NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

RULES AND REGULATIONS OF B.TECH PROGRAM

Effective from 2015-2016

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

Vision

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to

the society

Mission

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

To be a global knowledge hub in mechanical engineering education, research, entrepreneurship and industry outreach services.

Mission

- Impart quality education and training to the nurture globally competitive mechanical engineers.
- Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.
- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

Graduate Attributes

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives

PEO.1	Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.
PEO.2	Apply modern computational, analytical, simulation tools and techniques to address the challenges faced in mechanical and allied engineering streams.
PEO.3	Communicate effectively using innovative tools and demonstrate leadership & entrepreneurial skills.
PEO.4	Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career and organizational goals.

Mapping of Mission statements with program educational objectives

Mission	PEO1	PEO2	PEO3	PE04
Impart quality education and training to the nurture globally competitive mechanical engineers.	3	3	2	1
Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.	3	2	2	1
Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.	1	1	3	1

Mapping of program educational objectives with graduate attributes

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
PEO1	3	3	3	2	2	3	-	1	1	2	2	2
PEO2	3	3	3	3	3	2	1	1	1	-	1	2
PEO3	2	2	2	2	3	3	2	2	2	3	-	1
PEO4	1	1	1	-	1	2	2	1	3	3	2	2

Program Outcomes: At the end of the program the student will be able to

PO1	Apply knowledge of mathematics, science and engineering to analyze, design and evaluate mechanical components & systems using state -of-the-art IT tools.
PO2	Analyze problems of mechanical engineering including thermal, manufacturing and industrial systems to formulate design requirements.
PO3	Design, implement, and evaluate mechanical systems and processes considering public health, safety, cultural, societal and environmental issues.
PO4	Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.
PO5	Apply current techniques, skills, knowledge and computer based methods & tools to develop mechanical systems.
PO6	Analyze the local and global impact of modern technologies on individual organizations, society and culture.
PO7	Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco friendly environment.
PO8	Exhibit responsibility in professional, ethical, legal, security and social issues.
PO9	Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goals.
PO10	Communicate effectively in diverse groups and exhibit leadership qualities.
PO11	Apply management principles to manage projects in multidisciplinary environment.
PO12	Pursue life-long learning as a means to enhance knowledge and skills.

Mapping of program outcomes with program educational objectives

	PEO1	PEO2	PEO3	PEO4
PO1	3	3	2	1
PO2	3	3	2	1
PO3	3	3	2	1
PO4	2	3	2	1
PO5	2	3	3	1
PO6	3	2	3	2
PO7	1	1	2	2
PO8	1	1	2	1
PO9	1	1	3	3
PO10	2	1	3	3
PO11	2	2	1	2
PO12	2	2	1	2

CURRICULAR COMPONENTS

Degree Requirements for B. Tech in Mechanical Engineering

Category of Courses	Credits Offered	Min. credits to be earned
Basic Science Core (BSC)	32	32
Engineering Science Core (ESC)	33	33
Humanities and Social Science Core (HSC)	07	07
Program Core Courses (PCC)	88	88
Departmental Elective Courses (DEC)	24	18
Open Elective Courses (OPC)	6	6
Program major Project (PRC)	6	6
EAA: Games and Sports (MDC)	0	0
Total	**196**	190

SCHEME OF INSTRUCTION

B.Tech. (Mechanical Engineering) Course Structure

B. Tech. I - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA101	Mathematics – I	4	0	0	4	BSC
2	HS101 ME102	English for Communication (or) Engineering Graphics	3 2	0 0	2 3	4 4	HSC ESC
3	PH101 CY101	Physics (or) Chemistry	4 4	0 0	0 0	4 4	BSC BSC
4	EC101 EE101	Basic Electronics Engineering (or) Basic Electrical Engineering	3 3	0 0	0 0	3 3	ESC ESC
5	CE102 ME101	Environmental Science & Engineering (or) Basic Mechanical Engineering	3 3	0 0	0 0	3 3	ESC ESC
6	CS101 CE101	Prob. Solving and Computer Programming (or) Engineering Mechanics	4 4	0 0	0 0	4 4	ESC ESC
7	PH102 CY102	Physics Lab (or) Chemistry Lab	0 0	0 0	3 3	2 2	BSC BSC
8	CS102 ME103	Prob. Solving and Computer Programming Lab (or) Workshop Practice	0 0	0 0	3 3	2 2	ESC ESC
9	EA101	EAA: Games and Sports	0	0	3	0	MDC
		TOTAL	**21**	**0**	**11**	**26**	
			20	**0**	**12**	**26**	

B.Tech. I - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA151	Mathematics – II	4	0	0	4	BSC
2	ME102 HS101	Engineering Graphics (or) English for Communication	2 3	0 0	3 2	4 4	ESC HSC
3	CY101 PH101	Chemistry (or) Physics	4 4	0 0	0 0	4 4	BSC BSC
4	EE101 EC101	Basic Electrical Engineering (or) Basic Electronics Engineering	3 3	0 0	0 0	3 3	ESC ESC
5	ME101 CE102	Basic Mechanical Engineering (or) Environmental Science & Engineering	3 3	0 0	0 0	3 3	ESC ESC
6	CE101 CS101	Engineering Mechanics (or) Problem Solving and Computer Programming	4 4	0 0	0 0	4 4	ESC ESC
7	CY102 PH102	Chemistry Lab (or) Physics Lab	0 0	0 0	3 3	2 2	BSC BSC
8	ME103 CS102	Workshop practice (or) Problem Solving and Computer Prog. Lab	0 0	0 0	3 3	2 2	ESC ESC
9	EA151	EAA: Games and Sports	0	0	3	0	MDC
	Total		**20**	**0**	**12**	**26**	
			21	**0**	**11**	**26**	

II - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA236	Transformation Techniques	3	0	0	3	BSC
2	MM235	Materials Engineering	4	0	0	4	ESC
3	ME201	Thermodynamics	3	1	0	4	PCC
4	ME202	Kinematics of Machinery	3	0	0	3	PCC
5	CE235	Fluid Mechanics and Hydraulic Machines	3	1	0	4	PCC
6	CE236	Mechanics of Solids	3	1	0	4	PCC
7	CE237	Fluid Mechanics and Hydraulic Machines Laboratory	0	0	3	2	PCC
8	CE238	Material Testing Laboratory	0	0	3	2	PCC
		TOTAL	**19**	**3**	**6**	**26**	

II - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA285	Numerical and Statistical Methods	3	0	0	3	BSC
2	EC285	Electronic Measurement Systems	3	0	0	3	ESC
3	ME251	Turbomachines	3	1	0	4	PCC
4	ME252	Design of Machine Elements – 1	3	1	0	4	PCC
5	ME253	Manufacturing Technology	4	0	0	4	PCC
6	ME254	Machine Drawing	2	0	3	4	PCC
7	ME255	Manufacturing Technology Laboratory	0	0	3	2	PCC
8	EC286	Basic Electronics Laboratory	0	0	3	2	ESC
		TOTAL	**18**	**2**	**9**	**26**	

III - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat.
1	ME301	Internal Combustion Engines	3	0	0	3	PCC
2	ME302	Dynamics of Machinery	3	1	0	4	PCC
3	ME303	Machine Tools and Metrology	4	0	0	4	PCC
4	ME304	Management Science and Productivity	4	0	0	4	PCC
5	ME305	Mechanical Measurements	3	0	0	3	PCC
6		Departmental Elective – 1	3	0	0	3	DEC
7	ME306	Thermal Engineering Laboratory	0	0	3	2	PCC
8	ME307	Dynamics and Measurements Laboratory	0	0	3	2	PCC
		TOTAL	**20**	**1**	**6**	**25**	

III - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat.
1	SM335	Engineering Economics and Accountancy	3	0	0	3	HSC
2	ME351	Heat and Mass Transfer	3	1	0	4	PCC
3	ME352	Design of Machine Elements – 2	3	1	0	4	PCC
4	ME353	Machining Science	3	1	0	4	PCC
5		Open Elective – 1	3	0	0	3	OPC
6		Departmental Elective -2	3	0	0	3	DEC
7	ME354	Heat Transfer and Fuels Laboratory	0	0	3	2	PCC
8	ME355	Machining and Metrology Laboratory	0	0	3	2	PCC
		TOTAL	**18**	**3**	**6**	**25**	

IV - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat.
1	ME401	Refrigeration and Air- Conditioning	3	0	0	3	PCC
2	ME402	CAD/CAM	4	0	0	4	PCC
3		Open Elective – 2	3	0	0	3	OPC
4		Departmental Elective -3	3	0	0	3	DEC
5		Departmental Elective -4	3	0	0	3	DEC
6	ME403	CAD/CAM Laboratory	0	0	3	2	PCC
7	ME449	Project Work Part-A	0	0	3	2	PRC
		TOTAL	**16**	**0**	**6**	**20**	

IV - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat.
1	ME451	Mechatronics	3	0	0	3	PCC
2		Departmental Elective – 5	3	0	0	3	DEC
3		Departmental Elective – 6	3	0	0	3	DEC
3		Departmental Elective – 7	3	0	0	3	DEC
4	ME452	Mechatronics Lab	0	0	3	2	PCC
5	ME491	Seminar	0	0	3	1	PCC
7	ME499	Project Work Part-B	0	0	6	4	PRC
		TOTAL	**12**	**0**	**12**	**19**	

List of Electives

III Year I Semester

ME311 Advanced Thermodynamics

ME318 Finite Element Method

ME325 Advanced Welding Technology

ME326 Advanced Metal Casting and NDT

ME332 Operations Research

III Year II Semester

ME361 Computational Fluid Dynamics

ME362 Automobile Engineering

ME368 Mechanical Vibrations

ME369 Design of Mechanisms

ME375 Advanced Metal Forming

ME376 Machine Tool Design

ME382 Production Planning and Control

ME383 Design and Analysis of Experiments

IV Year I Semester

ME411 Non-Conventional Energy Sources

ME412 Convective Heat Transfer

ME413 Advanced I.C. Engines

ME418 Engineering Acoustics

ME419 Rotor Dynamics

ME420 Mechanics of Composite Materials

ME425 Advanced Manufacturing Processes

ME426 Tool Design

ME427 Micro and Nano Manufacturing

ME428 Design for Manufacturing

ME431 New Venture Creation

ME432 Total Quality Management

ME433 Advanced Operations Research

ME434 Supply Chain Management

IV Year II Semester

ME461 Cryogenics

ME462 Power Plant Engineering

ME463 Gas Dynamics

ME464 Energy Systems and Management

ME468 Micro and Smart Systems

ME469 Rapid Prototyping

ME470 Condition Monitoring

ME471 Innovative Design

ME475 Nano Materials Processing and Properties

ME476 Advanced Materials and Processing

ME477 Design and Application of Engineering Materials

ME478 Industrial Automation

ME479 Industrial Robotics

ME480 Flexible Manufacturing Systems

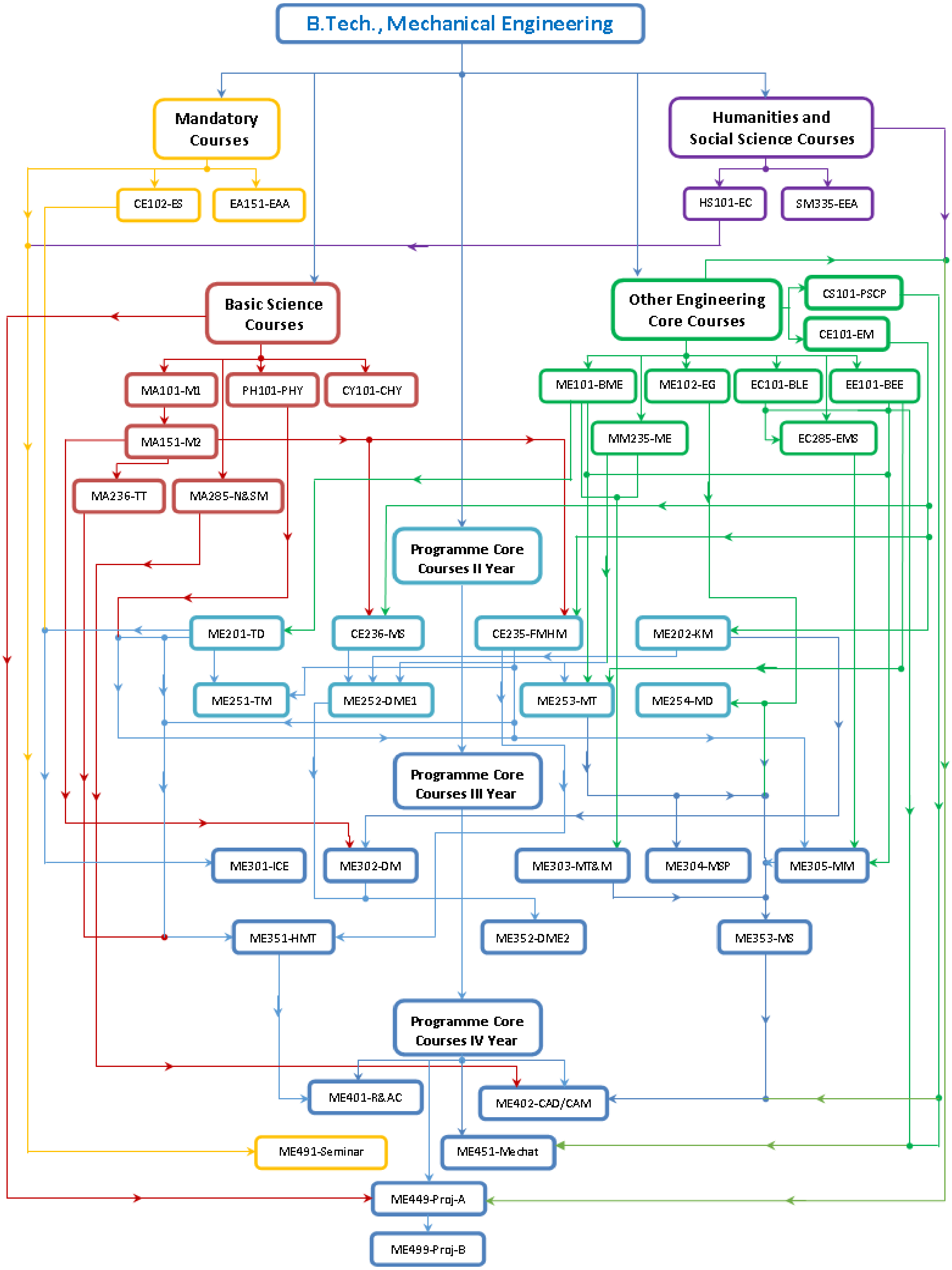
ME482 Project Management

ME483 Reliability Engineering

ME484 Theory of Constraints

B.TECH IN MECHANICAL ENGINEERING

PRE-REQUISITE CHART



DETAILED SYLLABUS

MA101	MATHEMATICS – I	BSC	4 – 0 – 0	4 Credits

Pre-requisites: None.

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

CO1	Solve linear system equation
CO2	Determine the Eigen values and vectors of a matrix
CO3	Determine the power series expansion of a function
CO4	Estimate the maxima and minima of multivariable functions
CO5	Solve any given first order ordinary differential equation
CO6	Solve any higher order linear ordinary differential equation with constant coefficients

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Matrix Theory: Elementary row and column operations on a matrix, Rank of matrix – Normal form – Inverse of a matrix using elementary operations –Consistency and solutions of systems of linear equations using elementary operations, linear dependence and independence of vectors - Characteristic roots and vectors of a matrix - Caley-Hamillton theorem and its applications, Complex matrices, Hermitian and Unitary Matrices - Reduction to diagonal form - Reduction of a quadratic form to canonical form – orthogonal transformation and congruent transformation.

Differential Calculus: Rolle's theorem; Mean value theorem; Taylor's and Maclaurin's theorems with remainders, Expansions; Indeterminate forms; Asymptotes and curvature; Curve tracing; Functions of several variables, Partial Differentiation, Total Differentiation, Euler's theorem and generalization, maxima and minima of functions of several variables (two and three variables) – Lagrange's method of Multipliers; Change of variables – Jacobians.

Ordinary differential equations of first order: Formation of differential equations; Separable equations; equations reducible to separable form; exact equations; integrating factors; linear first order equations; Bernoulli's equation; Orthogonal trajectories and Newton's law of cooling.

Ordinary linear differential equations of higher order: Homogeneous linear equations of arbitrary order with constant coefficients - Non-homogeneous linear equations with constant coefficients; Euler and Cauchy's equations; Method of variation of parameters; System of linear differential equations, Vibrations of a beam.

Reading:

1. R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics*, Narosa Pub. House, 2008.
2. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, *Higher Engineering Mathematics*, Khanna Publications, 2009.

HS101	ENGLISH FOR COMMUNICATION	HSC	3 – 0 – 2	4 Credits

Pre-requisites: None

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

CO1	Understand basic grammar principles.
CO2	Write clear and coherent passages.
CO3	Write effective letters for job application and complaints.
CO4	Prepare technical reports and interpret graphs.
CO5	Enhance reading comprehension.
CO6	Comprehend English speech sound system, stress and intonation

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Grammar Principles and Vocabulary Building: -Exposure to basics of grammar- parts of speech, with emphasis on tenses—active and passive voice- their usage- reported speech -Idioms and Phrases—their meanings and usage, Vocabulary development through prefixes, suffixes and word roots

Effective Sentence Construction –clarity and precision in construction—strategies for effectiveness in writing

Paragraphs: Definition- structure- Types and Composition-unity of theme- coherence- organisation patterns

Note-making – its uses- steps in note-making—identification of important points-reduction to phrases –selection of suitable note format- types of notes—tree diagram, block list, table-

Letter Writing: Business, Official and Informal letters-- communicative purpose-strategy- letter format and mechanics- letters of request , complaint and invitation-

Reading techniques: Skimming and Scanning – quick reading for gist and –suggesting titles- looking for specific information

Description of Graphics- kinds of graphs- their construction and use and application in scientific texts- interpretation of graphs using expressions of comparison and contrast

Reading Comprehension – reading to retrieve information ––techniques of comprehension - find clues to locate important points- answering objective type questions –inference, elimination

Technical Report-Writing - kinds of reports-proposals, progress and final reports- their structure- features- process of writing a report-editing

Book Reviews- Oral and written review of a chosen novel/play- a brief written analysis including summary and appreciation- oral presentation of the novel before class

Reading

A Textbook of English for Engineers and Technologists (combined edition, Vol. 1 & 2) ; Orient BlackSwan 2010

ME102	ENGINEERING GRAPHICS	ESC	2 – 0 – 3	4 Credits

Pre-requisites: None

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

CO1	Draw orthographic projections of lines, planes and solids.
CO2	Construct isometric scale, isometric projections and views.
CO3	Draw sections of solids including cylinders, cones, prisms and pyramids.
CO4	Draw projections of lines, planes, solids, isometric projections and sections of solids including cylinders, cones, prisms and pyramids using AutoCAD

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1						1	1
CO2	3	3	1	3	1						1	1
CO3	3	3	1	3	1						1	1
CO4	3	2	1	3	3						1	1

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns.

Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales.

Orthographic projection of points: Principles of Orthographic projection, Projections of points.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Section of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views – simple objects.

Auto-CAD practice: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES tool bar, Standard Tool bar, LAYERS

Reading:

1. N.D. Bhat and V.M. Panchal, Engineering Graphics, Charotar Publishers 2013
2. E. Finkelstein, “AutoCAD 2007 Bible”, Wiley Publishing Inc., 2007

PH101	PHYSICS	BSC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Solve engineering problems by applying the concepts of wave and particle nature of radiant energy.
CO2	Use lasers as light sources for low and high energy applications.
CO3	Understand the nature and characterization of acoustic design, nuclear accelerators and new materials.
CO4	Apply the concepts of light in optical fibers, light wave communication systems, holography and for sensing physical parameters.
CO5	Construct a quantum mechanical model to explain the behavior of a system at microscopic level.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Interference: Superposition principle, Division of amplitude and wave front division, Interferometers (Michelson, Fabry-Perot, Mach Zehnder), Applications.

Diffraction: Fraunhoffer diffraction (single, double & multiple slits), Resolving power, Dispersive power, Applications.

Polarization: Production & detection of polarized light, wave plates, optical acivity, Laurents Half-shade polarimeter, photoelasticity and applications.

Lasers: Basic principles of Lasers, He-Ne, Nd-YAG, CO_2 and semiconductors lasers, applications of lasers, Holography and holographic NDT.

Optical Fibers: Light propagation in Optical fibers, types of optical fibers, optical fibers for communication and sensing.

Functional Materials: Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, biomaterials, high temperature materials, smart materials and their applications, Introduction to Nano materials.

Modern Physics: Qualitative review of different experiments, de-Broglie waves, Dual nature of matter, Schrodinger wave equation, wave function and its interpretation, potential well problems in one dimension, Tunneling, Uncertainty principle, Particle Accelerators: Cyclotron, Synchro Cyclotron, Betatron and applications.

Acoustics: Introduction, Reverberation and reverberation time, growth and decay of energy, Sabine's formula, absorption coefficient and its measurement, factors affecting architectural acoustics, production, detection and applications of Ultrasound.

Reading:

1. Halliday, Resnic and Walker, Fundamentals of Physics, 9^{th} Ed.,John Wiley, 2011
2. Beiser A, Concepts of Modern physics, 5^{th} Ed., McGraw Hill International, 2003
3. Ajoy Ghatak, Optics, 2^{nd} Ed., Tata McGraw Hill, 1994
4. M.Armugam, Engineering Physics, Anuradha Agencies, 2003

CY101	CHEMISTRY	BSC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand and apply the concepts in electrochemistry and corrosion science.
CO2	Understand the concepts in molecular interactions.
CO3	Understand the Synthesis and analysis of modern materials.
CO4	Apply the concepts of organic chemistry for synthesis.
CO5	Understand the Synthesis and applications of polymer science.
CO6	Identify the structures of organic molecules using photo chemistry and Chemical spectroscopy.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus

Electrochemistry: Review of the concepts of electrode potentials, Nernst equation, Reference electrodes, Ion selective electrodes – Concept – Glass electrode – Determination of pH of a solution using a glass electrode – Derivation of equation between E_{cell} and pH, Determination of F^- ion using fluoride electrode (Numerical calculations), Chemically modified electrodes (CMEs) – Concept, CMEs as potentiometric and amperometric sensors, Electrochemical energy systems, Electrochemistry of secondary cells e.g. Lead – acid and Ni-Cd cells, Rechargeable lithium batteries, Fuel cells – Electrochemistry of a H_2–O_2 fuel cell, methanol–O_2 fuel cell

Corrosion and Its Prevention: Electrochemical theory of corrosion, Corrosion due to dissimilar metal cells (galvanic cells), Corrosion due to differential aeration cells, Uniform corrosion, pitting corrosion and stress corrosion cracking, Effect of pH, Potential-pH diagram for Iron, temperature and dissolved oxygen on corrosion rate, Corrosion prevention and control by cathodic protection

Molecular Interactions: Molecular orbital theory applicable to understanding of bonding in heteronuclear diatomic molecules, e.g. CO and NO, Molecular orbital energy diagram of an Octahedral complex, MO diagram of a molecule involving charge transfer (e.g. $KMnO_4$), Nature of supramolecular interactions: ion-ion interactions, ion-dipole interactions, dipole-dipole interactions, hydrogen bonding, cation-л interactions, л-л interactions, van der Walls forces, Concept of self-assembly involving different types of interactions (Micellar formation; Membrane Formation; Surface films)

Chemistry of Nanomaterials: Introduction to Nanomaterials, Chemical synthesis of nanomaterials : sol-gel method, Reverse micellar method, electrolytic method, Characterization of nanoparticles by BET method, Characterization of nanomaterials by TEM (includes basic principle of TEM), Applications of nanomaterials in Industry as drug delivery materials, as catalysts, in water treatment.

Basic Principles Of Organic Chemistry: Introducion, Homolytic and Heterolytic cleavages and free radicals Carbocations, carbanions and addition reactions Elimination and substitution reactions.

Stereochemistry: chirality, optical activity, enantiomers and diastereomers, Projection formulae and geometrical isomerism, Reactions - Hofmann reaction and Riemer-Tiemann reaction, Diels-Alder reaction and Cannizaro reaction, Skraup synthesis.

Polymer Chemistry: Concept of polymerization – Types of polymerization, Chain growth polymerization – mechanisms of free radical and cationic polymerizations, Mechanisms of simple anionic polymerization and co-ordination anionic polymerization (complex forming mechanism), Step-growth polymerization ,Mechanism and examples,

Thermoplastic resins and Thermosetting resins: Examples and applications, Conducting polymers: Mechanism of conduction in polymers – Examples – and applications.

