essentials in Python	18ECM06 Analog and Digital Communication	18EEM06 – Measurement and Instrumentation	18MEM06 Hydraulics and Pneumatics	18MTM06 Characterization of Materials
18CEM07 Green Building Technology	18CSM07 Advanced Database System Concepts	18ECM07 Communication Networks (CN)	18EEM07 – Electrical Machines	18MEM07 Design of Machine Elements	18MTM07 Automotive, Aerospace and Defense Materials
-----	18CSM08 Virtualization and Cloud Computing	18ECM08 Fundamentals of IoT	18EEM08 – Electric Drives and Control	18MEM08 Heat and Mass Transfer	-----
-----	-----	18ECM09 Wireless Sensors and Networking (WSN)	18EEM09 – Electric Vehicle and Control	18MEM09 Metrology and Quality Control	-----
-----	-----	18ECM10 Basics of Embedded Systems	18EEM10 –Electric Energy Conservation and Auditing	18MEM10 Dynamics of Machinery	-----

LIST OF MINOR DEGREE - VERTICALS

S.No.	Course Code	Course	Cat	Hours/Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
CIVIL ENGINEERING										
1	18CEM01	Construction Materials	OE	3	0	0	3	40	60	100
2	18CEM02	Building Construction & Equipment's	OE	3	0	0	3	40	60	100
3	18CEM03	Concrete Technology	OE	3	0	0	3	40	60	100
4	18CEM04	Environmental Engineering	OE	3	0	0	3	40	60	100
5	18CEM05	Basics of Transportation Engineering	OE	3	0	0	3	40	60	100
6	18CEM06	Repair and Rehabilitation of Structures	OE	3	0	0	3	40	60	100
7	18CEM07	Green Building Technology	OE	3	0	0	3	40	60	100
COMPUTER SCIENCE AND ENGINEERING										
1	18CSM01	Programming in C++	OE	3	0	0	3	40	60	100
2	18CSM02	Advanced Data Structures and Algorithms	OE	3	0	0	3	40	60	100
3	18CSM03	Computer Organization and Design	OE	3	0	0	3	40	60	100
4	18CSM04	Advanced Operating Systems	OE	3	0	0	3	40	60	100
5	18CSM05	Data Communication and Computer Networks	OE	3	0	0	3	40	60	100
6	18CSM06	Programming Essentials in Python	OE	3	0	0	3	40	60	100
7	18CSM07	Advanced Database System Concepts	OE	3	0	0	3	40	60	100
8	18CSM08	Virtualization and Cloud Computing	OE	3	0	0	3	40	60	100
ELECTRONICS AND COMMUNICATION ENGINEERING										
1	18ECM01	Electron Devices	OE	3	0	0	3	40	60	100
2	18ECM02	Digital Electronics	OE	3	0	0	3	40	60	100
3	18ECM03	Electronic Circuits	OE	3	0	0	3	40	60	100
4	18ECM04	Signal Processing	OE	3	0	0	3	40	60	100
5	18ECM05	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100

6	18ECM06	Analog and Digital Communication	OE	3	0	0	3	40	60	100
7	18ECM07	Communication Networks	OE	3	0	0	3	40	60	100
8	18ECM08	Fundamentals of IoT	OE	3	0	0	3	40	60	100
9	18ECM09	Wireless sensors and networking	OE	3	0	0	3	40	60	100
10	18ECM10	Basics of Embedded systems	OE	3	0	0	3	40	60	100
ELECTRICAL AND ELECTRONICS ENGINEERING										
1	18EEM01	Linear and Digital Electronics Circuits	OE	3	0	0	3	40	60	100
2	18EEM02	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100
3	18EEM03	Control Systems	OE	3	0	0	3	40	60	100
4	18EEM04	Measurements and Instrumentation	OE	3	0	0	3	40	60	100
5	18EEM05	Electrical Machines	OE	3	0	0	3	40	60	100
6	18EEM06	Electric Drives and Control	OE	3	0	0	3	40	60	100
7	18EEM07	Electric Vehicles and Control	OE	3	0	0	3	40	60	100
8	18EEM08	Electrical Energy Conservation and Auditing	OE	3	0	0	3	40	60	100
9	18EEM09	SMPS and UPS	OE	3	0	0	3	40	60	100
10	18EEM10	Utilization of Electrical Energy	OE	3	0	0	3	40	60	100
MECHANICAL ENGINEERING										
1	18MEM01	Engineering Thermodynamics	OE	3	0	0	3	40	60	100
2	18MEM02	Fluid Mechanics and Machinery	OE	3	0	0	3	40	60	100
3	18MEM03	Manufacturing Processes	OE	3	0	0	3	40	60	100
4	18MEM04	Materials Engineering	OE	3	0	0	3	40	60	100
5	18MEM05	Kinematics of Machinery	OE	3	0	0	3	40	60	100
6	18MEM06	Hydraulics and Pneumatics	OE	3	0	0	3	40	60	100
7	18MEM07	Design of Machine Elements	OE	3	0	0	3	40	60	100
8	18MEM08	Heat and Mass Transfer	OE	3	0	0	3	40	60	100
9	18MEM09	Metrology and Quality Control	OE	3	0	0	3	40	60	100

10.	18MEM10	Dynamics of Machinery	OE	3	0	0	3	40	60	100
METALLURGICAL ENGINEEING										
1	18MTM101	Advanced Physical Metallurgy	OE	3	0	0	3	40	60	100
2	18MTM102	Thermodynamics and Kinetics in Metallurgy	OE	3	0	0	3	40	60	100
3	18MTM103	Mechanical Behaviour of Materials	OE	3	0	0	3	40	60	100
4	18MTM104	Rate Processes in Metallurgy	OE	3	0	0	3	40	60	100
5	18MTM105	Corrosion and Surface Engineering	OE	3	0	0	3	40	60	100
6	18MTM106	Materials Characterization	OE	3	0	0	3	40	60	100
7	18MTM107	Automotive, Aerospace and Defence Materials	OE	3	0	0	3	40	60	100

B.E. – CIVIL ENGINEERING - MINOR DEGREE

18CEM01	**CONSTRUCTION MATERIALS**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the characteristics and Properties of Stones and Brick
2	To impart knowledge on Cement, Aggregate and Mortar
3	To understand the behaviour of concrete and seasoning timber
4	To study the Parts and types of flooring and roofing
5	To study carpentry, arches, lintels and finishing works.

Unit I	**STONES, BRICKS**	**9**	**0**	**0**	**9**

Building Stone –classification of rocks-characteristics of good building stone – deterioration and preservation of stone work – tests on stones - Bricks- manufacture of clay bricks -classification - tests on bricks- bricks for special use- refractory bricks.

Unit II	**CEMENT, AGGREGATES, MORTAR**	**9**	**0**	**0**	**9**

Cement- composition- manufacturing process-wet and dry processes. Aggregates –coarse and fine aggregates-characteristics and function. Mortar- properties- uses- types of mortars- selection of mortars for various Civil Engineering construction.

Unit III	**CONCRETE, TIMBER AND OTHER MATERIALS**	**9**	**0**	**0**	**9**

Concrete- ingredients - principles of hardened concrete- Special concrete- types.
Timber- characteristics- seasoning-preservation- Panels of laminates. Glass- properties- uses. Steel- Uses - market forms.

Aluminum and other metallic materials for construction.

Paints, Varnishes and Distempers-types-properties.

Unit IV	**FLOORING AND ROOFING**	**9**	**0**	**0**	**9**

Components of floor- selection of flooring materials- suitability of floors for various applications. damp proof course, causes of dampness- effect of dampness - requirements of good stairs - classification of stairs -Roofs - types of roofs- requirements - pitched roof - lean to roof-gable roof-hip roof-flat roof-RCC roof.

Unit V	**CARPENTARY, ARCHES, LINTELS AND FINISHING WORKS**	**9**	**0**	**0**	**9**

Location of doors and windows - size of doors - types of doors - fixture and fastenings for doors and windows - arches - classification - stability of an arch - lintels - classification of lintels - steel lintel. scaffolding - component parts - shoring - methods of plastering - defects in plastering - pointing - objectives- methods of pointing

Total= 45 Periods

Text Books:	
1	B.C. Punmia, Building Construction, Laxmi Publications; Eleventh edition -2021
2	S.C.Rangwala, Building Construction,CharotarPublishing House Pvt. Ltd, 34th Edition - 2022
3	P. Purushothama Raj., Building Construction Materials and Techniques, Pearson Education India, First Edition - 2017
Reference Books:	
1	Shetty M.S., Concrete Technology (Theory and Practice), S.Chand& Company Ltd.,2021.
2	Rangwala S.C., Engineering Materials (Material Science) revised and enlarged by Rangwala K.S. and Rangwala P.S., Charotar Publishing House, 2010.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and characterize and properties of Stone and brick	Remember
CO2	Understand the manufacturing process of cement and functions of mortar	Understand
CO3	Identify the age of timber and preservation methods of timber	Remember
CO4	Differentiate the types of roofing and flooring	Understand
CO5	Understand the miscellaneous works such as carpentry, lintels, Arch, etc.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
CO2	-	2	-	-	-	2	3	-	-	-	-	-	-	-	-
CO3	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
CO4	1	-	2	-	2	3	2	-	-	-	-	-	-	-	-
CO5	1	-	-	-	3	-	2	-	-	-	-	-	-	-	-
Avg	1	2	2	-	2	3	2	-	-	-	-	-	-	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM02	BUILDING CONSTRUCTION & EQUIPMENT				Semester		
PREREQUISITES			**Category**	**OE**	**Credit**		**3**
NIL			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Learning Objectives

1	Able to gain basic knowledge in construction methods.
2	Able to gain basic knowledge in equipment.
3	Able to gain basic knowledge in machineries.
4	Able to gain basic knowledge in fire safety principles.
5	Able to gain basic knowledge in green technology.

Unit I	**CLASSIFICATION OF BUILDINGS, FOUNDATIONS AND TYPES OF MASONRY**	**9**	**0**	**0**	**9**
Component parts of a building -Their functions. Classification of buildings according to National building code. Site investigation for foundation as per N.B.C, Types of foundation and prevention of dampness at basement level,Classification of stone masonry					
Unit II	**DOORS, WINDOWS, LINTELS, SCAFFOLDING AND STAIRCASES**	**9**	**0**	**0**	**9**
Doors and windows – parts of door and window – Types of Door and windows–Ventilators – fixed, swinging type and louvered. Lintels – Functions, Scaffolding – Purpose and types –Location of stairs.Types of stairs					
Unit III	**ROOFS, FLOORINGS, PROTECTIVE AND DECORATIVE FINISHES**	**9**	**0**	**0**	**9**
Roof Beams and Roof Slabs – Types of Roofing Systems – Methods of Termite Proofing – Methods of Damp proofing. Types of floors- Plastering (Interior and Exterior) – Pointing for Walls and Floors using Grouts – White Washing, Color Washing with different Color Shades available in the Markets – Painting – Types of Painting for Interior and Exterior application.					
Unit IV	**CONSTRUCTION EQUIPMENTS**	**9**	**0**	**0**	**9**
Selection of equipment for earthwork excavation, drilling, blasting, tunnelling, erection and dewatering and pumping, concreting, material handling and erection of structures					
Unit V	**GREEN BUILDING TECHNOLOGY**	**9**	**0**	**0**	**9**
Introduction to green technology – types and importance; zero waste and r concept, green materials – green concrete (purpose and limitations), green buildings, green engineering.					

Total= 45 Periods

Text Books:	
1	Building Construction by S.C.Rangawala
2	Construction Technology by Sarkar Oxford University Press
3	Building Material & Construction by S.P. Arora& S. P. Bindra
Reference Books:	
1	Hopkinson And Kay J.D., The Lighting of Building, Faber and Faber, London.
2	Koerner, R.M, Construction & Geotechnical Methods in Foundations Engineering, McGraw Hill, 1984
3	Varna M., Construction Equipment and Its Planning & Applications, Metropolitan Books Co, 1979

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Organize the construction technique to be followed in brick and stone masonry, concreting, flooring, roofing and plastering etc.	Create
CO2	Select safe practices in building construction activities	Evaluate
CO3	Clarify the different types of roofs, floor and productive materials of buildings	understand
CO4	Select the relevant equipment for building construction	Evaluate
CO5	Apply the Principles of green building technology.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	3	2	2	2	1	1	-	-	-	-	1
CO2	-	-	-	-	3	2	2	2	2	2	-	-	-	-	1
CO3	-	-	-	-	2	3	2	2	2	1	-	-	-	-	1
CO4	-	-	-	-	2	2	3	1	1	2	-	-	-	-	1
CO5	-	-	-	-	2	3	2	2	2	2	-	-	-	-	1
Avg	-	-	-	-	2.4	2.4	2.2	1.8	1.6	1.6	-	-	-	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM03	CONCRETE TECHNOLOGY			Semester			
PREREQUISITES		Category	OE	Credit			3
NIL		Hours/Week	L	T	P		TH
			3	0	0		3

Course Learning Objectives

1	To understand the properties of ingredients of concrete.
2	To study the behavior of concrete at its fresh and hardened state.
3	To study about the concrete design mix.
4	To know about the procedures in concrete at different stage.
5	To understand special concrete and their uses.

Unit I	INTRODUCTION	9	0	0	9

Concrete materials, Cement: Field and laboratory tests on cement, Types of cement and their uses, different tests for aggregates. Methods for manufacturing of cement- Wet and dry process. Hydration of cement, Bogue’s compound.

Unit II	ADMIXTURES	9	0	0	9

Accelerating admixtures, Retarding admixtures, water reducing admixtures, Air entraining admixtures, coloring agent, Plasticizers. Batching, Mixing, Transportation, placing of concrete, curing of Concrete

Unit III	MIX DESIGN	9	0	0	9

Factors influencing mix proportion, Mix design by ACI method and I.S. code method, Design of high strength concrete.

Unit IV	BEHAVIOUR OF CONCRETE	9	0	0	9

Strength of concrete, Shrinkage and temperature effects, creep of concrete, permeability of concrete, durability of concrete, Corrosion, Causes and effects, remedial measures, Thermal properties of concrete, Micro cracking of concrete.

Unit V	SPECIAL CONCRETE	9	0	0	9

Light-weight concrete, Fibre reinforced concrete, Polymer modified concrete, Ferro cement, Mass concrete, Ready-mix concrete, Self-compacting concrete, Quality control, Sampling and testing, Acceptance criteria.

Total= 45 Periods

Text Books:

1	Neville A.M Properties of Concrete, Pearson publication, 2012.
2	Shetty M.S Concrete technology, S.Chand and Company Ltd, New Delhi 2022.
3	Santha Kumar A.R Concrete Technology, Oxford university Press, NewDelhi, 2022.
4	Mehta K.P Concrete Technology, Chand & Co, NewDelhi, 2006.
5	Robert RatayForensic Structural Engineering Handbook, McGraw Hill LLC, 2009

Reference Books:	
1	Indian Standard Recommended Guide lines for Concrete Mix Design, IS:10262 – 2019, Bureau of Indian Standards, NewDelhi.
2	Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete IS:383-1970 R2011, Bureau of Indian Standards, NewDelhi.
3	Gambhir.M.L,Concrete Technology, Volume I & II, Tata McGraw-HillBookCompany,Third print, 2003
4	Krishna Raju N. Design of Concrete Mixes, CBS publishers. NewDelhi, 2002.
5	Stephen E. Petty,Forensic Engineering: Damage Assessments for Residential and Commercial Structures,CRCpress,Taylor& Francis,2013.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To identify suitable materials to be used in the cement concrete by conducting various tests as per BIS code.	Evaluate
CO2	To know about the specific applications and uses of admixtures.	Understand
CO3	Design the concrete mix using ACI and BIS code methods.	Create
CO4	Determine the properties of fresh and hardened of concrete.	Evaluate
CO5	Design special concretes and to Ensure quality control while testing/ sampling and acceptance criteria for pre and post construction work.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	3	-	1	1	1	2	1	1	1	-	1
CO2	-	-	-	-	3	-	3	-	1	1	-	-	2	-	1
CO3	-	-	-	-	3	-	3	-	-	1	-	-	1	-	1
CO4	-	-	-	-	3	2	1	-	-	-	-	-	-	-	1
CO5	-	-	-	-	3	3	3	1	1	3	1		3	-	1
Avg	-	-	-	-	3	2.5	2.2	1	1	1.75	1	1	1.75	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

<table>
<tr><td>18CEM04</td><td colspan="2">ENVIRONMENTAL ENGINEERING</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">NIL</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To evaluate the sources of water and analyse its characteristics and processes in water treatment, express the analysis of distribution network</td></tr>
<tr><td>2</td><td colspan="6">To design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and its disposal</td></tr>
<tr><td>3</td><td colspan="6">To predict the sources, effects, dispersion of air pollutants air quality management and its control measures</td></tr>
<tr><td>4</td><td colspan="6">To identify the characteristics and sources of municipal solid wastes, its collection methods, off-site processing of municipal solid wastes and its recovery, disposal methods</td></tr>
<tr><td>5</td><td colspan="6">To assess the sources, effects and control measures of noise pollution</td></tr>
<tr><td>Unit I</td><td colspan="2">WATER TREATMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Water Quality and its Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.</td></tr>
<tr><td>Unit II</td><td colspan="2">WASTEWATER TREATMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Sewerage system design, quantity and quality of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.</td></tr>
<tr><td>Unit III</td><td colspan="2">AIR POLLUTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.</td></tr>
<tr><td>Unit IV</td><td colspan="2">SOLID WASTE MANAGEMENT</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).</td></tr>
<tr><td>Unit V</td><td colspan="2">NOISE POLLUTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Noise pollution: Sources; Health effects; Standards; Measurement and control methods</td></tr>
<tr><td colspan="7" align="right">Total= 45 Periods</td></tr>
</table>

Text Books:	
1	Garg, S.K. Water supply Engineering, Khanna Publishers, New Delhi, 2010.
2	Garg, S.K. Sewage water disposal and Air pollution, Khanna Publishers, New Delhi, 2010.
3	George Tchobanoglous et.al., Integrated Solid Waste Management, McGraw-Hill, Publishers, 1993.
4	Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.

Reference Books:	
1	Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2	Peavy S.W., Rowe D.R. and Tchobanoglous G. Environmental Engineering, McGraw Hill, NewDelhi, 1985.
3	Metcalf and Eddy,M.C., Wastewater Engineering – Treatment &Reuse,TataMcGraw-Hill Publications, New Delhi,2003.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the sources of water supply, analyze the characteristics of water with its standards and various unit operations and processes in water treatment, express the analysis of distribution network	Remember
CO2	Expertise design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and disposal and justify the methods for disposal of sewage	Analyze
CO3	Predict the sources, effects, dispersion of air pollutants air quality management and its control measures	Apply
CO4	Aware about the characteristics, types and sources of municipal solid wastes, Learn the collection methods, Know about off-site processing of municipal solid wastes and its recovery, disposal methods	Remember
CO5	Understand the sources, effects and control methods of noise pollution	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	1	3	2	1	1	2	1	1	3	-	2
CO2	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO3	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO4	2	1	3	1	1	3	1	-	-	2	2	1	3	-	2
CO5	2	-	3	-	-	3	-	-	-	2	1	1	3	-	2
Avg	2	1	3	1.3	1	3	1.3	1	1	2	1.6	1	3	-	2
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM05	BASICS OF TRANSPORTATION ENGINEERING			Semester		
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	The objective of the course is to educate the students on various components of highway engineering.
2	To educate the geometric design concepts of highway engineering
3	To develop skills on construction and maintenance of highway.
4	Ability to plan various civil engineering aspects of railways and educate various components of railways
5	The course enables the students to develop skill on evaluation and maintenance of railway track.

Unit I	CROSS SECTIONAL ELEMENTS OF HIGHWAYS	9	0	0	9

Classification of Highways - Classification and Cross Section of Urban and Rural Roads (IRC), Highway Cross Sectional Elements- Right of Way, Carriage Way, Camber, Kerbs, Shoulders and Footpaths (IRC Standards), Sight Distances - Stopping Sight Distance (SSD), Overtaking Sight Distance (OSD), Sight Distance at Intersections, Intermediate Sight Distance and Illumination Sight Distance - Cross Sections of Different Class of Roads -

Unit II	GEOMETRIC DESIGN OF HIGHWAYS	9	0	0	9

Horizontal Alignments – Superelevation, Widening of Pavements on Horizontal Curves, Vertical Alignments - Rolling. Limiting, Exceptional and Minimum Gradients, Summit and Valley Curves -Geometric Design of Hill Roads (IRC Standards Only)

Unit III	CONSTRUCTION AND MAINTENANCE OF HIGHWAY	9	0	0	9

Construction of Flexible and Rigid Pavements – Defects in Flexible and Rigid Pavements -Highway Drainage – Evaluation and Maintenance of Pavements.

Unit IV	RAILWAY PLANNING AND DESIGN	9	0	0	9

Permanent Way, its Components and Functions of Each Component: Rails - Types of Rails, Rail Fastenings, Concept of Gauges, Coning of Wheels, Creeps Sleepers - Functions, Materials, Density. Ballasts - Functions, Materials, Ballast less Tracks Geometric Design of Railway Tracks Gradients and Grade Compensation, Super-Elevation, Widening of Gauges in Curves, Transition Curves, Horizontal and Vertical Curves.

Unit V	RAILWAY TRACK CONSTRUCTION MAINTENANCE AND OPERATION	9	0	0	9

Points and Crossings – Turnouts, Track circuiting, Signaling, Interlocking, Lay Outs of Railway Stations and Yards, Rolling Stock, Tractive Power, Track Resistance, Level Crossings.

Total= 45 Periods

Text Books:

1	Khanna K., Justo C.E.G., Highway Engineering Revised 10th Edition Khanna Publishers, Roorkee, 2014
2	Kadiyalil. R, Engineering Traffic and Transport Planning, Khanna Publishers, New Delhi, 2019.
3	Chandola S.P. Transportation Engineering-2019

Reference Books:	
1	Sharma S.K., Principles Practice and Design of Highway Engineering, S. Chand & Co Ltd. New Delhi, 2006
2	Guidelines Of Ministry of Road Transport and Highways, Government of India.
3	Agarwal M.M., Indian Railway Track, 14th Edition, Prabha and Co., New Delhi, 2002.
4	Saxena S.C. Highway & Traffic Engineering, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Classify roads as per Indian Road Congress and describe the principles of highway alignment	Understand
CO2	Determine the highway geometric elements	Analyse
CO3	Differentiate between types of pavements, their construction and design principles	Analyse
CO4	Explain the functions of components of Railways	Understand
CO5	Carry out the various methods for track alignment & procedure for construction of railway & maintenance of track	Apply

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
CO2	2	3	2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	2	2	3	1	3	-	-	-	1	-	-
CO4	-	-	-	-	2	2	3	1	2	-	-	-	-	-	-
CO5	-	-	-	-	2	2	3	1	2	-	-	-	1	-	-
Avg	2	3	2	2	2	2	3	1	2.25	-	-	-	1	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM06	REPAIR AND REHABILITATION OF STRUCTURES				Semester	
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	Study the various types and properties of repair materials
2	Learn various distress and damages to concrete structures
3	Understand the importance of maintenance of structures
4	Assess the damage to structures using various tests
5	Learn various repair techniques of damaged structures, corroded structures

Unit I	**MAINTENANCE AND REPAIR STRATEGIES**	**9**	**0**	**0**	**9**

Maintenance, repair and rehabilitation, Facts of Maintenance, importance of Maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.

Unit II	**SERVICEABILITY AND DURABILITY OF CONCRETE**	**9**	**0**	**0**	**9**

Quality assurance for concrete construction, concrete properties- strength, permeability, thermal properties and cracking-effects due to climate, temperature, chemical, corrosion- Design and construction errors-effects of cover thickness and cracking.

Unit III	**MATERIALS AND TECHNIQUES FOR REPAIR**	**9**	**0**	**0**	**9**

Special concretes and mortar, concrete chemical, special elements for accelerated strength gain, expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, fibre reinforced concrete, rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings and cathodic protection.

Unit IV	**REPAIRS, REHABILITATION AND RETROFITTING OF STRUCTURES**	**9**	**0**	**0**	**9**

Strengthening of Structural elements, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.

Unit V	**DEMOLITION TECHNIQUES**	**9**	**0**	**0**	**9**

Demolition methods by machines, explosives, Advanced techniques-Demolition sequences, dismantling techniques, safety precautions in dismantling and demolition, Engineered demolition techniques for dilapidated structures- case studies

Total= 45 Periods

Text Books:

1	Shetty, M.S, Concrete Technology- Theory and Practice, S. Chand and company, New Delhi,2019
2	Repair and protection of concrete structures by Noel P. Mailvaganam, CRC Press,1991.
3	CPWD: Handbook on Repair & Rehabilitation of R.C.C. Buildings, CPWD, Govt. of India, 2002, updated reprint 2011

Reference Books:	
1	Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low-cost housing, “RHDC.NBO” Anna University, July 1992.
2	Raikar R.N.,Learning from failures- deficiencies in design, construction and services – R&D Centre (SDCPL), Raikar bhavan, Bombay,1987
3	Palaniyappan, N., Estate management, Anna Institute of Management, Chennai,1992.
4	Lakshmipathy, M. etal., Lecture notes of workshop on Repairs and Rehabilitation of structures, 29-30th October 1999.
5	https://nptel.ac.in/courses/114106035/38

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Demonstrate the condition of structures	Understand
CO2	Inspect and evaluate the damaged structure	Analyze
CO3	Implement the repairing techniques of a structure	Analyze
CO4	Identify and Use different materials for repairing works	Apply
CO5	Demonstrate the dismantling and demolishing structures	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO2	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO3	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO4	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO5	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
Avg	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM07	GREEN BUILDING TECHNOLOGY			Semester			
PREREQUISITES		Category		OE	Credit		3
NIL		Hours/Week		L	T	P	TH
				3	0	0	3
Course Learning Objectives							
1	To Know various aspects of green buildings						
2	To Learn the principles of planning and orientation of buildings.						
3	To Relate the construction of green building with prevailing energy conservation policy and regulations.						
4	To Know and identify different green building construction materials.						
5	To Learn different rating systems and their criteria						
Unit I	**INTRODUCTION TO GREEN BUILDING**			9	0	0	9
Introduction, Necessity, Definition & concept of Green Building, Issues and strategies of Green Building, Principles and Benefits of Green Building, Components/ features of Green Building, Energy Efficiency, Water efficiency, Material Efficiency, Indoor Air Quality.							
Unit II	**SITE SELECTION AND PLANNING**			9	0	0	9
Site selection, Site selection strategies, Landscaping, building form, orientation, building envelope and fenestration, material and construction techniques, roofs, walls, fenestration and shaded finishes, Environmental design (ED) strategies for building construction, Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, recycle and reuse systems, Waste Management.							
Unit III	**ENERGY AND ENERGY CONSERVATION**			9	0	0	9
Introduction, Environmental impact of building constructions, present scenario, Need of energy conservation, Concepts of embodied energy, operational energy and life cycle energy, Methods to reduce operational energy, Energy efficient building, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.							
Unit IV	**BUILDING MATERIALS**			9	0	0	9
Green building materials and products- Bamboo, Rice husk ash concrete, plastic bricks, Bagasse particle board, Insulated concrete forms. use of materials with recycled content such as blended cements, pozzolana cements, flyash bricks, vitrified tiles, materials from agro and industrial waste, reuse of waste material-Plastic, rubber, Newspaper wood, Nontoxic paint, green roofing.							
Unit V	**RATING SYSTEM**			9	0	0	9
Introduction to Leadership in Energy and Environmental Design (LEED) criteria, Indian Green Building council (IGBC) Green rating, Green Rating for Integrated Habitat Assessment. (GRIHA) criteria, National Productivity council (NPC) Ministry of New and Renewable Energy (MNRE) Bureau of Energy efficiency (BEE) -BER (Building Energy Rating) – Certificates.							
							Total= 45 Periods

Text Books:	
1	Kibert, C.J., Sustainable construction: Green Building design and Delivery, John Wiley Hobouken, NewJersey, 3rd Edition, 2012.
2	Chauhan, D S Sreevasthava, S K., Non-conventional Energy Resources, New Age International Publishers, NewDelhi, 4th Edition, 2021

Reference Books:	
1	O.P. Gupta, Energy Technology, Khanna Publishing House, NewDelhi
2	Jagadeesh, K S, Reddy Venkatta Rama &Nanjunda Rao, K S., Alternative Building Materials and Technologies, New Age International Publishers,Delhi.
3	Sam Kubba., Handbook of Green Building Design and Construction, Butterworth- Heinemann.
4	Means R S, Green Building - Project Planning and Cost Estimating, John Wiley &Sons
5	Sharma K V, Venkataseshaiah P., Energy Management and Conservation, IK International.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concepts of Green Building	Understand
CO2	Discuss the Planning of Green Building.	Understand
CO3	Explain the concept of Energy and Energy Conservation.	Understand
CO4	Select appropriate green building material and technique.	Understand
CO5	Summarize the Green Building Functions in various organizations.	Understand

<u>COURSE ARTICULATION MATRIX</u>

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	1	-	2	3	-	-	-	2	1	2	-	-
CO2	1	1	1	2	1	-	-	-	-	-	-	-	2	-	-
CO3	-	1	3	-	2	-	-	-	-	-	-	-	2	-	-
CO4	-	1	2	-	3	-	-	-	-	-	2	-	2	-	-
CO5	1	1	2	3	2	-	-	-	-	-	2	-	2	-	-
Avg	1	1	2	2	2	2	3	-	-	-	2	1	2	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

B.E. – COMPUTER SCIENCE ENGINEERING - MINOR DEGREE

18CSM01	PROGRAMMING IN C++					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand and develop the object oriented programming concepts.
2	To familiarize and design the template functions and classes
3	To disseminate and apply exception handling mechanisms.
4	To learn and exploit stream classes.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Procedure oriented programming paradigm - Object oriented programming paradigm - Basic concepts of object oriented programming, benefits of OOP, application of OOP - C++ fundamentals –structure of C++ program, tokens, data types - Operators and expressions - Control structures - Functions.

Unit II	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.

Unit III	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Inheritance – defining derived classes, types, virtual base classes, abstract classes, constructor in derived classes - Pointers-pointers to objects, this pointer, pointer to derived classes - Virtual functions.

Unit IV	**TEMPLATES AND EXCEPTION HANDLING**	**9**	**0**	**0**	**9**

Generic Classes – class template, class templates with multiple parameters - Generic Functions - function templates, function templates with multiple parameters, member function templates - Exception handling – basics, exception handling mechanism, rethrowing an exception – Exception handling options – understanding terminate() and unexpected() – the uncaught_exception() function – bad_exception().

Unit V	**CONSOLE I/O AND FILE HANDLING**	**9**	**0**	**0**	**9**

C++ Stream Classes – unformatted I/O operations, formatted console I/O operations, manipulators - Files-classes for file operation, opening and closing a file, detecting end of file, files modes, sequential file operations, random file operations.

Total (45 L) =45 Periods

Text Books:

1	E. Balagurusamy “Object –Oriented Programming with C++” Sixth Edition Tata McGraw-Hill

Reference Books:

1	Herbert Schildt, "The Complete Reference C++", Fifth Edition, Tata McGraw Hill
2	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley
3	K.R.Venugopal, Rajkumar Buyya, T.Ravishankar , Mastering in C++, Second Edition, Tata McGraw Hill

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Build the object oriented programming concepts.	Apply
CO2	Familiarize and build the template functions and classes	Understand
CO3	Disseminate and apply exception handling mechanisms.	Apply
CO4	Depict and exploit steam classes.	Understand

18CSM02	ADVANCED DATA STRUCTURES AND ALGORITHMS					
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the concepts of ADTs
2	To Learn linear data structures – lists, stacks, and queues
3	To have knowledge about non-linear data structures like trees and graphs
4	To understand concepts about searching and sorting and hashing techniques

Unit I	**LINEAR DATA STRUCTURES – LIST**	**9**	**0**	**0**	**9**

Abstract Data Types (ADTs) – List ADT - Array based Implementation - Linked List Implementation – Singly Linked Lists - Circularly Linked Lists - Doubly-Linked Lists - Applications of Lists – Polynomial Manipulation – All operations (Insertion, Deletion, Merge, Traversal).

Unit II	**LINEAR DATA STRUCTURES –STACKS AND QUEUES**	**9**	**0**	**0**	**9**

Stack ADT - Operations - Applications of Stacks - Evaluating Arithmetic Expression - Conversion of infix to postfix Expression - Queue ADT - Operations - Circular Queue - DeQueue - Applications of Queue

Unit III	**NON LINEAR DATA STRUCTURES – TREES**	**9**	**0**	**0**	**9**

Tree ADT – Tree traversals – Binary Tree ADT – Expression Trees – Applications of Trees – Binary Search Tree ADT – Threaded Binary Trees- AVL Trees – B-Tree – Heaps - Operations of Heaps - Priority Queues - Binary Heap - Max Heap - Min Heap - Applications of Heap.

Unit IV	**NON LINEAR DATA STRUCTURES – GRAPHS**	**9**	**0**	**0**	**9**

Definition – Representation of Graphs –Types of Graphs - Graph Traversals - Breadth First Search - Depth First Search - Application of Graph Structures: Shortest Path Problem: Dijkstra’s Algorithm - Minimum Spanning Trees: Prim’s Algorithm - Kruskal’s Algorithms

Unit V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**	**0**	**0**	**9**

Searching: Linear Search - Binary Search - Sorting Algorithms - Insertion Sort - Selection Sort - Shell Sort - Bubble Sort - Quick Sort - Merge Sort - Radix Sort - Hashing: Hash Functions – Separate Chaining – Open Addressing – Rehashing – Extendible Hashing.

Total (45 L) =45 Periods

Text Books:

1	Mark Allen Weiss, “ Data Structures and Algorithm Analysis in C ”, 4/E Pearson Education, 2013.

Reference Books:

1	Seymour Lipschutz, “Data Structures With C “,(Schaum`s Outline Series) Published by Tata McGraw-Hill Education Pvt. Ltd., 2015
2	Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, “Fundamentals of Data Structures In C”, Second Edition, Silicon Press, 2008.
3	Richard F.Gilberg & Behrouz A.Forouzan, “Data Structures: A Pseudo code Approach With C”, Second Edition, Cengage Learning Publishers,2005.
4	Classic Data Structures”, Second Edition by Debasis Samanta, PHI Learning, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Implement various abstract data types to solve real time problems by using Linear Data Structures	Apply
CO2	Apply the different Non-Linear Data Structures to solve problems	Apply
CO3	Analyze and implement graph data structures to solve various computing problems.	Analyze
CO4	Critically analyze the various sorting and searching algorithms	Analyze

18CSM03	COMPUTER ORGANIZATION AND DESIGN					
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the basic structure and operations of digital computer
2	To learn the working of different arithmetic operations
3	To understand the different types of control and the concept of pipelining
4	To study the hierarchical memory system including cache memory and virtual memory
5	To understand the different ways of communication with I/O devices and standard I/O interfaces

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Functional units ,Basic Operational Concepts, Bus Structure ,Memory Locations and Addresses, MemoryOperations, Instruction and Instruction Sequencing, Addressing modes.

UNIT II	**ARITHMETIC UNIT**	**9**	**0**	**0**	**9**

Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, BoothAlgorithm, Fast Multiplication, Integer Division, Floating point number operations.

UNIT III	**PROCESSOR UNIT AND PIPELINING**	**9**	**0**	**0**	**9**

Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards ,Data path & Control Considerations.

UNIT IV	**MEMORY SYSTEMS**	**9**	**0**	**0**	**9**

Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory,Memory Management requirements, Secondary Storage Device.

UNIT V	**INPUT AND OUTPUT ORGANIZATION**	**9**	**0**	**0**	**9**

Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/O Interfaces (PCI, SCSI, USB).