Review Of Chemical Spectroscopy: Review of electromagnetic spectrum, Quantization of energy, Born – Oppenheimer approximation, Frank Condon Principle Vibrational spectra (Infra-red) of diatomic molecules – Selection rules Determination of force constant Problems, Identification of functional groups using IR spectroscopy Electronic spectroscopy - Types of electronic transitions –calculation of chromophoric absorptions For Diene and ene-one chromophors Qualitative analysis by electronic spectroscopy, Lambert – Beer's law-Applications in Quantitative analysis and problems,

NMR spectroscopy: Basic principles, Concept of chemical shift. Concept of spin-spin splitting and examples, Applications of UV,I.R and ^{1}H NMR spectra in the determination of structures of Ethyl alcohol, Dimethyl ether, Acetic acid and Benzyl alcohol.

Photo Chemistry: Principles of photochemistry – Rates of intermolecular processes, Jablonski diagram – fluorescence, phosphorescene and Chemiluminescence, Types of Photochemical Organic reactions, Laws of photochemistry and quantum yields-problems, Photosensitized reactions

Reading

1. P. W. Atkins & Julio de Paula, Atkins Physical Chemistryl Chemistry, Oxford University Press York, 7th Edn, 2002
2. Shashi Chawla, A Text Book of Engineering Chemistry, 3rd Edition, Dhanpat Rai & Co New Delhi, 2007.
3. S. Vairam, P. Kalyani & Suba Ramesh, Engineering Chemistry, Ist Edn, John Wiley & Sons, India,2011
4. Lee J.D., Concise Inorganic Chemistry ,7th Edn, Blackwel Science Publications Oxford, London, 2004.
5. Jerry March., Advanced Organic Chemistry, 6th Edn, John Wiley & Sons, New Jersy, 2007.
6. FehFuYen, Chemistry for Engineers, Imperial College Press,2008
7. Octave Levenspiel, *Chemical Reaction Engineering*, 2nd Edition, Wiley India, 2006.
8. Smith J.M., *Chemical Engineering Kinetics,* 3rd Edition, McGraw Hill,1981.

EC101	BASIC ELECTRONICS ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Characterize semiconductors, diodes, transistors and operational amplifiers
CO2	Design simple analog circuits
CO3	Design simple combinational and sequential logic circuits
CO4	Understand functions of digital multimeter, cathode ray oscilloscopes and transducers in the measurement of physical variables
CO5	Understand the fundamental principles of radio communication.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus

Electronics Systems: Introduction to electronics, review of p-n junction operation, diode applications, Zener diode as regulator.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications, simple RC coupled amplifier and frequency response. Cascaded amplifiers, FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive feedback merits and demerits, Principle of oscillators, LC and RC oscillators.

Integrated Circuits: Operational amplifiers, Applications adder, subtractor, Integrator and Differentiators.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Flip-Flops, counters and shift registers, data converters, Analog to Digital and Digital to Analog converters (ADC/DAC's).

Electronics Instrumentation: Measurement, Sensors, Laboratory measuring instruments: digital multi-meters, Cathode ray oscilloscopes (CRO's).

Principles of Communication: Need for Modulation, Modulation and Demodulation techniques.

Reading:

1. Neil Storey, “Electronics A Systems Approach”, 4/e - Pearson Education Publishing Company Pvt Ltd, 2011.
2. Salivahanan, N Suresh Kumar, “Electronic Devices and Circuits” 3/e, McGraw Hill Publications, 2013.
3. Bhargava N. N., D C Kulshreshtha and S C Gupta, “Basic Electronics & Linear Circuits”, Tata McGraw Hill, 2/e, 2013 .

EE101	BASIC ELECTRICAL ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze and solve electric and magnetic circuits
CO2	Identify the type of electrical machines for a given application
CO3	Recognize the ratings of different electrical apparatus
CO4	Identify meters for measuring electrical quantities

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1			2					1
CO2	3	2	2	2			1					1
CO3	3	2	2	2			1					1
CO4	3	1	2	2			2	2				1

Detailed Syllabus

DC Circuits: Kirchhoff's Voltage & Current laws, Superposition Theorem, Star – Delta Transformations.

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of Single Phase Series & Parallel Circuits, Solution of Three Phase circuits and Measurement of Power in Three Phase circuits.

Magnetic Circuits: Fundamentals and Solution of Magnetic Circuits, Concepts of Self and Mutual Inductances, Coefficient of Coupling.

Single Phase Transformers: Principle of Operation of a Single Phase Transformer, EMF equation, Phasor diagram, Equivalent Circuit, Determination of Equivalent Circuit Parameters, Regulation and Efficiency of a single phase transformer. Principle of Operation of an Auto Transformer.

DC Machines: Principle of Operation, Classification, EMF and Torque equations, Characteristics of Generators and Motors, Speed Control Methods and Starting Techniques.

Three Phase Induction Motor: Principle of Rotating Magnetic Field, Principle of Operation of 3-φ I.M, Torque-Speed Characteristics of 3-φ I.M, Starting Methods and Applications of Three Phase Induction Motors.

Measuring Instruments: Moving Coil and Moving Iron Ammeters and Voltmeters, Dynamometer Type Wattmeter and Induction Type Energy Meter

Reading

1. Edward Hughes, ELBS, Electrical Technology – 10th Edition, 2010
2. Vincent Del Toro, Electrical Engineering Fundamentals – 2nd Edition, PHI, 2003
3. V.N. Mittle, “Basic Electrical Engineering” – TMH Edition 2000

CE102	ENVIRONMENTAL SCIENCE & ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand environmental problems arising due to developmental activities
CO2	Identify the natural resources and suitable methods for conservation and sustainable development
CO3	Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
CO4	Identify the environmental pollutants and abatement devices.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		3			2	3	2			2	1
CO2	2		3			2	3	2			2	1
CO3	2		3			2	3	2			2	1
CO4	2		3			2	3	2			2	1

Detailed syllabus:

Introduction: Environment, Definition, scope and importance, Multidisciplinary nature of environmental studies.

Natural Resources: Forest Resources – use and over – exploitation of forests, deforestation, timber extraction, mining, dams and their effects on forests and tribal people. Water Resources- Use and over – utilization of surface and groundwater, floods, droughts, conflicts over water, dams – benefits and problems. Mineral Resources – Use and exploitation, environmental effects of extracting and using mineral resources. Agricultural Land and Food Resources – Land as a resources, land degradation, man induces landslides, soil erosion and desertification; World food problems, changes caused agricultural and overgrazing, effects of modern agricultural practices, fertiliser and pesticide problems, water logging, salinity, case studies. Energy Resources – Growing energy needs, renewable and non-renewable, energy sources, Sources of alternate energy sources, Case studies, Energy Conservation.

Ecosystem and Biodiversity: Ecosystems – Concept of an ecosystem, structure and function of an ecosystem, Food chain, food webs and ecological pyramids, Energy flow in ecosystem, producers and consumers, Ecological succession. Biodiversity and its Conservation – Introduction, definition, genetic, species and ecosystem diversity, value of biodiversity, Consumptive use, productive use, Social, ethical, aesthetic and optional values, biodiversity at global, national and local values, India as a mega-diversity nation, hotspots of biodiversity, threats to biodiversity – habitat loss, poaching of wildlife, man-wildlife conflicts, endangered and endemic species of India, conservation of biodiversity – In-situ and ex-situ conservation of biodiversity.

Environmental Pollution: Causes, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear radiation hazards, Solid waste management- sources of solid wastes, effects and control measures of urban industrial wastes; Pollution case studies, disaster Management – floods, earthquakes, cyclones and landslides.

Environment and Society: Role of an individual in prevention of pollution, consumerism and waste products, unsustainable to sustainable development, water conservation, rainwater harvesting, watershed management, wasteland reclamation, observance and popularization of Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Wildlife protection act, Forest conservation act, Issues involved in enforcement of environmental legalizations, population growth, variation among nations, Environment and human health: epidemics, Women and child welfare, Role of information technology in environment and human health.

Reading

1. Henry J.G. and Heinke G.W. (2004), "Environmental Science and Engineering", Second Edition, Prentice Hall of India, New Delhi
2. Chandrasekhar M (2004), "Environmental Science", Hi-Tech Publishers, Hyderabad
3. Masters G.M. (2004)," Introduction to Environmental Engineering and Science", Second Edition, Prentice Hall of India, New Delhi
4. Garg, S.K and Garg, R., (2006), Ecological and Environmental Studies, Khanna Publishers, Delhi.
5. Bharucha, E .,(2003), "Environmental Studies", University Publishing Company, New Delhi.
6. De A.K. (2002), "Environmental Chemistry", New Age India Publication Company, New Delhi.
7. Chauhan, A.S., (2006), EnvironmentalStudies, Jain Brothers, New Delhi
8. Deswal, S and Deswal A., (2004), A Basic Course in Environmental Studies, Dhanpat Rai & Co. Delhi.

ME101	BASIC MECHANICAL ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand basics of thermodynamics and components of a thermal power plant
CO2	Identify engineering materials, their properties, manufacturing methods encountered in engineering practice
CO3	Understand basics of heat transfer, refrigeration and internal combustion engines
CO4	Understand mechanism of power transfer through belt, rope, chain and gear drives
CO5	Understand functions and operations of machine tools including milling, shaping, grinding and lathe machines

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Introduction to Thermodynamics - Concept of a System – Types of Systems, Thermodynamic Equilibrium, Properties, State, Process and Cycle, Zeroth Law, Energy Interactions - Heat and Work, Types of Work, Work interactions in a closed System for various processes

First and Second Laws of Thermodynamics: First Law: Cycle and Process, Specific Heats (c_p and c_v), Heat interactions in a Closed System for various processes, Limitations of First Law, Concept of Heat Engine (H.E.) and Reversed H.E. (Heat Pump and Refrigerator), Efficiency/COP, Second Law: Kelvin-Planck and Clausius Statements, Carnot Cycle, Carnot Efficiency, Statement of Clausius Inequality, Property of Entropy, T-S and P-V Diagrams

Thermal Power Plant: Thermal Power Plant Layout – Four Circuits, Rankine Cycle, Boilers: Fire Tube vs Water Tube; Babcock & Wilcox, Cochran Boilers, Steam Turbines : Impulse vs Reaction Turbines, Compounding of Turbines: Pressure Compounding, Velocity Compounding, Pressure-Velocity Compounding, Condensers: Types – Jet & Surface Condensers, Cooling Towers

Manufacturing Processes: Engineering Materials: Classification, Properties of Materials, Manufacturing Processes: Metal Casting, Moulding, Patterns, Metal Working: Hot Working and Cold Working, Metal Forming: Extrusion, Forging, Rolling, Drawing

Internal Combustion Engines and Refrigeration: IC Engines: 2 - Stroke and 4 - Stroke Engines, S.I. Engine and C.I. Engine: Differences, P-V and T-S Diagrams

Refrigeration System and Refrigerants: Principle and working of standard vapor compression refrigeration system and Brief description of Refrigerants

Heat Transfer: Heat Transfer: Modes; Thermal Resistance Concept, Conduction: Composite Walls and Cylinders, Combined Conduction and Convection: Overall Heat Transfer Co-efficient, Simple Numerical Problems: Heat Transfer

Welding: Welding: Gas Welding and Arc Welding, Soldering, Brazing

Power Transmission: Transmission of Mechanical Power: Belt Drives – Simple Numerical Problems, Gear Drives – Simple Numerical Problems

Basics of Automotive Vehicle: Lay out of Automobile Transmission; Brakes – Types, Clutch, Differential

Machine Tools and Machining Processes: Machine Tools Machine Tools: Lathe Machine, Lathe Operations, Milling Machine-Types, Milling Operations, Shaper and Planer Machines: Differences, Quick-Return Motion Mechanism, Drilling Machine: Operations, Grinding Machine: Operations

Reading:

1. Elements of Mechanical Engineering – M. L. Mathur, F. S. Mehta and R. P. Tiwari, Jain Brothers, New Delhi.
2. Engineering Heat Transfer - Gupta & Prakash, Nem Chand & Brothers, New Delhi.
3. Workshop Technology (Vol. 1 and 2) – B. S. Raghuvanshi, Dhanpath Rai and Sons, New Delhi.

CS101	PROBLEM SOLVING AND COMPUTER PROGRAMMING	ESC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Develop algorithms for mathematical and scientific problems.
CO2	Explore alternate algorithmic approaches to problem solving
CO3	Understand the components of computing systems
CO4	Choose data types and structures to solve mathematical and scientific problems
CO5	Develop modular programs using control structures
CO6	Write programs to solve real world problems using object oriented features

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to computers and Basics of C++: Hardware, software, SDLC, Algorithm, Program, Origins of the C++ Language, C++ and Object-Oriented Programming, Data types, Identifiers, Variables, Assignment Statements, Escape Sequences, Naming Constants, Arithmetic Operators and Expressions, Integer and Floating-Point Division, Type Casting, Increment and Decrement Operators and Console input/output.

Flow of Control:Boolean Expressions, Branching Mechanism (simple if, if-else, nested if-else, switch case, break, exit statements) and Loops (while, do-while, for, continue statement).

Functions: Predefined Functions, Programmer Defined functions (call-by-value, call-by-reference), Procedural Abstraction, Local and global variables, Function overloading and Recursive functions.

Arrays: Introduction to arrays, one dimensional array (selection sort, bubble sort, linear search and binary search), multi dimensional arrays and arrays in function call.

Pointers and Dynamic Arrays: Pointer Variables, Basic Memory Management, Dangling Pointers, Dynamic Variables and Automatic Variables, Pointers as Call-by-Value Parameters, Creating and Using Dynamic Arrays and Multidimensional Dynamic Arrays.

Strings: C Strings, Character Manipulation Tools and Standard String Class

Streams and File I/O: I/O Streams, File I/O (read, write and appending a file), Character I/O, Checking for the End of a file and Formatting Output with Stream Functions.

Structures and Classes: Structure definition, structure variables, structure variables in function call, Class definition, Encapsulation and Access Specifiers, Inheritance, Polymorphism, Method overloading

Reading

1. Walter Savitch, *Problem Solving with C++*, Sixth Edition, Pearson, 2007
2. Cay Horstmann, Timothy Budd, *Big C++*, Wiley, Indian Edition, 2006

CE101	ENGINEERING MECHANICS	ESC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Determine the resultant force and moment for a given force system.
CO2	Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction.
CO3	Calculate the motion parameters for a body subjected to a given force system.
CO4	Determine the deformation of a shaft and understand the relationship between material constants.
CO5	Determine the centroid and second moment of area

Mapping of course outcomes with program outcomes

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

Detailed syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints – Freebody diagrams

Spatial Force systems - Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system - Problems

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Mechanics of Deformable Bodies - Stress & Strain at a point- Normal and shear stresses, Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume.

Centroid & Moment of Inertia - Centroid & M.I – Arial & Mass M.I – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles - Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Direct Central Impact – coefficient of restitution, Curvilinear Motion – Projectile Motion, Work & Energy in Curvilinear motion.

Dynamics of Rigid Bodies - Rigid body rotation – Kinematics - Kinetics, Problems – Work & Energy in Rigid body rotation, Plane Motion – Kinematics, Problem – Instantaneous center of rotation.

Reading

1. J.L.Meriam & L.G. Kraige, Engineering Mechanics, 7th Ed, John Wiley & sons, 2012.
2. Timoshenko and Young, Engineering Mechanics, 3rd Ed, Mc Graw Hill Publishers, 2006.
3. Gere and Timoshenko, Mechanics of Materials, 2nd Ed, CBS Publishers, 2011.

PH102	PHYSICS LAB	BSC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Use CRO, Signal generator, spectrometer, polarimeter and GM counter for making measurements.
CO2	Test optical components using principles of interference and diffraction of light
CO3	Determine the selectivity parameters in electrical circuits.
CO4	Determine the width of narrow slits, spacing between close rulings using lasers and appreciate the accuracy in measurements.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	2		1		1	1		1
CO2	2	2	1	3	2		1		1	1		1
CO3	2	2	1	3	2		1		1	1		1
CO4	2	2	1	3	2		1		1	1		1

List of experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings
2. Determination of Wavelength of He-Ne laser – Metal Scale
3. Measurement of Width of a narrow slit using He- Ne Laser
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of capacitance by using R-C circuit
6. Determination of resonating frequency and bandwidth by LCR circuit
7. Measurement of half life of radioactive source using GM Counter
8. Diffraction grating by normal incidence method

Reading:

Printed Manual supplied to the students.

CY102	CHEMISTRY LAB	BSC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Synthesize polymers.
CO2	Analyze ores and bleaching powder.
CO3	Estimate the Hardness of water in terms of Calcium and Magnesium ions.
CO4	Separate organic compounds using chromatographic techniques.
CO5	Standardize solutions using titration, conductivity meter, pH-meter, potentiometer and colorimeter.
CO6	Verify Freaundlish adsorption isotherm

Mapping of course outcomes with program outcomes

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

List of Experiments:

Cycle 1

1. Standardization of potassium permanganate
2. Determination of MnO2 in Pyrolusite
3. Determination of Iron in Haematite
4. Determination of available Chlorine in bleaching powder and of Iodine in Iodized salt
5. Determination of hardness of water and of calcium in milk powder
6. Chemistry of blue printing
7. Preparation of phenol formaldehyde resin

Cycle 2

1. Conductometric titration of an Acid vs Base
2. pH-metric titration of an Acid vs Base
3. Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$
4. Colorimetric titration of potassium permanganate
5. Determination of rate of corrosion of mild steel in acidic environment in the absence and presence of an inhibitor
6. Determination of salt content by Ion-exchange
7. Separation of Ions by paper chromatography
8. Verification of Freaundlich adsorption isotherm

Reading:

1. Valentin, W. G. “A Course of Qualitative Chemical Analysis” Read Books Design, 2010; ISBN:1446022730, 9781446022733.
2. G. Svehla: Vogel's Qualitative Inorganic Analysis. J. Mendham, R. C. Denny, J. D. Barnes, M. J. K. Thomas: Vogel’s Text Book of Quantitative Chemical Analysis.
3. G. N. Mukherjee: Semi-Micro Qualitative Inorganic Analysis (CU Publications) Vogel’s Text Book of Practical Organic Chemistry (5th Edition).
4. N. G. Mukherjee: Selected Experiments in Physical Chemistry.

CS102	PROBLEM SOLVING AND COMPUTER PROGRAMMING LAB	ESC	0 – 0 – 3	2 Credits

Pre-requisites: None.

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

CO1	Design and test programs to solve mathematical and scientific problems
CO2	Develop and test programs using control structures
CO3	Implement modular programs using functions
CO4	Develop programs using classes

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	3					1		1
CO2	3	3	1	2	3					1		1
CO3	3	3	1	2	3					1		1
CO4	3	3	1	2	3					1		1

Detailed Syllabus:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.
8. Programs on inheritance and polymorphism.

Reading:

1. Walter Savitch, Problem Solving with C++, 6th Edition, Pearson, 2008.
2. R.G. Dromey, How to solve it by Computer, Pearson, 2008.

ME103	WORKSHOP PRACTICE	ESC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Study and practice on machine tools and their operations
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3	Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4	Apply basic electrical engineering knowledge for house wiring practice

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1							1
CO2	3	2	2	2	1							1
CO3	2	3	2	1	1	1	1					1
CO4	2	3	2	1	1	1	1					1

List of Experiments:

Fitting Trade:

1. Preparation of T-Shape Work piece as per the given specifications.
2. Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding.
3. Practice marking operations.

Plumbing:

1. Practice of Internal threading, external threading, pipe bending, pipe fitting.
2. Pipes with coupling for same diameter and with reducer for different diameters.
3. Practice of T-fitting, Y-fitting, Gate valves fitting.

Machine shop:

1. Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools)
2. Demonstration of different operations on Lathe machine
3. Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting.
4. Study of Quick return mechanism of Shaper.

Power Tools:

1. Study of different hand operated power tools, uses and their demonstration
2. Practice of all available Bosch Power tools.

Carpentry:

1. Study of Carpentry Tools, Equipment and different joints.
2. Practice of Cross Half lap joint, Half lap Dovetail joint and Mortise Tenon Joint

House Wiring:

1. Introduction to House wiring, different types of cables. Types of power supply, types of motors, Starters, distribution of power supply, types of bulbs, parts of tube light, Electrical wiring symbols.
2. Stair case wiring: Demo and Practice (2 switches with one lamp control)
3. Godown wiring

Foundry Trade:

1. Introduction to foundry, Patterns, pattern allowances, ingredients of moulding sand and melting furnaces. Foundry tools and their purposes
2. Demo of mould preparation
3. Practice – Preparation of mould by using split pattern.

Welding:

1. Introduction, Study of Tools and welding Equipment (Gas and Arc welding)
2. Selection of welding electrode and current, Bead practice.
3. Practice of Butt Joint, Lap Joint.

Reading:

1. Raghuwanshi B.S., Workshop Technology Vol. I & II, Dhanpath Rai & Sons.
2. Kannaiah P. and Narayana K.L., Workshop Manual, 2nd Edn, Scitech publishers.
3. John K.C., Mechanical Workshop Practice. 2nd Edn. PHI 2010.
4. Jeyapoovan T.and Pranitha S., Engineering Practices Lab Manual, 3rd Edn. Vikas Pub.2008.

MA151	MATHEMATICS – II	BSC	4 – 0 – 0	4 Credits

Pre-requisites: MA101: Mathematics - I

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

CO1	Solve linear differential equations using Laplace transforms.
CO2	Evaluate multiple integrals and improper integrals.
CO3	Convert line integrals to area integrals.
CO4	Convert surface integrals to volume integrals.
CO5	Determine potential functions for irrotational force fields.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Laplace Transformation: Laplace transform - Inverse Laplace transform - properties of Laplace transforms - Laplace transforms of unit step function, impulse function and periodic function - convolution theorem - Solution of ordinary differential equations with constant coefficients and system of linear differential equations with constant coefficients using Laplace transform.

Integral Calculus: Fundamental theorem of integral calculus and mean value theorems; Evaluation of plane areas, volume and surface area of a solid of revolution and lengths. Convergence of Improper integrals – Beta and Gamma integrals – Elementary properties – Differentiation under integral sign. Double and triple integrals – computation of surface areas and volumes – change of variables in double and triple integrals.

Vector Calculus : Scalar and Vector fields; Vector Differentiation; Level surfaces - directional derivative - Gradient of scalar field; Divergence and Curl of a vector field - Laplacian - Line and surface integrals; Green's theorem in plane; Gauss Divergence theorem; Stokes' theorem.

Reading:

1. R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics*, Narosa Pub. House, 2008.
2. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, *Higher Engineering Mathematics*, Khanna Publications, 2009.

MA236	TRANSFORMATION TECHNIQUES	BSC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Determine Fourier series expansion of functions
CO2	Evaluate improper integrals involving trigonometric functions
CO3	Determine solutions of PDE for vibrating string and heat conduction
CO4	Evaluate real integrals using residue theorem
CO5	Transform a region to another region using conformal mapping

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms : Complex form of Fourier series - Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Partial Differential Equations: Solutions of Wave equation, Heat equation and Laplace's equation by the method of separation of variables and their use in problems of vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow including polar form.

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, evaluation of real integrals using residue theorem, Bilinear transformations, conformal mapping.

Reading :

1. R.K.Jain and S.R.K.Iyengar, *Advanced Engineering Mathematics*, Narosa Pub. House, 2008.
2. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8^{th} Edition, 2008.
3. B.S.Grewal, *Higher Engineering Mathematics*, Khanna Publications, 2009.

MM235	MATERIALS ENGINEERING	ESC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the crystal structure and classification of materials.
CO2	Understand methods of determining mechanical properties and their suitability for applications.
CO3	Classify cast irons and study their applications.
CO4	Interpret the phase diagrams of materials.
CO5	Select suitable heat-treatment process to achieve desired properties of metals and alloys.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Crystal geometry: Space Lattices, Unit cells, Crystal Structure, Crystal directions and planes, Crystal Imperfections: Line defects, Point defects, Surface defects, Geometry and Properties of dislocation

Constitution of alloys: Types of solid solution, Substitutional and Hume Rothary's rules for solid solution, Construction and interpretation of Binary equilibrium diagram, Isomorphous, Eutectic and Peritectic diagrams, Intermediate phases and phase rule, Iron-Carbon diagram

Heat treatment:Isothermal transformation curves, Annealing, Normalising, Hardening, Tempering, Austempering & Martempering, Age hardening, Surface hardening

Cast irons and alloy steels:Types of Cast irons: White, Grey, Malleable and Nodular etc., Properties and application of cast irons, Effect of alloying elements on structure of steels and on the critical temperatures, Effect of common alloying elements on plain carbon steels, Properties and uses of Silicon and Hadfield Manganese steels, High speed steels and Stainless steel.