Total (45 L) =45 Periods

Text Books:

1	Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill,5th Edition, 200

Reference Books:

1	Patterson and Hennessey, “Computer Organization and Design ". The Hardware/Software interface,Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2	Hayes, “Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006
3	Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley,2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the working principles of computer componets	Understand
CO2	Design the arithmetic and processing units	Create
CO3	Analyze the various computer components	Analyze

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18CSM04	ADVANCED OPERATING SYSTEMS				Semester		
PREREQUISITES		**Category**	**OE**	**Credit**			**3**
		Hours/Week	**L**	**T**	**P**		**TH**
			3	**0**	**0**		**3**

Course Learning Objectives	
1	To understand the structure and functions of Operating systems
2	To understand the process concepts and scheduling algorithms
3	To understand the concept of process synchronization and deadlocks
4	To learn various memory management schemes
5	To illustrate various file systems and disk management strategies

		L	T	P	TH
UNIT I	**INTRODUCTION AND OPERATING SYSTEM STRUCTURES**	**9**	**0**	**0**	**9**
Main frame Systems, Desktop Systems, Multiprocessor Systems, Distributed Systems, Clustered Systems, Real Time systems, Hand held Systems; Operating Systems Structures - System Components, Operating System Services, System calls, System Programs, System Design and Implementation.					
UNIT II	**PROCESS MANAGEMENT**	**9**	**0**	**0**	**9**
Processes-Process Concepts, Process Scheduling, Operation on Processes, Co-Operating Processes, InterProcess Communication; Threads- Multithreading Models, Threading Issues; CPU Scheduling-Basic Concepts, Scheduling Criteria, Scheduling Algorithms.					
UNIT III	**PROCESS SYNCHRONIZATION AND DEADLOCKS**	**9**	**0**	**0**	**9**
Process Synchronization- The Critical Section Problem, Synchronization Hardware, Semaphores, Classical Problem of Synchronization, Monitors; Deadlocks- Deadlock Characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance ,Deadlock Detection, Recovery from Deadlock.					
UNIT IV	**MEMORY MANAGEMENT AND VIRTUAL MEMORY**	**9**	**0**	**0**	**9**
Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.					
UNIT V	**FILE SYSTEM AND MASS-STORAGE STRUCTURE**	**9**	**0**	**0**	**9**
File System Interface - File Concepts, Access methods, Directory Structure, File Sharing, File Protection; File System Implementation- File System Structure and Implementation, Directory Implementation, Allocation Methods, Free Space Management; Mass-Storage Structure - Disk Structure, Disk scheduling, Disk Management, RAID Structure; Case study: Linux system.					
Total (45 L) =45 Periods					

Text Books:	
1	Abraham Silberschatz, P.B.Galvin, G.Gagne —Operating System Concepts 6th edition, John Wiley & Sons, 2003.
Reference Books:	
1	Andrew S. Tanenbaum, —Modern Operating Systems, PHI , 2nd edition, 2001
2	D.M.Dhamdhere, “Systems Programming and Operating Systems ", 2nd edition, Tata McGraw Hill Company, 1999.
3	Maurice J. Bach, —The Design of the Unix Operating System, 1st edition, PHI, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify the components and their functionalities in the operating system	Apply
CO2	Apply various CPU scheduling algorithms to solve problems	Apply
CO3	Analyze the needs and applications of process synchronization and deadlocks	Analyze
CO4	Apply the concepts of memory management including virtual memory and page replacement to the issues that occur in real time applications	Apply
CO5	Solve issues related to file system implementation and disk management	Apply

<table>
<tr><td>18CSM05</td><td colspan="3">DATA COMMUNICATION AND COMPUTER NETWORKS</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To study the concepts of data communications and functions of different ISO/OSI reference architecture</td></tr>
<tr><td>2</td><td colspan="7">To understand the error detection and correction methods and also the types of LAN</td></tr>
<tr><td>3</td><td colspan="7">To study the concepts of subnetting and routing mechanisms</td></tr>
<tr><td>4</td><td colspan="7">To understand the different types of protocols and congestion control</td></tr>
<tr><td>5</td><td colspan="7">To study the application protocols and network security</td></tr>
<tr><td>UNIT I</td><td colspan="3">DATA COMMUNICATIONS AND PHYSICAL LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Data Communication; Networks- Physical Structures (Types of Connections, Physical Topology),Categories of Networks, Interconnection of Networks: Internetwork; Protocols and Standards; Network Models-The OSI Model, Layers in the OSI Model, Addressing; Transmission media-Guided Media, Unguided Media.</td></tr>
<tr><td>UNIT II</td><td colspan="3">DATA LINK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction-Types of errors, Redundancy, Detection versus Correction, Modular Arithmetic; Block Coding-Error Detection and Correction (VRC,LRC,CRC, Checksum, Hamming Code);Data link Control- Flow Control (Stop- and-Wait, Sliding Window),Error Control (Automatic Repeat Request, Stop-and-wait ARQ, Sliding Window ARQ), HDLC; Local Area Networks-Ethernet, Token Bus, Token Ring, FDDI.</td></tr>
<tr><td>UNIT III</td><td colspan="3">NETWORK LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Network Layer services-Packet Switching-Network Layer Performance-IPv4 addresses-IPv6 addressing- Subnetting-Bridges-Gateways- Routers-Routing Algorithm-Distance Vector Routing, Link State Routing.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">TRANSPORT LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Duties of the Transport layer-User Datagram Protocol-Transmission Control Protocol- Congestion Control and Quality of Service-Congestion, Congestion Control, Quality of Service, Techniques to improve QoS, Integrated Services.</td></tr>
<tr><td>UNIT V</td><td colspan="3">PRESENTATION LAYER AND APPLICATION LAYER</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Domain Name System - Domain Name Space, DNS in the Internet; Electronic Mail-FTP- HTTP- World Wide Web.</td></tr>
<tr><td colspan="8" align="right">Total (45 L) =45 Periods</td></tr>
</table>

Text Books:	
1	Behrouz A.Ferouzan, “Data Communications and Networking”, 4th Edition, Tata McGraw-Hill, 2007.
Reference Books:	
1	Andrew S. Tanenbaum, “Computer networks “PHI, 4th edition 2008
2	William Stallings,” Data and computer communications”, 10th edition,PHI, 2012
3	Douglas E. comer,” Internetworking with TCP/IP-Volume-I”, 6th edition,PHI, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Classify the fundamentals of data communications and functions of layered architecture	Understand
CO2	Apply the error detection and correction methods and also identify the different network technologies	Apply
CO3	Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and routing technologies	Analyze
CO4	Illustrate the transport layer principles and reliable data transfer using protocols	Apply
CO5	Analyze the application layer protocols and also the use of network security	Analyze

18CSM06	PROGRAMMING ESSENTIALS IN PYTHON			Semester		
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives	
1	To learn Python data structures, conditional and control structures and files
2	To study Python Modules, packages, Functions and Exceptions.
3	To describe Object oriented programming features and Regular Expressions.
4	To learn about Web programming, GUI Programming and Database programming

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Python: Features - The Basics-Python Objects-Numbers-Sequences-Mapping and set types- Conditionals and loops-if statement-else statement-elif-Conditional Expressions-while statement-for statement-break-continue.					
UNIT II	**FUNCTIONS, MODULES AND PACKAGES**	**9**	**0**	**0**	**9**
Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments-variable scope-Recursion, Modules-Packages.					
UNIT III	**FILES AND EXCEPTIONS**	**9**	**0**	**0**	**9**
Files and Input/ Output –Errors and Exceptions-Introduction-Detecting and handling Exceptions-Context Management-Raising Exceptions-Assertions-Standard Exceptions.					
UNIT IV	**OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSIONS**	**9**	**0**	**0**	**9**
Object Oriented Programming Introduction-Classes-class Attributes-Instances-Instances attributes-Building and Method Invocation-Static methods and class Methods-Inheritance-Operator overloading - Regular Expressions-Network Programming – Multithreaded Programming					
UNIT V	**ADVANCED TOPICS**	**9**	**0**	**0**	**9**
GUI Programming- Web Programming-Database Programming					
					Total (45 L) =45 Periods

Text Books:	
1	Wesley J.Chun-“Core Python Programming” –Prentice Hall, Second Edition, 2006.
Reference Books:	
1	Swaroop C N, “ A Byte of Python “, ebshelf Inc., 1st Edition, 2013
2	“A Practical Introduction to python programming”, Brian Heinold,Mount St.Mary’s University,2012
3	Learning to Program with Python,” Richard L. Halterman”., Southern Adventist University

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Level**
CO1	Develop programs using control structures and files.	Create
CO2	Create own Python Modules, packages, functions and Exceptions.	Create
CO3	Illustrate Object oriented Programming features and Regular Expressions.	Apply
CO4	Create own Web programs, GUI and database programs.	Create

22CSM07	ADVANCED DATABASE SYSTEM CONCEPTS			Semester		
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the fundamentals of data models ,SQL queries and relational databases
2	To make a study of database design using ER Diagram and normalize
3	To impart knowledge in transaction processing.
4	To make the students to understand the file operations and indexing
5	To familiarize the students with advanced databases

UNIT I	RELATIONAL DATABASES	9	0	0	9

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL.

UNIT II	DATABASE DESIGN	9	0	0	9

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form.

UNIT III	TRANSACTION	9	0	0	9

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery – Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

UNIT IV	IMPLEMENTATION TECHNIQUES	9	0	0	9

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

UNIT V	ADVANCED TOPICS	9	0	0	9

Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL – XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Data Warehousing and Data Mining - information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, Henry F.Korth and S.Sundarshan “Database System Concepts”, Sixth Edition,Tata McGraw Hi 2011.

Reference Books:

1	Ramez Elamassri and Shankant B-Navathe, “Fundamentals of Database Systems”, Sixth Edition,Pearson Education, 2011.
2	C.J. Date, “An Introduction to Database Systems”, Eighth Edition, Pearson Education Delhi, 2008.
3	Raghu Ramakrishnan, ―Database Management Systems, Fourth Edition, McGraw-Hill CollegePublications, 2015.
4	G.K.Gupta,”Database Management Systems”, Tata McGraw Hill, 2011.

E-References:

1.	Lecture Series on Database Management System by Dr.S.Srinath, IIIT Bangalore, nptl

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the basic concepts of the database and data models.	Understand
CO2	Design a database using ER diagrams and map ER into Relations and normalize the relations.	Create
CO3	Develop a simple database for applications	Create

<table>
<tr><td>18CSM08</td><td colspan="4">VIRTUALIZATION AND CLOUD COMPUTING</td><td colspan="2">Semester</td><td></td></tr>
<tr><td colspan="3">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="3" rowspan="2"></td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="8">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="7">To introduce the broad perceptive of Parallel Computing, Distributed Computing and Cloud Computing.</td></tr>
<tr><td>2</td><td colspan="7">To understand the concept of Virtualization</td></tr>
<tr><td>3</td><td colspan="7">To identify the approaches of SLA and programming model in Cloud</td></tr>
<tr><td>4</td><td colspan="7">To understand the Cloud Platforms in Industry and Software Environments.</td></tr>
<tr><td>5</td><td colspan="7">To learn to design the trusted Cloud Computing system</td></tr>
<tr><td>UNIT I</td><td colspan="3">INTRODUCTION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Principles of Parallel and Distributed Computing – Elements of Parallel and Distributed Computing, Technologies for Distributed Computing; Vision of Cloud, Defining a Cloud, characteristics and benefits; Cloud Computing Architecture- Cloud Reference Model, Types of Clouds, Open Challenges.</td></tr>
<tr><td>UNIT II</td><td colspan="3">VIRTUALIZATION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Introduction, Characteristics of Virtualized environments, Virtualization techniques-Machine Reference Model, Hardware-Level Virtualization, Programming Language-Level Virtualization, Application-Level Virtualization ,Other types of Virtualization, Virtualization and Cloud computing, Pros and cons of Virtualization, Technology examples-Xen: Para virtualization, VMware: Full Virtualization.</td></tr>
<tr><td>UNIT III</td><td colspan="3">SLA MANAGEMENT IN CLOUD COMPUTING AND PROGRAMMING MODEL</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Traditional Approaches to SLA Management, Types of SLA, Life Cycle of SLA, SLA Management in Cloud; Data Intensive Computing - Technologies for Data Intensive Computing, MapReduce Programming Model.</td></tr>
<tr><td>UNIT IV</td><td colspan="3">CLOUD INDUSTRIAL PLATFORMS AND SOFTWARE ENVIRONMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Cloud Platforms in Industry - Amazon Web Service, Google App Engine; Cloud Software Environments –Eucalyptus, OpenNebula; Aneka Cloud Application Platform-Aneka Framework Overview, Anatomy of Aneka Container.</td></tr>
<tr><td>UNIT V</td><td colspan="3">CLOUD SECURITY AND APPLICATIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">An Introduction to the Idea of Data Security, The Current State of Data Security in the Cloud, Cloud Computing and Data Security Risk, Cloud Computing and Identity; The Cloud, Digital Identity, and Data Security, Content Level Security, Pros and Cons; Cloud Scientific Applications.</td></tr>
<tr><td colspan="8">Total (45L) = 45 Periods</td></tr>
</table>

<table>
<tr><td colspan="2">Text Books:</td></tr>
<tr><td>1</td><td>Rajkumar Buyya, Christian Vecchiola, S.Tamarai Selvi, ‘Mastering Cloud Computing-Foundations and Applications Programming”, TMGH,2013.(Unit- I,II & IV)</td></tr>
<tr><td>2</td><td>RajKumar Buyya, James Broberg, Andrezei M.Goscinski, “Cloud Computing: Principles and paradigms”,2011(Unit-III & V)</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td>1</td><td>Kai Hwang.GeoffreyC.Fox.JackJ.Dongarra, “ Distributed and Cloud Computing ,From Parallel Processing to The Internet of Things”, 2012 Elsevier</td></tr>
<tr><td>2</td><td>Barrie Sosinsky, “Cloud Computing Bible”, Wiley Publisher, 2011</td></tr>
</table>

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain the main concepts and architecture of Parallel computing, Distributed Computing and Cloud Computing.	Understand
CO2	Analyze the concept of Virtualization	Analyze
CO3	Identify the approaches of SLA and programming model in Cloud	Apply
CO4	Analyze the Cloud Platforms in Industry and Software Environments.	Analyze
CO5	Identify the security issues in scientific and real time applications.	Apply

B.E. – ELECTRONICS AND COMMUNICATION ENGINEERING - MINOR DEGREE

18ECM01	**ELECTRON DEVICES**					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To introduce components such as diodes, BJTs and FETs, their characteristics and applications
2.	To understand, analyse and design of simple diode and transistor circuits.
3.	To know the switching characteristics of components and the concept of rectifiers and power supplies

Unit I	**EXTRINSIC SEMICONDUCTOR AND PN JUCTIONS**	**9**	**0**	**0**	**9**

N and P type semiconductor and their energy band structures- Law of electrical neutrality-calculation of location of Fermi level and free electron and hole densities in extrinsic semiconductors-Mobility, drift current and conductivity-diffusion current-continuity equation- Hall effect and its applications. Band structure of PN junction – current component in a PN junction- derivation of diode equation-temperature dependence of diode characteristics and equivalent models.

Unit II	**SWITCHING CHARACTERISTICS OF PN JUNTION AND SPECIAL DIODES**	**9**	**0**	**0**	**9**

Calculation of transition and diffusion capacitance- varactor diode-charge control description of diode-switching characteristics of diode- mechanism of avalanche and Zener breakdown-temperature dependence of breakdown voltages-backward diode-tunneling effect in thin barriers - tunnel diode-photo diode-light emitting diodes.

Unit III	**BIPOLAR JUNCTION TRANSISTORS**	**9**	**0**	**0**	**9**

Construction of PNP and NPN transistors- BJT current components-emitter to collector and base to collector current gains-base width modulation CB, CE and CC characteristics- breakdown characteristics- Ebers-Moll model - transistor switching times- Photo translator.

Unit IV	**FIELD EFFECT TRANSISTORS**	**9**	**0**	**0**	**9**

Construction and characteristics of JFET-relation between pinch off voltage and drain current derivation. MOSFETS - enhancement and depletion types. CMOS circuits. MOS capacitance, BICMOS, SOI CMOS.

Unit V	**RECTIFIERS AND POWER SUPPLIES**	**9**	**0**	**0**	**9**

Half-wave, full-wave and bridge rectifiers with resistive load. Analysis for Vdc and ripple voltage with C, CL, L-C and C-L-C filters. Voltage multipliers Zener diode regulator. Electronically regulated d.c power supplies. Line regulation, output resistance and temperature coefficient.

Total (45L)= 45 Periods

Text Books:

1.	JaconMillman& Christos C. Halkias, " Electronic Devices and Circuits" Tata McGraw-Hill, 1991.

2.	Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory 8th edition.", PHI, 2002
Reference Books:	
1.	Donald A. Neaman. " Semiconductor Physics and Devices" 3rd Ed., Tata McGraw-Hill 2002
2.	S. Salivahanan, N. Suresh kumar and A. Vallavaraj, Electronic Devices and Circuits, TMH, 1998.
3.	Ben, G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education 2000
4.	Floyd, "Electronic Devices", Sixth edition, Pearson Education, 2003.
E-References:	
1.	https://archive.nptel.ac.in/courses/108/108/108108122/
2.	https://www.youtube.com/watch?v=qqQ8wO-lNmI
3.	https://slideplayer.com/slide/12438044/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Interpret various applications of diode.	Applying
CO2	Classify various configurations and biasing technique of BJT	Applying
CO3	Apply the knowledge of using special devices for various applications	Understanding
CO4	Discuss operation, biasing and applications of JFET.	Analysing
CO5	Design power supplies and rectifiers	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	2	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO3	2	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO4	2	2	1	-	-	-	-	-	-	-	-	-	2	2	1
CO5	2	2	1	-	-	-	-	-	-	-	-	-	3	2	2
Avg	2	2	1	-	-	-	-	-	-	-	-	-	2.2	2	1.5

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM02	DIGITAL ELECTRONICS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives	
1	To introduce basic postulates of boolean algebra and show the correlation between expressions
2	To Introduce the methods for Simplifying Boolean expressions
3	To Outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
4	To introduce the Concept of Memories and programmable logic devices
5	To illustrate the concept of synchronous and Asynchronous sequential circuits

Unit I	**NUMBER SYSTEMS AND LOGIC GATES**	**9**	**0**	**0**	**9**
Number Systems - signed Binary numbers - Binary Arithmetic - Binary codes -conversion from one code to another - Boolean Algebra and Minimization Techniques - Canonical forms – Conversion between canonical forms – Simplifications of Boolean expressions using Karnaugh map - LOGIC GATES - Implementations of Logic Functions using gates.					
Unit II	**COMBINATIONAL CIRCUITS**	**9**	**0**	**0**	**9**
Design procedure – Adders/Subtractor – Serial adder/ Subtractor - Parallel adder/ Subtractor- BCD adder- Multiplexer/ Demultiplexer - encoder / decoder – code converters.					
Unit III	**SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**
Design Procedure - Flip flops: SR, JK, T, D and JKMS – Triggering of Flip-flop - Realization of flip flops – Moore and Mealy – Counters: Asynchronous / Ripple counters – Synchronous counters – Modulo n counter. Register: shift registers- Universal shift register.					
Unit IV	**ASYNCHRONOUS SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**
Design of fundamental mode circuits – primitive state / flow table – Minimization of primitive state table –state assignment. Problems in Asynchronous Circuits: Cycles – Races – Hazards. Design of Hazard Free Circuits: Static, Dynamic Hazards elimination					
Unit V	**PLD AND MEMORY DEVICES**	**9**	**0**	**0**	**9**
Classification of memories –RAM organization –ROM organization. Programmable Logic Devices: Programmable Logic Array (PLA) - Programmable Array Logic (PAL). Implementation of combinational logic using MUX, ROM, PAL and PLA.					
Total (45 L) = 45 Periods					

Text Books:	
1	M. Morris Mano, Digital Design, 4.ed.,Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2008
2	R.P.Jain, Modern Digital Electronics, 4th edition, TMH, 2010.
Reference Books:	
1	S. Salivahanan and S. Arivazhagan, Digital Circuits and Design, 2nd ed., Vikas Publishing House Pvt. Ltd, New Delhi, 2004
2	Charles H.Roth. “Fundamentals of Logic Design”, Thomson Publication Company, 2003.
3	Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, 5 ed., Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
4	John F.Wakerly, Digital Design: Principles and practices, PHI, 2006
E-Reference:	
1	http://nptel.ac.in/noc/individual_course.php?id=noc15-ec01

2	https://nptel.ac.in/courses/117105080/6
3	https://nptel.ac.in/courses/117105080/12

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Minimize Boolean expressions and implement using logic gates	Applying
CO2	Design and analyse combinational logic circuits.	Analysing
CO3	Design and analyse synchronous and asynchronous sequential logic circuits	Analysing
CO4	Understand the concepts of memories and PLDs	Understanding
CO5	Implement circuits using memory and PLDs.	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	3	2	3	2	-	-	-	-	2	1	-
CO2	3	3	2	2	3	3	2	1	1	-	-	-	3	2	-
CO3	2	2	3	3	2	1	2	1	1	-	-	-	2	2	-
CO4	2	1	2	1	2	2	3	1	-	-	-	-	2	1	-
CO5	2	1	2	1	3	2	1	2	-	-	-	-	3	2	-
Avg	2.4	1.8	2.2	1.8	2.6	2	2.2	1.4	1	-	-	-	2.4	1.6	-

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM03	ELECTRONIC CIRCUITS					
PREREQUISITES		CATEGORY	OE	Credit		3
Electron Devices		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives

1	To perform analysis on Small signal amplifiers and large signal amplifiers.
2	To give a comprehensive exposure to all types of discrete amplifiers and oscillators.
3	To understand the various linear and non-linear applications of op-amp

Unit I	MIDBAND ANALYSIS OF SMALL SIGNAL AMPLIFIERS	9	0	0	9

BJT – Need for biasing - Fixed bias circuit - Load line and quiescent point. Different types of biasing circuits. Use of Self bias circuit as a constant current circuit. CE, CB and CC amplifiers. Method of drawing small-signal equivalent circuit. Mid-band analysis of various types of single stage amplifiers to obtain gain - input impedance and output impedance. Miller's theorem. Darlington connection using similar and Complementary transistors. Methods of increasing input impedance using Darlington connection and bootstrapping. CS, CG and CD (FET) amplifiers. Multistage amplifiers-Basic emitter coupled differential amplifier circuit. Differential gain - CMRR. Use of constant current circuit to improve CMRR.

Unit II	LARGE SIGNAL AMPLIFIERS	9	0	0	9

Low frequency & High frequency analysis of amplifiers -Hybrid – pi equivalent circuit of BJTs.-High frequency equivalent circuit of FETs. Gain-bandwidth product of FETs. General expression for frequency response of multistage amplifiers. Calculation of overall upper and lower cut off frequencies of multistage amplifiers. Amplifier rise time and sag time and their relation to cut off frequencies. Classification of amplifiers (Class A, B, AB, C&D), Efficiency of class A, RC coupled and transformer-coupled power amplifiers. Class B complementary-symmetry, push-pull power amplifiers. Calculation of power output, efficiency and power dissipation. Crossover distortion and methods of eliminating it. Calculation of actual power handling capacity of transistors with and without heat sink. Heat sink design.

Unit III	OSCILLATORS	9	0	0	9

Feedback Amplifier: Block diagram - Gain with feedback - Barkhausen Criterion - Mechanism for start of oscillation and stabilization of amplitude - Analysis of Oscillator using Cascade connection of RC and LC filters - RC phase shift Oscillator - Wien bridge Oscillator and Twin-T Oscillators - Analysis of LC Oscillators: Colpitts – Hartley – Clapp - Miller and Pierce oscillators - Frequency range of RC Oscillators - Electrical equivalent circuit of Crystal.

Unit IV	TUNED AMPLIFIERS AND MULTIVIBRATORS	9	0	0	9

Analysis of single tuned and synchronously tuned amplifiers - Class C tuned amplifiers and their applications - Efficiency of Class C tuned Amplifier- Collector coupled and Emitter coupled Astable Multi vibrator – Mono stable Multi vibrator – Bistable Multi vibrator - Triggering methods – Mono stable and Astable Blocking Oscillators using Emitter and base timing.

Unit V	OPERATIONAL AMPLIFIERS AND ITS APPLICATIONS	9	0	0	9

Basic structure and principle of operation - Calculation of differential gain - Common Mode gain, CMRR - OP-AMP design - DC and AC characteristics of OP-AMP. Applications: Inverting and non-inverting amplifiers - Integrator and Differentiator - Summing amplifier - Precision rectifier - Schmitt trigger and its applications - Active filters: Low pass, high pass, band pass and band stop filters - Sine wave oscillators – Comparator – Multi vibrator.

Total (45 L) = 45 Periods

Text Books:

1	B.Visvesvara Rao, K.Raja Rajeswari, P.Chalam Raju Pantulu, K.Bhaskara Rama Murthy, "Electronic Circuits-II", Pearson Education,2012
2	D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2011.

Reference Books:

1	Millman J. and Taub H., "Pulse Digital and Switching waveform", 3rd Edition, McGraw-Hill International , 2011.

2	Sedera& Smith, "Micro Electronic Circuits", 4 th Edition, Oxford University Press, Chennai.
3	Michael Jacob, 'Applications and Design with Analog Integrated Circuits', Prentice Hall of India, 1996.
4	K.R.Botkar, 'Integrated Circuits', 10th edition, Khanna Publishers, 2010.
e-Reference:	
1	http://nptel.ac.in/courses/117105080/40
2	http://nptel.ac.in/courses/117108038/1
3	https://freevideolectures.com/course/2915/linear-integrated-circuits

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	To analyze small signal amplifiers and Large signal Amplifiers.	Applying
CO2	Analyze the frequency response characteristics of amplifiers	Applying
CO3	Develop insight of on oscillator design.	Applying
CO4	Construct and analyse tuned amplifiers and multivibrators.	Applying
CO5	Develop competence in linear and nonlinear Op amp circuit analysis.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO4	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO5	1	2	1	2	-	-	-	-	-	-	-	-	1	2	1
Avg	2.4	2	1	2	-	-	-	-	-	-	-	-	1	2	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM04	SIGNAL PROCESSING					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand and perform Fourier and Laplace analysis on signals and systems respectively.
2.	To analyse the Discrete Fourier Transform, Fast Fourier Transform algorithms.
3.	To design and realize IIR, FIR filters.

Unit I	**INTRODUCTION TO SIGNALS AND SYSTEMS**	**9**	**0**	**0**	**9**

Classification of Signals: Even and Odd Signal - Energy and power signals - Continuous time (CT) and Discrete time (DT) signals - Continuous and Discrete amplitude signal -. System properties and representation: linearity - Tme-invariance – Causality – Stability - Realizability. - Linear Time-Invariant (LTI) systems: Impulse response and step response – Convolution – Correlation - System representation through differential equations and difference equations.

Unit II	**ANALYSIS OF SIGNAL AND SYSTEMS**	**9**	**0**	**0**	**9**

Introduction to Fourier Transform, Fourier Series, Relating the Laplace Transform to Fourier Transform, Frequency response of continuous time systems. Introduction to z- Transform.

Unit III	**DISCRETE FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Introduction to DFT – Properties of DFT - Circular convolution - FFT algorithms – Radix-2 FFT algorithms – Decimation in Time and Decimation in Frequency algorithms.

Unit IV	**INFINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Characteristics of Analog Butterworth filter - Chebyshev filter - Low pass filter, High pass filter, Band pass filter and Band stop filter - Transformation of analog filters in to equivalent digital filters using bilinear transformation method - Realization structure for IIR filters-Direct form - Cascade form - Parallel form.

Unit V	**FINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Linear phase response of FIR filter - FIR design using window method: Rectangular, Hamming, Hanning and Blackmann Windows - Park-McClellan's method - Realization structures for FIR filters - Linear phase structures and Direct form structure - Comparison of FIR and IIR filters.

Total (45L)= 45 Periods

Text Books:

1.	A.Anand Kumar, “Signals and Systems” , 3rd Edition, PHI, 2013.
2.	John G Proakis and Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, 4th Edition, Pearson Education, 2009.

Reference Books:	
1.	Alan V Oppenheim, Alan S Willsky and S Hamid Nawab, “Signals and Systems”, 2nd edition, PHI Learning Private Limited, New Delhi, 2010.
2.	B.P. Lathi, "Principles of Signal Processing and Linear Systems", Oxford University Press, 2009.
3.	Emmanuel C. Ifeacher, Barry W. Jervis, “Digital Signal Processing: A Practical Approach”, 2nd Edition, Pearson Education, 2004.
4.	S.K. Mitra, “Digital Signal Processing, A Computer Based approach”, 4th Edition, McGraw-Hill, 2010.
E-References:	
1.	http://nptel.ac.in/courses/117104074/
2.	https://www.coursera.org/learn/dsp
3.	https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Analyse and understands different types of signals.	Analysing
CO2	Represent continuous signals and systems in time and frequency domain using different transforms.	Analysing
CO3	Analyse the need for Discrete Fourier Transform, Fast Fourier Transform algorithms in digital signals & systems.	Analysing
CO4	Design and realize IIR filters.	Applying
CO5	Design and realize FIR filters.	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO2	3	2	2	3	3	2	-	-	-	-	-	-	2	2	2
CO3	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO4	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO5	1	1	1	1	1	-	-	-	-	-	-	-	2	2	1
Avg	2.6	1.8	2	2.2	1.8	2	1						1.6	1.6	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM05	MICROPROCESSORS AND MICROCONTROLLERS					
PREREQUISITES		CATEGORY	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To familiarise with 8086 and 8051 architectures.
2.	To interface 8086 microprocessor and 8051 microcontrollers with peripherals by programming.
3.	To gain basic knowledge of PIC microcontrollers.

Unit I	**8086 MICROPROCESSOR ARCHITECTURE**	9	0	9
Overview of Microcomputer systems-8086 Architecture – Pin Assignments – Internal Architecture – Addressing modes-Instruction Formats- Directives and Operators-Assembly process.				
Unit II	**PROGRAMMING AND INTERFACING OF 8086**	9	0	9
Fundamental I/O considerations- Programmed I/O- Interrupt I/O- Basic 8086 Configurations- Minimum Mode-Maximum Mode-System Bus timing- I/O Interfaces-Peripheral Interfacing using 8255 PPI - 8279 Keyboard/Display controller - 8251 USART.				
Unit III	**8051 ARCHITECTURE**	9	0	9
8051 architecture - Registers in 8051 - Pin description - 8051 parallel I/O ports - memory organization - Instruction set — Addressing modes				
Unit IV	**PROGRAMMING AND INTERFACING OF 8051**	9	0	9
Assembly language programming.8051Timers - Serial Port Programming - Interrupts Programming - LCD and Keyboard Interfacing - ADC, DAC and Sensor Interfacing - Motor Control.				
Unit V	**PIC MICROCONTROLLERS**	9	0	9
Main characteristics of PIC microcontrollers – PIC microcontroller families-Memory-Program Memory – RAM Data Memory - Instruction set and timers in PIC				
				Total (L+T) = 45 periods

Text Books:	
1.	Yu-Cheng Liu, Glenn A. Gibson,” Microcomputer Systems, The 8086/8088 Family”, Pearson, 2e, 2019.
2.	Muhammad Ali Mazidi, Janice GillispieMazidi, RolinD.McKinlay, “The 8051 Microcontroller and Embedded Systems using Assembly and C”, 2e, 2022.
Reference Books:	
1.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, 2nd Edition, Pearson education, 2011.
2.	Martin Bates,”PIC Microcontrollers-An Introduction to Microelectronics”, 3e, Elsevier, 2011.
3.	Mathur Sunil,”Microprocessor 8086: Architecture, Programming and Interfacing” PHI Learning Pvt. Ltd. 2011.
4.	Salvador PinillosGimenez,” 8051 Microcontrollers Fundamental Concepts, Hardware, Software and Applications in Electronics”, Springer 2019.
E-References:	
1.	Ashraf Almadhoun,”A Detailed Look Into PIC Microcontroller and Its Architecture”, Amazon 2020.
2.	https://nptel.ac.in/courses/108105102
3.	http://www.satishkashyap.com/2012/02/video-lectures-on-microprocessors-and.html

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe and analyse the architecture of 8086 microprocessor and 8051 architectures.	Remembering
CO2	Develop assembly language programs and Interface peripherals with 8086.	Applying
CO3	Develop assembly language programs and Interface peripherals with 8051.	Applying
CO4	Determine application specific circuit for real-time applications.	Understanding
CO5	Associate appropriate PIC microcontroller for a given application.	Understanding

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	2	-	1	-	-
CO2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2
CO5	2	2	-	2	-	-	-	-	-	-	-	-	2	2	-
Avg	2	2	2	2	-	-	-	-	-	-	2	-	1.8	2	2

18ECM06	ANALOG AND DIGITAL COMMUNICATION					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understand analog and digital communication techniques.
2.	Learn data and pulse communication techniques.
3.	Be familiarized with source and Error control coding.

Unit I	**INFORMATION THEORY**	**9**	**0**	**0**	**9**

Uncertainty, information and entropy – Source coding theorem – Shannon Fano coding – Huffman coding – Discrete memoryless channels – Mutual information – Channel capacity – Channel coding theorem.

Unit II	**ANALOG COMMUNICATION**	**9**	**0**	**0**	**9**

Noise: Source of Noise – External Noise- Internal Noise- Noise Calculation. Introduction to Communication Systems: Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of various Analog Communication System (AM – FM – PM).

Unit III	**DIGITAL COMMUNICATION**	**9**	**0**	**0**	**9**

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM).

Unit IV	**PULSE COMMUNICATION AND MULTIPLE ACCESS TECHNIQUES**	**9**	**0**	**0**	**9**

Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System (PAM – PTM – PCM). Multiple access techniques: FDMA, CDMA, TDMA, SDMA.

Unit V	**ERROR CONTROL CODING**	**9**	**0**	**0**	**9**

Linear block codes - Cyclic codes - Convolution codes – Maximum likelihood decoding of convolutional codes – Sequential decoding of convolutional codes – Trellis codes – Applications.

Total (45L)= 45 Periods

Text Books:

1.	Simon Haykin, “Communication Systems”, 4th Edition, John Wiley & Sons, 2014.
2.	J.G.Proakis, M.Salehi, ―Fundamentals of Communication Systems‖, Pearson Education 2014.

Reference Books:

1.	B.P.Lathi, ―Modern Digital and Analog Communication Systems‖, 4th Edition, Oxford University Press, 2013.
2.	D.Roody, J.Coolen, ―Electronic Communications, 4th edition PHI 2015.
3.	B.Sklar, ―Digital Communications Fundamentals and Applications‖, 5th Edition Pearson Education 2017
4.	H P Hsu, Schaum Outline Series - ―Analog and Digital Communications‖ TMH, 5th edition 2006

E-References:

1.	https://onlinecourses.nptel.ac.in/noc21_ee74/preview
2.	https://nptel.ac.in/courses/117101051
3.	https://www.digimat.in/nptel/courses/video/117105143/L51.html

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO	:	Apply the concepts of Random Process to the design of Communication	Applying
CO	:	Apply analog and digital communication techniques.	Applying
CO	:	Understand the use of data and pulse communication techniques.	Understanding
CO	:	Analyze Source and Error control coding.	Analysing
CO	:	Design AM communication systems and Angle modulated communication	Applying

COURSE ARTICULATION MATRIX															
COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2	3	2	1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	3	2	1
CO3	2	2	2	3	1	-	-	-	-	-	-	-	3	2	-
CO4	1	1	2	1	2	-	-	-	-	-	-	-	2	3	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-	2	3	1
Avg	1.8	1.8	2	1.6	1.4	-	-	-	-	-	-	-	2.6	2.5	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM07	**COMMUNICATION NETWORKS**						
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**	
		Hours/Week	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1. Understand the division of network functionalities into layers.
2. Be familiar with the components required to build different types of networks
3. Be exposed to the required functionality at each layer
4. Learn the flow control and congestion control algorithms

Unit I	**FUNDAMENTALS & LINK LAYER**	9	0	0	9
Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction					
Unit II	**MEDIA ACCESS & INTERNETWORKING**	9	0	0	9
Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)					
Unit III	**ROUTING**	9	0	0	9
Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6					
Unit IV	**TRANSPORT LAYER**	9	0	0	9
Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmiision Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements					
Unit V	**APPLICATION LAYER**	9	0	0	9
Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS- Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need forCryptography and Network Security – Firewalls.					
					Total (45L)= 45 Periods

Text Books:	
1.	Behrouz A Forouzan, Data Communications and Networking, 4th Edition, 2020

2.	James F. Kurose, Keith W. Ross, Computer Networking - A Top-Down Approach Featuring the Internet, Seventh Edition, Pearson Education, 2016.
Reference Books:	
1.	Nader. F. Mir," Computer and Communication Networks", Pearson Prentice Hall Publishers, 2nd Edition, 2014.
2.	Alberto Leon-Garcia, IndraWidjajaCommunication Networks 2nd Edition McGraw-Hill Education, 2003
3.	Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", McGraw Hill Publisher, 2011.
4.	Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Fifth Edition, Morgan Kaufmann Publishers, 2011.
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc22_ee61/preview
2.	https://www.ee.iitb.ac.in/~sarva/courses/EE706/2012/EE706LecNotes.pdf
3.	http://www.cs.kent.edu/~farrell/net01/lectures/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the basic concept in modern data communication and different level of layers in the protocol	Understanding
CO2	Analyse the functions and services of data link layer	Analysing
CO3	Categorize the functions and services of network layer	Understanding
CO4	Examine the basic functions of transport layer and congestion in networks	Understanding
CO5	Analyse the concepts of various network applications and data security	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	-	-	-	-	-	-	-	2	-	1
CO2	2	1	2	-	1	-	-	-	-	-	-	-	2	1	1
CO3	2	1	1	-	-	-	-	-	-	-	-	-	3	1	2
CO4	3	2	1	-	2	-	-	-	-	-	-	-	2	-	2
CO5	2	1	1	-	1	-	-	-	-	-	-	-	1	1	1
Avg	2.2	1.2	1.2	-	1.25	-	-	-	-	-	-	-	2	1	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM08	INTERNET OF THINGS						
PREREQUISITES		**CATEGORY**	**OE**	**Credit**			**3**
		Hours/Week	**L**	**T**		**P**	**TH**
			3	**0**		**0**	**3**

Course Objectives

1	To understand Smart Objects and IoT Architectures
2	To learn about various IOT-related protocols
3	To build simple IoT Systems using Arduino and Raspberry Pi
4	To understand data analytics and cloud in the context of IoT
5	To develop IoT infrastructure for popular applications

Unit I	**FUNDAMENTALS OF IOT**	**9**	**0**	**0**	**9**

Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects

Unit II	**IoT PROTOCOLS**	**9**	**0**	**0**	**9**

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT

Unit III	**DESIGN AND DEVELOPMENT**	**9**	**0**	**0**	**9**

Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.

Unit IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**9**	**0**	**0**	**9**

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG

Unit V	**CASE STUDIES/INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model - Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

Total (45 L) = 45 Periods

Text Books:

1	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
2	ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015

Reference Books:

1	Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).