Non-ferrous metals and alloys: Properties and uses of important non-ferrous metals like Cu, Al, Pb, Sn, Zn. Study of important non-ferrous alloys: Brass & Bronzes, Bearing alloys, Al alloys & Monel, Die-casting alloys.

Mechanical properties: Hardness and hardness measurement, Elastic and elastic properties, Resolved shear stress, Tensile properties, Impact properties and ductile to brittle transition temperature (DBTT), Fatigue, Creep.

Materials: Types, Properties of polymer, Application of polymer, Ceramics, Composites, Electronic materials, Magnetic materials

Reading

1. S. H. Avner, Introduction of Physical Metallurgy, Mc-Graw Hill, 1987
2. V. Raghavan, Materials Science and Engineering 4ed., Prentice Hall, 1999
3. G. E. Dieter, Mechanical Metallurgy, Mc-Graw Hill, 1987
4. D.S.Clark and W. Varney, Physical Metallurgy for Engineers 2ed., East-West, 1994

ME201	THERMODYNAMICS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the concepts of continuum, system, control volume, thermodynamic properties, thermodynamic equilibrium, work and heat.
CO2	Apply the laws of thermodynamics to analyze boilers, heat pumps, refrigerators, heat engines, compressors and nozzles.
CO3	Evaluate the performance of steam power cycles.
CO4	Evaluate the available energy and irreversibility.
CO5	Evaluate properties of pure substances and gas mixtures.
CO6	Analyze air standard cycles applied in prime movers.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of the course. Examination and Evaluation patterns. Scope and applications of thermodynamics.

Fundamental Concepts and Definitions: Concept of continuum, microscopic and macroscopic approach, system, control volume, dimensions and units, force, weight, State, path, process, isolated system, adiabatic system, thermodynamic equilibrium, illustrative problems, thermodynamic definition of work, different forms of work, path function, illustrative problems, Heat, temperature and zeroth law of thermodynamics, thermometry, illustrative problems.

First Law of Thermodynamics: First law applied to a system undergoing a cyclic process and a change of state, concept of energy, nature of energy, pure substance, two property rule, numerical problems. First law applied to a control volume, general energy equation, steady flow energy equation on unit mass and time basis, application of SFEE for devices such as boiler, turbine, heat exchangers, pumps, nozzles, etc. Illustrative problems

Second Law of Thermodynamics: Limitations of the first law, definition of a heat engine, heat pump, refrigerator, thermal efficiency and the coefficient of performance. Kelvin-Planck and Clausius statements of the second law, their equivalence, reversible heat engine, Carnot theorems and corollaries. Reversible process, irreversible process, factors responsible for making a process irreversible. Carnot cycle, thermodynamic temperature scale. Entropy, Clausius theorem, Clausius inequality, Principle of increase of entropy, available and unavailable energy, irreversibility, problems. Third law of thermodynamics, absolute entropy

Ideal Gas and Real Gas: Ideal gas, relation among the specific heats, internal energy, enthalpy. Analysis of isochoric, isobaric, isothermal, isentropic, isenthalpic processes, representation of the above processes on P-v, T-s planes. Determination of work, heat, entropy and enthalpy changes during the above processes, problems. Characteristic gas equations of a real gas, virial coefficients, law of corresponding states, compressibility factor, generalized compressibility chart, problems

Ideal Gas Mixtures: Gravimetric and volumetric analysis, Dalton's law, Amagat's law, mole fraction, volume fraction, evaluation of properties of gas mixtures, adiabatic mixing of gases at different temperatures and pressures, non-adiabatic mixing, mixing of gases in steady flow, problems

Steam: Behaviour of pure substance (steam) with reference to T-v, P-T, P-V, P-h & T-s diagrams, Triple and critical points, properties of steam, Quality of steam, its determination using throttling and separating-throttling calorimeters. Steam processes; expressions for the change in internal energy, enthalpy, work, heat, entropy in various processes, Mollier chart, Carnot cycle, Rankine cycle, modified Rankine cycle, illustrative problems.

Airstandard Cycles: Assumptions for air standard cycles, Analysis of Otto, Diesel, Dual combustion, Joule/Brayton cycles, illustrative problems

Reading:

1. P.K.Nag, Engineering Thermodynamics, TMH, New Delhi, 2013
2. G.J.Vanwylen and R.E.Sonntag, Fundamentals of Classical Thermodynamics, Wiley Eastern, New Delhi, 2008
3. Yonus A Cengel and Michale A Boles, Thermodynamics: An Engineering Approach, McGraw Hill, 2002
4. A.Venkatesh, Basic Engineering Thermodynamics, TMH, 2012

ME202	KINEMATICS OF MACHINERY	PCC	3 – 0 – 0	3 Credits

Pre-requisites: CE101: Engineering Mechanics

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

CO1	Understand the principles of kinematic pairs, chains and their classification, DOF, inversions, equivalent chains and planar mechanisms.
CO2	Analyze the planar mechanisms for position, velocity and acceleration.
CO3	Synthesize planar four bar and slider crank mechanisms for specified kinematic conditions.
CO4	Evaluate gear tooth geometry and select appropriate gears for the required applications.
CO5	Design cams and followers for specified motion profiles.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Mechanisms and Inversions: Rigid body, Mechanism and Machine, Kinematic Link, Kinematic Pair, Degrees of Freedom, Classification, Kinematic Chain, Linkage, Mechanism and Structure, Gruebler’s Criterion for degrees of freedom, Mobility, Four Bar mechanism, Slider- Crank mechanism, Kinematic inversions, Double slider-crank mechanism, Inversions

Velocity and Acceleration Analysis: a. Velocity analysis: Instantaneous centre method, Kennedy’s theorem, Locating instantaneous centres, Relative velocity method for slider-crank mechanism, and crank and slotted lever mechanism.

b. Acceleration analysis: Klein’s construction, slider crank mechanism, Coriolis acceleration component, Crank and slotted lever mechanism.

Kinematic Synthesis: Dimensional synthesis, function generation, path generation and motion generation, Synthesis of Four Bar linkage for specified Instantaneous conditions, Hirsch horn’s method of components.

Gears and Gear trains: Classification, Terminology, Law of Gearing, Interferences, methods of avoiding interferences, path of contact, arc of contact.

Simple gear train, compound gear train, reverted gear train, planetary/epicyclic gear train, Sun and planet gear.

Cams: face follower, knife edge follower, Analysis of follower motion.

Reading:

1. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, East West Press Pvt. Ltd., New Delhi (2000)
2. S. S. Rattan, Theory of Machines, 3rd edition, McGraw-Hill Publications, New Delhi (2011)
3. Shigley J. E. and John Joseph Uicker, Theory of Machines and Mechanisms, 2nd edition McGraw-Hill international edition (2003)

CE235	FLUID MECHANICS & HYDRAULIC MACHINES	PCC	3 – 1 – 0	4 Credits

Pre-requisites: None

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

CO1	Apply conservation laws to fluid flow problems in engineering applications.
CO2	Design experimental procedure for physical model studies.
CO3	Design the working proportions of hydraulic machines.
CO4	Compute drag and lift coefficients using the theory of boundary layer flows.
CO5	Analyze and design free surface and pipe flows
CO6	Formulate and solve one dimensional compressible fluid flow problems

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Purpose of study of fluid mechanics for design and operation of engineering systems in the fields of Mechanical Engineering, Aeronautical Engineering, Metallurgical Engineering, Civil Engineering, Biomedical Engineering, Chemical Engineering. Fundamental difference between a solid and fluid, constituent relationships for solids and fluids, conservation principles applied in fluid mechanics

Review of physical meaning of Mathematics necessary for understanding of fluid mechanics, review of analogies in mass transfer and heat transfer

Description of fluid flow: with reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow.

Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.

Continuity equation, Euler's equation of motion, Bernoulli's equation, Impulse momentum equation and applications.

Dimensional Analysis as a tool in design of experiments, identification of non dimensional numbers and their significance, dimensional analysis methods.

Equations of motion for laminar flow of a Newtonian fluid - Viscous flow – Navier-Stoke's equations, simple exact solutions for Hydrodynamic lubrication.

Boundary Layer Theory-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows.

Turbulence, universal velocity distribution laws of turbulence, smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks, Free surface flow.

Compressible flows– Isentropic flows – Adiabatic flow with friction - Frictionless flow with heat addition – Shock waves.

Principles of Hydraulic Turbines – Impulse and Reaction Turbines - Pelton Turbine – Francis Turbine – Kaplan Turbine, working principles, design principles.

Centrifugal pumps – Axial flow pumps, working principles, design principles.

Reading:

1. Introduction to Fluid Mechanics, Robert W. Fax, Philip J. Pritchard, Alan T. McDonald. Wiley India Edition. (Wiley Student Edition Seventh 2011).
2. Fluid Mechanics Franck .M White Tata Mc GrawHill Publication 2011.
3. Shames, "*Mechanics of Fluids*", McGraw Hill Book Co., New Delhi, 1988
4. Streeter V.L., Benjamin Wylie, "*Fluid Mechanics*", Mc Graw Hill Book Co., New Delhi, 1999

CE236	MECHANICS OF SOLIDS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CE101: Engineering Mechanics

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

CO1	Understand statically determinate and indeterminate problems.
CO2	Determine the resistance and deformation in members subjected to axial, flexural and torsional loads.
CO3	Evaluate principal stresses, strains and apply the concept of failure theories for design.
CO4	Analyze and design thin, thick cylinders and springs.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1			2					1
CO2	3	3	2	2			2					1
CO3	3	3	2	1			2					1
CO4	3	3	3	1			2					1

Detailed Syllabus:

Resistance and Deformation: Concept of Resistance and deformation - Determinate and Indeterminate problems in Tension and Compression - Thermal Stresses - pure shear – Young’s modulus of elasticity, Poisson’s ratio, Modulus of rigidity and Bulk modulus - Relation between elastic constants - Stress-strain diagrams for brittle and ductile materials - working stress - Strain energy in tension and compression - Impact loading.

Thin and Thick Cylinders: Thin and Thick Cylinders – spherical shells subjected to internal fluid pressure – Wire wound thin cylinders – Compound cylinders – Shrink fit.

Shear Force And Bending Moment: Types of supports - Types of beams – Types of loads – articulated beams - Shear Force and Bending Moment diagrams.

Theory Of Simple Bending: Assumptions - Bending stresses in beams - Efficiency of various cross sections - Composite beams.

Shear Stress Distribution: Flexural shear stress distribution in different cross sections of beams.

Torsion of Circular cross sections: Theory of pure torsion - transmission of Power in Solid and Hollow circular shafts – Combined bending and torsion.

Principal Stresses and Strains: Analysis of Biaxial state of stress with and without shear - Mohr's Circle

Theories of failure: Dilation – Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.

Deflection Of Beams: Slope and deflection of beams - Double Integration method – Macaulay's method – strain energy method.

Springs: Axial load and torque on helical springs – stresses and deformations – strain energy – compound springs - leaf springs.

Reading

1. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, 2011.
2. E.P.Popov, Engineering Mechanics of Solids, PHI, 2009.
3. S. B. Junarkar, Mechanics of Structures, Charotar Publishers, 2010.

CE237	FLUID MECHANICS & HYDRAULIC MACHINES LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Develop procedure for standardization of experiments.
CO2	Calibrate flow discharge measuring device used in pipes channels and tanks.
CO3	Determine fluid and flow properties.
CO4	Characterize laminar and turbulent flows.
CO5	Compute drag coefficients.
CO6	Test the performance of pumps and turbines.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

a. Calibration of Venturi – Metre, Orifice metre (discharge measuring device in pipes)
b. Calibration of Orifice and mouthpiece (discharge measuring device in Tanks).
c. Calibration of Triangular – Notch and rectangular notch (discharge measuring device in Channels).
d. Measurement of Viscosity of water, SAE – 10 Oil By Hazen Poiseuille method and that of gleserene by Stoke’s method.
e. Determination of Darcy Friction Factor, relative roughness for laminar and turbulent flows.
f. Determination of Manning’s and Chezy’s coefficients for smooth and rough channels by gradually varied flow method.

g. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades and Pelton bucket.
h. Determination of Energy loss in Hydraulic jump.
i. Computation of pressure drag coefficient for flow past a cylinder in a subsonic wind tunnel.
j. Performance Characteristics of single stage centrifugal pump, multi stage centrifugal pump,
k. Submersible pumps, and varying speed centrifugal pump.
l. Performance Characteristics of Pelton turbine, Francis turbine, and Kaplan turbine.

Reading:

1. K.L.Kumar.“Enginering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995

CE238	MATERIAL TESTING LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: CY101: Chemistry

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

CO1	Conduct tension test on steel, aluminium, copper and brass
CO2	Perform compression tests on spring and wood.
CO3	Determine elastic constants using flexural and torsion tests.
CO4	Determine hardness of metals

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2				1	1		1
CO2	3	3	2	2	2				1	1		1
CO3	3	3	2	2	2				1	1		1
CO4	3	3	2	2	2				1	1		1

List of Experiments:

1. To study the stress -strain characteristics of (a) Mild Steel and (b) Tor steel by conducting tension test on U.T.M
2. To study the stress - strain characteristics of (a) Copper and (b) Aluminium by conducting tension test on Hounsfield Tensometer
3. To find the Compressive strength of wood and punching shear strength of G.I. sheet by conducting relevent tests on Housfield Tensometer
4. To find the Brinnell's and Vicker's hardness numbers of (a) Steel (b) Brass (c)Aluminium (d) Copper by conducting hardness test.
5. To determine the Modulus of rigidity by conducting Torsion test on (a) Solid shaft (b) Hollow shaft
6. To find the Modulus of rigidity of the material of a spring by conducting Compression test.
7. To determine the Young's modulus of the material by conducting deflection test on a simply supported beam.
8. To determine the Modulus of elasticity of the material by conducting deflection test on a Propped Cantilever beam.
9. To determine the Modulus of elasticity of the material by conducting deflection test on a continuous beam
10. Ductility test for steel
11. Shear test on Mild Steel rods

MA285	NUMERICAL AND STATISTICAL METHODS	BSC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Estimate chance of occurrence of events by normal distribution.
CO2	Analyze the null hypothesis for large and small number of samples.
CO3	Fit a curve for the given data using least squares method.
CO4	Solve initial value problems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		1	1							1
CO2	3	2		1	1							1
CO3	3	2		1	1							1
CO4	3	2		1	1							1

Detailed Syllabus:

Statistics and Probability: Review of fundamental concepts of probability, Moments and Moment generating function of Discrete and continuous distributions, Binomial, Poisson and Normal distributions, fitting these distributions to the given data, Testing of Hypothesis - Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means, F-test for comparison of variances,. Chi-square test for goodness of fit. – Correlation, regression.

Numerical Analysis: Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves. Calculation of dominant eigen value by iteration, Gauss Seidal iteration method to solve a system of equations and convergence (without proof). Numerical solution of algebraic and transcendental equations by Regula-Falsi method Newton-Raphson's method.

Lagrange interpolation, Newton's divided differences, Forward, backward and central differences, Newton's forward and backward interpolation formulae, Gauss's forward and backward interpolation formulae, Numerical differentiation at the tabulated points with forward backward and central differences. Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule and Romberg integration. Taylor series method, Euler's method, modified Euler's method, Runge-Kutta method of 2^{nd} & 4^{th} orders for solving first order ordinary differential equations.

Reading :

1. S.C.Gupta and V.K.Kapoor, *Fundamentals of Mathematical Statistics*, S.Chand & Co, 2006.
2. Jain, Iyengar and Jain, *Numerical methods for Scientific and Engineering Computation,* New Age International Publications, 2008.
3. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8^{th} Edition, 2008.

EC285	ELECTRONIC MEASUREMENT SYSTEMS	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Handle an instrument and understand the basic calibration, possible errors and measures to minimize them based on their characteristics.
CO2	Acquire knowledge on sensors and their suitability in application of measuring different physical quantities and their ranges.
CO3	Understand the output from different sensors and design a suitable signal conditioning circuits to carry out further analysis.
CO4	Acquire knowledge regarding analog /digital converters and their role in data recording and acquisition systems.
CO5	Understand various display devices, principle of operation and their working.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Measurement, Instrumentation and Calibration: Introduction, Classification of transducers, types of applications of measurement instrumentation, performance characteristics, error in measurements, calibration and standards, static and dynamic characteristics of instrument.

Transducers: Classifications, selection criteria, smart sensors, measurement of displacement, strain, pressure, acceleration, force, torque, temperature, flow, level and miscellaneous measurements.

Signal conditioning circuits: bridge circuits, operational amplifier circuits for signal processing, instrumentation amplifier, filters, recovery of signals.

Data acquisition, Display and recording systems: classification, comparison and characteristics of digital devices, transmission and recording systems, analog to digital convertors, data acquisition systems.

Reading:

1. Transducers and Instrumentation by D.V.S.Murty,PHI.
2. Introduction to measurements and Instrumentation by Arun K Gosh, PHI 2009.

3. Electronic Instrumentation by H S kalsi, 3rd edition, 2011, Mc. Graw Hill pub.
4. Measurement systems by E.O.Deoblin, D N Manik, 5th edition,2007,TMH.
5. Electronic Measurements and Instrumentation by K C Jain, Jain Brothers pub.
6. Introduction to Measurement systems, Beantley.
7. Instrument transducers, K.P. Neubert.
8. Electronic measurements by Terman and Petit.

ME251	TURBOMACHINES	PCC	3 – 1 – 0	4 Credits

Pre-requisites: ME201: Thermodynamics, CE235: Fluid Mechanics and Hydraulic Machines

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

CO1	Apply thermodynamic concepts to analyze turbo machines.
CO2	Analyze power plant and propulsion cycles.
CO3	Analyze impulse and reaction turbo machines for energy transfer.
CO4	Design gas turbine and steam turbine components.
CO5	Evaluate the performance of turbo machine components.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Review of Basics: Introduction to Prime Movers, Gas Turbines, Review of Basic principles – Thermodynamics, Review of Basic principles – Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines – Energy Equation, Dimensional Analysis, Airfoil Theory.

Ideal Gas Turbine Cycles: Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, Inter cooling Cycle.

Practical Gas Turbine Cycles: Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, Efficiencies, change in the composition of the working fluid.

Propulsion Cycles: Jet Propulsion Cycles and their Analysis for turbojet, turboprop and turbofan engines-efficiency and specific thrust Factors Affecting Flight Performance & Methods of Thrust Augmentation.

Centrifugal Compressors: Centrifugal Compressors- Principle of Operation, T-s diagram, Energy equation, velocity triangles, types of blades. Analysis of Flow, Performance Characteristics.

Axial Flow Compressors: Axial Flow Compressors – Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles. Analysis of Flow. Work done factor, Stage efficiency, Degree of reaction, Performance characteristics

Combustion Chambers: Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber, Gas Turbine Combustion Emissions.

Gas Turbines: Axial Flow Gas Turbines – Impulse and reaction Turbines, Single Impulse stage, Single Reaction stage, Performance characteristics.

Rankine Cycle: Properties of Pure Substances, Property diagrams, Steam Power plant Layout, Rankine Cycle- Analysis, Modified Rankine Cycle, Combined Cycle

Steam Nozzles: Steam Nozzles- Introduction, Area- velocity relationship, Mass flow rate, Choking of Nozzles, Performance characteristics of Nozzles, Super saturated flow

Steam Turbines: Steam Turbines – Impulse and reaction Turbines, Compounding of steam turbines, Multistage reaction Turbines, Reheat factor and Efficiency, Governing of Steam Turbines

Reading:

1. Ganesan, V., Gas Turbines 3/e, Tata McGraw Hill Book Company, New Delhi, 2010.
2. Vasandani, V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand and Co Publishers, New Delhi, 2011.
3. Saravanmuttoo, H.I.H., Rogers, G.F.C. and Cohen H., Gas Turbine Theory, 6/e. Pearson Prentice Education, 2008.

ME252	DESIGN OF MACHINE ELEMENTS – I	PCC	3 – 1 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the customers' need, formulate the problem and draw the design specifications.
CO2	Understand component behavior subjected to loads and identify the failure criteria.
CO3	Analyze the stresses and strains induced in a machine element.
CO4	Design a machine component using theories of failure.
CO5	Design keys, cotters, couplings and joints including riveted, bolted and welded joints.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Engineering Design and classification, Basic design procedure, requirement of machine element, traditional design methods, standards and codes, selection of preferred sizes, Engineering material and its classification, Stress-strain curves, ferrous and non ferrous materials, mechanical properties of engg materials, designation of steels, heat treatment of steels, selection of materials. Manufacturing considerations and their selection, hot and cold working of metals, design for manufacture and assembly

Concept of Machine Design: Types of loads, stresses and strain, modes of failure, Principal stresses, theories of failure, Rakine theory, Guests theory, Von Mises theory, selection of failure theories Design of simple machine parts, design of cotter and knuckle joint.

Design of Threaded Joints: Forms of screw threads, nomenclature, thread series, designation, power screws, and advantages over v-threads, stress in screwed threads, bolts of uniform strength, empirical relation for initial tightening, eccentrically loaded riveted joints.

Design of Riveted Joints: Types of rivet joints, rivet heads, terminology, caulking and fullering, analysis, of riveted joint, efficiency of a riveted joint, design of boiler joints and structural joints, eccentrically loaded riveted joints.

Design of Welded Joints: Welding process, merits and demerits of welded joint over riveted joints, Types of welded joints, weld symbols, Strength of parallel and fillet weld, strength of a welded joint - , eccentrically loaded welded joints, weld subject to bending moment, torsional moment.

Reading:

1. Bhandari, V B., Design of Machine Elements, 3/e, Tata McGraw Hill Book Company, New Delhi, 2009.
2. Norton, R. L., Machine Design: An Integrated Approach, 3/e, Pearson, 2004.
3. Shigley, J.E and Mischke, C. R. Mechanical Engineering Design, 6/e, Tata McGraw Hill, 2005.
4. Paul H Black and O. E. Adams, P., Machine Design, 3/e, Mc Graw Hill Book Company, Inc., New York, USA., 2007.
5. Kannaiah, P., Machine Design, 2/e, Scitech Publication Pvt. Ltd., 2009.

ME253	MANUFACTURING TECHNOLOGY	PCC	4 – 0 – 0	4 Credits

Pre-requisites: ME101: Basic Mechanical Engineering, ME102: Engineering Graphics

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

CO1	Select materials, types and allowances of patterns used in casting and analyze the components of moulds.
CO2	Design core, core print and gating system in metal casting processes
CO3	Understand arc, gas, solid state and resistance welding processes.
CO4	Develop process-maps for metal forming processes using plasticity principles
CO5	Identify the effect of process variables to manufacture defect free products.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Engineering materials and its properties, and Classification of manufacturing processes.

Casting: Introduction, Advantages of casting and its applications, Steps involved in making a casting, Patterns and Pattern making: Types of patterns, Materials used for patterns, Pattern allowances, Moulding sand: Molding sand composition, Testing sand properties, Sand preparation, Reclamation of molding sand, Core: Core sands, Types of cores, Core prints, Chaplets, Forces acting on the molding flasks, Principles of Gating, Gating ratio and Design of Gating systems, Core, Core print. Crucible melting and cupola operation, Steel making processes, Charge calculations. Solidification of casting, Concept, Solidification of pure metal and alloys, Short & long freezing range alloys. Risers, Types function and design, Casting design considerations, Special casting processes: Centrifugal, Die, Investment, CO_2 Molding. Casting defects, Causes and remedies.

Welding: Classification of welding process, Arc welding, Weld bead geometry, V-I Characteristic curves of power source , Problems on V-I Characteristic, Shielded metal arc welding, Submerged arc welding, Gas Tungsten arc welding, Gas Metal arc welding. Co_2 welding, Gas welding, Gas cutting, Applications and advantages and disadvantages of the above processes, Resistance welding, Seam welding, Projection welding, Upset welding, and Flash butt welding. Heat affected zones in welding, Methods to minimize HAZ, Soldering & Brazing: Types and its applications, Special welding processes: Thermit welding, Friction welding, Diffusion Bonding, Electron beam welding, and Laser beam welding.