2	Jan Ho¨ ller, VlasiosTsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
3	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
4	Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.
E-References:	
1	https://online.stanford.edu/courses/xee100-introduction-internet-things
2	https://www.udemy.com/topic/internet-of-things/
3	https://www.netacad.com/courses/iot

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of IoT.	Understanding
CO2	Analyze various protocols for IoT.	Applying
CO3	Design a PoC of an IoT system using Rasperry Pi/Arduino	Applying
CO4	Apply data analytics and use cloud offerings related to IoT.	Applying
CO5	Analyze applications of IoT in real time scenario	Analysing

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO2	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO3	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
CO4	2	2	2	1	1	-	-	-	-	-	1	-	2	2	2
CO5	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
Avg	2	1.6	2.4	1.4	1	-	-	-	-	-	1.4	-	2	2	2

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM09	WIRELESS SENSORS AND NETWORKING					
PREREQUISITE:		**CATEGORY**	**OE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Learn fundamental of Ad hoc network and architecture
2.	Understand the MAC and routing protocols.
3.	Have an in-depth knowledge on QoS, security and sensor network platforms

Unit I	**ROUTING PROTOCOLS**	9	0	0	9

Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).

Unit II	**ARCHITECTURES OF WSN**	9	0	0	9

WSN application examples, Types of applications, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Single-Node Architecture: Hardware Components, Energy Consumption of Sensor Nodes, Operating systems and execution environments

Network Architecture: Sensor Network Scenarios, Optimization goals and figures of merit, Design principles of WSN, Service interfaces of WSNs, gateway concepts.

Unit III	**MAC PROTOCOLS AND ROUTING PROTOCOLS**	9	0	0	9

Image compression: Predictive techniques – PCM – DPCM - DM - Transform coding - Introduction to JPEG - JPEG-2000 - JBIG standards - Study of EZW. Video compression: Video signal representation – ITU-T Recommendation H.261 – Model based coding – The MPEG-1 Video Standard - The MPEG-2 Video Standard: H.262 - ITU-T Recommendation H.263.

Unit IV	**QUALITY OF SERVICE AND ADVANCED APPLICATION SUPPORT**	9	0	0	9

Quality of Service: Coverage and deployment, Reliable data transport, Single packet delivery, Block delivery, Congestion control and rate control - Advanced application support: Advanced in-network processing, Security and Application-specific support.

Unit V	**SENSOR NETWORK PLATFORMS AND TOOLS**	9	0	0	9

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.

Total (45L) = 45 Periods

Text Books:	
1.	C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education – 2008
2.	Holger Karl and Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2007.
Reference Books:	
1.	Feng Zhao and LeonidesGuibas, "Wireless sensor networks ", Elsevier publication - 2004.
2.	Charles E. Perkins, ―Ad Hoc Networking‖, Addison Wesley, 2000.
3.	William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004
4.	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", Computer Networks, Elsevier, 2002, 394 - 422.
E-References:	
1.	https://nptel.ac.in/courses/106105183
2.	https://nptel.ac.in/courses/106105183
3.	https://archive.nptel.ac.in/courses/106/105/106105160/

Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Know the basics of Ad hoc networks and Wireless Sensor Networks	Understanding
CO2	Have a knowledge on architecture of Wireless Sensor Networks	Applying
CO3	Apply the knowledge to identify MAC and routing protocols	Applying
CO4	Understand the transport layer and security issues possible in Ad hoc and sensor networks	Understanding
CO5	Be familiar with the OS used in Wireless Sensor Networks and build basic modules	Remembering

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	3	3	2	-	-	-	3	3	3	-	2
CO2	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
CO3	3	3	3	3	3	3	2	-	-	-	3	3	3	-	2
CO4	3	3	2	3	3	3	2	-	-	-	2	3	3	-	2
CO5	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
Avg	3	3	2	3	3	3	2	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM10	BASICS OF EMBEDDED SYSTEMS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Microprocessors and Mmicrocontrollers		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives

1	To impart knowledge on embedded system architecture and embedded development Strategies
2	To understand the bus Communication in processors and peripheral interfacing
3	To understand basics of Real Time Operating System

UNIT I	**BASICS OF EMBEDDED SYSTEMS**	9	0	0	9

Introduction - Fundamental Components of Embedded Systems - Challenges for Embedded Systems - Examples - Programming Languages - Recent Trends in Embedded Systems - Architecture of Embedded Systems - Embedded Design Life Cycle - Selection Process - Hardware Software Partitioning - Development Environment.

UNIT II	**MEMORY MANAGEMENT AND INTERRUPTS**	9	0	0	9

Memory Access Procedure - Types of Memory - Memory Management Methods - DMA – Memory Interfacing - Polling Vs Interrupts - Types of Interrupts - Interrupt Latency - Interrupt Priority – Programmable Interrupt Controllers - Interrupt Service Routines

UNIT III	**COMMUNICATION INTERFACES**	9	0	0	9

Interfacing Buses - Serial Interfaces - RS232/UART - RS422/RS485 - I2C Interface - SPI Interface - USB – CAN - IRDA - Ethernet - IEEE 802.11 – Bluetooth

UNIT IV	**REAL TIME OPERATING SYSTEMS**	9	0	0	9

Real-Time Concepts - Task Management - Task Scheduling - Classification of Scheduling Algorithms - Clock Driven Scheduling - Event Driven Scheduling - Resource Sharing - Priority Inheritance Protocol - Priority Ceiling Protocol - Inter Task Communication - Mutex - Semaphores - Message Queues - Timers - Commercial RTOS.

UNIT V	**VALIDATION AND DEBUGGING**	9	0	0	9

Host and Target Machines - Validation Types and Methods - Host Testing - Host-Based Testing Setup - Target Testing - Remote Debuggers and Debug Kernels - ROM Emulator - Logical Analyzer – Background Debug Mode - InCircuit Emulator CASE STUDY: RFID Systems - GPS Navigation System – Development of Protocol Converter.

Total (45 L) = 45 Periods

Text Books:

1	Sriram V Iyer and Pankaj Gupta, ―Embedded Real-time Systems Programming‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2	Arnold S Berger, ―Embedded Systems Design - An Introduction to Processes, Tools and Techniques, Elsevier, New Delhi, 2011.

Reference Books:

1	Prasad K V K K, ―Embedded/Real-Time Systems: Concepts, Design and Programming – The Ultimate Reference, Himal Impressions, New Delhi, 2003
2	Heath, "Embedded Systems Design‖", Newnes an Imprint of Elsevier, Massachusetts, 2003.
3	Tammy Noergaard, "Embedded Systems Architecture‖, Newnes an Imprint of Elsevier, Massachusetts, 2006.
4	Raj Kamal, 'Embedded System-Architecture, Programming, Design', McGraw Hill, 2013

E-References:

1	https://lecturenotes.in/subject/225/embedded-system-es
2	https://nptel.ac.in/courses/108102045/19

3	https://www.coursera.org/learn/introduction-embedded-systems.

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Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Outline the concepts of embedded systems	Understanding
CO2	Understand the concept of memory management system and interrupts.	Understanding
CO3	Know the importance of interfaces.	Understanding
CO4	Understand real time operating system concepts.	Understanding
CO5	To realize the applications of validation and debugging.	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	3	3	1	3	-	-	-	-	-	-	3	3	3	-	2
CO2	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
CO3	3	3	3	3	-	-	-	-	-	-	3	3	3	-	2
CO4	3	3	2	3	-	-	-	-	-	-	2	3	3	-	2
CO5	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
Avg	3	3	2	3	-	-	-	-	-	-	2.8	3	3	-	2

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

B.E. - ELECTRICAL AND ELECTRONICS ENGINEERING - MINOR DEGREE

18EEM01	**LINEAR AND DIGITAL ELECTRONICS CIRCUITS**		**SEMESTER**			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electron Devices and Circuits		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Objectives:						
1.	To impart knowledge on the characteristics& applications of Operation Amplifier, functional diagram and applications of linear ICs.					
2.	To simplify the switching functions					
3.	To design the combinational logic circuits and sequential logic circuits					
Unit I	**OPERATIONAL AMPLIFIERS**		**9**	**0**	**0**	**9**
Operational amplifiers - Equivalent circuit, voltage transfer curve - Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs. Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.						
Unit II	**APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS**		**9**	**0**	**0**	**9**
DC & AC amplifiers- Summing, Scaling and Averaging amplifiers-Instrumentation amplifier- Voltage to Current converter for floating and grounded loads - Current to voltage converter - Integrator, Differentiator. Voltage comparators - Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters. Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.						
Unit III	**COMBINATIONAL LOGIC CIRCUITS**		**9**	**0**	**0**	**9**
Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and QuineMcCluskey (Tabulation) method. Design:Adders -Subtractors– 2 bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder**.**						
Unit IV	**SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**		**9**	**0**	**0**	**9**
Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.						
Unit V	**ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**		**9**	**0**	**0**	**9**
Fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.						
						Total (45L+0T) = 45 Periods

Text Books:	
1.	Ramakant A Gayakward, “Op-Amps and Linear Integrated Circuits”, Fourth Edition, Pearson Education, 2003.
2.	Donald.E.Neaman, “Electronic Circuit, Analysis and Design”, Tata McGraw Hill Publishing Company Limited, Second Edition, 2002.
3.	D.Roy Chowdhury and Shail B. Jain, “Linear Integrated Circuits”, Fourth Edition, New Age International (P) Ltd Publishers, 2014.
4.	M. Morris Mano, “Digital Design” , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .
5.	S. Salivahanan and S. Arivazhagan, “Digital Circuits and Design”, Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 201
Reference Books:	

1.	Jacob Millman, Christos C.Halkias, "Integrated Electronics - Analog and Digital circuits system", Tata McGraw Hill 2003.
2.	R.P.Jain, "Modern Digital Electronics", Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, "Digital Fundamentals", Pearson Education, Inc, New Delhi, 2015
4.	Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and Tadulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1											2		
CO2	3	2	1	1									3		
CO3	3	2		2	2								3	3	
CO4	3	2	3	1	2							2	3	3	1
CO5	3	2	3	1	2							2	3	3	1
Avg.	**2.8**	**1.8**	**2.3**	**1.25**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2.8**	**3**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM02	MICROPROCESSOR AND MICROCONTROLLER			SEMESTER			
PREREQUISTIES		**CATEGORY**		**PE**	**Credit**		**3**
C Programming		**Hours/Week**		**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:	
1.	To study the architecture of µP8085 and µC 8051.
2.	To study the Interrupt structure of 8085 and 8051.
3.	To do simple applications development with programming 8085 and 8051.

UNIT I	**8085 8 BIT MICROPROCESSOR**	**9**	**0**	**0**	**9**
Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.					
UNIT II	**8051 8 BIT MICROCONTROLLER**	**9**	**0**	**0**	**9**
Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.					
UNIT III	**INTERFACING WITH 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**
Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.					
UNIT IV	**EXTERNAL COMMUNICATION INTERFACE**	**9**	**0**	**0**	**9**
Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.					
UNIT V	**APPLICATIONS OF MICROCONTROLLERS**	**9**	**0**	**0**	**9**
Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems.					
Total (45L+0T)= 45 Periods					

Text Books:	
1.	R.S. Gaonkar, 'Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3.	Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003.
Reference Books:	
1.	R. Kamal, "Embedded System", McGraw Hill Education, 2009.
2.	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.
E-References;	
1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of Microprocessor and Microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	1	1								1	1	1	
CO2	2	1	1	1								1	1	1	
CO3	2	3	2	3	2							1	1	1	2
CO4	2	3	3	3	2							2	2	2	2
CO5	2	3	3	3	2							2	2	2	2
Avg.	**2**	**2.2**	**2**	**2.2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1.4**	**1.4**	**1.4**	**2**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM03	CONTROL SYSTEMS			SEMESTER		
PREREQUISTIES		CATEGORY	PE	Credit		3
Electrical Machines and Electric circuit analysis		Hours/Week	L	T	P	TH
			1	1	0	3

Course Objectives:

1.	To understand the methods of representation of physical systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the designing compensators for a feedback control system.

UNIT I	MODELLING OF LINEAR TIME INVARIANT SYSTEMS	6	9	0	9

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics - Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation– Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	TIME RESPONSE ANALYSIS	6	3	0	9

Standard test signals – Time response of first order and second order systems –time domain specifications - Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	FREQUENCY RESPONSE ANALYSIS	6	3	0	9

Correlation between time and frequency response: Second order systems – Frequency domain specifications - Polar plots – Bode plots – Computation of Gain Margin and Phase Margin –– Constant M and N-circles – Nichols chart.

UNIT IV	STABILITY OF CONTROL SYSTEM	6	3	0	9

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	COMPENSATOR AND CONTROLLER DESIGN	6	3	0	9

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators – Design of compensators using root locus and Bode plot techniques-PID controller: Design using reaction curve and Ziegler - Nichols technique.

Total (30L+15T) = 45 Periods

Text Books:

1.	A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2.	I.J. Nagrath, and M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1.	K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 5th Edition, 2021.
2.	M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2018.

E-Reference

1.	https://nptel.ac.in/courses/107106081
2.	https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2							1	3	2	1
CO2	3	3	3	2	2							1	3	2	1
CO3	3	3	3	2	2							1	3	2	1
CO4	3	3	3	2	2							1	3	2	1
CO5	3	3	3	2	2							1	3	2	1
Avg	**3**	**3**	**2.8**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM04	MEASUREMENTS AND INSTRUMENTATION			SEMESTER			
PREREQUISTIES			**CATEGORY**	**PE**	**Credit**		**3**
Electric Circuit Analysis			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**

Course Objectives:	
1.	To educate the fundamental concepts and characteristics of measurement System
2.	To introduce the fundamentals of electrical and electronic instruments for measurement of Electrical and Non-electrical quantities
3.	To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters					
UNIT II	**MEASUREMENT OF POWER , ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**
Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter					
UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**
Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and De Sauty's bridge					
UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**
DC Potentiometer- Crompton's Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.					
UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**
Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors					
					Total (45L+0T)= 45 Periods

Text Books:	
1.	A.K. Sawhney, 'A Course in Electrical & Electronics Measurement & Instrumentation', Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, 'Measurements Systems- Application and Design', Tata McGraw Hill publishing company, 2015.
Reference Books:	
1.	D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, 2015.
3.	Martin Reissland, ' Electrical Measurements', New Age International(P) Ltd., Delhi, 2011.
E-Reference:	
1	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select an appropriate transducer for measurement of non-electrical quantities	L4: Analysing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	2	3				1		2		2	2	1	1
CO2	1	3			3					2		1	2	1	
CO3	1	1		2	1	1	2		1				1	2	1
CO4	1	1		1	1		2	2	1		2	2	1	3	1
CO5	2	2	3	1	2	2	1			1	3		1	2	
Avg	**1.4**	**1.8**	**2.5**	**1.75**	**1.75**	**1.5**	**1.67**	**1.5**	**1**	**1.67**	**2.5**	**1.67**	**1.4**	**1.8**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM05	ELECTRICAL MACHINES		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge on construction, working and performance of DC generators and motors.
2.	To deliberate the construction, working and performance of single phase and three phase transformers.
3.	To impart knowledge on construction, working and performance of synchronous generators and motors.
4.	To impart knowledge on construction, principle of operation and performance of single and three-phase induction motors.

UNIT I	**DC GENERATORS**	**9**	**0**	**0**	**9**

Principle of operation, constructional details, types - EMF equation, armature reaction, demagnetizing and cross magnetizing Ampere turns, compensating winding, commutation, methods of improving commutation, interpoles, Open circuit and load characteristics of different types of DC Generators. Parallel operation of DC Generators, applications of DC Generators.

UNIT II	**DC MOTORS**	**9**	**0**	**0**	**9**

Principle of operation, significance of back emf, torque equation and power developed by armature, load characteristics of shunt, series and compound type motors, starting methods, speed control methods - losses and efficiency calculation, condition for maximum efficiency. Testing of DC Machines: Brake test, Swinburne's test, Hopkinson's test, Retardation test, Separation of core losses - applications of DC motors**.**

UNIT III	**TRANSFORMER**	**9**	**0**	**0**	**9**

Single phase transformer: Construction and principle of operation, working of practical transformer - equivalent circuit, voltage regulation, losses and efficiency- testing : polarity test, open circuit and short circuit tests, back-to back test, all day efficiency, parallel operation, applications.

Autotransformer: Construction and working, saving of copper - applications, **Three phase transformer**: construction, types of connections and their comparative features.

UNIT IV	**SYNCHRONOUS GENERATOR AND MOTOR**	**9**	**0**	**0**	**9**

Synchronous Generator: Constructional and working details – Types of rotors – EMF equation – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus - Synchronizing and parallel operation – Synchronizing torque - Voltage regulation – EMF, MMF and ZPF method – steady state power angle characteristics – Two reaction theory – slip test.

Synchronous Motor: Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed -Hunting – natural frequency of oscillations – damper windings- synchronous condenser.

UNIT V	**THREE PHASE AND SINGLE PHASE INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Three phase induction motor: Constructional details – Types of rotors –- Principle of operation – Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Starters: DOL, Autotransformer and Star delta starters – Speed control methods: Voltage control, Frequency control and pole changing – V/f control – Slip power recovery Scheme.

Single phase induction motor: Constructional details – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – split phase, Capacitor-start, capacitor start and capacitor run Induction motor.

Total (45L+0T)= 45 Periods

Text Books:

1.	I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 5th Edition, 2017.
2.	P. S. Bimbhra, "Electric Machinery", Khanna Publishers, 2nd Edition, 2021.
3.	B.L.Theraja and A.K.Theraja," A text book of Electrical Technology - Volume-II", S.Chand & Company Ltd., New Delhi, 23rd Edition, 2009.

Reference Books:

1.	B.R.Gupta, 'Fundamental of Electric Machines' New age International Publishers,3rd Edition, Reprint 2015.

2.	Murugesh Kumar, 'Electric Machines', Vikas Publishing House Pvt. Ltd, First edition, 2010.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, 'Electric Machinery', Mc Graw Hill publishing Company Ltd, 6th Education, 2017.
4.	Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 4th Edition 2017.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the construction and working principle of DC machines, and Interpret various characteristics of DC machines.	L2: Understanding
CO2	:	Compute various performance parameters of the machine, by conducting suitable tests.	L5: Evaluating
CO3	:	Describe the working principle of transformer, auto transformer, three phase transformer connection, and determine the efficiency and regulation.	L3: Applying
CO4	:	Understand the construction and working principle of Synchronous Machines.	L3: Applying
CO5	:	Understand the construction and working principle, speed control of three phase and single phase induction motor.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	1	1	1			1				1	3	2	1
CO2	3	3	1	1	1			1				1	3	2	1
CO3	3	3	1	1	1			1				1	3	2	1
CO4	3	3	1	1	1			1				1	3	2	1
CO5	3	3	1	1	1			1				1	3	2	1
Avg.	**3**	**3**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**3**	**2**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM06	ELECTRICAL DRIVES AND CONTROL		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know about the operation analyse of chopper fed DC drive, both qualitatively and quantitatively.
2.	To understand the operation and performance of AC motor drives.

UNIT I	**DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES**	**9**	**0**	**0**	**9**

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	**MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE**	**9**	**0**	**0**	**9**

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	**INDUCTION MOTOR CHARACTERISTICS**	**9**	**0**	**0**	**9**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	**CONTROL OF SLIP RING INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery. .