Metal Forming: Nature of plastic deformation, Hot and cold working, Strain hardening, Recovery, Recrystallization and grain growth. Rolling: Principle, Types of rolling mills and products, Roll passes, Forces in rolling and power requirements. Extrusion: Basic extrusion process and its characteristics, Hot extrusion and cold extrusion, Impact extrusion, Hydrostatic extrusion. Forging: Principles of forging, Tools and dies, Types: Smith forging, Drop Forging, Forging hammers, Rotary forging, forging defects. Wire Drawing. Sheet metal forming: Spring back effect, Stamping, Blanking, Bending, Drawing, Piercing, Coining, Embossing, Stretch forming, Hot and cold spinning. Special forming: Hydro forming, High energy rate forming.

Powder metallurgy: Introduction, Production and characterization of powders, Compaction and of metal powders: Die compaction, and Hot Isostatic pressing, Sintering of powder compacts, Post sintering operations, Applications.

Reading:

1. Ghosh, A., and Malik, A. K., Manufacturing Science, Affiliated East west Press Pvt. Ltd., 2008.
2. Rao PN, Manufacturing Technology, 3/e, TMH, New Delhi, 2010.
3. Serope Kalpajian, and Steven R. Schmid, Manufacturing Engineering and Technology, Pearson Education, Inc. 2002(Second Indian Reprint).
4. P.C. Sharma, “A text book of production technology”, S. Chand and Company, IV Edition, 2003

ME254	MACHINE DRAWING	PCC	2 – 0 – 3	4 Credits

Pre-requisites: ME102: Engineering Graphics

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

CO1	Draw the development of surfaces for sheet metal working applications.
CO2	Understand the representation of materials used in machine drawing.
CO3	Draw the machine elements including keys, couplings, cotters, riveted, bolted and welded joints.
CO4	Construct an assembly drawing using part drawings of machine components.
CO5	Represent tolerances and the levels of surface finish of machine elements.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Development of Surfaces: Draw the development of surfaces for Prisms, Cylinders, Pyramids and Cones.

Representation of elements of machine drawing: Engineering Materials, Surface finishes, tolerences, sectional views, Screw threads.

Component Drawings: Bolts and Nuts, Locking devices, Keys and Cotter joints, Knuckle Joint, Revitted joints, Shaft Couplings, Bearings and Pipe joints.

Assembly Drawing Practice: Draw the assembly drawings of Stuffing Box, Pedestal Bearing using the component drawings.

Machine Drawing practice using AutoCAD.

Reading:

1. Bhatt, N.D., Machine Drawing, Charotar Publishing House, 2003.
2. Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., Machine Drawing, Tata McGraw Hill Book Company, New Delhi, 2000.
3. Kannaih, P., Production Drawing, New Age International , 2009

ME255	MANUFACTURING TECHNOLOGY LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: ME253: Manufacturing Technology

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

CO1	Fabricate joints using gas welding and arc welding.
CO2	Evaluate the quality of welded joints using non-destructive testing methods.
CO3	Test the properties of moulding sands.
CO4	Perform injection moulding studies on plastics.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1	1			3	3	1	1
CO2	1	2	1	1	1	1			3	3	1	1
CO3	1	2	2	2	1	1			3	3	1	1
CO4	1	2	2	2	2	2			3	3	1	1

List of Experiments

1. Fabricate the butt joint in the given samples by using shielded metal arc welding in the given samples
2. Fabricate the butt joint in the given samples by using shielded metal submerged arc welding
3. Fabrication of circumferential butt joint in the given samples by using shielded metal arc welding
4. Fabricate the butt joint in the given samples by using gas welding
5. Fabricate the butt joint in the given samplesby using tungsten inert gas welding
6. Fabricate the similar metal plates in the given samples using resistance spot welding
7. Joint the rectangular cross section plates in the given samples by flash butt welding
8. Identification welding defects by liquid penetration test in the welded sample
9. Identification of welding defects by implant testing. In the welded sample
10. Demonstration on sweep pattern and core making in mould prepartion
11. Calculate the amount of the clay content in the given moudling sand
12. Find out the grain fineness number of the given moulding sand

13. Find out the green shear and green compression strength of the given moulding sand
14. Calculate the permeability of the given moulding sand
15. Find out the dry shear and dry compression strength of the given moulding sand
16. Find out shatter index of the given moulding sand
17. Demonstration casting of at least two products.

Reading:

Manufacturing Technology Lab manual

EC286	BASIC ELECTRONICS	ESC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	To get diode, BJT and JFET VI characteristics
CO2	To verify zener diode as regulator and full wave rectifier and filters
CO3	To test single stage BJT amplifier and single stage JFET amplifier
CO4	To check RC phase shift oscillator's performance
CO5	To verify logic gates using 74LS00 IC and op amp as inverting and non-inverting amplifier (µA 741)

Mapping of course outcomes with program outcomes

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

List of Experiments

1. Diode characteristics
2. Zener diode as regulator
3. Full wave rectifier and filters
4. Bipolar junction transistor characteristics
5. Junction field effect transistor characteristics
6. Single stage BJT amplifier
7. RC phase shift oscillator
8. 8. Single stage JFET amplifier
9. Verification of logic gates using 74LS00 IC
10. Op amp as inverting and non-inverting amplifier (µA 741)

ME301	INTERNAL COMBUSTION ENGINES	PCC	3 – 0 – 0	3 Credits

Pre-requisites: ME201: Thermodynamics.

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

CO1	Understand working and performance of IC Engines through thermodynamic cycles.
CO2	Understand combustion phenomena in SI and CI engines and factors influencing combustion chamber design.
CO3	Outline emission formation mechanism of IC engines, its effects and the legislation standards.
CO4	Understand working principles of instrumentation used for engine performance and emission parameters.
CO5	Evaluate methods for improving the IC engine performance.
CO6	Understand the latest developments in IC Engines and alternate fuels.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Classification: Classification based on fuel, working cycle, method of fuel supply. Ignition and Governing. Scavenging of two stroke engines. Fuel – air cycles & actual air cycles and their analysis

Spark Ignition Engines: Flame speed-effect of turbulence and other parameters. Normal and abnormal combustion. Auto ignition and Pre ignition. Fuel requirements, knock ratings, combustion chambers. Carburetion-mixture strength requirements. Simple carburettor-limitations, compensating arrangements. Gasoline injection systems.

Compression Ignition Systems: Low and high speed types.Air utilization and output. Combustion process-Ignition delay. Knocking and effect of variables. Fuel requirements and rating. Combustion chambers. Fuel injection systems.

Super Charging: Types of engine supercharging. Engine supercharging devices. Turbo charging.

Performance of IC Engines: Measurement of engine power, analysis of engine performance. Factors effecting efficiency and power, heat loss, pumping loss. Geometry, Speed, Air/Fuel ratio. Heat balance test. BIS standards for testing and rating.

Modern Developments: Wankel engine. Stratified charge engine. Dual-fuel engines. HCCI-concept.

Engine Emissions: SI and CI engine emissions. Harmful effects. Emissions measurement methods. Methods for controlling emissions. EURO and BHARAT emission norms.

Alternate Fuels For IC Engines: Need for use of alternate fuels. Use of alcohol fuels. Biodiesel. Biogas and Hydrogen in engines.

Reading:

1. Ganesan,V., Internal Combustion Engines, Tata McGraw Hill Publishing Company, 2007.
2. Mathur, M.L., and Sharma, R.P., A Course in Internal Combustion Engines, Dhanpat Rai and Sons, 2008.
3. John, B.H., Internal Combustion Engine Fundamentals, McGraw Hill, 1988.

ME302	**DYNAMICS OF MACHINERY**	**PCC**	**3 – 1 – 0**	**4 Credits**

Pre-requisites: None

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

CO1	Understand free and forced vibrations of single degree freedom systems.
CO2	Analyze balancing problems in rotating and reciprocating machinery.
CO3	Characterize and design flywheels.
CO4	Understand the gyroscopic effects in ships, aero planes and road vehicles.
CO5	Analyze and design centrifugal governors.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Vibrations: What are vibrations? Are vibrations harmful or useful? Essential elements of a vibrating system. Free vibrations of undamped system. Drawing free body diagrams and deriving equations of motion. Properties of simple harmonic motion. Introducing the term *natural frequency*. Applications of energy methods, namely, energy method and Rayleigh's method. Studying the effect of parameters on vibrations. Practical Examples.

Introducing different kinds of excitations. Study of vibrations of undamped system under harmonic excitation. Effect of frequency of excitation on the amplitude of vibrations. Magnification Factor. Practical examples. Resonance. Vibrations under resonance.

How a damper works? Study of free vibrations of spring mass damper system. Concepts of critical damping coefficient and damping factor. Under damping, critical damping and over damping. What do they mean physically? Practical examples.

Vibrations of spring mass damper system under harmonic excitation. Magnification Factor. Phase difference between excitation and motion. Dependence of Magnification Factor and Phase difference on frequency of excitation. Vectorial representation of forces in a vibrating system. Physical reasoning of effect of various elements in the system. Use of complex vector in vibration problems.

Study of problem of rotating unbalance. Problem of whirling of shafts. Critical speed and its practical importance in the design of shafts. Application of Dunkerley's method and Rayleigh's method for estimating the critical speed of shafts. Problem of vibration isolation. Practical problems.

Multi degree freedom systems and analysis. Free vibrations. Concepts of normal mode vibrations, natural frequencies, mode shapes, nodes. Correct definition of natural frequency.

Balancing:Balancing problem. Rotor balancing problem. Single plane and two plane balancing. Unbalanced forces and couples. Static and dynamic balancing. Balancing of rotors by analytical method and graphical method. Balancing machines.

Flywheels: Purpose of flywheel. Working principle of flywheel. Concept of dynamically equivalent link. Force analysis of single slider crank mechanism. Turning moment on the crank shaft. Turning moment diagrams. Maximum fluctuation of energy and its determination. Coefficient of fluctuation of speed. Design of flywheels. Rim type flywheel versus solid type flywheel.

Gyroscope: What is a gyro? Principle of gyroscope. Roll, Yaw and pitch motions. Practical problems. Gyroscopic effect in a two wheeler, car, ship and aeroplane.

Governors: Necessity of governor. Flywheels versus Governors. Different types of governors. Working principle of centrifugal governors. Concept of control force. Control force diagram. Definition of stability of governor. Condition for stability. Concept of isochronism. Sensitivity of governor. Energy of governor. Gravity controlled and spring controlled governors. Characteristics of Watt governor, Porter governor, Proell governor, Hartnell governor, Hartung governor. Hunting of governors.

Reading:

1. Shigley, J.E., and Uicker, J.J., Theory of Machines and Mechanisms, McGraw Hill International Editions, New York, Edition II, 2003.
2. Norton, R.L., Design of Machinery – An introduction to Synthesis and Analysis of Mechanisms and Machines, McGraw Hill International Editions, New York, Edition II, 2000.

ME303	MACHINE TOOLS AND METROLOGY	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand working of lathe, shaper, planer, drilling, milling and grinding machines.
CO2	Comprehend speed and feed mechanisms of machine tools.
CO3	Estimate machining times for machining operations on machine tools
CO4	Identify techniques to minimize the errors in measurement.
CO5	Identify methods and devices for measurement of length, angle, gear & thread parameters, surface roughness and geometric features of parts.
CO6	Design the limit gauges.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Machine Tools

Generatrix and Directrix, Elements of M/C Tools, M/C Tool drives, Classification of Machine Tools

Lathe: Types, Parts, Feed Mechanisms, Specifications of lathe, Lathe Operations, Accessories and Attachments, Machining time estimation

Shaper and Planer: Types, Specifications, Crank and slotted link mechanism, Stroke length and position adjustments, Automatic feed mechanisms, Shaper Vs Planer, Machining time estimation

Drilling: Operations, Types, Mechanisms, Nomenclature of a drill, Machining time estimation

Milling: Types, Up Milling Vs Down Milling, Types of milling cutters, Operations, Machining time estimation, Dividing head

Grinding: Specification and selection of grinding wheels, Truing, Dressing, Classification of Grinding wheels

Finishing Processes: Lapping, Honing and Super-finishing processes

Metrology

General Concepts: Generalized measurement system, Basic terminology, Errors in Measurement

Linear and Angular Measurements: Length Measuring Instruments, Angle measuring instruments

Limits, Fits, Tolerances and Gauging: Interchangeability, Terminology, Types of fit, Basic-Hole System, Basic-Shaft System, Problems, Tolerance grades, Metric fits, Design of limit gauges

Comparators: Mechanical, Pneumatic, optical, electrical and electronic comparators

Gear and Screw Thread Measurements: Gear measurement: Introduction and Classification of gears; Forms of gear teeth; Gear tooth terminology; Methods of measuring tooth thickness, tooth profile & pitch, Gear Errors; Screw Thread Measurement: Terminology, Forms of thread, Errors in threads, Measurement of major, minor and effective diameters (2-wire and 3-wire methods)

Surface Roughness Measurement: Components of surface texture, Need for surface roughness measurement, Measurement of surface roughness, Roughness characterization, Roughness grades.

Geometric Form Measurement: Straightness, Flatness, Roundness, Coordinate Measuring Machine.

Reading:

1. Kalpakjian, S. and Steven R. Schmid*, Manufacturing, Engineering & Technology*, Pearson.
2. Rao, P.N., *Manufacturing Technology–Metal Cutting and Machine Tools*, Tata McGraw Hill, New Delhi, 2000.
3. Hajra Chowdary, S.K., and Hajra Chowdary, A.K., *Elements of Workshop Technology*, Vol. II, Asia Publishing House, Bombay, 2003.
4. I.C. Gupta, *Engineering Metrology,* Dhanpat Rai & Sons, 2003
5. R. K. Jain, *Engineering Metrology*, Khanna Publishers, 19/e, 2005.

ME304	MANAGEMENT SCIENCE AND PRODUCTIVITY	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand the evolutionary development of management thought and general principles of management.
CO2	Apply marketing concepts and tools for successful launch of a product.
CO3	Understand the role of productivity in streamlining a production system.
CO4	Apply the inventory management tools in managing inventory.
CO5	Apply quality engineering tools to the design of products and process controls.
CO6	Apply project management tools to manage projects.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

General Management: Introduction of the course, Evolution of industry and professional management, Functions of Management, Organization Structures, Hawthorne Experiments, Motivational Theories and Leadership Styles, American and Japanese Style of Management.

Marketing Management: Marketing management process, 4 P's of marketing mix, Target marketing, Product Life Cycle and marketing strategies.

Production Management: Production systems classification and characterization, Production strategies, Process management, Facility Design.

Productivity and Workstudy: Productivity and its role in the economy, Techniques for improving productivity, Method study, Principles of motion economy, Stop watch time study, Work sampling.

Quality Management: Dimensions of quality, Process control charts, Acceptance sampling, Taguchi's total quality control, Quality function deployment, Introduction to TQM.

Inventory Management: Purpose of inventories, Inventory costs, ABC classification, Economic Order Quantity (EOQ), P and Q systems of inventory control.

Project Management: Project activities, Network diagrams, Critical path method, PERT, Project Feasibility Studies.

Reading:

1. Koontz H and Weihrich H, *Essentials of Management*, 7th Ed., McGraw-Hill , New York 2007.
2. Kotler P, *Marketing Management*, 13th Ed., Prentice Hall of India/Pearson, New Delhi 2009.
3. Chase, Shankar, Jacobs and Aquilano, *Operations and Supply Management*, 12th Ed., Tata McGraw Hill, New Delhi 2010.

ME305	MECHANICAL MEASUREMENTS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Estimate errors and uncertainty in measurements using statistical analysis.
CO2	Understand working principles in the measurement of field quantities.
CO3	Identify sensors for measurement of vibration, thermo-physical properties and radiation properties of surfaces.
CO4	Understand the conceptual development of zero, first and second order systems.
CO5	Interpret International Standards of measurements (ITS-90) and identify Internationally accepted measuring standards for measurands.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction

Presentation of experimental data: Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis.

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers

Thermometry: Overview of thermometry, Thermoelectric temperature measurement, Resistance thermometry, Pyrometer, Other methods, issues in measurements.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods.

Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, etc.

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.

Other measurements: Basics in measurement of torque, force, strain

Advanced topics: Issues in measuring thermo physical properties of micro and Nano fluidics

Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS

Reading:

1. Mechanical Measurements by Thomas G Beckwith, Pearson publications
2. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications
3. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications.

ME306	THERMAL ENGINEERING LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Conduct constant speed and variable speed tests on IC engines and interpret their performance.
CO2	Estimate energy distribution by conducting heat balance test on IC engines
CO3	Evaluate performance parameters of steam power plant.
CO4	Determine performance parameters of refrigeration and air-conditioning systems.
CO5	Evaluate the performance of turbomachines.

Mapping of course outcomes with program outcomes

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

List of Experiments:

1. Performance test on twin cylinder air cooled diesel engine
2. Valve timing diagram
3. Retardation test on Kirloskar diesel engine
4. Performance characteristics of an Axial flow fan
5. Morse Test on Hindustan Engine
6. Performance characteristics of a single stage centrifugal blower
7. Heat balance test on Kirloskar engine
8. Performance test on single cylinder SI engine
9. Load test on Steam turbine
10. Test on steam condenser
11. Steam Calorimeter
12. Demonstration of boiler

Reading:

1. Vasandani V.P. and Kumar, D.S., *Treatise on Heat Engineering*, Chand & Co Publishers, New Delhi, 2011.
2. Ganesan, V., Gas Turbines 3rd Edition, Tata McGraw Hill Book Company, New Delhi, 2010.
3. Mathur, M.L., and Sharma, R.P., A Course in Internal Combustion Engines, Dhanpat Rai and Sons, 2008.

ME307	DYNAMICS AND MEASUREMENTS LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Characterize and calibrate measuring devices.
CO2	Identify and analyze errors in measurement.
CO3	Analyze measured data using regression analysis.
CO4	Measure balancing parameters of rotors
CO5	Measure vibration parameters in single degree freedom systems.

Mapping of course outcomes with program outcomes

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

List of Experiments:

Dynamics Laboratory:

1. To estimate the acceleration due to gravity using bifilar pendulum.
2. To determine the mass moment of inertia of a given object using a trifilar pendulum.
3. To verify the natural frequency of a bar resting on a cylindrical surface.
4. To verify the natural frequency of a semi cylindrical shell resting on a horizontal surface.
5. To find the location of center of mass and the moment of inertia of a given connecting rod.
6. To determine the viscous damping coefficient by direct merthod
7. To estimate the damping using logarithmic decrement.
8. To determine the damping coefficient of a viscous damper in a spring mass damper system.
9. To determine the coefficient of friction using a vibrating system involving coulomb damping.

10. To determine the natural frequencies of a coupled pendulum.
11. To get exposed to rotor balancing machine.
12. To physically experience the gyroscopic effect.

Measurements Laboratory:

1. To Calibrate Bourdon pressure gauge using Dead weight pressure gauge.
2. To determine the mass flow rate of air using hot wire anemometer and orifice meter.
3. To demonstrate working principle of LVDT and compare with micro meter.
4. To verify the pressure reading recorded by electronic transducer and Bourdon gauge and regression analysis.
5. To compare the temperature reading recorded by thermocouples, RTD, thermometers.
6. To demonstrate the working of IR thermal transducer and recording high temperatures.
7. To estimate the Relative Humidity.
8. To do statistical analysis on load cell test rig.
9. To demonstrate torque measurement and do regression analysis.
10. To Demonstrate DAS .

Reading:

1. Mechanical Measurements by Thomas G Beckwith, Pearson publications
2. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications
3. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications.

ME311	ADVANCED THERMODYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME201: Thermodynamics.

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

CO1	Understand Maxwell's and thermodynamic relations of gas mixtures.
CO2	Estimate thermodynamic properties of gas mixtures.
CO3	Identify the models to estimate the properties of real gases.
CO4	Analyse reactive and non-reactive gas mixtures using the concepts of statistical thermodynamics and kinetic theory of gases.
CO5	Analyze chemical reaction and combustion of gas-mixtures.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Revision of Thermodynamics: I Law of Thermodynamics, II Law of Thermodynamics, Entropy, Availability

Properties of Gases and Gas Mixtures: Equations of State, changes in internal energy, enthalpy and entropy for an ideal gas, Equations of state for a real gas, Virial Expansions, Law of Corresponding States, Generalized Compressibility Chart, Reduced coordinates, Other Equations of state, Dalton's Law of Partial Pressures, Internal Energy, Enthalpy and Entropy and Specific Heats of Gas Mixtures, Gibbs Function of a Mixture.

Thermodynamic Relations: Some Mathematical Theorems, Maxwell's Relations, T-ds Equations, Difference in Heat Capacities, Ratio of Heat Capacities, Energy Equation, Claussius-Clapeyron Equation, Joule-Thomson Coefficient, Evaluation of Thermodynamic Properties from Equation of State, Mixtures of Variable Composition, Conditions of Equilibrium for a Heterogeneous System, Gibbs Phase Rule, Types of Equilibrium, Conditions of Stability, Third Law of Thermodynamics.

Reactive Mixtures: Degree of Reaction, Reaction Equilibrium, Equilibrium Constant, Law of Mass Action, Thermal Ionization of Monatomic Gas, Gibbs Function Change, Fugacity and Activity, Enthalpy of Formation, Enthalpy of Combustion, Heating Values, Adiabatic Flame

Temperature, Second Law Analysis of reactive Systems, Chemical Exergy, Second Law Efficiency.

Statistical Thermodynamics: Quantum Hypothesis, Quantum Principle Applied to a System of Particles, Wave-Particle Duality, De Broglie Equation, Heisenberg's Uncertainty Principle, Schrodinger's Wave Equation, Probability Function, Particle in a Box, Rigid Rotator, Harmonic Oscillator, Phase Space, Maxwell-Boltzmann Statistics, Stirling's Approximation, Bose-Einstein Statistics, Fermi-Dirac Statistics, Partition Function, Entropy and Probability, Monatomic Ideal Gas, Principle of Equi-partition of Energy, Statistics of a photon gas, Electron Gas, Thermodynamic Properties.

Kinetic Theory of Gases: Molecular Model, Distribution of Molecular Velocities, Molecular Collisions with a Stationary Wall, Maxwell-Boltzmann Velocity Distribution, Average, Root-Mean Square and Most Probable Speeds, Molecules in a Certain Speed Range, Energy Distribution Function, Specific Heat of a Gas, Specific Heat of a Solid.

Transport Processes in Gases: Mean Free Path and Collision Cross-section, Distribution of Free Paths, Transport Properties.

Reading:

1. Cengel, Y.A & Boles, M.A., *Thermodynamics-An Engineering Approach*, TMH, 2011.
2. Borgnakke, C & Sonntag, R.E., Fundamentals *of Thermodynamics*, Wiley, 2009.
3. Nag, P.K., *Basic and Applied Thermodynamics*, TMH, 2009.
4. Smith, J.M. etal, *Introduction to Chemical Engineering Thermodynamics*, TMH, 2005.
5. Mcquarrie, D.A., and Simon, J.D., *Molecular Thermodynamics*, Viva Books, 2004.

ME318	FINITE ELEMENT METHOD	DEC	3 – 0 – 0	3 Credits

Pre-requisites: CE236: Mechanics of Solids

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

CO1	Apply finite element method to solve problems in solid mechanics, fluid mechanics and heat transfer.
CO2	Formulate and solve problems in one dimensional structures including trusses, beams and frames.
CO3	Formulate FE characteristic equations for two dimensional elements and analyze plain stress, plain strain, axi-symmetric and plate bending problems.
CO4	Implement *and* solve the finite element formulations using MATLAB.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2			3				1	1		1
CO2	3	3	1	1	3							
CO3	3	3	1	1	3							
CO4	1	2			3		2					2

Detailed Syllabus:

Introduction: Historical Perspective of FEM and applicability to mechanical engineering problems.

Mathematical Models and Approximations: Review of elasticity, mathematical models for structural problems, Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation, Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models; Ritz, Rayleigh-Ritz and Gelarkin's methods. Philosophy and general process of Finite Element method.

Finite Element Formulation: Concept of discretisation, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility, Assembly and boundary considerations.

Finite element Method in One Dimensional Structural problems: 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, interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations.

Two dimensional Problems: 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, subparametric, Isoparametric and superparametric elements. General considerations in finite element analysis of two dimension problems. Introduction plate bending elements and shell elements.

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.

Dynamic Analysis: 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.

FEM in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Finite element applications in one dimensional potential flows; Formulation based on Potential function and stream function.