UNIT V	**CONTROL OF SRM AND BLDC MOTOR DRIVES.**	**9**	**0**	**0**	**9**

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine - Sensing and logic switching scheme,-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlledd Brushless dc motor drive

Total (45L+0T)= 45 Periods

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3.	Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-Reference

1	https://www.iith.ac.in/~ketan/drives.htmL

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying

CO5	:	Analyze the SRM and BLDC motor drive control	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1	3			1	1					1	3	2	
CO2	3	3	1	3		1	1					1	3	2	
CO3	3	3	3	3	1	1	1					1	3	2	
CO4	1	3	3	2	1	1	1					1	3	2	
CO5	3	3	3	3	1	1	1					1	3	2	
Avg.	**2.6**	**2.6**	**2.6**	**2.75**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**-**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM07	ELECTRIC VEHICLES AND CONTROL		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical drives and control		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**
Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains					
UNIT II	**PLUG-IN HYBRID ELECTRICVEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**
Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy					
UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**
Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles					
UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**
Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages					
UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**
Energy Management System(EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS					
Total (45L+0T)= 45 Periods					

Text Books:	
1.	Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles” CRC Press, 2016
Reference Books:	
1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,“Vehicular Electric Power Systems”, Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010
E-Reference:	
1	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding
CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

COURSE ARTICULATION MATRIX														
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1		1	3	1		1					1	1	2	1
CO2	1	2	3	1			2					2	1	2	
CO3	1	1			2		3						1	1	1
CO4	3	1	2	1	2		1					2	1	2	1
CO5	1	2	1	2	1							1	1	2	1
Avg	**1.4**	**1.5**	**1.75**	**1.75**	**1.5**	**-**	**1.75**	**-**	**-**	**-**	**-**	**1.5**	**1**	**1.8**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM08	ELECTRICAL ENERGY CONSERVATION AND AUDITING		SEMESTER				
PREREQUISITES		CATEGORY	PE	Credit		3
Power Generation, Transmission and Distribution System		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:	
1.	To get knowledge about basics of energy and energy scenario of India.
2.	To familiarise the energy conservation methods.
3.	To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.

UNIT I	ENERGY SCENARIO	9	0	0	9
Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.					
UNIT II	**BASICS OF ENERGY**	**9**	**0**	**0**	**9**
Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.					
UNIT III	**ENERGY MANAGEMENT AND AUDIT**	**9**	**0**	**0**	**9**
Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.					
UNIT IV	**ENERGY EFFICIENCY**	**9**	**0**	**0**	**9**
Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.					
UNIT V	**ENERGY EFFICIENT TECHNOLOGIES**	**9**	**0**	**0**	**9**
Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.					
					Total (45 L+ 0 T) = 45 Periods

Text Books:	
1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2,	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
3.	Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018
Reference Books:	
1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2,	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom’s Taxonomy Mapped**
CO1	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	Recognize the various forms of energy.	L1: Understanding
CO3	Interpret energy management methods and energy auditing.	L3: Applying
CO4	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	Familiar with the advanced energy efficient technologies.	L4: Analysing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1	2	3	2	2		3					1	2	2	1
CO2	1	2	2	2	2		3					1	2	2	1
CO3	2	2	2	3	2		3					1	1	3	1
CO4	2	3	2	2	3		3					1	3	3	1
CO5	2	2	3	1	2		3					1	3	2	1
Avg	**1.6**	**2.2**	**2.4**	**2**	**2.2**	**-**	**3**	**-**	**-**	**-**	**-**	**1**	**2.2**	**2.4**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM09	SMPS AND UPS			SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**			**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**	
			3	**0**	**0**	**3**	

Course Objectives:

1.	To impart knowledge about modern power electronic converters and their applications in power utility.
2.	To impart knowledge about Resonant converters and UPS.

UNIT I	**DC-DC CONVERTERS**	**9**	**0**	**0**	**9**
Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.					
UNIT II	**SWITCHED MODE POWER CONVERTERS**	**9**	**0**	**0**	**9**
Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.					
UNIT III	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**
Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.					
UNIT IV	**DC-AC CONVERTERS**	**9**	**0**	**0**	**9**
Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.					
UNIT V	**POWER CONDITIONERS, UPS, AND FILTERS**	**9**	**0**	**0**	**9**
Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for power electronic applications – Selection of capacitors.					
Total (45L+0T)= 45 Periods					

Text Books:

1.	Simon Ang, Alejandro Oliva,” Power-Switching Converters”, Third Edition, CRC Press, 2010.
2.	M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1.	Ned Mohan, Tore.M.Undeland, William.P.Robbins, “Power Electronics Converters, Applications and Design”, 3rd Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, “Power Electronics circuits, devices and applications”, 3rd Edition, PHI, New Delhi, 2007.

E-References:

1.	NPTEL Course: Power Electronics, IIT-B.
2.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding
CO5	:	Identify the filters and UPS.	L2: Understanding

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	2	2			1					2	2	2	1
CO2	1	1	3	2			1					2	3	3	2
CO3	2	2	2	3			1					1	2	2	1
CO4	2	1	1	2			1					2	2	3	2
CO5	1	1	2	1			1					1	2	2	1
Avg.	**1.6**	**1.2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1.6**	**2.2**	**2.4**	**1.4**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM10	UTILIZATION OF ELECTRICAL ENERGY		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines, Power System, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the economics of power generation, tariff and energy conservation methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff –– availability based Tariff- (ABT) – Battery Energy storage system (BESS)- Frequency based energy measurement - need for electrical energy conservation – methods.- Introduction to energy audit

UNIT II	**ILLUMINATION**	**9**	**0**	**0**	**9**

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

UNIT III	**HEATING AND WELDING**	**9**	**0**	**0**	**9**

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

UNIT IV	**ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45L+0T)= 45 Periods

Text Books:

1.	C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Pvt.Ltd, 2003.
2.	Eric Openshaw Taylor, "Utilisation of Electric Energy", English Universities Press Limited, 1937
3.	J.B. Gupta, "Utilization of Electric Power and Electric Traction", S.K.Kataria and Sons, 2002.

Reference Books:

1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, "A Course in Utilization of Electrical Energy", Khanna Publishers, Delhi, 2003.
2.	H. Partab, "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Co, New Delhi, 2004.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of power generation, tariff and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1	1	1	1	2	1	2	2	1	1	1	2	2	3
CO2	2	3	2	3	1	1	2	1	1			1	3	3	2
CO3	3	3	1	3	1	1	2	1					2	2	3
CO4	1	2	2	3	3	1	2	1					2	3	2
CO5	3	1	1	2	1	1	2	1		1		1	2	2	3
CO6	1	3	3	3	3	1	2	2				1	3	3	2
Avg	**2.17**	**2.17**	**1.67**	**2.5**	**1.67**	**1.17**	**1.83**	**1.33**	**1.5**	**1**	**1**	**1**	**2.33**	**2.5**	**2.5**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

B.E. – MECHANICAL ENGINEERING - MINOR DEGREE

18MEM01	**ENGINEERING THERMODYNAMICS** *(Use of standard thermodynamic tables, Mollier diagram are permitted)*				
PRE-REQUISITE:	**CATEGORY**	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To impart the knowledge on concepts of zeroth and first law of thermodynamics.
2.	To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.
3.	To teach properties of pure substance.
4.	To impart knowledge on the concepts of steam power cycle.
5.	To derive thermodynamic relations for ideal and real gases.

UNIT I	**BASIC CONCEPT AND FIRST LAW**	**9**	**0**	**0**	**9**

Role of Thermodynamics in Engineering and Science - Applications of Thermodynamics. Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems, Property, state, path and processes, quasi-static process, Thermodynamic equilibrium, Displacement work, P-V diagram. Zeroth law of thermodynamics – concept of temperature and heat. First law of thermodynamics – application to closed and open systems, steady flow processes with reference to various thermal equipment.

UNIT II	**SECOND LAW AND ENTROPY**	**9**	**0**	**0**	**9**

Heat engine – Refrigerator – Heat Pump, Second law of thermodynamics – Kelvin's and Clausius statements- Equivalence of these statements their corollaries. Reversibility and irreversibility. Carnot cycle, reversed Carnot cycle. Clausius inequality, Concept of entropy, principle of increase of entropy, T-s diagram, T-ds equations, Entropy.

UNIT III	**PROPERTIES OF PURE SUBSTANCES**	**9**	**0**	**0**	**9**

Steam - formation and its thermodynamic properties - 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 IV	**STEAM POWER CYCLE**	**9**	**0**	**0**	**9**

Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	**IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS**	**9**	**0**	**0**	**9**

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro's law, Vander Waal's equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, Tds, relations, Clausius Clapeyron equations and Joule Thomson Coefficient.

Total (45L)= 45 Periods

Text Books:

1.	Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
2.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
3.	Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4.	Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:	
1.	Cengel, “Thermodynamics- An Engineering Approach”, 3rd Edition, Tata McGraw Hill, 2015.
2.	Merala C, Pother, Craig W and Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata McGrawHill, New Delhi, 2004.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concepts of zeroth, first and second law of thermodynamics.	Remember
CO2	Analyze the various work and heat interactions for different types of processes for closed and open systems	Evaluate
CO3	Evaluate the different properties of pure substances using steam tables and Mollier chart	Evaluate
CO4	Analyze the performance of steam power cycle.	Analyze
CO5	Derive thermodynamic relations for ideal and real gases.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2			1					1	3	1	1
CO2	3	3	2	2			1					1	3	1	1
CO3	3	3	3	2		1	1					1	3	1	1
CO4	2	3	2	2		1	1					1	3	1	1
CO5	3	3	2	2		1						1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**		**1**	**1**					**1**	**3**	**1**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM02	FLUID MECHANICS AND MACHINERY				
PRE-REQUISITE:	**CATEGORY**	**PE**	**Credit**		**3**
1.Engineering Physics 2.Engineering Chemistry 3.Engineering Mathematics	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic concepts and properties of fluids.
2.	To analyze the kinematic and dynamic concepts of fluid flow.
3.	To understand the various incompressible fluid flow through pipes and between parallel plates.
4.	To apply the principles of fluid mechanics to design and operation of hydraulic turbines.
5.	To apply the principles of fluid mechanics to design and operation of hydraulic pumps.

UNIT I	**INTRODUCTION AND FLUID STATICS**	**9**	**0**	**0**	**9**

Basic concepts and units of measurement of physical quantities- Classification of fluids - Properties of fluids – density, relative density, vapour pressure, surface tension, Capillarity and viscosity. Fluid statics- hydrostatic pressure, buoyancy and Archimedes' principle.

UNIT II	**FLUID KINEMATICS AND DYNAMICS**	**9**	**0**	**0**	**9**

Classification of fluid flow - system and control volume - Lagrangian and Eulerian description for fluid flow - flow patterns-streamline, pathline, streakline and timeline. Velocity potential function and Stream function - continuity equation and its applications. Fluid dynamics - Bernoulli's equation and its applications. Dimensional analysis – Buckingham's theorem, dimensional homogeneity, similarity-laws and models.

UNIT III	**FLOW THROUGH PIPES AND PLATES**	**9**	**0**	**0**	**9**

Incompressible fluid flow-Laminar flow- Hagen-Poiseuille equation, shear stress, pressure gradient relationship - flow through pipes and flow between parallel plates. Turbulent flow – flow through pipes, friction factors in turbulent flow - total energy line, hydraulic gradient line, flow through pipes in series and parallel- Moody's friction factor chart. Power transmission-Boundary layer flows - Boundary layer thickness, momentum thickness, energy thickness-boundary layer separation.

UNIT IV	**HYDRAULIC TURBINES**	**9**	**0**	**0**	**9**

Hydraulic turbines classification-impulse and reaction turbines-Working Principle, work done-efficiency and performance curves for Pelton, Francis and Kaplan turbines (Only descriptive) - Comparison between impulse and reaction turbine-specific speed degree of reaction -draft tubes.

UNIT V	**HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Classification of hydraulic pumps- Centrifugal pumps - working principle, specific speed, performance curves and priming(Only descriptive) - Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps (Only descriptive) - Working principles of gear and vane pumps.

Total (45L)= 45 Periods

Text Books:

1.	Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed", Laxmi Publication Pvt Ltd, 2010.
2.	Rajput, R.K., "A Textbook of Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2011.
3.	Subramanya. K., "Fluid Mechanics and Hydraulic Machines", Tata McGraw Hill Publishing Company Ltd, 2011.

Reference Books:	
1.	White, "Fluid Mechanics, 8 Ed", McGraw Hill India, 2017.
2.	Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics 8 th Edition", Wiley, 2016.
3.	Yunuscengel, John. M.cimbala, "Fluid Mechanics Fundamentals and Applications", McGraw Hill, 2017.
4.	Som, S.K, Biswas.G and SumanChakraborty, "Introduction to Fluid Mechanics and Fluid Machines", Tata McGraw Hill India, 2011.
5.	Dr.P.N.Modi, Dr.S.M.Seth, "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard book house, 2018.
E-References:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on fluid mechanics.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the basic concepts and properties of fluids.	Remember
CO2	Analyze the kinematic and dynamic concepts of fluid flow.	Analyze
CO3	Understand the various incompressible fluid flow through pipes and between parallel plates.	Understand
CO4	Apply the principles of fluid mechanics to design and operation of hydraulic turbines.	Apply
CO5	Apply the principles of fluid mechanics to design and operation of hydraulic pumps.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1				2				1		2	2	1
CO2	3	3	1		2								2	2	1
CO3	2	3	2	2	1								2	2	1
CO4	3	3	3	2	1	2	1						2	2	1
CO5	3	3	3	2	1	2	1						2	2	1
Avg	**2.8**	**2.6**	**2**	**2**	**1.25**	**2**	**1.3**				**1**		**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM03	MANUFACTURING PROCESSES					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics 2. Engineering Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.
2.	To develop design concepts of various manufacturing processes.
3.	Gain knowledge to select appropriate manufacturing processes for various parts.
4.	To develop an entrepreneur skill among the students.
5.	To evaluate and select plastic deformation processes for various parts.

UNIT I	**CASTING**	**9**	**0**	**0**	**9**

Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gating and risering design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.

UNIT II	**WELDING**	**9**	**0**	**0**	**9**

Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.

UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**

Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.

UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**

Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.

Total (45L) = 45 Periods

Text Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1.	Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.
2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe the operational features of various casting processes, design gate and riser and discover various defects in casting.	Understand
CO2	Explain various metal joining processes and compare them.	Understand
CO3	Summarize several types of metal forming processes and select suitable method for different applications.	Analyze
CO4	Analyze various manufacturing methods for plastics and their needs in industry.	Analyze
CO5	Describe various sheet metal forming processes, load estimation calculation and principles of powder metallurgy	Understand

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1						1			1	2	1
CO2	2	1	2	1		1			1	1			1	2	1
CO3	1	1	1	1						1			1	1	1
CO4	1	1	1		1					1			1	1	1
CO5		1							1	1			1		1
Avg	**1.5**	**1**	**1.5**	**1**	**1**	**1**			**1**	**1**			**1**	**1.5**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM04	**MATERIALS ENGINEERING**					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering Physics 2. Engineering Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2.	To learn basic principles in metallurgy and materials engineering.
3.	To identity and select suitable engineering materials based on their applications.

UNIT I	**PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

Crystal structures, Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Binary isomorphous alloy systems – Eutectic, Eutectoid, Peritectic systems. Lever rule, Equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements – Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

UNIT II	**HEAT TREATMENT**	**9**	**0**	**0**	**9**

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation hardening. Heat treatment of HSS tools, gears, springs and gauges.

UNIT III	**FERROUS AND NON FERROUS METALS**	**9**	**0**	**0**	**9**

Plain carbon steels – Tool steels - maraging steels – HSLA steels .Stainless steels- ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray cast iron, white cast iron, malleable cast iron, S.G.Iron. Copper alloys – Brass, Bronze and Cupronickel, Aluminium alloys, Bearing alloys.

UNIT IV	**MECHANICAL PROPERTIES AND TESTING**	**9**	**0**	**0**	**9**

Mechanical properties of engineering materials - Mechanisms of plastic deformation, slip and twinning – Creep, Fatigue and Fracture - Types of fracture – Testing of materials - tension, compression and shear loads - fatigue and creep tests – hardness and its effects – testing for hardness (Brinell, Vickers and Rockwell) - Impact test - Izod and Charpy.

UNIT V	**NON DESTRUCTIVE TESTING AND SURFACE ENGINEERING**	**9**	**0**	**0**	**9**

Non Destructive Testing: Basic principles - Testing method - Radiographic testing, Ultrasonic testing, Magnetic Particle Inspection and Liquid Penetrant Inspections. Introduction to surface engineering - Definition, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics.

Total (45L) = 45 Periods

Text Books:

1.	Kenneth G. Budinski and Michael K. Buinski, "Engineering Materials", Prentice Hall of India Ltd, 2002.
2.	Raghavan, V, "Materials Science and Engineering", Prentice Hall of India (P) Ltd., 1999.
3.	Aswani.K.G, "A Text Book of Material Science", S.Chand and Co. Ltd., New Delhi, 2001.
4.	Khanna O.P., "A Text Book of Materials Science and Metallurgy", DhanpatRai Sons, 2004.

Reference Books:

1.	William. D.Callsber, "Material Science and Engineering", John Wiley and Sons, 1997.
2.	Sydney.H.Avner, "Introduction to Physical Metallurgy" Mc Graw Hill Book Company, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the formation of materials and their classification based on atomic structure.	Understand
CO2	Understand the principles of various heat treatment processes in fabrication industry.	Understand
CO3	Describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry	Understand
CO4	Describe various types of failure and select methods for destructive testing	Understand
CO5	Select methods for non destructive testing	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	2	1	1	1						2	3	1
CO2	1		2	1	1	2	1						2	3	1
CO3		1	1	1	1		1						3	2	1
CO4		2	2	1	1	1	1						2	3	1
CO5		2	2	2	1		1						2	2	1
Avg	**1**	**1.5**	**1.8**	**1.4**	**1.0**	**1.3**	**1**						**2.2**	**2.6**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM05	KINEMATICS OF MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering graphics. 2.Engineering Mechanics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:	
1.	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2.	To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3.	To understand basics of cam profile and its displacement.
4.	To understand the basic concepts of toothed gearing and kinematics of gear trains.
5.	Illustrate the effects of friction drives in transmission system.

UNIT I	**BASICS OF MECHANISMS**	**9**	**0**	**0**	**9**

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider-crank chains Limit positions- Mechanical advantage - Transmission angle- Description of some common mechanisms- Quick return mechanism, straight-line generators.

UNIT II	**KINEMATIC ANALYSIS**	**9**	**0**	**0**	**9**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centres - kinematic analysis of simple mechanisms- slider-crank mechanism dynamics Coincident points- Coriolis component of acceleration introduction to linkage synthesis three Position graphical synthesis for motion and path generation.

UNIT III	**KINEMATICS OF CAM**	**9**	**0**	**0**	**9**

Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical method for cam profile design.

UNIT IV	**GEARS AND GEAR TRAINS**	**9**	**0**	**0**	**9**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference / undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V	**FRICTION IN MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Surface contacts- sliding and rolling friction- friction drives- friction in screw threads – bearings and lubrication- friction Clutches- belt and rope drives.

Total (45L) = 45 Periods

Text Books:	
1.	Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2.	Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:	
1.	Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2.	Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.

3.	Erdman AG and Sandor G N, "Mechanism Design, Analysis and Synthesis", Vol.I, PHI Inc., 1997.
4.	Ambekar A.G, "Mechanism and Machine Theory" Prentice Hall of India, New Delhi, 2007.
5.	John Hannah and Stephens R C, "Mechanisms of Machines", Viva Low Price Student Edition, New Delhi, 1999.
E-References:	
1.	https://archive.nptel.ac.in/courses/112/104/112104121/
2.	https://nptel.ac.in/courses/112106270
3.	http://velhightech.com/Documents/ME8492 Kinematics of Machinery.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Demonstrate and understand the concepts of various mechanisms and pairs.	Apply
CO2	Analyze the velocity and acceleration of simple mechanisms.	Analyze
CO3	Construct the cam profile for various motion.	Create
CO4	Solve problems on gears and gear trains.	Evaluate
CO5	Evaluate the friction in transmission system	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1									3	1	
CO2	3	2	2	1									3	1	
CO3	3	2	2	1									3	1	
CO4	3	2	2	1									3	1	
CO5	3	2	2	1									3	1	
Avg	**3**	**2**	**2**	**1**									**3**	**1**	

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM06	HYDRAULICS AND PNEUMATICS				
PRE-REQUISITE:	**CATEGORY**	**PE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To enable the students understand the basics of hydraulics and pneumatics
2.	Applying the working principles of hydraulic actuators and control components.
3.	Designing and develop hydraulic circuits and systems.
4.	Applying the working principles of pneumatic power system and its components.
5.	Solving problems and troubles in fluid power systems.

UNIT I	FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS	9	0	0	9

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – 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 criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II	HYDRAULIC ACTUATORS AND CONTROL COMPONENTS	9	0	0	9

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary actuators - Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories; Reservoirs, Pressure Switches – Filters – types and selection - Applications – Fluid Power ANSI Symbols – Problems.

UNIT III	HYDRAULIC CIRCUITS AND SYSTEMS	9	0	0	9

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double - Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail - Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications - Mechanical, hydraulic servo systems.

UNIT IV	PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS	9	0	0	9

Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – classification - single cylinder and multi cylinder circuits - Cascade method – Integration of fringe circuits, Electro Pneumatic System – Elements – Ladder diagram – timer circuits problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V	DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING	9	0	0	9

Servo systems, Hydro mechanical servo systems, electro hydraulic servo systems and proportional Valves, Introduction to electro hydraulic pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits, failure and troubleshooting. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs. Case studies: A simple sequence, synchronize circuits using hydraulic and pneumatics components.

Total (45L) = 45 Periods

Text Books:

1.	Manjumdar S.R, "Oil Hydraulics", Tata McGraw-Hill, December 2002.

2.	Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2013.
Reference Books:	
1.	Andrew Parr, “Hydraulic and Pneumatics”, Jaico Publications House, 2005.
2.	Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997
3.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 2010
4.	Shanmugasundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
5.	Srinivasan.R. “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Select the components as per the application	Evaluate
CO2	Apply the working principles of hydraulic actuators and control components.	Apply
CO3	Design and develop hydraulic circuits and systems.	Create
CO4	Apply the working principles of pneumatic power system and its components.	Apply
CO5	Solve problems and troubles in fluid power systems.	Evaluate

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	1										1	1	1
CO2		2	2	1									1	1	1
CO3	1	2	3			1							1	2	1
CO4	1	1	3	2	2								2	1	1
CO5	1	1	2										1	1	1
Avg	**1.25**	**1.4**	**2.2**	**1.5**	**2**	**1**							**1.2**	**1.2**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

18MEM07	DESIGN OF MACHINE ELEMENTS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Student should study engineering mechanics. 2. Student should study kinematic of machinery.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understanding of background in mechanics of materials and design of machine components.
2.	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3.	An understanding the design of shafts and couplings.
4.	Familiarize the design of energy storing elements and engine components.
5.	An appreciation of the relationships between component level design and overall machine system design and performance

UNIT I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**	**9**	**0**	**0**	**9**
Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .					
UNIT II	**DESIGN OF SHAFTS AND COUPLINGS**	**9**	**0**	**0**	**9**
Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings.					
UNIT III	**DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS**	**9**	**0**	**0**	**9**
Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.					
UNIT IV	**DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS**	**9**	**0**	**0**	**9**
Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting rods and crank shafts.					
UNIT V	**DESIGN OF BEARINGS**	**9**	**0**	**0**	**9**
Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings.					
					Total (45L) = 45 Periods

Text Books:

1.	Bhandari V.B, “Design of Machine Elements”, Tata McGraw Hill Book Co, 2020
2.	Md.Jalaludeen.S, “A text book of Machine Design”, Anuradha Publications, 2006

Reference Books:

1.	Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2.	Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.

3.	Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4.	PSG Tech, "Design Data Handbook", M/s.DPV Printers, Coimbatore, 2009
E-References:	
1.	https://nptel.ac.in/courses/112105124
2.	Design of Machine Elements - V. B. Bhandari - Google Books
3.	A Textbook of Machine Design by R.S.Khurmi And J.K.Gupta [tortuka]_1490186411865.pdf | DocDroid

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Understand the influence of steady and variable stresses in machine component design.	Understand
CO2	Apply the concepts of design to shafts, keys and couplings.	Apply
CO3	Familiarize the design of temporary and permanent joints.	Understand
CO4	Design the various energy storing elements and engine components.	Analyse
CO5	Familiarize the design of various types of bearings.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	2		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**		**1.0**	**1.0**				**1.0**		**3.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM08	HEAT AND MASS TRANSFER					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.The laws and basic concepts of thermodynamics 2. The concept of energy transfers and their conversion principles		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES	
1.	Understanding the science behind conduction heat transfer and its applications.
2.	Differentiating the concepts of forced and natural convection heat transfer.
3.	Describing the laws and concepts of radiation heat transfer.
4.	Understanding phase change processes and analyzing heat exchangers.
5.	Studying the concept of mass transfer process and its modes.

UNIT-I	**CONDUCTION HEAT TRANSFER**	**9**	**0**	**0**	**9**
General Differential equation – Cartesian(derivation of General Differential Equation), Cylindrical (derivation of General Differential Equation) and Spherical Coordinates – One DimensionalSteady State Heat-Concepts of electrical analogy, Conduction — plane and Composite Systems – Conduction with Internal HeatGeneration., Critical thickness of insulation. Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infiniteand Infinite Solids –Use of Heisler's charts.					
UNIT-II	**CONVECTION HEAT TRANSFER**	**9**	**0**	**0**	**9**
Conservation equations, boundary layer concept – Forced convection: external flow – flow over plates, cylinders, spheres and bank of tubes. Internal flow – entrance effects. Free convection –flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.					
UNIT-III	**BOILING, CONDENSATION AND HEAT EXCHANGERS**	**9**	**0**	**0**	**9**
Regimes of Pool boiling and Flow boiling, Nusselt's theory of condensation- correlations in boiling and condensation. Heat Exchanger types - Overall Heat Transfer Co-efficient – Fouling Factors. LMTD and NTU methods.					
UNIT-IV	**RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**
Radiation laws - Black Body and Gray body Radiation - Shape Factor - Electrical Analogy -Radiation Shields.					
UNIT-V	**MASS TRANSFER**	**9**	**0**	**0**	**9**
Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion - Equimolal counter diffusion. Basic Convective Mass Transfer Problems.					
					Total(45L) = 45 Periods

TEXT BOOKS:	
1	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2017
2	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, 2014.
REFERENCE BOOKS:	
1	Yunus A. Cengel, "Heat Transfer A Practical Approach" – Tata McGraw Hill, 5 th Edition - 2013
2	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2017
3	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 2012
4	Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the mechanism of heat conduction under steady and transient conditions.	Apply
CO2	Develop solutions to problems involving convective heat transfer.	Create
CO3	Design a heat exchanger for any specific application.	Understand
CO4	Adopt the concept of radiation heat transfer in real time systems.	Understand
CO5	Develop solutions to problems involving combined heat and mass transfer.	Apply

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2		1						3	3	1
CO2	3	3	3	3	2		1						3	3	1
CO3	3	3	3	3	2		1						3	3	1
CO4	3	3	3	3	2		1						3	2	1
CO5	2	2	2	2	1		1						3	1	
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**		**1**						**3**	**2.4**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

<table>
<tr><td>18MEM09</td><td colspan="2">METROLOGY AND QUALITY CONTROL</td><td colspan="5"></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>CATEGORY</td><td>PE</td><td colspan="2">Credit</td><td colspan="2">3</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2">Horus/Week</td><td>L</td><td>T</td><td>P</td><td colspan="2">TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td colspan="2">3</td></tr>
<tr><td colspan="8">COURSE OBJECTIVES</td></tr>
<tr><td>1.</td><td colspan="7">Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty</td></tr>
<tr><td>2.</td><td colspan="7">Applying the applications of linear and angular measuring instruments</td></tr>
<tr><td>3.</td><td colspan="7">Interpretation of various tolerance symbols.</td></tr>
<tr><td>4.</td><td colspan="7">Applying the SQC methods in manufacturing.</td></tr>
<tr><td>5.</td><td colspan="7">Applying the advances in measurements for quality control.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>UNIT-I</td><td colspan="3">BASICS OF MEASUREMENT SYSTEM AND DEVICES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalized measurement system - mechanical loading – static characteristics of instruments – factors considered in selection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty.</td></tr>
<tr><td>UNIT-II</td><td colspan="3">CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000 quality standards. Comparators- mechanical, electrical, optical and pneumatic.</td></tr>
<tr><td>UNIT-III</td><td colspan="3">GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor‘s principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors, base pitch measurement. Principle of interferometry, laser interferometer, Machine vision, Fundamental of GD&T. Inspection of straightness, flatness, roundness deviations.</td></tr>
<tr><td>UNIT-IV</td><td colspan="3">STATISTICAL QUALITY CONTROL</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Surface finish – terminology and measurements – Optical measuring instruments –Acceptance test for machines. Statistical Quality Control - Control charts - Sampling plans.</td></tr>
<tr><td>UNIT-V</td><td colspan="3">SIX SIGMA</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="8">Six sigma: Define measure, analyse, improve and control phases. Analyze phase tools: CommonTools: Histogram, Box Plot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA Multi variate analysis.</td></tr>
<tr><td colspan="8" align="right">Total(45L) = 45 Periods</td></tr>
</table>

TEXT BOOKS:	
1	Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018
2	Beckwith.T.G, Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006
REFERENCE BOOKS:	
1	Jain.R.K, ―Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.
2	Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.

3	Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.
4	Alan S Morris, —Measurement and Instrumentation Principles, Butterworth, 2006.
5	De Feo J A and Barnard W W, —Six Sigma: Break trough and BeyondG, Tata McGraw-Hill, New Delhi, 2005.
E-REFERENCES:	
1	https://nitsri.ac.in/Department/Mechanical%20Engineering/MEC_405_Book_2,_for_Unit_2B.pdf
2	https://www.nist.gov/system/files/documents/srm/NIST-SRM-RM-Articlefinal.pdf
3	https://www.researchgate.net/publication/319587859_Computer-Aided_Metrology-CAM

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty.	Understand
CO2	Apply the working principle and the applications of linear and angular measuring instruments.	Apply
CO3	Interpret of various tolerance symbols.	Apply
CO4	Apply the SQC methods in manufacturing.	Apply
CO5	Apply the advances in measurements for quality control in manufacturing industries.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1							2	1	2				2	1	
CO2							3	1	2				1	2	
CO3							2	1					2	1	
CO4				3			2		1				1	2	
CO5				2				3	1				2	1	
Avg				**2.5**			**2.25**	**1.5**	**1.5**				**1.6**	**1.4**	
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

18MEMI10	DYNAMICS OF MACHINERY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:	
1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work.
2.	To facilitate the students, to understand the concept of balancing of rotating and reciprocating masses.
3.	To teach concepts of free vibration analyses of one and two degree-of-freedom rigid body systems
4.	To teach concepts of forced vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects.
5.	To learn about the concept of various types of governors.

UNIT I	**FORCE ANALYSIS**	**9**	**0**	**0**	**9**
Static Force Analysis, Free Body Diagrams, Conditions of Two, Three and Four Force Members. Inertia Forces and D'Alembert's Principle – Inertia Force Analysis in Reciprocating Engines – Crank Shaft Torque. Flywheels – Turning Moment Diagrams and Fluctuation of Energy of reciprocating engine mechanisms, Coefficient of Fluctuation of Energy and Speed, Weight of Flywheel Required.					
UNIT II	**BALANCING**	**9**	**0**	**0**	**9**
Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines					
UNIT III	**FREE VIBRATION**	**9**	**0**	**0**	**9**
Basic Features of Vibratory Systems – Types – Single Degree of Freedom System – Transverse Vibration of Beams – Natural Frequency by Energy Method, Dunkerly's Method - Critical Speed - Damped Free Vibration of Single Degree Freedom System -Types of Damping – Free Vibration with Viscous Damping, Critically Damped System, Under Damped System. Torsional Systems: Natural Frequency of Two and Three Rotor Systems.					
UNIT IV	**FORCED VIBRATION**	**9**	**0**	**0**	**9**
Response to Periodic Force – Harmonic Force – Force caused by Unbalance – Support Motion - Logarithmic Decrement- Magnification Factor – Vibration Isolation and Transmissibility.					
UNIT V	**GOVERNORS**	**9**	**0**	**0**	**9**
Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors – Characteristics - Effect of friction - Controlling Force - other governor mechanisms.					
					Total (45L) = 45 Periods

TEXT BOOKS:	
1.	Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2.	Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi
REFERENCE BOOKS:	
1.	Ballaney, P.L., "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2.	Shigley, J.E. and Uicker, J.J., "Theory of Machines and Mechanisms", TMH ND, 1998.
3.	Amithabha Ghosh, and Ashok Kumar Malik., "Theory of Mechanisms and Machines", 2nd Ed., Affiliated East and West Press Limited, 1998.
4.	Prof.Nakara, IIT-Delhi Reference Books

E-REFERENCES:	
1.	www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of-Machinery-ebook
2.	http://nptel.ac.in/courses/112104114/

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Apply basic principles of mechanisms in mechanical system.	Apply
CO2	Familiarize the static and dynamic analysis of simple mechanisms.	Understand
CO3	Analyze the mechanical systems subjected to free vibration.	Analyze
CO4	Analyze mechanical systems subjected to forced vibration.	Analyze
CO5	Analyze the various types of governors and its speed control mechanism.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	3	1					1		3	2	1	2
CO2	2	2	3	2	1					1		3	2	1	2
CO3	2	2	3	2						1		3	2	1	2
CO4	2	2	3	2	1					1		3	2	1	2
CO5	1	2	3	2						1		3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1**					**1.0**		**3.0**	**2.0**	**1.0**	**1.8**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

MINOR DEGREE: METALLURGICAL ENGINEEING

18MTM01	**ADVANCED PHYSICAL METALLURGY**		**Semester**			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.					
Unit I	**CRYSTAL STRUCTURES**		**9**	**0**	**0**	**9**
Review of atomic bonds, Lattice, unit cell, crystal systems and Bravais lattices; Principal crystal structures – BCC, FCC, HCP and its characteristics; Miller indices for crystallographic planes and directions, interplanar spacing; Volume, planar and linear atomic density; Polymorphism and allotropy; CsCl, NaCl, Diamond structures; single crystal and polycrystalline and amorphous materials; isotropy and anisotropy; Simple problems in the above topics						
Unit II	**CRYSTALLINE IMPERFECTIONS**		**9**	**0**	**0**	**9**
Types of point defects, effect of temperature on vacancy concentration, interstitial sites-octahedral and tetrahedral sites; Line defects – dislocations – Edge, screw and mixed dislocations, Burger's vector, slip and twinning; Planar defects – grain boundaries, tilt boundaries, small angle grain boundaries; ASTM grain size number, grain size determinations; Volume defects; Simple problems in the above topics.						
Unit III	**ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL**		**9**	**0**	**0**	**9**
Diffusion mechanisms, steady state diffusion and non-steady state diffusion-Fick's first law and second law; Kirkendall effect and Darken's equation; Factors affecting diffusion; Industrial applications of diffusion processes; Simple problems in the above topics; Basic principles of solidification of metals and alloys; Growth of crystals– Planar growth, dendritic growth, Solidification time, dendrite size; Cooling curves; Cast or Ingot structure, Solidification defects – Control of casting structure; Directional solidification – single crystal growth; Simple problems in the above topics.						
Unit IV	**PHASE DIAGRAMS**		**9**	**0**	**0**	**9**
Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Phase diagram determination; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling- Coring and its effects, homogenization; Binary eutectic system - composition and amount of phases, development of microstructure; Eutectoid, Peritectic and monotectic reaction, Phase diagrams with intermediate phases and compounds; Ternary phase diagrams. Simple problems in the above topics.						
Unit V	**IRON-CARBON PHASE DIAGRAM**		**9**	**0**	**0**	**9**
Iron-carbon diagram, Phases in Fe-C system, Invariant reactions, Microstructure of slowly cooled steels, composition and amount of phases, Effect of Alloying elements on Fe-C system, Type, structure, properties and applications of Plain Carbon Steels and different types of Cast iron; IS Specification for Steels and Cast Irons, Simple problems in above topics.						
						Total (45+0) = 45 Hours

Text Books:	
1	Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition, 2007.
2	William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, JohnWiley & Sons, New York, USA, 1997.
Reference Books:	
1	Avner S H."An Introduction to Physical Metallurgy", McGraw Hill Book Co, New York, USA, 1997.
2	Donald R Askeland," Essentials of Material Science and Engineering ", Thomson Learning, India Edition, 2007
3	Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi, 199.
4	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-Hill Inc, New York, 1993.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic crystal structure, orientation and their influence on macroscopic properties.	L2: Understanding
CO2	:	Discuss the role of imperfections in strengthening the materials.	L2: Understanding
CO3	:	Diagonise the diffusion mechanism in solidification of materials under different conditions.	L4:Analysing
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3:Applying
CO5	:	Construct the Fe-Fe_3C phase diagram and discuss various properties of steel and cast iron.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1		1	
CO2	1	1				1	1						1			1
CO3	1	1	1	1		1							1	1		
CO4	1	1		1	1								1			
CO5	1	1		1									1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