Algorithmic Approach for problem solving: Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions. Guidelines for code development. Introduction to commercial FE packages.

Reading:

1. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. Singiresu S.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012
4. Zeincowicz, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.

ME325	ADVANCED WELDING TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand solid state welding processes and applications.
CO2	Identify suitable reinforcement and matrix materials for preparation of composites using friction stir processing.
CO3	Understand basic principle of electron beam and laser beam processes and its application.
CO4	Understand weldability of cast iron and high carbon steel.
CO5	Select welding power sources.
CO6	Understand the importance of grain growth mechanism and related properties.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Solid state welding: classification of solid state welding processes, Adhesive bonding , advantages and applications.

Friction welding: Friction welding process variables, welding of similar and dissimilar materiasl, Defective analysis of friction welded components, Friction welding of materials with inter layer.

Friction stir welding: Processes parameters, tool geometry, welding of Aluminium alloys, Friction stir welding of Aluminum alloys and Magnesium alloys.

Electron Beam welding (EBW): Electron Beam welding process parameters, atmospheric affect Defective analysis of Electron beam welds and Electron Beam welding dissimilar materials.

Laser Beam welding (LBW): Laser Beam welding process parameters, atmospheric affect and Laser Beam welding of steels.

Selection power source : Constant voltage and constant current power sources.

Weldability of cast iron and steel : weldability studies of cast iron and steel,

Reading:

1. Nadkarni S.V., *Modern Welding Technology*, Oxford IBH Publishers, 1996.
2. Parmar R. S., *Welding Engineering and Technology*, Khanna Publishers, 2005.
3. D. L. Olson, T. A. Siewert, *Metal Hand Book, Vol 06, Welding, Brazing and Soldering*, ASM International Hand book Metals Park, Ohio USA, 2008.

ME326	ADVANCED METAL CASTING AND NDT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME253: Manufacturing Technology

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

CO1	Understand basics of metal casting, casting defects and remedies.
CO2	Identify casting features, modeling techniques, graphical user interface and exchange formats.
CO3	Design gating system for metal casting processes
CO4	Perform economic and castability analysis using Auto-CAST software.
CO5	Apply NDT techniques to identify the casting defects.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Metal casting-overview: Applications and production, historical perspective, casting processes.

Solid modeling of castings: casting features, modeling techniques, graphical user interface, model representation model exchange formats, model verification.

Pattern, mould and core design: Orientation and parting, mould parting analysis, pattern design, cored features, core print design and analysis, mould cavity layout.

Feeder design and analysis: Casting solidification, solidification time and rate, feeder location and shape, feeder and neck design, feed aid design, solidification analysis, vector element method, optimization and validation.

Gating design and analysis: Mould filling, gating system and types, gating channel layout, optimal filling time, gating element design, mould filling analysis, numerical simulation, optimization and validation.

Process planning and costing: Casting process selection, process steps and parameters, tooling cost estimation, material cost estimation, and conversion cost estimation.

Design for castability: Product design for castability, process friendly design, and castability analysis.

Non-Destructive testing

Liquid penetrant test: Physical Principles, Procedure for penetrant testing, Penetrant testing methods, sensitivity, Applications and limitations. Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Applications of ultrasonic testing, Advantages and limitations. Thermography: Basic principles, Detectors and equipment, techniques, application

Radiography: Basic principle, Electromagnetic radiation sources, radiographic imaging Inspection techniques, applications, limitations, typical examples. Eddy current test: Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations. Acoustic emission: Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection

Reading:

1. Practical Non-Destructive testing- Baldev Raj, T.Jaya Kumar et.al.
2. B.Ram Prakash, ISO9000 and NDE Vol.2, interline publishing, 1993
3. NDT-Hand book
4.Metal casting: CAD and Analysis by B.Ravi –PH Publication.
5.Foundry Technology by P.L.Jain

ME332	OPERATIONS RESEARCH	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the concepts of operations research modelling approaches.
CO2	Formulate and solve engineering and managerial situations as LPP.
CO3	Formulate and solve engineering and managerial situations as Transportation and Assignment problems.
CO4	Formulate multi-stage applications into a dynamic programming framework.
CO5	Solve Integer programming problems.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Historical overview of operations research, fundamentals of OR Modelling Approach.

Linear Programming: Basic assumptions, formulation, graphical method, simplex method, duality theory, primal-dual relationships, sensitivity analysis.

Transportation and Assignment Problems: Specific features of transportation problem, streamlined simplex method for solving transportation problems, special features of assignment problems, Hungarian method for solving assignment problems.

Dynamic Programming: Characteristics, principle of optimality, solution procedure, deterministic problems.

Integer programming: Special features, binary integer programming models, branch-and-bound technique, cutting-plane method, introduction to nonlinear programming.

Reading:

1. Taha H.A., *Operations Research*, 9th Edition, Prentice Hall of India, New Delhi, 2010.
2. Kanti Swarup., Man Mohan., and Gupta, P.K., *Introduction to Operations Research*, 7th Edition, Sultan chand & Sons, New Delhi, 2005.
3. Hillier, F.S., and Lieberman G.J., *Introduction to Operations Research*, 7th Edition, TMH, 2009.

SM335	ENGINEERING ECONOMICS AND ACCOUNTANCY	HSC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Prepare accounting records and summarize and interpret the accounting data for managerial decisions.
CO2	Understand the macro-economic environment of the business and its impact on enterprise.
CO3	Understand cost elements of the product and its effect on decision making.
CO4	Understand the concepts of financial management and smart investment.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3			2	2	2		1	2	1
CO2	1	2	3			2	2	2		1	2	1
CO3	1	2	3			2	2	2		2	2	1
CO4	1	2	3			2	2	2		2	2	1

Detailed Syllabus:

Engineering Economics: Introduction to Engineering Economics – Fundamental concepts – Time value of money – Cash flow and Time Diagrams – Choosing between alternative investment proposals – Methods of Economic analysis. The effect of borrowing on investment- Various concepts of National Income – Significance of National Income estimation and its limitations, Inflation –Definition – Process and Theories of Inflation and measures to control, New Economic Policy 1991 – Impact on industry.

Accountancy: Accounting Principles, Procedure – Double entry system – Journal – Ledger, Trail Balance – Cash Book – Preparation of Trading, Profit and Loss Account – Balance sheet.

Cost Accounting – Introduction – Classification of costs – Methods of costing – Techniques of costing – Cost sheet and preparation of cost sheet- Breakeven Analysis – Meaning and its application, Limitations.

Reading:

1. Henry Malcom Stenar-Engineering Economic Principles, McGraw Hill Pub.
2. Dewett K.K., “Modern Economic Theory”, Siltan Chand & Co.
3. Agrawal AN,”Indian Economy” Wiley Eastern Ltd, New Delhi
4. Jain and Narang “Accounting Part-I’, Kalyani Publishers
5. Arora, M.N. “Cost Accounting”, Vikas Publications.

ME351	HEAT AND MASS TRANSFER	PCC	3 – 1 – 0	4 Credits

Pre-requisites: ME201: Thermodynamics

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

CO1	Understand the basic modes of heat transfer.
CO2	Compute temperature distribution in steady-state and unsteady-state heat conduction.
CO3	Understand and analyse heat transfer through extended surfaces.
CO4	Interpret and analyze forced and free convection heat transfer.
CO5	Understand the principles of radiation heat transfer and basics of mass transfer.
CO6	Design heat exchangers using LMTD and NTU methods.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Heat Transfer – Different Modes, Governing Laws, Applications to Heat Transfer, Simple Problems pertaining to the above.

General Heat Conduction Equation: Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel, Various Numerical Problems concerned to the above.

Steady-state radial heat conduction problems in Polar System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cylindrical system with various possible boundary conditions, Thermal Resistances in Series, Various Numerical Problems concerned to the above.

Steady-state radial heat conduction problems in Spherical System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Spherical system with various possible boundary conditions, Thermal Resistances in Series, Various Numerical Problems concerned to the above.

Critical Thickness of Insulation: Concept, Derivation and Numerical Problems

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications, Numerical Problems covering all the topics.

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts: Solutions to various one-dimensional problems using the charts, Numerical problems.

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Numerical Problems, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions, Numerical Problems.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions, Numerical Problems.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, View factor algebra, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield, Numerical problems on all the above topics.

Heat Exchangers: Definition, Classification, LMTD method, Effectiveness - NTU method, Analytical Methods, Numerical Problems, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts, Numerical Problems.

Mass Transfer: Definition, Examples, Fick's law of diffusion, Fick's law as referred to ideal gases, Steady-state equi-molal counter diffusion of ideal gases, Mass diffusivity.

Reading:

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.
4. Alan J. Chapman, Heat Transfer, 4th Edition, Macmillan, New York, 1987.

ME352	DESIGN OF MACHINE ELEMENTS-II	PCC	3 – 1 – 0	4 Credits

Pre-requisites: ME252: Design of Machine Elements – 1

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

CO1	Understand the concepts of principal stresses, theories of failure, stress concentration and fatigue loading.
CO2	Design shafts, couplings and gears.
CO3	Analyze the pressure distribution and design journal bearings.
CO4	Design belts, springs, brakes, clutches and engine parts.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1			2				2
CO2	3	3	2	2	2							2
CO3	3	3	2	3	2							2
CO4	3	3	3	2	2							2

Detailed Syllabus:

Introduction: What is Design? Examples to explain the process of design. Review of fundamental concepts such as different types of loading, column buckling, Impact loading, principle stresses, theories of failure.

What is stress concentration? Importance in design. How stress concentration leads to failure? How stress concentration is accounted for in the design. Stress concentration factors. Theoretical and actual stress concentration factors. Notch sensitivity. Ductile and Brittle materials.

Dynamic loading. Practical examples. S – N curve. Definition of endurance limit. Gerber's Parabola, Goodman's line, Soderberg Line and the Line of safe stress. How machine elements are designed under dynamic loading.

Shafts and Couplings:Types of loading on shafts. Causes of stress concentration in shafts. Design of shafts based on strength. Design of shafts based on rigidity. Use of fatigue and stress concentration factors. Practical examples.

Purpose of shaft couplings. Different types of couplings. Different types of keys. Design of a sunk key. Design of muff coupling. Design if split muff coupling. Design of flanged coupling. Various constructional features. Flexible couplings and their design.

Gears:Standard system of gears. Standard modules. Stresses produced in a gear tooth. Concept of uniform strength beam. Shape of uniform strength cantilever beam with point load at its free end. Lewis equation. Proportions of gear tooth. Design of gear tooth based on strength.

Checking the design under dynamic loading conditions and wear loading conditions. Buckingham equations 1 and 2. Flexural endurance limit and surface endurance limit. Surface hardness and heat treatment process.

Bearings: Conditions of proper lubrication. Mechanism of dry friction. Petroff's law. Assumptions involved in Petrof's law. Hydrodynamic lubrication. Practical examples. How do hydrodynamic conditions develop in a bearing? McKeey's equation. Thick and thin film lubrications. Stability of lubrication. Bearing modulus. Heat balance in journal bearing. Design of journal bearings. Sommerfeld number. Introducing hydrostatic bearings. Introducing magnetic bearings.

Antifriction bearings. Advantages and disadvantages. Different types of antifriction bearings. A qualitative comparison of performance of antifriction bearings with journal bearings. Basic static and basic dynamic load ratings. Equivalent radial load. Selection of bearings from manufacturers catalogue.

Belts: Belts and their construction. Flat belts versus V- belts. Open and cross belt arrangement. Ratio of tensions. Centrifugal tension. Effect of centrifugal tension. Design of belts. Practical examples.

Rope drives. Constructional features of a rope. Specification of a rope. Chain drive, its merits and demerits. Constructional features of a chain drive.

Brakes:Different types of brakes. Concept of self energizing and self locking of braked. Practical examples. Band and block brakes.

Clutches:Necessity of a clutch in an automobile. Design of clutch. Uniform pressure and uniform wear.

Engine parts: Design of engine parts such as Piston, Connecting rod, Crank shaft, Clutches.

Reading:

1. Shigley, J.E., and Mischke, C.R., *Mechanical Engineering Design*, McGraw Hill International Editions, New York, Edition VI, 2003.
2. Norton, R.L., *Design of Machinery – An introduction to Synthesis and Analysis of Mechanisms and Machines*, McGraw Hill International Editions, New York, Edition II, 2002.
3. Black and Adams, *Machine Design*, McGraw Hill and Co, New Delhi, 2002.

ME353	MACHINING SCIENCE	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MM235: Materials Engineering, ME303: Machine Tools and Metrology, ME305: Mechanical Measurements

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

CO1	Understand ASA and ORS systems of tool geometry and their inter-relations.
CO2	Develop relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperature in orthogonal cutting.
CO3	Select cutting fluids, tool materials and coatings to control tool wear and temperature.
CO4	Evaluate cutting speed to minimize production cost and maximize production rate.
CO5	Understand the working principles, applications and importance of modern machining processes.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, Classification of Mfg. Processes, History of Machining, Scope and Significance of Machining

Geometry of Cutting Tools: Geometry of single-point turning tool: Tool-in hand system, ASA system, Significance of various angles of SPTT, Orthogonal Rake System (ORS), Normal Rake System (NRS), Conversions between ASA and ORS systems

Mechanics of Machining: Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built-Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Effect of tool geometry on cutting forces and surface finish

Thermal aspects in machining: Sources of heat generation, Effects of temperature, Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature.

Tool wear, Tool life, Machinabilty: Wear Mechanisms, Types of tool wear, Tool Life and Machinability

Machining Economics: A brief treatment for single pass turning operations

Cutting Tool Materials: Desirable Properties of tool materials, Characteristics of Cutting Tool Materials, Indexable inserts, Coated tools,

Cutting Fluids: Functions, characteristics and types, Selection of cutting fluids

Mechanics of Multipoint machining processes: Mechanics of Milling process, Mechanics of Grinding (plunge grinding and surface grinding)

Modern Machining Processes: An overview of modern machining processes – Classification, Mechanical Processes – Ultrasonic, water jet and abrasive jet machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electrochemical Processes – Chemical machining, electro chemical machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electric Discharge Machining (sinking EDM and Wire cut EDM) - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Plasma Arc Machining, Electron Beam Machining, Ion Beam Machining, Laser Beam Machining

Reading:

1. Kalpakjian, S. and Steven R. Schmid*, Manufacturing, Engineering & Technology*, Pearson, 2007
2. P. C. Pandey and H. S. Shan, *Modern Machining Processes,* TMH, 2002.
3. Amitabha Ghosh and Mallik, *Manufacturing Science*, East-West Press, 1985
4. V. K. Jain, *Advanced manufacturing Processes*, Allied Publishers Pvt. Ltd, 2002

ME354	HEAT TRANSFER AND FUELS LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: ME201: Thermodynamics

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

CO1	Measure important properties of fuels and oils.
CO2	Evaluate the variation of volumetric efficiency of a two-stage reciprocating air compressor as a function of receiver pressure.
CO3	Estimate heat transfer coefficient in forced convection.
CO4	Measure heat transfer coefficient in free convection and correlate with theoretical values.
CO5	Estimate the effective thermal resistance in composite slabs and efficiency in pin-fins.
CO6	Determine surface emissivity of a test plate.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Abel's apparatus: Determination of flash and fire points of a given oil sample

Redwood Viscometer No. 1: Determination of kinematic and absolute viscosities of an oil sample given

Distillation apparatus: Determination of distillation characteristic of a given sample of gasoline

Two-Stage Reciprocating Air-Compressor: Determination of volumetric efficiency of the compressor as a function of receiver pressure

Pin-Fin Apparatus: Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment

Natural Convection Apparatus: Determination of experimental and empirical values of convection heat transfer coefficient from a Vertical Heated Cylinder losing heat to quiescent air

Composite Slab Apparatus: Determination of theoretical end experimental values of equivalent thermal resistance of a composite slab

Forced Convection Apparatus: Determination of theoretical, experimental and empirical values of convection heat transfer coefficient for internal forced convection through a circular GI pipe

Emissivity Apparatus: Determination of surface emissivity of a given aluminium test plate at a given absolute temperature

Heat Pipe Demonstrator: Demonstration of near isothermal characteristic exhibited by a heat pipe in comparison to stainless steel and copper pipes

Reading:

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

ME355	MACHINING AND METROLOGY LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: ME303: Machine Tools and Metrology, ME353: Machining Science

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

CO1	Perform plain turning, step turning, knurling, threading, eccentric turning, chamfering and facing operations on a lathe.
CO2	Estimate the chip reduction coefficient and shear angle on a shaping machine.
CO3	Drill holes and produce internal threads.
CO4	Machine spur and helical gears on a milling machine.
CO5	Prepare setups and measure dimensional and geometrical features of components.
CO6	Measure surface roughness of components.

Mapping of course outcomes with program outcomes

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

List of Experiments:

Machining Cycle

1. Thread cutting and chamfering on lathe *(Demo: Split-half nut)*
2. Eccentric turning *(Demo: Different types of chucks, Belt, Chain and Gear drives)*
3. Spur Gear and Helical milling *(Demo: Indexing)*
4. Chip reduction coefficient on shaper *(Demo: 1. Quick-return mechanism, 2. Pawl and Ratchet mechanism, 3. Rack & Pinion mechanism)*
5. Drilling & Tapping *(Demo: 1. Hydro-copying M/C, 2. Capstan and Turret lathes)*
6. EDM & ECM

Metrology Cycle

1. Taper measurement
2. Thread measurement using floating carriage diameter measuring machine
3. Straightness measurement using auto-collimator
4. Inspection of work pieces using comparators
5. Gear tooth measurement
6. Demonstrations on surface roughness measurement & CMM

Reading:

1. Kalpakjian, S. and Steven R. Schmid*, Manufacturing, Engineering & Technology*, Pearson, 2007
2. I.C. Gupta, Engineering Metrology, Dhanpat Rai and Sons, 2003.

ME361	COMPUTATIONAL FLUID DYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME201: Thermodynamics

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

CO1	Develop mathematical models for flow phenomena.
CO2	Analyze mathematical and computational methods for fluid flow and heat transfer simulations.
CO3	Solve computational problems related to fluid flows and heat transfer.
CO4	Evaluate the grid sensitivity and analyze the accuracy of a numerical solution.
CO5	Evaluate flow parameters in internal and external flows.
CO6	Develop flow simulation code for fluid flow and heat transfer problems.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

Governing Equations of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Mathematical Behavior of Partial Differential Equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic Aspects of Discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Parabolic Partial Differential Equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability Analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.

Elliptic Equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.

Hyperbolic Equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Scalar Representation of Navier-Stokes Equations: Equations of fluid motion, numerical algorithms: ftcs explicit, ftbcs explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, btcs and btbcs implicit algorithms, applications.

Grid Generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation

Finite Volume Method For Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetra hedral Elements, 2-D Heat conduction with Triangular Elements

Numerical Solution of Quasi One Dimensionl Nozzle Flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.

Text Books:

1. Anderson, J.D.(Jr), *Computational Fluid Dynamics*, McGraw-Hill Book Company, 1995.
2. Hoffman, K.A., and Chiang, S.T., *Computational Fluid Dynamics*, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., *Computational Fluid Dynamics*, Cambridge University Press, 2003.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., *Computational Fluid Mechanics and Heat Transfer*, McGraw Hill Book Company, 2002.

ME362	AUTOMOBILE ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME101: Basic Mechanical Engg., ME201: Thermodynamics,

ME301: Internal Combustion Engines

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

CO1	Understand the basic lay-out of an automobile.
CO2	Understand the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
CO3	Understand the principles of transmission, suspension, steering and braking systems.
CO4	Understand automotive electronics.
CO5	Study latest developments in automobiles.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Automobiles, Classification of Automobiles.

Power Plant: Classification, Engine Terminology, Types of Cycles, working principle of an IC engine, advanced classification of Engines- Multi cylinder engines, Engine balance, firing order.

Fuel System and Ignition System and Electrical system: spark Ignition engines- Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburettor, direct injection of petrol engines. Compression Ignition engines, Fuel Injection System- air & solid injection system, Pressure charging of engines, super charging and turbo charging, Components of Ignition systems, battery ignition system, magneto ignition system, electronic ignition and ignition timing. Main electrical circuits, generating & stating circuit, lighting system, indicating devices, warning lights, speedometer.

Lubricating system and cooling systems: Functions & properties of lubricants, methods of lubrication-splash type, pressure type, dry sump, and wet sump & mist lubrication. Oil filters, oil pumps, oil coolers. Characteristics of an effective cooling system, types of cooling system, radiator, thermostat, air cooling & water cooling.

Chassis: Systems in an automobile, body, chassis frame, parts of the automobile body, terminology, automobile frames, functions, constructions, sub frames, materials and defects in frames.

Transmission, axles, clutches, propeller shafts and differential: Types of gear boxes, automatic transmission, electronic transmission control, functions and types of front and rear axles, types and functions of the clutches, design considerations of Hotchkiss drive torque tube drive, function and parts of differential and traction control.

Steering System: functions of steering mechanism, steering gear box types, wheel geometry.

Breaking and suspension system: functions and types of brakes, operation and principle of brakes, constructional and operational classification and parking brake. Types of springs shock observers, objectives and types of suspension system, rear axles suspension, electronic control and proactive suspension system.

Automotive air conditioning: ventilation, heating, air condition, refrigerant, compressor and evaporator.

Wheels and tyres: Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.

Reading:

1. Crouse, W.H., and Anglin, D.L., Automotive Mechanics, Tata McGraw Hill, New Delhi, 2005.
2. Heitner, J., Automotive Mechanics, Affiliated South West Press, New Delhi, 2000.
3. Narang, G.B., Automobile Engineering, Khanna Publishers, New Delhi, 2001.
4. Kamaraju Ramakrishna, Automobile Engineering, PHI Learning pvt. Ltd., New delhi-2012.

ME368	MECHANICAL VIBRATIONS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the causes and effects of vibration in mechanical systems.
CO2	Develop schematic models for physical systems and formulate governing equations of motion.
CO3	Understand the role of damping, stiffness and inertia in mechanical systems
CO4	Analyze rotating and reciprocating systems and compute critical speeds.
CO5	Analyze and design machine supporting structures, vibration isolators and absorbers.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

SDF systems: Formulation of equation of motion: Newton –Euler method, De Alembert's method, Energy method,

Free Vibration:: Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation.

Forced vibration response: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration,

Two degree of freedom systems: Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion

Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.

Multi degree of freedom systems: Introduction , Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.

Continuous systems: Introduction to continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method.

Reading:

1. L. Meirovich, Elements of Vibration analysis, 2nd Ed. Tata Mc-Grawhill 2007
2. Reference Books:
3. Singiresu S Rao, Mechanical Vibrations. 4th Ed. , Pearson education 2011
4. W.T., Thompson, Theory of Vibration. CBS Publishers
5. Clarence W. de Silva , Vibration: Fundamentals and Practice, CRC Press LLC, 2000

ME369	DESIGN OF MECHANISMS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME202: Kinematics of Machinery.

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

CO1	Perform kinematic and dynamic analysis of planar mechanisms with rigid-bodies.
CO2	Evaluate the suitability of existing designs for a given task.
CO3	Simulate the kinematic parameters generated by planar mechanisms.
CO4	Design a mechanism for practical implementation in the machinery.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2		2							
CO2	3	3	2		2		2					
CO3	3	3	2	2	3	2						
CO4	3	3	2		2							

Detailed Syllabus:

Introduction: Reviewing basic concepts of mechanisms and machine theory. Plane and space mechanisms, with practical examples. Kinematic pairs, kinematic inversions, degrees of freedom. Deferent methods of generation quick return motion with practical examples. Velocity and acceleration analyses.

Mobility of Mechanisms: Grashoff's criterion for four bar mechanisms and slider crank mechanism. Derivation of the criterion. Linkages with more than four links, geared five bar linkages. Six bar linkages. Grashof's type rotatability criteria for higher order linkages. Mechanisms with springs as links, practical examples. Practical considerations for creating good quality designs. Linkages versus cams.

Synthesis of Mechanisms: Type synthesis, quantitative synthesis, dimensional synthesis. Function, path, motion generation. Two position and three position synthesis with practical examples.

Position analysis: Function generation and accuracy points. Structural error and Chebyschev spacing of points. Freudenstin's equation for three point synthesis of four bar mechanism and also slider crank mechanism. Synthesizing four bar and slider crank mechanisms for three instantaneous conditions using Freudenstin's equation. Hirschhorn's method of components for synthesizing four bar mechanism instantaneous conditions. Synthesis of four bar mechanism for four accuracy points and five accuracy points.

Straight line Mechanisms: Approximate straight line mechanism, Watt mechanism, Robert mechanism, Chebyschev mechanism, Hoeken mechanism. Practical examples.

Exact straight line mechanism: Derivation of general conditions to be satisfied. Analysis of Peaucellier mechanism, Hart's mechanism.

Coupler Curves: Coupler curves of four bar mechanism. Cusp and Crunode. Hornes and Nelson Atlas of four bar coupler curves and use of the same for designing a four bar mechanism for a practical application. Symmetrical curves and non symmetrical four bar linkages. Single dwell mechanism with revolute pairs. Double dwell mechanisms. Practical examples.Geared five bar coupler curves. Cognates. Robert- Chebyschev theorm for identical coupler curves.

Reading:

1. Robert L. Nortan, Design of Machinery, McGraw Hill Internation Edition, New York, 2006.
2. Shigley, J.E and Joseph Uicker, J. Theory of Machines and Mechanisms, McGraw Hill International Editions, 2^{nd} edition, 2003.
3. Hamilton H. Mabie and Fred L. Ocvirk, Mechanisms and Dynamics of Machinery, John Wiley & Sons, New York, Delhi, 2000.

ME375	ADVANCED METAL FORMING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME253: Manufacturing Technology

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

CO1	Solve for strain rates, temperatures and metallurgical states in forming problems using constitutive relations.
CO2	Develop process maps for metal forming processes using plasticity principles.
CO3	Estimate formability limits for sheets and bulk metals.
CO4	Evaluate high energy rate deformation process parameters.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3								1	1
CO2	3	3	3	2	2	2	2				1	1
CO3	3	3	3	2	2	2	2				1	1
CO4	3	3	3								1	1

Detailed Syllabus:

Introduction: Introduction of metal forming as a manufacturing process and its relation with other processes, Metal Forming from systems point of view, Advantages of metal forming as a manufacturing process, Classifications of metal forming processes, Forming equipments, Presses (mechanical, hydraulic).

Theoretical analysis: Theory of plasticity, Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow- Problems.

HERF: Overview of various metal forming operations: Conventional Vs High velocity forming methods – Material behaviour - stress waves and deformation in solids – Stress wave induced fractures.

Bulk Forming Processes: Forging; open-die forging, closed-die forging, coining, nosing, upsetting, heading, extrusion and tooling, Rod, wire and tube drawing, Rolling; flat rolling, shape rolling and tooling, spinning, hydro forming, rubber-pad forming, explosive forming, problems.

Sheet Forming Processes: Blanking, piercing, press bending, deep drawing, stretch forming, formability tests, forming limit diagrams, process simulation for deep drawing and numerical approaches, Case studies.

Problems & Case Studies: Case studies on the manufacturing aspects of products using the lessons learnt.

Reading:

1. Surender Kumar, Technology of Metal Forming Processes, Prentice- Hall, Inc., 2008.
2. Henry S. Valberg, Applied Metal Forming - Including FEM Analysis, Cambridge University Press, 2010.

ME376	MACHINE TOOL DESIGN	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME254: Machine Design, ME303: Machine Tools and Metrology,

ME353: Machining Science

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

CO1	Understand basic motions involved in a machine tool.
CO2	Design machine tool structures.
CO3	Design and analyze systems for specified speeds and feeds.
CO4	Select subsystems for achieving high accuracy in machining.
CO5	Understand control strategies for machine tool operations.
CO6	Apply appropriate quality tests for quality assurance.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to Machine Tool Drives and Mechanisms: Introduction to the course, Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission

Regulation of Speeds and Feeds: Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design

Design of Machine Tool Structures: Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriages

Design of Guideways, Power Screws and Spindles: Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slideways, Design of Anti-Friction Guideways, Combination Guideways, Design of Power Screws.

Design of Spindles and Spindle Supports: Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings.

Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness

Acceptance Tests

Reading:

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 2010
2. G.C. Sen and A. Bhattacharya**,** Principles of Machine Tools, New Central Book Agency, 2009.
3. D. K Pal, S. K. Basu, “Design of Machine Tools”, 5th Edition. Oxford IBH, 2008
4. N. S. Acherkhan, “Machine Tool Design”, Vol. I, II, III and IV, MIR publications, 1968

ME382	PRODUCTION PLANNING AND CONTROL	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME304: Management Science & Productivity.

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

CO1	Understand production systems and their characteristics.
CO2	Evaluate MRP and JIT systems against traditional inventory control systems.
CO3	Understand basics of variability and its role in the performance of a production system.
CO4	Analyze aggregate planning strategies.
CO5	Apply forecasting and scheduling techniques to production systems.
CO6	Understand theory of constraints for effective management of production systems.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to Production Systems: Production Systems: Classification & Characterization, Overview of Production Planning and Control issues, Review of EOQ & inventory control systems.

Material Requirement Planning: Dependent Demand & Material Requirement Planning, Structure of MRP system, MRP Calculations, Planning Issues, Implementation Issues.

Just in Time Production Systems: Just-in-Time System: Evolution, Characteristics of JIT Systems, Continuous Improvement, The Kanban System, Strategic Implications of JIT System.

Factory Physics: Basic factory dynamics, Variability basics, Push and pull production systems.

Aggregate Planning: Aggregate Planning: Purpose & Methods, Reactive and Aggressive Alternatives, Planning Strategies, LP Formulation, Master Production Scheduling.

Scheduling: Scheduling in Manufacturing, Sequencing Operations for One Machine, Sequencing Operations for a two-station Flow Shop, Job Shop Dispatching.

Forecasting Methods: Demand Forecasting: Principles and Methods, Judgment methods, Causal methods, Time-series methods.

Issues in PPC: Special features in Planning & Control of Product-focused Systems and Process-focused Systems, Theory of Constraints.

Reading:

1. Krajewski L.J. and Ritzmen L.P., *Operations Management: Strategy and Analysis*, 9th Edition, Pearson Education, 2010.
2. Chase, R.B., Jacobs, F.R. and Aquilano, N.J., *Operations Management for Competitive Advantage*, 11th Edition, Tata McGraw Hill Book Company, New Delhi, 2010.
3. Hopp, WJ and Spearman, ML, Factory Physics: Foundations of Manufacturing Management, McGraw Hill International Edition, Third Edition, 2008.

ME383	DESIGN AND ANALYSIS OF EXPERIMENTS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify objectives and key factors in designing experiments.
CO2	Develop appropriate experimental design to conduct experiments.
CO3	Analyze experimental data and draw valid conclusions.
CO4	Develop empirical models using experimental data to optimize process parameters.
CO5	Design robust products and processes using parameter design approach.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.

Reading:

1. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
2. Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

ME401	REFRIGERATION AND AIR-CONDITIONING	PCC	3 – 0 – 0	3 Credits

Pre-requisites: ME201: Thermodynamics.

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

CO1	Understand the principles and applications of refrigeration systems.
CO2	Understand vapour compression refrigeration system and identify methods for performance improvement.
CO3	Study the working principles of air, vapour absorption, thermoelectric and steam-jet refrigeration systems.
CO4	Analyze air-conditioning processes using the principles of psychrometry.
CO5	Evaluate cooling and heating loads in an air-conditioning system.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Introduction to Refrigeration –Basic Definition, ASHRAE Nomenclature

Air Refrigeration: Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits, analysis.

Vapour Compression Refrigeration System(VCRS): Vapour Compression Refrigeration system – Carnot Vapour compression refrigeration cycle, Working and analysis, Limitations, Standard Vapour Compression Refrigeration system, Working and analysis, Effects of sub cooling and super heating, Multi-Pressure or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water inter cooling.

Refrigerants: Classification, Selection of Refrigerants and Nomenclature of refrigerants, Desirable Properties of an ideal refrigerant, A discussion on Ozone layer Depletion and Global Warming

Refrigeration systems Equipment: Refrigeration System Equipment – Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Vapour Absorption systems: Other types of Refrigeration systems – Vapour Absorption Refrigeration Systems, Absorbent – Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyser Assembly

Other systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration system

Psychrometry: Introduction to Air-Conditioning, Basic Definition, Classification, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Psychrometry – Air-water vapour mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart.

Air-Conditioning: Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Numerical Problems, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Reading:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora C.P., Refrigeration and Air-conditioning, Tata Mc Graw –Hill, New Delhi
3. Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, Mc Graw - Hill, New Delhi

Data Book:

Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, Mathur M.L. & Mehta F.S., Jain Brothers

ME402	CAD/CAM	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None.

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

CO1	Understand geometric transformation techniques in CAD.
CO2	Develop mathematical models to represent curves and surfaces.
CO3	Model engineering components using solid modeling techniques.
CO4	Develop CNC programs to manufacture industrial components.
CO5	Understand the elements of an automated manufacturing environment.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to CAD/CAM: Introduction to CAD/CAM/CIM, CAD/CAM input devices, CAD/CAM output devices, CAD/CAM Software.

Transformations of geometry: Translation, Scaling, Reflection, Rotation, Homogeneous representation of transformation, Concatenation of transformations.

Geometric Modelling of Curves: 3-D Wire frame modelling, Modelling of cubic spline, Bezier and B-spline curves.

Geometric Modelling of Surfaces: Basic surfaces entities, Surface of revolution, blends, intersections, Modelling of analytical & sculptured surfaces.

Geometric Modelling of Solids: Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling.

Data Exchange Formats and Applications: Data exchange formats, Finite element analysis, Rapid prototyping.

Computer Aided Manufacturing (CAM): Introduction to Computer Numerical Control (CNC), Structure of NC machine tools, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling, Automatic tool changers & Work holding devices.

CNC Programming: Part programming fundamentals, Manual Part Programming, APT Programming, Geometric & motion commands, Post processor commands.

Robotics: Anatomy & configuration of robot, Characteristics of robots, Grippers, Application of robots in manufacturing, Robot programming.

Group Technology: Introduction to Group technology, Part classification & coding systems: OPITZ, MICLASS.

Computer Aided Process Planning (CAPP): Introduction to CAPP, Variant & Generative methods of CAPP, advantages of CAPP.

Flexible Manufacturing System (FMS): Components of FMS, FMS equipment & control, FMS case studies.

Computer Integrated Manufacturing (CIM): Elements of CIM, CIM case studies

Reading:

1. Ibrahim Zeid and Sivasubramanian, R., CAD/CAM Theory and Practice, Tata McGraw Hill Publications, New Delhi, 2009.
2. Yoram Koren, Computer Control of Manufacturing Systems, McGraw Hill Publications, 2005.
3. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi, 2010.

ME403	CAD/CAM LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Draw complex geometries of machine components in sketcher mode.
CO2	Write programs to generate analytical and synthetic curves used in engineering practice.
CO3	Generate freeform shapes in part mode to visualize components.
CO4	Create complex engineering assemblies using appropriate assembly constraints.
CO5	Develop G and M codes for turning and milling components. Generate automated tool paths for a given engineering component.
CO6	Generate automated tool paths for a given engineering component.

Mapping of course outcomes with program outcomes

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

List of Experiments:

1. Introduction to Pro/E and working with sketch mode
2. Working with creating features (Extrude & Revolve), Working Datum Planes
3. MATLAB Programming for Analytical Curves
4. Working with the tools like Hole, Round, Chamfer and Rib
5. Working with the tools like Pattern, Copy, Rotate, Move and Mirror
6. MATLAB Programming for Synthetic Curves
7. Working with advanced modeling tools (Sweep, Blend, Variable section Sweep, Swept Blend & Helical Sweep)
8. Assembly modelling in Pro/E, Generating, editing and modifying drawings in Pro/E

9. Practice on CNC Sinutrain Turning
10. Practice on CNC Sinutrain Milling
11. CNC programming for turned components using FANUC Controller
12. CNC programming for milled components using FANUC Controller
13. Automated CNC Tool path & G-Code generation using Pro/E/MasterCAM
14. Demo on FDM Rapid Prototyping machine

ME449	PROJECT WORK PART-A	PRC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Identify a topic in advanced areas of Mechanical Engineering.
CO2	Review literature to identify gaps and define objectives & scope of the work.
CO3	Generate and implement innovative ideas for social benefit.
CO4	Develop a prototypes/models, experimental set-up and software systems necessary to meet the objectives.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2	1		1	3	2	1	2
CO2	2	2			1	2	1	1	2	2		2
CO3	2	2	1	2	2	2	2	1	2	2		2
CO4	2	2	3	3	3	2	2	2	2	1	1	2

ME411	NON CONVENTIONAL ENERGY RESOURCES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify renewable energy sources and their utilization.
CO2	Understand the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
CO3	Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas and hydrogen.
CO4	Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.
CO5	Identify methods of energy storage for specific applications.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Global warming; Introduction to Renewable Energy Technologies

Energy Storage: Introduction; Necessity of Energy Storage; Energy Storage Methods

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems

Wind Energy: Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

Fuel cells: Overview; Classification of fuel cells; Operating principles; Fuel cell thermodynamics

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Other forms of Energy: Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles

Reading:

1. Sukhatme S.P. and J.K.Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources,Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

ME412	CONVECTIVE HEAT TRANSFER	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand principles of forced and free convection heat transfer processes.
CO2	Formulate and solve convective heat transfer problems.
CO3	Estimate heat dissipation from heat transfer devices.
CO4	Evaluate energy requirements for operating a flow system with heat transfer.
CO5	Understand current challenges in the field of convective heat transfer.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Course structure, Basics of Thermodynamics, Fluid mechanics and Heat transfer

Fundamental Principles: Continuity, momentum and energy equations, Reynolds transport theorem, Second law of TD, Rules of Scale analysis, Concept of Heat line visualization

Laminar forced convection: External flows: Boundary layer concept, velocity and thermal boundary layer, Governing equations, Similarity solutions, various wall heating conditions, Flow over sphere, wedge and stagnation flow

Laminar forced convection: Internal flows: Fully developed laminar flow: Constant heat flux, Constant wall temperature, developing length

External Natural convection: Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Boundary layer equations, Scale analysis, Low and high Prandtl number fluids, vertical walls, horizontal walls, sphere

Internal Natural Convection: Natural convection in enclosures: isothermal and constant heat flux side walls, triangular enclosures, heated from below, inclined enclosures, annular space between horizontal cylinders.

Turbulent boundary layer flow: Boundary layer equations, mixing length model, flow over single cylinder, cross flow over array of cylinders, Natural convection along vertical walls, Turbulent duct flow

Reading:

1. Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2. Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, New York, 2001.

ME413	ADVANCED I. C. ENGINES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME201: Thermodynamics, ME301: Internal Combustion Engines

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

CO1	Classify combustion chambers of IC engines and understand combustion phenomena in IC engines
CO2	Understand the working of stratified charge engine, low heat rejection engine and rotary combustion engine
CO3	Analyze exhaust emissions, methods to control the pollutants and list the emission standards.
CO4	Study the design and development of viable engines working with alternate fuels.
CO5	Understand advanced combustion processes including HCCI, PCCI and RCCI engines.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction-Review of fundamentals of IC engines-classification, design and operating parameters-performance characteristics.

Combustion:- Combustion in Spark Ignition engines- flame propagation-stages of combustion-normal combustion- theoretical and actual p-theta diagrams- effect of spark timing on combustion-Highest Useful Compression Ratio-Factors affecting combustion process-ignition lag-Detonation-ignition quality of fuel- Octane rating. Combustion in Compression Ignition Engines-Stages of CI engine combustion process-air motion within the CI engine-swirl, squish, tumble and turbulence- effect of injection timing on CI engine combustion process-delay period-Knocking- ignition quality of CI engine fuel-Cetane rating.

Combustion chambers:- Desirable characteristics of combustion chambers for SI and CI engines-effect of surface to volume ratio-L, I, F and T-head and fast burn combustion chambers for SI engines-direct and indirect injection combustion chambers for CI Engines.

Advanced Fuel Injection systems for SI and CI engines:-Mixture preparation for SI engines-Limitations of carburetion system-fuel injection system for SI engine-mechanical and electronic fuel injection systems – L-jetronic and D-jetronic, multi point fuel injection systems for SI engine. Objectives of good fuel injection syste for CI engines-Limitations of mechanical injection systems for CI engines-Common rail direct injection system for CI engine-working, advantages and limitations.

Modern trends in the development of IC Engines:-Charge stratification-Stratified charge engine-Texaco combustion process, Ford PROCCO and Honda CVCC. Concept of low heat rejection engines-Thermal barrier coatings-Roary combustion engine-Wankel engine.

Engine emissions and control:-Engine emissions-evaporative and exhaust emissions-mechanism of formation of emissions including CO,HCs, NOx and PM in SI and CI engines-Methods of control of engine emissions-in cylinder control and after treatment techniques-Use of catalysts, catalytic converters and particulate traps. Emission norms-legislation- EURO and Bharath Stage norms.

Alternate fuels:- Need for alternate fuels-desirable characteristics of good alternate fuel-Petroleum derived alternate fuels and renewable fuels-biofuels- ethanol, biogas, vegetable oils-Biodiesel. Advantages and limitations of alternate fuel run engines.

Advanced Combustion processes:- Limitations of conventional combustion processes of SI and CI engines-Concept of Homogeneous Charge Compression Ignition, Premixed Charge compression Ignition, Reactive Charge Compression Ignition

Reading:

1. V. Ganesan, Internal Combustion Engines, Tata Mc Graw Hill Co.2008
2. M.L.Mathur and R.P.Sharma,A first course in IC Engines, Dhanpat Rai & Sons, 2003.
3. H.N.Gupta, Fundamentals of IC Engines, PHI Publications, 2006.
4. John B.Heywood, IC Engine Fundamentals, Mc Graw Hill Co. 1988.
5. W.W. Pulkrabek, Intorduction to IC Engines, PHI, 2004

ME418	ENGINEERING ACOUSTICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand wave propagation, absorption, transmission, reflection and radiation.
CO2	Formulate acoustic problems for reduction of sound levels.
CO3	Analyze and design resonant systems including pipes, mufflers, Helmholtz resonators.
CO4	Evaluate architectural acoustics reverberation time, direct echoes and acoustical amplification.
CO5	Analyze the acoustic levels and analytical predictions.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Review of vibrations, resonance and frequency, Transverse wave equation, Spherical and cylindrical wave equation, Acoustic intensity, decibel scales,

Acoustic wave propagation: Transmission through different media, reflection from solid surfaces, radiation and reception of acoustic waves, absorption and attenuation of sound, Cavities and wave guides.

Pipes, Resonators, and Filters: Resonance in pipes, standing waves, Absorption of sound, Helmholtz resonator, acoustic impudence, acoustic filters.

Damping Attenuation and Absorption: Viscous attenuation of sound, absorption by atmosphere, attenuation in water, absorption in fluid filled pipes, damping in solids.

Architectural Acoustics: Sound in enclosures, direct and reverberant sounds, sound absorption materials, acoustic factors in architectural design, standing waves and normal modes in enclosures.

Noise Control: The auditory system, Effects of noise on humans, noise measurement and criterion, treatment at source and treatment of transmission path, Analysis and design of mufflers for automotive applications.

Reading:

1. Robert D Finch. Introduction to acoustics, PHI 2008
2. Michael Moser, Michael Maser, S. Zimmermann, Engineering Acoustics: An introduction to Noise Control, 2/e, Springer, 2009.
3. Frank J Fahy, Foundations of Engineering Acoustics, Academic Press, 2000.
4. Michael Moeser, Michael Maser, Engineering Acoustics: An Introduction to Noise Control, Springer, 2004.

ME419	ROTOR DYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME368: Mechanical Vibrations, ME318: Finite Element Method

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

CO1	Understand principles of rotor bearing systems.
CO2	Analyze dynamic behaviour of rotor bearing system.
CO3	Predict the response of a rotor bearing system through analytical and computational models.
CO4	Identify the malfunctions in rotating machinery using vibration measurements

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	1	2					1
CO2	3	3	2	2	3	1	2					2
CO3	3	3	1	2	3	1	2					3
CO4	2	2	1	3	3	1	1					3

Detailed Syllabus:

Introduction: Introduction to rotor dynamics, Review of Vibration of single and multi degree of freedom systems. Rotating and reciprocating unbalances in mechanical systems.

Linear Rotor dynamics: Equation of motion for Rotating systems, Undamped Jeffcott Rotor, Free whirling, Unbalance response, Shaft Bow, Jeffcott Rotor with viscous damping – Free whirling, Unbalance response, Shaft Bow, Jeffcott Rotor with structural damping – Free whirling, Unbalance response, frequency dependent loss factors.

Discrete multi-degree of freedom rotors: Introduction, Transfer matrix approach for rotor systems, The finite element method for rotors, Beam elements, spring elements, Mass elements, Assembly and constraints Computation of critical speeds, Computation of unbalance response, Campbell and root locus diagrams.

Transmission Shafts: Euler-Bernoulli and Timoshenko beam models. Dynamic stiffness, Free Torsional and axial vibrations and critical speeds

Rotor Bearing Interaction : Rigid body and flexural modes, Isotropic rotors on Anisotropic supports, nonisotropic rotors on isotropic supports, Linearization of bearing Characteristics, Rolling element bearings, Fluid film bearings, Magnetic bearings, Bearing alignment in multi rotor bearings

Malfunctioning of Rotors: Measurement of vibration data in rotor systems, Data processing, Signature analysis, Identification of malfunctioning using measured data.

Reading:

1. Giancarlo Genta, Dynamics of Rotating Systems, Springer, 2009
2. Rao, J.S., Rotor Dynamics, 3 Ed. New Age International, 2003

ME420	MECHANICS OF COMPOSITE MATERIALS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the concepts of composite materials.
CO2	Analyze macro and micro mechanical behaviour of a lamina.
CO3	Develop governing equations for bending, buckling and vibrations in laminated plates.
CO4	Analyze and design composite structures used in automobile and aerospace applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	2	3	3	1	1	2	2
CO2	2	3	2	2	1	3	2	2	1	1	2	3
CO3	1	2	2	2	1	1	2	2	1	2	1	2
CO4	2	2	3	3	1	1	1	1	1	1	2	2

Detailed Syllabus:

Introduction to composite materials: Introduction, What is a composite material, Current and potential advantages of fibre reinforced composites, Applications of composite materials, Military, civil, space, automotive and commercial applications

Macro and micro mechanical behaviour of a lamina: Stress strain relations for anisotropic materials, Restrictions on engineering constants, Strengths of an orthotropic lamina, Biaxial strength criteria for orthotropic lamina

Micro mechanical behaviour of lamina and laminates: Mechanical of material approach to stiffness, Elasticity approach to stiffness, Classification lamination theory, Special cases, strength of laminates

Bending, Buckling and Vibration of laminated plates: Governing equations for bending buckling and vibration of laminated plates, Deflection of simply supported laminated plates, Vibration of simply supported laminated plates

Design of composite structures: Introduction, design philosophy, Anisotropic analysis, Bending extension coupling, Micromechanics, Non linear behaviour, Interlaminar stresses, transverse shearing, Laminate optimization

Reading:

1. Ronald F. Gibson, Principles of composite material mechanics, CRC Press, 2011.
2. Robert M Jones, Mechanics of Composite Materials, Taylor & Francis, 2000.
3. Lawrence E. Nielsen, Nielson, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC press, 2000

ME425	ADVANCED MANUFACTURING PROCESSES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand abrasive and electrical discharge machining processes.
CO2	Understand principles and applications of electron beam, ion beam and laser hybrid welding processes.
CO3	Understand the relation between the process parameters and mechanical properties.
CO4	Understand forming process for thin sections
CO5	Understand the principles and applications of friction stir welding processes

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Advanced manufacturing processes: Abrasive machining and advantages and applications.

Electrical discharge Machining: process parameters, applications advantages and limitations.

Stir casting, organic processes, Magnetic moulding, high pressure moulding, metal injection moulding, centrifugal casting.

Electron beam welding and Laser beam welding: Principle, application and advantages of EBW and LBW, process parameters.