<table>
<tr><td>18MTM02</td><td colspan="2">THERMODYNAMICS AND KINETICS IN METALLURGY</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="2">PREREQUISITES</td><td>Category</td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="2" rowspan="2">Engineering physics and Engineering chemistry</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="6">To learn the basic principles and concepts of thermodynamics in the field of Metallurgy and materials; and to learn about equations and their applications.</td></tr>
<tr><td>Unit I</td><td colspan="2">FUNDAMENTAL CONCEPT AND INTERNAL ENERGY</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Introduction: System and surrounding, Classification of systems, Path and state properties, Thermodynamic processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics: Heat and work, Internal energy, Heat capacity of materials, Cp-Cv relations, Nernst Equation, Enthalpy, Thermochemistry Hess's law, Kirchoff's law, Maximum flame temperature.</td></tr>
<tr><td>Unit II</td><td colspan="2">ENTROPY AND AUXILARY FUNCTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Second law of thermodynamics: Carnot cycle, Entropy - Statistical interpretation of entropy, Free energy, Combined statement of first and second laws, Thermodynamic functions - Maxwell's relations, Gibbs Helmholtz equation. Third and Zeroth laws of thermodynamics : Definition, concept and applications</td></tr>
<tr><td>Unit III</td><td colspan="2">THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon equation, Troutons rule. Le Chatelier's principle, Vant Hoff's equation. Equilibria in phase diagrams: Phase rule, Phase stability, Thermodynamics of surfaces, interfaces and defects, P-G-T diagrams, Application of free energy - composition diagrams to the study of alloy systems.</td></tr>
<tr><td>Unit IV</td><td colspan="2">THERMODYNAMICS OF SOLUTIONS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Gibbs - Duhem equation, Partial and integral molar quantities, chemical potential, Ideal solutions - Raoult's law, Real solutions, Activity coefficient, Henry's law, Alternative standard states, Sievert's law, Mixing functions and excess functions, Regular solutions, Applications of Gibbs - Duhem equation.</td></tr>
<tr><td>Unit V</td><td colspan="2">THERMODYNAMICS OF REACTIONS AND KINETICS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="7">Electro chemical process: Cells, Interconversion of free energy and electrical work, Determination of thermodynamic quantities using reversible cells, Solid electrolytic cells. Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction.</td></tr>
<tr><td colspan="7" align="right">Total (45+0) = 45 Hours</td></tr>
</table>

Text Books:	
1	Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon, 1977.
2	Ahindra Ghosh, Text book of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002
3	. David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis, 2008
Reference Books:	
1	David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995.
2	Dr S.K Dutta,Prof A.B.Lele – Metallurgical thermodynamics kinetics and numericals,S.Chand& co Ltd.,New Delhi 2011
3	Darken LS and Gurry R W,"Physical Chemistry of Metals", CBS publications and distributors, 2002.
4	Parker R H, "An introduction to chemical metallurgy", Pergamon press, New York, second edition, 1978.
5	Kapoor M.L., "Chemical and Metallurgical Thermodynamics Vol. I and II", Nem Chand, 1st Ed., 1981

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the fundamental concepts of thermodynamics and internal energy	L2: Understanding
CO2	:	State the thermodynamics entropy and auxilary functions.	L2: Understanding
CO3	:	Identify the basic laws, chemical potential and phase equilibria.	L4:Analysing
CO4	:	Describe the thermodynamics of the solution and various important equations.	L2: Understanding
CO5	:	Apply to solve problems related to electrochemical processes and kinetics.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1										1		1	
CO3	1	1		1	1								1			
CO4	1			1	1								1		1	1
CO5	1	1				1	1						1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM03	MECHANICAL BEHAVIOUR OF MATERIALS			Semester			
PREREQUISITES			OE	Credit			3
Engineering physics		Hours/Week	L	T	P		TH
			3	0	0		3
Course Learning Objectives							
1	To know the fundamental concepts of deformation behaviour for structural engineering applications.						
Unit I	**DISLOCATIONS AND PLASTIC DEFORMATION**		9	0	0		9
Strength of perfect crystal and need for dislocations; Characteristics of dislocations – Edge dislocation, Screw dislocation, Burger's vector, mixed dislocation, dislocation loops; Movement of dislocation – Pierls stress, Cross slip, Climb; Dislocations in FCC, HCP and BCC lattice; Stress fields and energies of dislocations, forces on and between dislocations; Dislocation density; Intersections of dislocations – Jogs and kinks; Dislocation multiplication; Dislocation pile-ups; Deformation by slip and twinning; Critical resolved shear stress; Deformation bands and kink bands.							
Unit II	**STRENGTHENING MECHANISMS**		9	0	0		9
Strain hardening; Grain boundary strengthening; Solid solution strengthening - yield-point phenomenon, strain ageing; Precipitation hardening - Conditions for precipitation hardening, Ageing, Formation of precipitates, coarsening of precipitates, Mechanism of strengthening; Dispersion strengthening; Fiber strengthening; Martensite strengthening - examples for above strengthening mechanisms from ferrous and non-ferrous systems, Bauschinger effect; Preferred orientation; Sever plastic deformation.							
Unit III	**FRACTURE AND FRACTURE MECHANICS**		9	0	0		9
Types of fracture – ductile and brittle fracture, Ductile to Brittle Transition Temperature (DBTT), Metallurgical factors affecting DBTT, determination of DBTT, Hydrogen embrittlement and other embrittlement, Theoretical cohesive strength of metals, Griffith's theory of brittle fracture, Orowan's modification. Fracture mechanics - introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD, J integral.							
Unit IV	**FATIGUE BEHAVIOUR AND TESTS**		9	0	0		9
Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermo-mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.							
Unit V	**CREEP BEHAVIOUR AND TESTS**		9	0	0		9
Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametetric methods of extrapolation. Deformation Mechanism Maps							
							Total (45+0) = 45 Hours

Text Books:	
1	George. E. Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004
2	Marc Andr’e Meyers, Krishan Kumar Chawla, “Mechanical Behavior of Materials”, Cambridge University Press, UK, 2009.
Reference Books:	
1	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
2	Davis.H.E. Troxell G.E., Hauck.G.E.W. “The Testing of Engineering Materials”, McGraw-Hill, 1982.
3	Wulff et al Vol. III “Mechanical Behavior of Materials”, John Wiley and Sons, New York, USA, 1983.
4	Honeycombe R.W.K., “Plastic Deformation of Materials”, Edward Arnold Publishers, 1984

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the mechanical behaviour of materials.	L2: Understanding
CO2	:	Discuss the strengthening mechanisms of materials.	L2: Understanding
CO3	:	List the various types of fractures and their mechanisms, fracture mechanics and various theories describing fracture mechanics.	L2: Understanding
CO4	:	Discuss the fatigue behaviour and the mechanism of fatigue, SN curve and fatigue testing machines.	L2: Understanding
CO5	:	Describe the creep behaviour and mechanism, factors affecting creep and creep testing machines.	L2: Understanding

<u>COURSE ARTICULATION MATRIX</u>

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1		1	1								1	1		
CO3	1	1	1		1										1	1
CO4	1	1				1	1								1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

18MTM04	RATE PROCESSES IN METALLURGY			Semester			
PREREQUISITES				**OE**	**Credit**		**3**
Engineering physics			**Hours/Week**	**L**	**T**	**P**	**TH**
				3	**0**	**0**	**3**
Course Learning Objectives							
1	To learn the basic principles and concepts of kinetics in the domain of metallurgy and materials; to learn about equations and their applications; And to appreciate that metallurgical kinetics as a Knowledge base with abundant applications.						
Unit I	**INTRODUCTION**			**9**	**0**	**0**	**9**
Introduction: Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat and mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.							
Unit II	**KINETICS OF SOLID-FLUID REACTION**			**9**	**0**	**0**	**9**
Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step, Concentration boundary layer, definition and significance of heat and mass transfer coefficient, Theoretical models for mass transfer coefficients, Correlations for heat and mass transfer coefficients							
Unit III	**LIQUID-SOLID PHASE TRANSFORMATION**			**9**	**0**	**0**	**9**
Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing.							
Unit IV	**SOLID STATE PHASE TRANSFORMATIONS**			**9**	**0**	**0**	**9**
Nucleation and growth Kinetics, homogeneous and heterogeneous transformation, Precipitation: Coherency, age hardening, particle Coarsening. Ostwald ripening, Order-disorder transformation, spinodal decomposition, massive transformations							
Unit V	**SOLID STATE PHASE TRANSFORMATIONS IN STEEL**			**9**	**0**	**0**	**9**
Reconstructive and displacive transformations; Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology of pearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite and lower bainite; Martensitic transformation: Mechanism- diffusionless displacive nature; morphology of high carbon and low carbon martensite.							
							Total (45+0) = 45 Hours

Text Books:	
1.	Ahindra Ghosh and Sudipto Ghosh, A Text book of Metallurgical Kinetics, PHI learning Pvt. Ltd., New Delhi, 2014
2.	H.S. Ray, Kinetics of Metallurgical Reactions, International Science publisher, 1993.
3.	F. Habashi, Kinetics of Metallurgical Processes, Metallurgy Extractive Québec, 1999.
4.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon, 1977.
Reference Books:	

1.	Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Transformations in Metals, P.G. Shewmon, Mc-Graw Hill, 1969.
2.	Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997.
3.	Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
4.	Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the thermodynamic aspects of phase changes.	L2: Understanding
CO2	:	Discuss the fundamentals of solid –fluid reactions.	L2: Understanding
CO3	:	Explain the eutectic and peritectic solidifications and rapid solidification processes.	L2: Understanding
CO4	:	Describe the fundamentals of solidification.	L1: Remembering
CO5	:	Apply the solid state phase transformations in steel.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1			1
CO2	1	1			1	1									1	1
CO3	1	1		1	1								1	1		
CO4	1	1		1	1									1		1
CO5	1		1			1	1								1	1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

<table>
<tr><td>18MTM05</td><td colspan="5">CORROSION AND SURFACE ENGINEERING</td><td colspan="3">Semester</td><td></td></tr>
<tr><td colspan="5">PREREQUISITES</td><td></td><td>OE</td><td colspan="2">Credit</td><td>3</td></tr>
<tr><td colspan="5" rowspan="2">Engineering chemistry</td><td rowspan="2">Hours/Week</td><td>L</td><td>T</td><td>P</td><td>TH</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="10">Course Learning Objectives</td></tr>
<tr><td>1</td><td colspan="9">To understand the corrosion and surface engineering, with its application in engineering field.</td></tr>
<tr><td>Unit I</td><td colspan="5">MECHANISMS AND TYPES OF CORROSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Principles of direct and Electro chemical Corrosion, Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion, Galvanic series-specific types of corrosion such as uniform, Pitting, Intergranular, Cavitations, Crevice Fretting, Erosion and Stress Corrosion, corrosion fatigue, hydrogen damage –Factors influencing corrosion</td></tr>
<tr><td>Unit II</td><td colspan="5">TESTING AND PREVENTION OF CORROSION</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Corrosion testing techniques and procedures- Corrosion Testing ASTM Standards, Pitting Corrosion Test, Hydrogen Induced Cracking Test, Sulphide Stress Corrosion Cracking Test- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Special surfacing processes.</td></tr>
<tr><td>Unit III</td><td colspan="5">CORROSION OF INDUSTRIAL COMPONENTS</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Corrosion in fossil fuel power plants, Automotive industry, Chemical processing industries, corrosion in petroleum production operations and refining, Corrosion of pipelines- wear of industrial components.</td></tr>
<tr><td>Unit IV</td><td colspan="5">SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Diffusion coatings –Electro and Electroless Plating –Hot dip coating –Hard facing-Metal spraying, Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.</td></tr>
<tr><td>Unit V</td><td colspan="5">THIN LAYER ENGINEERING PROCESSES</td><td>9</td><td>0</td><td>0</td><td>9</td></tr>
<tr><td colspan="10">Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Coating of tools, TiC, TiN, Al_2O_3 and Diamond coating-Properties and applications of thin coatings.</td></tr>
<tr><td colspan="10">Total (45+0) = 45 Hours</td></tr>
</table>

Reference Books:	
1.	Fontana. G., Corrosion Engineering, McGraw Hill,1985.
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prenticehall,1992.
3.	ASM Metals Hand Book –Vol. 5, Surface Engineering,1996.
4.	Denny A Jones, “Principles and prevention of corrosion”, 2^{nd}edition, Prentice Hall, New Jersey,1995.
5.	ASM International, Surface Engineering for Corrosion and Wear Resistance,2005.
6.	Schweitzer. P.A., Corrosion Engineering Hand Book, 3rd Edition, Marcel Decker, 1996.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Name the different types of corrosion and their mechanism.	L2: Understanding
CO2	:	Estimate corrosion resistance by different tests.	L4:Analysing
CO3	:	Explain the corrosion behavior of different metals in different industries.	L2: Understanding
CO4	:	Classify the different forms of processing techniques of surface engineering materials.	L1: Remembering
CO5	:	Select the type of deposition and spraying technique.	L3:Applying

<u>COURSE ARTICULATION MATRIX</u>

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		
CO2	1	1		1		1							1	1		
CO3	1	1	1	1			1								1	1
CO4	1	1		1	1										1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM06	MATERIALS CHARACTERIZATION			Semester		
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To acquire knowledge on various characterizations, chemical and thermal analysis of metallurgical components using its analysis tools.

Unit I	**OPTICAL MICROSCOPY**	**9**	**0**	**0**	**9**

Metallographic specimen preparation. Macro-examination -applications. Metallurgical microscope - principle, construction and working, , Optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources, lens aberrations and their remedial measures, Various illumination techniques-bright field , dark field, phase-contrast, polarized light illuminations, interference microscopy, high temperature microscopy; Quantitative metallography – Image analysis.

Unit II	**X-RAY DIFFRACTION**	**9**	**0**	**0**	**9**

Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method and powder method. Diffraction intensity – structure factor calculation. X-ray diffractometer -general features, filters and counters. Applications of X-ray diffraction in materials characterisation – Determination of crystallite size, crystal structure, precise lattice parameter, measurement of stress.

Unit III	**ELECTRON MICROSCOPY**	**9**	**0**	**0**	**9**

Electron beam - specimen interactions. Construction and operation of Transmission Electron Microscopy – Diffraction effects and image formation, various imaging modes, selected area diffraction, applications, specimen preparation techniques. Scanning electron microscopy – principle, equipment, various operating modes and applications, Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis. Introduction to HRTEM, FESEM, EBSD.

Unit IV	**SPECTROSCOPIC TECHNIQUES**	**9**	**0**	**0**	**9**

X-ray spectroscopy – EDS and WDS. Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy and Secondary ion mass spectroscopy / ion microprobe. Optical emission spectroscopy, Atomic Absorption spectroscopy and X-ray fluorescence spectroscopy - principle, construction, working and applications. UV-Vis, FTIR and Raman spectroscopy.

Unit V	**THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES**	**9**	**0**	**0**	**9**

Thermal Analysis: Principles of differential thermal analysis, differential scanning calorimetry and thermo-graviometric analysis – Instrumentation and applications. Advanced characterization techniques: Scanning probe microscopy - STM and AFM - principle, instrumentation and applications. Field ion microscopy including atom probe - principles, instrumentation and applications.

Total (45+0) = 45 Hours

Text Books:

1.	Cullity, B.D., Elements of X Ray Diffraction, Addison-Wesley Publishing Company Inc, Philippines, 1978
2.	Brandon, D. and W.D. Kaplan, Microstructural Characterization of Materials, John Wiley & Sons Ltd, England, 2013.
3.	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008

Reference Books:	
1.	ASM Handbook, Volume 10, Materials Characterization, ASM international, USA, 1986.
2.	Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
3.	Phillips V A, Modern Metallographic Techniques and their Applications, Wiley Eastern, 1971.
4.	Angelo, P. C., Materials Characterization, Reed Elsevier India Pvt Ltd, Haryana, 2013.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the principles of metallurgical microscope, optical properties and various illumination techniques.	L2: Understanding
CO2	:	Analyze the various diffraction methods, X-ray diffractometer and determination of crystal parameter.	L4:Analysing
CO3	:	Discuss the principles of TEM, SEM, EPMA.	L2: Understanding
CO4	:	Explain various spectroscopic techniques,	L2: Understanding
CO5	:	Discuss the chemical and thermal analysis using advanced methods.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	`1		1	1								1		1	
CO2	1	1	1	1		1							1			1
CO3	1		1			1	1					1	1			1
CO4	1	1		1	1							1	1			1
CO5	1	1		1	1								1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0					1.0	1.0		1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM07	**AUTOMOTIVE, AEROSPACE AND DEFENCE MATERIAL**		**Semester**			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**
Course Learning Objectives						
1	To understand the properties and applications various materials suitable for automobile, aircraft and defnce industries and its components.					
Unit I	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**		**9**	**0**	**0**	**9**
Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.						
Unit II	**MATERIALS FOR AUTOMOTIVE STRUCTURES**		**9**	**0**	**0**	**9**
Materials selection for bearings, leaf springs, chasis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and antifriction fluids, Tyres and tubes. Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.						
Unit III	**AEROSPACE METALS AND ALLOYS**		**9**	**0**	**0**	**9**
Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles. Heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – Effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys, powder metallurgy- application of materials in Thermal protection systems of Aerospace vehicles – super alloys						
Unit IV	**CERAMICS AND COMPOSITES**		**9**	**0**	**0**	**9**
Introduction – physical metallurgy – modern ceramic materials – cermet - cutting tools – glass ceramic –production of semi-fabricated forms - Plastics and rubber – Carbon/Carbon composites, Fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design.						
Unit V	**NUCLEAR WASTE AND RADIATION PROTECTION, IRRADIATION EFEFCTS**		**9**	**0**	**0**	**9**
Introduction-unit of nuclear radiation-Types of waste –disposal –ICRP recommendations-radiation hazards and prevention –radiation dose units - Irradiation Examination of Fuels, Irradiation behaviour of metallic uranium – irradiation growth, thermal cycling, swelling, adjusted uranium, blistering in uranium rods. Irradiation effects in ceramic oxide and mixed oxide fuels, definition and units of burn up, main causes of fuel element failure in power reactors and remedies to avoid failures.						
						Total (45+0) = 45 Hours

Reference Books:	
1.	ASM Handbook, “Selection of Materials Vol. 1 and 2”, ASM Metals Park, Ohio. USA, 1991.
2.	Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications Or Callister’s Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley India, Edition -2010.
3.	Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4.	Engineering Metallurgy Applied Physical Metallurgy, R. A. Higgins, 6th Edition

5.	Gladius Lewis, “Selection of Engineering Materials”, Prentice Hall Inc. New Jersey USA, 1995.
6.	Charles J A and Crane. F A. A., “Selection and Use of Engineering Materials”, 3rd Edition, Butterworths, London UK, 1996
7.	ASM Handbook. “Materials Selection and Design”, Vol. 20- ASM Metals Park Ohio.USA, 1997
8.	Cantor,“ Automotive Engineering: Lightweight, Functional, and Novel Materials”, Taylor & Francis Group, London, 2006

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Describe the materials selection criteria for engine and transmission systems.	L2: Understanding
CO2	:	Analyze the different materials used for automotive structures and Different electronic materials for automotive applications.	L4:Analysing
CO3	:	Explain various topics such as elements of aerospace materials and mechanical behaviour of materials,	L2: Understanding
CO4	:	Compare the ceramics and composites of aerospace materials	L4:Analysing
CO5	:	Examine the fuels for nuclear materials.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1			1							1	1		
CO3	1			1	1								1		1	
CO4	1	1	1				1						1			1
CO5	1	1		1	1								1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																