Hybrid welding process and advantages and applications and surfacing,

Introduction forming processes, advantages ,limitations and applications, Hydro, Magnetic and High velocity forming, design for forming, welding and injection moulding, and forming of thin sections

Text Books:

1. R. S. Mishra, *Friction Stir Welding and Processing,* ASM International, 2007.
2. Heine, Loper and Rosenthal, *“Principles of Metal Casting”*, Tata McGraw-Hill, New Delhi, 2008.
3. Jain, Vijay K., Advanced Machining Process, Chapter-7 (A) Electric Discharge Machining (EDM), Allied Publishers Pvt. Ltd., New Delhi, 2004, 126-129

ME426	TOOL DESIGN	DEC	3 – 0 – 0	3 Credits

Pre-requisites: ME252: Design of Machine Elements-1, ME253: Manufacturing Technology, ME254: Machine Drawing, ME303: Machine Tools and Metrology, ME353: Machining Science

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

CO1	Interpret the geometrical and dimensional details of a production drawing.
CO2	Understand principles of locating and clamping systems.
CO3	Design jigs and fixtures for conventional and NC machining
CO4	Select and design progressive, compound or combination dies for press working operations
CO5	Design single point and multipoint cutting tools

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Basic principles of tool design: Tool design – An overview, Introduction to Jigs and fixtures.

Work holding devices: Basic principle of six point location, Locating methods and devices, Principle of clamping and Types of clamps.

Design of jigs: Type of Drill bushes, Classification of drill jigs, Design of drill jigs.

Design of fixtures: Design of milling fixtures, Design of turning fixtures

Introduction of press tool design: Introduction to Die cutting operations, Introduction to press and classifications, Die set assembly with components, Introduction to Centre of pressure, Examples of centre of pressure, Design of piercing die, Design of blanking die, Progressive, Compound and Combination dies .

Design of cutting tools: Introduction to cutting tools, Design of single point tool, Design of drill bit, Design of milling cutter

Brief introduction of NC machines work holding devices: Tool design for NC machines- An introduction, Fixture design for NC Machine, Cutting tools for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machine, Tool presetting for NC Machine.

Reading:

1. F.W.Wilson.F.W. "*Fundamentals of Tool Design*", ASME, PHI, New Delhi, 2010
2. Donaldson.C, G.H.Lecain and V.C.Goold "*Tool Design*", TMH, New Delhi, 2010

ME427	MICRO AND NANO MANUFACTURING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand manufacturing considerations at the micro and nano scale.
CO2	Understand design-and-analysis methods and tools used for micro and nano manufacturing
CO3	Select manufacturing methods, techniques and process parameters for material processing quality
CO4	Design and select industrially-viable processes, equipment and manufacturing tools for specific industrial products

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2			2			1
CO2	1	2	2	3	1				2		1	1
CO3	3	1	1	1	3		2	2	2			
CO4	3	3	3	2	3		1	2	2			1

Detailed Syllabus:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches,, challenges in Nanotechnology.

Nanomaterials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of nanomaterials- sol-gel process, Liquid solid reactions; Gas Phase synthesis of nanomaterials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing(GPC), Chemical Vapour Condensation(CVC)- Cold Plasma Methods, Laser ablation, Vapour – liquid –solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing(GPC).

Structural Characterization: X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).

Spectroscopic characterizations: Basic concepts of spectroscopy, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurement, Raman spectroscopy.

Surface Characterization: X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, Low Energy Ion Scattering Spectroscopy (LEISS), Secondary Ion Mass Spectroscopy (SIMS), Rutherford Backscattering Spectroscopy (RBS).

Thermal Characterization of Nanomaterials: DTA, TGA, DSC (Principle and Applications), Determination of thermo physical parameters.

Microfabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding. MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining.

Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

MEMS devices and applications: Pressure sensor, Inertial sensor, Optical MEMS and RF-MEMS, Micro-actuators for dual-stage servo systems.

Reading:

1. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
2. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
3. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
4. Robert F Speyer, Thermal Analysis of Materials, Marcel Dekker Inc, New York, 1994.
5. B.D. Cullity - Elements of X-Ray Diffraction, 3rd edition, Prentice Hall , 2002.
6. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture,” McGraw- Hill, 2008.

ME428	DESIGN FOR MANUFACTURING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: MM235: Materials Engineering, ME303: Machine Tools and Metrology

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

CO1	Understand the design principles of design for manufacturing processes
CO2	Estimates the cost of dies, molds and machined components based on die life.
CO3	Understand the design for manual assembly and automated assembly.
CO4	Design typical assemblies using principles of design for X concepts.
CO5	Understand the design rules for machining with single point and multi point cutting tools.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of the course, Design for manufacturing, Typical Case studies, Innovative product and service designs.

Material Selection: Requirements for material selection, systematic selection of processes and materials, ASHBY charts

Design for Casting: Basic characteristics and Mold preparation, Sand casting alloys, Design rules for sand castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cost, Design guidelines for Investment casting, Die casting cycle, Determination of optimum number of cavities, appropriate machine size, Die cost estimation, Design principles.

Design for Injection molding: Injection molding systems, Molds, molding cycle time, mold cost estimation, estimation of optimum number of cavities, Assembly techniques, Design Guidelines.

Design for Hot Forging: Characteristics of the forging process, forging allowances, flash removal, die cost estimation,Die life and tool replacement costs.

Design for Sheet metal working: Press selection, press brake operations, Design rules.

Design for Powder Metal processing: Powder metallurgy, tooling and presses for Compaction, Sintering, materials, heat treatments, Design guidelines.

Design for machining: Machining using single point cutting tools, multipoint cutting tools, abrasive wheels, Assembly, cost estimation for machined components, Design guidelines.

Design for Assembly: Design guidelines for manual assembly, large assemblies, analysis of an assembly, rules for product design for automation, design for robot assembly,Design for manufacture and Computer aided design.

Reading:

1. Geoffrey Boothroyd, Dewhurst.P, Knight.W*, roduct design for manufacture and assembly*, CRC press, 2002
2. George E Dieter, Engineering Design- A material processing approach, 5/E. Mc Graw hill international, 2003.
3. ASM Handbook, Design for manufacture, 2000.

ME431	NEW VENTURE CREATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Planning a Small Scale Enterprsies: Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE: Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies: Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.
2. D.F. Kuratko and T.V. Rao, Entrepreneurship: A South-Asian Perspective, Cengage Learning, 2013
3. Dr. S.S. Khanka, Entrepreneurial Development (4th ed.), S Chand & Company Ltd., 2012.
4. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.

ME432	TOTAL QUALITY MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Develop an understanding on quality management philosophies and frameworks.
CO2	Adopt TQM methodologies for continuous improvement of quality.
CO3	Measure the cost of poor quality, process effectiveness and efficiency to identify areas for improvement.
CO4	Apply benchmarking and business process reengineering to improve management processes.
CO5	Determine the set of indicators to evaluate performance excellence of an organization

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Definition of Quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs – Analysis, Techniques for Quality Costs, Basic concepts of Total Quality Management.

Historical Review: Quality Council. Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.

TQM Principles: Customer satisfaction - Customer Perception of Quality, Customer Complaints, Service Quality. Customer Retention, Employee Involvement - Motivation, Empowerment teams, Continuous Process Improvement - Juran Trilogy, PDSA Cycle, Kaizen, Supplier Partnership - Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures - Basic Concepts, Strategy, Performance Measure, Case studies.

TQM Tools: Benchmarking - Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) - House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) - Concept, Improvement Needs, FMEA - Stages of FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies.

Quality Systems: Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System - Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 - Concept, Requirements and Benefits, Case Studies

Reading:

1. Dale H.Besterfiled, “Total Quality Management”, *Pearson Education,* Delhi, 2006.
2. SubburajRamasamy, “Total Quality Management”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005.
3. Narayana V and Sreenivasan N.S., Quality Management - Concepts and Tasks, *New Age International,* Delhi, 1996.

ME433	ADVANCED OPERATIONS RESEARCH	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand game, queuing and decision theories
CO2	Apply queuing theory for performance evaluation of engineering and management systems.
CO3	Simulate and analyse engineering and managerial problems
CO4	Solve optimization problems using evolutionary computing methods

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2		2		2		1	1	2	1
CO2	3	3	2		2		2		1	1	2	1
CO3	3	3	2		2		2		1	1	2	1
CO4	3	3	2		2		2		1	1	2	2

Detailed Syllabus:

Game Theory: Formulation of two-person zero-sum games, games with mixed strategies, graphical solution procedure, solving by linear programming.

Decision Analysis: Decision making with and without experimentation, decision trees, utility theory.

Queuing Theory and simulation: Basic structure of queuing models, birth-and-death process, basic queuing models, blocking models, priority-discipline models, queuing networks, essence of simulation, generation of random numbers and observations, outline of simulation study.

Evolutionary optimization methods: Metaheuristics, Tabu search, simulated annealing, genetic algorithms.

Reading:

1. Taha, H.A., *Operations Research*, 9th Edition, Prentice Hall of India, New Delhi, 2010.
2. Hillier, F.S., and Lieberman, G.J., *Introduction to Operations Research*, 7th Edition, TMH, 2009.
3. Kalyanmoy Deb, *Multi-objective Optimization using Evolutionary Algorithms*, John Wiley & sons, 2001.

ME434	SUPPLY CHAIN MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the decision phases and apply competitive & supply chain strategies.
CO2	Understand drivers of supply chain performance.
CO3	Analyze factors influencing network design.
CO4	Analyze the influence of forecasting in a supply chain.
CO5	Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Reading:

1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, 4^{th} Edition, Pearson Education Asia, 2010.
2. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill, 2000.

ME451	MECHATRONICS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: EC101: Basic Electronics Engineering

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

CO1	Model, analyze and control engineering systems.
CO2	Identify sensors, transducers and actuators to monitor and control the behaviour of a process or product.
CO3	Develop PLC programs for a given task.
CO4	Evaluate the performance of mechatronic systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	2				2			1
CO2	1	1	1	3	1				2		1	1
CO3	3	3	1	1	3		1	1	1			
CO4	3	2	2	2	3		1	2	2			1

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing

Sensors: classification of sensors basic working principles, Displacement Sensor - Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD

Accelerometers, Velocity sensors – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor

Actuators: Electrical Actuators : Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

Basic System Models & Analysis: Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems.

Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of control systems, Feed back, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

Reading:

1. W. Bolton, “Mechatronics”, 5 th edition, Addison Wesley Longman Ltd, 2010
2. Devdas Shetty & Richard Kolk “Mechatronics System Design”, 3rd edition. PWS Publishing, 2009.
3. Alciatore David G & Histand Michael B, “Introduction to Mechatronics and Measurement systems”, 4th edition, Tata McGraw Hill, 2006.

Video references:

1. http://video_demos.colostate.edu/mechatronics
2. http:// mechatronics.me.wisc.edu

ME452	MECHATRONICS LAB	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Measure load, displacement and temperature using analogue and digital sensors.
CO2	Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
CO3	Develop RD2 xxx microcontroller programming to guide a robot.
CO4	Simulate and analyse PID controllers for a physical system using MATLAB.
CO5	Develop pneumatic and hydraulic circuits using Automaton studio.

Mapping of course outcomes with program outcomes

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

List of Experiments

1. DYNA 1750 Transducers Kit :-
    a. Characteristics of LVDT
    b. Principle & Characteristics of Strain Gauge
    c. Characteristics of Summing Amplifier
    d. Characteristics of Reflective Opto Transducer
2. Mobile Robot with P89V51RD2 microcontroller
    a. Program for Operating Buzzer Beep
    b. Program for Operating Motion control
    c. Program for Operating Direction control
    d. Program for Operating White line follower for the given arena

3. PLC PROGRAMMING
    a. Ladder programming on Logic gates ,Timers & counters
    b. Ladder Programming for digital & Analogy sensors
    c. Ladder programming for Traffic Light control, Water level control and Lift control Modules
4. AUTOMATION STUDIO software
    a. Introduction to Automation studio & its control
    b. Draw & Simulate the Hydraulic circuit for series & parallel cylinders connection
    c. Draw & Simulate Meter-in, Meter-out and hydraulic press and clamping.
5. MATLAB Programming
    a. Sample programmes on Matlab
    b. Simulation and analysis of PID controller using SIMULINK

ME491	SEMINAR	PCC	0 – 0 – 3	1 Credits

Pre-requisites: None.

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

CO1	Identify and compare technical and practical issues related to the area of course specialization.
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well organized report employing elements of technical writing and critical thinking.
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1		1	2		2	2	2		1
CO2		2				2		1	2	1		1
CO3						1	1	2	2	2		2
CO4	1	2	1	1		1	1	1	2	1		1

ME499	PROJECT WORK PART-B	PRC	0 – 0 – 6	4 Credits

Pre-requisites: None.

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

CO1	Identify methods and materials to carry out experiments/develop code.
CO2	Reorganize the procedures with a concern for society, environment and ethics.
CO3	Analyze and discuss the results to draw valid conclusions.
CO4	Prepare a report as per recommended format and defend the work.
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

Mapping of course outcomes with program outcomes

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

ME461	CRYOGENICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand principles of cryogenic systems.
CO2	Understand air and helium liquefaction processes.
CO3	Classify cascade refrigeration systems.
CO4	Understand principles of ultra-low temperature systems and their applications.
CO5	Evaluate storage systems used in cryogenic applications.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Definition and Engineering Applications of Cryogenics, Properties of solids for cryogenic systems

Refrigeration and Liquefaction: Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle

Ultra-low-temperature refrigerators: Definition and Fundamentals regarding ultra-low-temperature refrigerators, Equipment associated with low-temperature systems, Various Advantages and Disadvantages

Storage and Handling of Cryogenic Refrigerants: Storage and Transfer systems, Insulation, Various Types of Insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on

Applications: Broad Applications of Cryogenic Refrigerants in various engineering systems

Reading:

1. Traugott H.K. Frederking and S.W.K. Yuan, Cryogenics - Low Temperature Engineering and Applied Sciences, Yutopian Enterprises, 2005.
2. Arora, C.P., Refrigeration and Air-conditioning, Tata-McGraw Hill, 2008.
3. A. R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005.

ME462	POWER PLANT ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand functions of the components of power plant.
CO2	Understand the working of nuclear, thermal and oil based power plants.
CO3	Evaluate the design layout and working of hydro electric power plants.
CO4	Evaluate economic feasibility and its implications on power generating units.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	1	3				2			2
CO2	1	3	1	1	2	1			2			2
CO3	2	3	1	2	3				3			2
CO4	3	3		1	2				2			2

Detailed Syllabus:

Introduction, steam power plant, steam boilers, steam nozzles, steam turbines, steam condensers, cooling towers, cogeneration and combined cycles, nuclear power plants, hydroelectric power plants, power plant economics.

Reading:

1. Power plant engineering by 'Arrora & Domkundwar', Dhanpat Rai & Sons, New Delhi, 2008.
2. Power plant Technology by 'M.M.Ei-Wakil', McGraw Hill Com., 1985.
3. Power plant engineering by 'P C Sharma', S.K. Kataria & Sons, New Delhi, 2010.

ME463	GAS DYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Solve flow equations for quasi one dimensional flow through variable area ducts.
CO2	Analyze the flow through constant area ducts with friction and heat transfer.
CO3	Analyze flows with normal and oblique shocks.
CO4	Solve flow problems with supersonic velocities using shock-expansion theory.
CO5	Solve linearized velocity potential equation for multi-dimensional flows.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Review of basic fluid dynamic and thermodynamic principles, Conservation equations for inviscid lows

One Dimensional flow: One-dimensional wave motion, normal shock waves, Oblique shock waves, Prandtl-Meyer expansions and applications, Generalized one-dimensional flow

Nozzle Flow: Isentropic flow with area change, Flow with friction (Fanno flow), Flow with heat addition (Rayleigh flow), Method of characteristics (application to one-dimensional unsteady isentropic flow)

Supersonic Flow: Velocity Potential Equation, Numerical Techniques for Steady Supersonic Flow, Time Marching Technique for Supersonic Blunt Bodies and Nozzles

Reading:

1. Anderson, J.D Jr., Modern Compressible Flows, Tata McGraw Hill, 2012.
2. Yahya, S.M., Fundamentals of Compressible Flow, New age International Pub., 2013.
3. Zucrow, M., Gas Dynamics, Wiley India, 2013.

ME464	ENERGY SYSTEMS AND MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand principles of energy management and its influence on environment.
CO2	Comprehend methods of energy production for improved utilization.
CO3	Improve the performance of thermal systems using of energy management principles
CO4	Analyse the methods of energy conservation for air conditioning, heat recovery and thermal energy storage systems.
CO5	Evaluate energy projects on the basis of economic and financial criteria.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to Thermodynamics, Fluid Flow and Heat Transfer

Heat transfer media: Water, steam, Thermal fluids, Air-water vapour mixtures

Heat transfer equipment: Heat exchangers, Steam plant

Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems

Energy conversion systems: Furnaces, turbines

Heat recovery systems: Incinerators, regenerators and boilers

Energy Management: Principles of Energy Management, Energy demand estimation, Organising and Managing Energy Management Programs, Energy pricing

Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries

Economic Analysis: Scope, Characterization of an Investment Project

Case studies

Reading:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Murphy, W. R., Energy Management, Elsevier, 2007.
4. Smith, C. B., Energy Management Principles, Pergamon Press, 2007.

ME468	MICRO AND SMART SYSTEMS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Classify micro sensors and actuators and design smart systems.
CO2	Understand the role of smart actuators in micro machining.
CO3	Construct models of micro systems using conventional modelling techniques.
CO4	Compute response of an electro mechanical smart system using finite element method.
CO5	Study the reliability of electronic circuits and control methods used to develop micro and smart systems.
CO6	Understand methods for integration of micro and smart systems.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Overview of Micro and smart systems, Processing of Sensors, Actuators and micro structures, Applications in diverse fields including Biomedical, Defense, Automobile and Aerospace Engineering.

Micro Fabrication Processes: Overview of Micro Machining Technologies, miaturization, conventional and silicon micro machining techniques, Ultrasonic machining, sandblasting, laser ablation, spark erosion and photo lithography.

Modelling and Mechanics: Solid mechanics concepts for Micro and smart systems, Solid Modelling in Micro systems.

Finite Element Method: FEM applications for modelling and analysis of Coupled Electromechanical Systems.

Electronics and Packaging: Integration of mechanical components with electronics, Electronic circuits and control for micro and smart systems, scaling effects..

Reading:

1. G. K. Anantha Suresh, Micro and Smart Systems, Wiley India Pvt. Ltd., 2010.
2. G. K. Anantha Suresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V. Kasudev Aatre,
3. Micro and Smart Systems: Technology and Modeling, John Wiley & Sons, 2012.
4. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, Tata McGraw Hill Education Private Limited, 2002.

ME469	RAPID PROTOTYPING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify suitable time compression techniques for rapid product development.
CO2	Model complex engineering products and develop process plans for rapid production.
CO3	Analyse and select a rapid manufacturing technology for a given component.
CO4	Identify the errors during generation of STL files and minimize them.
CO5	Optimize FDM process parameters to improve the quality of the parts.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Need for time compression in product development, Usage of RP parts, Generic RP process, Distinction between RP and CNC, other related technologies, Classification of RP.

RP Software: Need for RP software, MIMICS, Magics, SurgiGuide, 3-matic, 3D-Doctor, Simplant, Velocity2, VoXim, SolidView, 3DView, etc., software, Preparation of CAD models, Problems with STL files, STL file manipulation, RP data formats: SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP.

Photopolymerization RP Processes: Stereolithography (SL), SL resin curing process, SL scan patterns, Microstereolithography, Applications of Photopolymerization Processes.

Powder Bed Fusion RP Processes: Selective laser Sintering (SLS), Powder fusion mechanism and powder handling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Applications of Powder Bed Fusion Processes.

Extrusion-Based RP Systems: Fused Deposition Modelling (FDM), Principles, Plotting and path control, Applications of Extrusion-Based Processes.

Printing RP Processes: 3D printing (3DP), Research achievements in printing deposition, Technical challenges in printing, Printing process modelling, Applications of Printing Processes.

Sheet Lamination RP Processes: Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

Beam Deposition RP Processes: Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Processing-structure-properties, relationships, Benefits and drawbacks.

Rapid Tooling: Conventional Tooling Vs. Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods.

Reverse Engineering: Reverse Engineering (RE) Methodologies and Techniques, Selection of RE systems, RE software, RE hardware, RE in product development.

Errors in RP Processes: Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS, etc.

RP Applications: Design, Engineering Analysis and planning applications, Rapid Tooling, Reverse Engineering, Medical Applications of RP.

Reading:

1. Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2010.
2. Ian Gibson., David W Rosen., Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

ME470	CONDITION MONITORING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand and apply maintenance schemes in industries.
CO2	Monitor condition of rotating machinery using signature, temperature and corrosion analysis.
CO3	Apply oil analysis technique to diagnose the wear debris.
CO4	Understand modern technologies for effective plant maintenance.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3					1
CO2	3	3	1	1	3	3	3		1			2
CO3	3	3	2	3	3	3	2		1			1
CO4	2	1	1	3	3	3	1					2

Detailed Syllabus:

Introduction: Failures – System, component and services failures – classification and its causes, Maintenance Schemes – objectives – types and economic benefits, break down, preventive and predictive monitoring.

Vibration Monitoring – causes and effects of vibration, review of mechanical vibration concepts – free and forced vibrations, vibration signature of active systems – measurement of amplitude, frequency and phase.

Vibration monitoring equipment– vibration sensors (contact and non-contact type) –factors affecting the choice of sensors, signal conditioners, recording and display elements, vibration meter and analyzers, measurement of overall vibration levels.

Contaminant analysis: Contaminants in used lubricating oils – monitoring techniques (wear debris) – SOAP technique, Ferrography, X-ray spectrometry, Particle classification.

Temperature Monitoring – Various techniques – thermograph, pyrometers, indicating paint and NDT methods.

Special Techniques: Ultrasonic measurement method, shock pulse measurement, Kurtosis, Acoustic Emission mentoring, critical speed analysis, shaft orbit analysis, Cepstrum analysis. Non-destructive techniques, Structural health monitoring weldments for surface and subsurface cracks

Reading:

1. Rao J. S., Vibration Condition Monitoring, Narosa Publishing House, 2/e 2000.
2. Isermann R., Fault Diagnosis Application, Springer-Verlag Berlin, 2011.
3. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000.
4. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill.
5. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

ME471	INNOVATIVE DESIGN	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the conceptual development techniques to find solution for a critical design issue.
CO2	Apply embodiment principles to translate the conceptual ideas to engineering design.
CO3	Apply environmental, ethical and social issues during innovative design process.
CO4	Design and develop innovative engineering products for industrial needs using robust design philosophy.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1		2		2		2		1	1
CO2	2	2			1						1	1
CO3		2	3			2	3				1	1
CO4		2	3			2		3			1	1

Detailed Syllabus:

Introduction: Innovations in Design, Engineering Design Process, Prescriptive and integrative models of design, Design Review and societal considerations.

Identification of Customer Need: Evaluating Customer requirements and survey on customer needs, Conversion of customer needs into technical Specifications, Information sources.

Concept Generation and Evaluation: Creativity and Problem solving, Brainstorming, Theory of Inventive Problem solving (TRIZ), Functional Decomposition of the problem for innovative concept development, Morphological design, Introduction to Axiomatic Design, Concept evaluation and decision making.

Embodiment Design: Introduction, Product Architecture, Configuration and Parametric design Concepts, Industrial Design.

Design for X: Design for Manufacturing, Design for Assembly, Design for Environment, Design for Reliability and Robustness, Introduction to FMEA.

Reading:

1. Nigel Cross, Engineering Design Methods, John Wiley, 2009.
2. George E. Dieter, Engineering Design, McGraw-Hill, 2009.
3. Genrich Altshuller, The Innovation Algorithm, Technical Innovation Centre, 2011.

ME475	NANOMATERIALS PROCESSING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand fundamentals of nano science with respect to material and processing methods.
CO2	Understand the properties of nano materials and compare with bulk materials.
CO3	Understand methodologies and techniques of synthesis, processing and characterization of major classes of nano materials.
CO4	Recognize major application areas of nano materials and nanotechnologies in contemporary world and generate creative solutions.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2			1	2	1		1
CO2	2		1		2			1	2	1		1
CO3	1	1	1		1		1	1	2	2		1
CO4	1	2	1		1		1	1	3	3		1

Detailed Syllabus:

Introduction: Why nanoscale materials? Overview, definitions, and examples. Top-down and bottom-up approaches. Atoms, clusters and Nanomaterials Introduction, Melting point of Gold Nanocrystal, Vapour pressure of Nanocrystals.

Nanomaterials Synthesis and Processing: *One Dimensional Nano-structures:*Nano wires and nano rods, Spontaneous growth: Evaporation and condensation growth, vapor-liquid-solid growth, stress induced recrystallization. Template based synthesis: Electrochemical deposition, Electro-phoretic deposition. Electrospinning and Lithography. *Two dimensional nano-structures:* Fundamentals of film growth. Physical vapour Depostion(PVD): Ebvaporation molecular beam epitaxy (MBE), Sputtering, Comparison of Evaporation and sputtering. Chemical Vapour Deposition (CVD): Typical chemical reactions, Reaction kinetics, transportant phenomena, CVD methods, diamond films by CVD.

Thin films: Atomic layer deposition (ALD), Electrochemical deposition (ECD), Sol-Gel films.

Special Nano Materials: Carbon fullerence and nano tubes: carbon fullerness ,formation, properties and applications. Carbon nano tubes: formation and applications.

Nanocomposites Synthesis and Processing: Introduction, Historical perspective, Different Synthesis methods of Nanocomposites- self Assembly or Bio-Mimetic processes, Film; Processing of Nanoparticles- Binding mechanisms in Nanoparticles, Dispersion of Nanoparticles, Stabilization of Nanoparticles; Special nanostructured materials- Fullerenes-

Magnetism and tunneling, Fullerenes films, other applications; Nanotubes- carbon Nanotubes; Onions-carbon onions, Porous silicon- Preparation methods.

Characterization of Nanomaterials: SEM, TEM, X-ray Diffraction, Optical microscopy, EDS.

Reading:

1. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
2. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
3. Guozhong Cao, Nano structures and Nano materials: Synthesis, properties and applications - Imperial College press, 2004.

ME476	ADVANCED MATERIALS AND PROCESSING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Classify manufacturing processes.
CO2	Understand principles of casting and solidification.
CO3	Understand manufacturing of porous powder metallurgical products.
CO4	Utilize forming and processing technologies to shape metals and ceramics.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	1	1					1	1
CO2	3	3	3	1	1	1					1	1
CO3	3	3	3	1	1	1					1	1
CO4	3	3	3	1	1	1					1	1

Detailed Syllabus:

Processing of Metallic materials: Introduction to solidification process, single crystal and poly crystalline materials, grain growth, temperature distribution during solidification process, Zone refining, Effect of inoculation in casting of various materials,Solidification time calculation,
Melting practice of steel and non fererous materials Production of MMC through casting processes and its characterization, advantages, limitations and applications.

Powder Metallurgy techniques in processing of materials: Introduction to powder metallurgy, various processes in powder metallurgy, Production of composites, Processing of ceramics, Rheological behaviour of composites, Characterization of composites before and after processing

Forming of metals, plastics and ceramics: Hot and cold Processing, Forming of glass, Forming of ceramics, Processing of polymers, Defective analysis of formed glass, ceramics and polymers, Characterization of composites before and after processing.

Reading:

1. Michel Ashby, Materials Engineering Science Processing and Design, Butterworth-Heinemann, 2007.
2. Y. Waseda, A. Muramatsu, Yoshio Waseda, Morphology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization, Springer, 2004.

ME477	DESIGN AND APPLICATIONS OF ENGINEERING MATERIALS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the principles of materials selection and design.
CO2	Understand basic properties, weighting factors and materials performance index.
CO3	Establish the criteria for material qualification and acceptance.
CO4	Apply design principles for manufacturing of aircraft wings, cutting tools and gas turbine blades.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1					1	1
CO2	3	3	1	1	1	1					1	1
CO3	3	3	3	3	1	1					1	1
CO4	3	3	3	3	3	3					1	1

Detailed Syllabus:

Introduction to Material Selection: General principles of materials selection and design based on requirements of function, property, process ability and cost, Methods for pre selection - Intuitive and Systematic Approach.

Quantitative methods of materials selection: Initial Screening of Materials, Comparing alternate Solutions, Materials Substitution, Normalization of properties, weighting factors, materials performance index.

Introduction to design codes: Criteria for material qualification and acceptance for important applications, Effect of Component Geometry, Factor of Safety, Reliability of Components, Product Reliability and Safety, Product Liability.

Case Studies on Material Selection: Materials for aircraft wings, cutting tools, gas turbine blades, liquid nitrogen containers, artificial hip replacement, and automobile value spring etc.

Reading:

1. N.A. Waterman and M.F. Ashby, *The Materials Selector*, Vol. I, II and III, Chapman & Hall, London, 2006.
2. Mahmoud M. Farag, *Materials Selection for Engineering Design: Structure, Properties and Applications*, Prentice Hall International, 2007.

ME478	**INDUSTRIAL AUTOMATION**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: None.

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

CO1	Enumerate principles, strategies and advantages of industrial automation.
CO2	Select level of automation and calculate manpower requirement.
CO3	Design material handling and material storage systems for an automated factory.
CO4	Automate shop floor controls and part/device identification methods.
CO5	Study the effect of automation by simulation and experimentation.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Principles and Strategies of Automation-Power to Accomplish the Automated Process, program of Instruction, Control System, Advanced automation Functions-safety Monitoring, maintenance and repair Diagnostics, error Detection and Recovery, levels of automations-Five levels of automation and control in manufacturing.

Material Handling systems and Design-Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage systems-Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.

Automatic identification methods-Overview of Automatic Identification Methods, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies.

Industrial control systems-Process Industries Vs Discrete Manufacturing Industries, Levels of Automation in the two industries, Variables and Parameters in the two industries.

Continuous Vs Discrete control- Continuous Control System, Discrete Control System.

Computer process control and its forms- Control Requirements, Capabilities of Computer Control, and Forms of Computer process Control.

Control system components-Sensors, Actuators, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Input/output Devices for Discrete Data.

Reading:

1. Groover, M.P., *Automation production Systems and Computer Integrated Manufacturing, Pearson Education*, 2003.
2. Krishna Kant*, Computer Based Industrial Control*, Prentice Hall of India, New Delhi, 2000.
3. Tiess Chiu Chang and Richard A.W., An Introduction to Automated Process planning Systems, Tata McGraw-Hill Publishing company, New Delhi, 2000.

ME479	INDUSTRIAL ROBOTICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the basic components of robots.
CO2	Differentiate types of robots and robot grippers.
CO3	Model forward and inverse kinematics of robot manipulators.
CO4	Analyze forces in links and joints of a robot.
CO5	Programme a robot to perform tasks in industrial applications.
CO6	Design intelligent robots using sensors.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Robotics-classification, Sensors-Position sensors, Velocity sensors, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors.

Grippers and Manipulators-Gripper joints, Gripper force, Serial manipulator, Parallel Manipulator, selection of Robot-Selection based on the Application

Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, Direct and Inverse Kinematics for industrial robots for Position and orientation.

Differential Kinematics and static- Dynamics-Lagrangian Formulation, Newton-Euler Formulation for RR & RP Manipulators,

Trajectory planning-Motion Control- Interaction control, Rigid Body mechanics, Control architecture- position, path velocity and force control systems, computed torque control, adaptive control, and Servo system for robot control.

Programming of Robots and Vision System- overview of various programming languages.

Application of Robots in production systems- Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection.

Reading:

1. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., *Robotics control, Sensing, Vision and Intelligence*, McGraw-Hill Publishing company, New Delhi, 2003.
2. Klafter, R.D., Chmielewski, T.A., and Negin. M, *Robot Engineering-An Integrated Approach*, Prentice Hall of India, New Delhi, 2002.
3. Craig, J.J., *Introduction to Robotics Mechanics and Control*, AddisonWesley, 1999.

ME480	FLEXIBLE MANUFACTURING SYSTEMS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand FMS and job-shop and mass production manufacturing systems.
CO2	Understand processing stations and material handling systems used in FMS environments.
CO3	Design and analyze FMS using simulation and analytical techniques.
CO4	Understand tool management in FMS.
CO5	Analyze the production management problems in planning, loading, scheduling, routing and breakdown in a typical FMS.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Understanding of FMS: Evolution of Manufacturing Systems, Definition, objective and Need, Components, Merits, Demerits and Applications of FMS

Processing stations: Machining Centers, Turning centers, CMM, Washing/ Deburring station, etc. Different Layouts and their Salient features

Material Handling System: An introduction, Conveyor, AGV, ASRS, Robots, etc. and their salient features.

Management technology: Tool Management, Configuration planning and routing, Production Planning and Control, Scheduling and control

Computer networks and control: Hardware, Software and database of FMS

Design of FMS: Performance Evaluation, Analytical model and Simulation model of FMS

Case studies: Typical FMS problems from researches papers

Reading:

1. Groover,M.P "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt.Ltd. New Delhi 2009

2. Tempelmeier.H and Kuhn.H. "Flexible Manufacturing system: Decision support for design and operation", John Wiley and Sons 2003.
3. Maleki A. "Flexible Manufacturing Systems: the technology and management". Prentice Hall International –2009

ME482	PROJECT MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the importance of projects and its phases.
CO2	Analyze projects from marketing, operational and financial perspectives.
CO3	Evaluate projects based on discount and non-discount methods.
CO4	Develop network diagrams for planning and execution of a given project.
CO5	Apply crashing procedures for time and cost optimization.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Introduction to Project Management, History of Project Management, Project Life Cycle.

Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing of Projects.

Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, Other network models.

Optimisation in PM: Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.

Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

Reading:

1. Prasanna Chandra, Project: A Planning Analysis, Tata McGraw Hill Book Company, New Delhi, 4th Edition, 2009.
2. Cleland, Gray and Laudon, Project Management, Tata McGraw Hill Book Company, New Delhi, 3rd Edition, 2007.
3. Jack R. Meredith., Samuel J. Jr. Mantel., *Project Management - A Managerial Approach*, John Wiley, 6th Edition, 2011.

ME483	RELIABILITY ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the concepts of reliability, availability and maintainability
CO2	Develop hazard-rate models to know the behaviour of components
CO3	Build system reliability models for different configurations
CO4	Asses reliability of components and systems using field and test data
CO5	Implement strategies for improving reliability of repairable and non-repairable systems

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics.

Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent & stress-dependent hazard models, bath-tub curve.

System Reliability Models: Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load-sharing models, stress-strength models, reliability block diagram.

Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems.

Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches; Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

Reading:

1. Ebeling CE, *An Introduction to Reliability and Maintainability Engineering*, TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, *Practical Reliability Engineering*, Wiley, 2012.

ME484	THEORY OF CONSTRAINTS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the philosophy of TOC.
CO2	Assess the system performance using throughput accounting.
CO3	Apply DBR and OPT methodologies for manufacturing scheduling.
CO4	Implement critical chain methodology for project scheduling
CO5	Understand TOC thinking process tools including CRT, EC, FRT and PRT

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Basic philosophy, local and global optima, five focusing steps of TOC, comparison with TQM & JIT philosophies.

Throughput Accounting: Financial and operating measures, local and global performance measures, throughput, inventory, operating expenses, linking concepts of throughput accounting with financial accounting.

Manufacturing Scheduling: Line and job shop processes, make-to-stock and make-to-order environments, scheduling rules, DBR methodology for scheduling line processes, OPT methodology for scheduling job shops, buffering and types of buffers, buffer management; Project Scheduling: Critical chain methodology, developing single-project critical chain plan, developing multi-project critical chain plan, buffer and threshold sizing, project risk management.

TOC Thinking Process: Current reality tree, evaporating clouds, future reality tree, prerequisite tree, transition tree.

Reading:

1. Dettmer H. W., Goldratt's *Theory of Constraints: A Systems Approach to Continuous Improvement*. ASQ Quality Press, Wiscousin, 1997.
2. Leach, L.P, *Critical Chain Project Management*, 2nd Edition, Artech House Inc, London, 2005.

CE390	ENVIRONMENTAL IMPACT ASSESSMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Identify the environmental attributes to be considered for the EIA study.
CO2	Formulate objectives of the EIA studies
CO3	Identify the suitable methodology and prepare Rapid EIA.
CO4	Prepare EIA reports and environmental management plans.
CO5	Plan the methodology to monitor and review the relief and rehabilitation works.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: The Need for EIA, Indian Policies Requiring EIA , The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.

Identifying the Key Issues: Key Elements of an Initial Project Description and Scoping, Project Location(s), Land Use Impacts, Consideration of Alternatives, Process selection: Construction Phase, Input Requirements, Wastes and Emissions, Air Emissions, Liquid Effluents, Solid Wastes, Risks to Environment and Human, Health, Socio-Economic Impacts, Ecological Impacts, Global Environmental Issues.

EIA Methodologies: Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS.

Reviewing the EIA Report: Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System,Integrated Impact Assessment.

Review of EMP and Monitoring: Environmental Management Plan, Identification of Significant or Unacceptable Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions, What should be monitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

Case Studies: Preparation of EIA for developmental projects- Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Nuclear fuel complex, Highway project, Sewage treatment plant, Municipal Solid waste processing plant, Tannery industry.

Reading:

1. Jain, R.K., Urban, L.V., Stracy, G.S., *Environmental Impact Analysis*, Van Nostrand Reinhold Co., New York, 1991.
2. Barthwal, R. R., *Environmental Impact Assessment*, New Age International Publishers, 2002
3. Rau, J.G. and Wooten, D.C., *Environmental Impact Assessment,* McGraw Hill Pub. Co., New York, 1996.
4. Anjaneyulu.Y., and Manickam. V., Environmental Imapact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.
5. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

EE390	LINEAR CONTROL SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Analyze electromechanical systems using mathematical modelling
CO2	Determine Transient and Steady State behavior of systems using standard test signals
CO3	Analyze linear and non-linear systems for steady state errors, absolute stability and relative stability
CO4	Design a stable control system satisfying requirements of stability and reduced steady state error

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	3	1	1					1
CO2	2	3		2	2	1						1
CO3	2	3		2	2	1						1
CO4	3	3	1	2	3	1	1					1

Detailed Syllabus:

Introduction – Types of Control Systems

Feedback & its effects

Mathematical modeling of Physical Systems and development of Block diagrams

Concept and use of Transfer function

Transfer function evaluation using Block diagram reduction technique

Concept of Signal flow graphs and Mason's gain formula

Introduction of Time Domain analysis of Control Systems

Unit step response of Standard Second order Control Systems, time domain indices and their significance

Steady state error constants

Concept of BIBO stability – Routh - Hurwitz criterion

Concept of P, PI and PID controllers – Effect of these controllers

Concept of Root Locus Technique – Theory – Rules in drawing Root Loci

Concept of Frequency Domain Analysis (Steady State Analysis), Polar Plots

Concept of Nyquist Stability Criterion, specific guidelines to draw Nyquist plots

Frequency Domain indices and their significance

Fundamentals of Bode plots, specific guidelines to draw Bode plots, Stability Analysis from Bode plots

Reading:

1. B.C. Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
2. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co. 2008.

EC390	COMMUNICATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand different modulation and demodulation schemes for analog communications.
CO2	Design analog communication systems to meet desired application requirements
CO3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO4	Elucidate the design tradeoffs and performance of communications systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2								1
CO2	3	2	2	2		2	2			1		1
CO3	3	2	1	2								1
CO4	3	2	1			2	2			1		1

Detailed Syllabus:

Signal Analysis: Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process , Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise In phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

AM (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM,FM,PCM and DM.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

Reading:

1. Communication Systems, S.Haykin, 4th Edn, John Wiley & Sons, Singapore, 2001.
2. Modern Digital & Analog Communication Systems, B.P. Lathi, 3rd Edn, Oxford University Press, Chennai, 1998.
3. Digital and Analog Communication Systems, Leon W.Couch II., 6th Edn, Pearson Education inc., New Delhi, 2001.
4. Communication Systems – A Bruce Carlson, PB Crilly, JC Rutledge, 4th Edn, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Develop basic understanding of microprocessor architecture.
CO2	Design Microprocessor and Microcontroller based systems.
CO3	Understand C, C++ and assembly language programming
CO4	Understand concept of interfacing of peripheral devices and their application.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1		2							1
CO2	2	3	1		2		2				1	1
CO3	1	2	3	3	2		2					1
CO4	2	2	1		2						1	1

Detailed Syllabus:

Microcomputer Organization: CPU, Memory, I/O, Operating System, Multiprogramming, Multi threading, MS Windows

80386 Micro Processors : Review of 8086,salient features of 80386,Architecture and Signal Description of 80386,Register Organization of 80386,Addressing Modes,80386 Memory management, Protected mode, Segmentation, Paging, Virtual 8086 Mode, Enhanced Instruction set of 80386,the Co- Processor 80387

Pentium & Pentium-pro Microprocessor: Salient features of Pentium microprocessor, Pentium architecture, Special Pentium registers, Instruction Translation look aside buffer and branch Prediction, Rapid Execution module, Memory management, hyper threading technology, Extended Instruction set in advanced Pentium Processors

Microcontrollers: Overview of micro controllers-8051 family microcontrollers, 80196 microcontrollers family architecture, instruction set, pin out, memory interfacing.

ARM Processor Fundamentals: Registers, current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor families, ARM instruction set, Thumb Instruction set-Exceptions Handing, Interrupts, Interrupt Handling schemes, firmware, Embedded operating systems, Caches-cache architecture, Cache policy, Introduction to DSP on the ARM, DSP on the ARM7TDMI, ARM9TDMI.

Case study-Industry Application of Microcontrollers

Reading:

1. Barry B. Brey: Intel Microprocessor Architecture, Programming and Interfacing-8086/8088,80186,80286,80386 and 80486,PHI,1995.
2. Muhammad Ali Mazidi and Mazidi:The 8051 Microcontrollers and Embedded systems, PHI, 2008
3. Intel and ARM Data Books on Microcontrollers.

EC442	ELECTRONIC MEASUREMENTS AND INSTRUMENTATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand appropriate and effective use of instruments.
CO2	Identify suitable instruments for typical measurements.
CO3	Identify transducers to measure strain, temperature etc.
CO4	Understand data acquisition system and general purpose interfacing bus and its applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1			1					1
CO2	3	2	2	2			1					1
CO3	3	2	2	2			1					1
CO4	3	1	2	1			1				2	1

Detailed Syllabus:

Measurement And Error: Sensitivity, Resolution, Accuracy and precision, Absolute and Relative types of errors, Statistical analysis, Probability of and Limiting errors, Linearity.

Instruments: D – Arsonval movement and basic principles of Measurement of Voltage, Current and Resistance in instruments. Analog and Digital Multimeters, Measurement of time and Frequency – Digital Frequency Meter and applications.

Impedance Measurement: Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems.

Oscilloscopes: Block diagram, probes, Deflection amplifier and delay line, Trigger Generator, Coupling, Automatic Time Base and Dual Trace Oscilloscopes, Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes.

Special instruments: Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer, FFT Analyzer.

Transducers (Qualitative Treatment Only): Classification and selection of Transducers, Introduction to strain, Load, force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements.

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS.

General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM.

Reading:

1. Electronic Measurements and Instrumentation, by Oliver and Cage, Mc Graw Hill.
2. Electronic Instrumentation & Measurement techniques, by W.D. Cooper & Felbrick, PHI. (Only for chapter Nos.2 and 7).
3. Electronic Instrumentation and Measurements by D.A. Bell, Reston.

MM390	METALLURGY FOR NON-METALLURGISTS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the characteristics and usefulness of metals and alloys.
CO2	Differentiate metals and alloys and their fabrication techniques.
CO3	Correlate the microstructure, properties, processing and performance of materials.
CO4	Select metal/alloy for engineering applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	2		1					1
CO2	2	3	2	1	2		1					1
CO3	2	3	1	1	1		3					1
CO4	2	3	1	1	2		1					1

Detailed Syllabus:

Introduction to Metallurgy

Structure of Metals and Alloys: Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals

Mechanical Properties: Plastic Deformation Mechanisms, Tensile, Creep, Fatigue, Fracture

Strengthening Mechanisms: Strain Hardening, Grain Size Refinement, Solid Solution Strengthening, Precipitation Hardening

Discovering Metals: Overview of Metals, Modern Alloy Production

Fabrication and Finishing of metal products: Metal Working and Machining

Testing of Metals: Both Destructive and Non-Destructive, Inspection and Quality Control of Metals

Engineering Alloys: Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, Nonferrous Metals

Heat Treatment: Annealing, Normalizing, Hardening, Tempering

Corrosion and its Prevention: Electro chemical considerations, Corrosion Rates, Passivity, Environmental Effects, Forms of Corrosion, Corrosion Environments, Oxidation; Durability of Metals and Alloys

The material selection processes: Case studies

Reading:

1. M. F. Ashby: Engineering Metals, 4th Edition, Elsevier, 2005.
2. R. Balasubramaniam (Adapted): Calister's Materials Science and Engineering, 7th Edition, Wiley India (P) Ltd, 2007.
3. Reza Abbaschian, Lara Abbaschian, R E Reed-Hill: Physical Metallurgy Principles, AffiliatedEast-West Press, 2009.
4. V Raghavan: Elements of Materials Science and Engineering- A First Course, 5th Edition, PHI Publications, 2006

CH390	NANOTECHNOLOGY AND APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the properties of Nano-materials and applications
CO2	Apply chemical engineering principles to Nano-particle production
CO3	Solve the quantum confinement equations.
CO4	Characterize Nano-materials.
CO5	Scale up the production Nano particles for Electronics and Chemical industries.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nano materials, Introduction to nano sizes and properties comparison with the bulk materials, Different Shapes and Sizes and Morphology.

Fabrication of Nanomaterials: Top Down Approach Grinding, Planetory milling and Comparison of particles, Bottom Up Approach - Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH,.

Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones Difference between Chemical Engineering procecesses and nanosynthesis processes

Quantum mechanics: Quantum mechanics Qunatum dots and its Importance, Pauli exclusion principle Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots Simiconductor quantum dots Semiconductor quantum dots : Introduction - Nanoclay Synthesis method, Applications of nanoclay

Nanomaterials charachterization – Instrumentation, Fractionation principles of Particle size measurements, Particle size and its distribution, Structural ,XRD, Zeta potential Electronic band structure Electron statistics Application: Optical transitions in solids , photonic crystals, Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Applications in Chemical Engineering - Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO_2,Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes Carbon arc bulk synthesis, commercial processes of synthesis of nanomaterials Nanoclay, Commercial case study of nano synthesis applications of Chemical Engineering, Nano inroganic materials of $CaCO_3$ synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices, BYK and other nanomaterial Industries ,Biological methods of synthesis

Nanobiology and other - Biological synthesis of nanoparticles and applications drug delivery, Nanocontainers and Responsive Relase of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nano materials, Environmental Impacts Case Study for Environmental and Societal Impacts

Reading

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons,2005.
4. Gabor L. Hornyak , H.F. Tibbals , Joydeep Dutta , John J. Moore Introduction to Nanoscience and Nanotechnology CRC Press

CH391	INDUSTRIAL SAFETY AND HAZARDS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and preventive measures.
CO4	Assess the risks using fault tree diagram.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	1	2	3	2		2		1
CO2			3			2	3	2		2	2	1
CO3			3	1	1	2	3	2		1	2	1
CO4	1	1	3	1	1	1	3	1		2		1

Detailed Syllabus:

Introduction-Toxicology-Relative toxicity-Industrial hygiene-Source models-Toxic release and dispersion models-Design basis-Pasquill-Gifford model-Fires and Explosions-The fire triangle-Sprays and Mists-Designs to prevent fires and explosions-Introduction to reliefs-Relief systems-Relief sizing-Process Hazards-Identification-Risk Assessment-Fault trees-Accident investigations-Layered investigations-Investigation Summary-Case Studies-System designs

Reading:

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall,2011.

2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

CS390	OBJECT ORIENTED PROGRAMMING	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand fundamental concepts in object oriented approach.
CO2	Analyze design issues in developing OOP applications.
CO3	Write computer programs to solve real world problems in Java.
CO4	Analyze source code API documentations.
CO5	Create GUI based applications.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Object- oriented thinking, History of object-oriented programming, overview of java, Object-oriented design, Structure of java program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors, garbage collection, Method overloading, passing objects as parameters, Inheritance, various forms and types of inheritance, Multilevel hierarchy, use of super, method overriding, Applications of method overriding, abstract classes, Packages with examples

Interfaces and implementation, Exception handling, types, throwing, creating own exceptions, Multithreading and concepts, its usage and examples, Input/output streams, String operations and examples, Collection classes-array, stack collection, bitset collection, Utility classes-string tokenizer, bitset, date, Applets- methods, creation, designing and examples, Event handling-event classes, Event listener interfaces, AWT classes, working with frames, AWT controls-layout manager, user interface components, Graphics programming

Reading:

1. Timothy Budd, "Understanding object-oriented programming with Java", Pearson publications.
2. Herbert Schildt, " The complete reference Java 2", TMH

BT390	GREEN TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Address smart energy and green infrastructure
CO2	Build models that simulate sustainable and renewable green technology systems
CO3	Understand the history, global, environmental and economical impacts of green technology
CO4	Address non-renewable energy challenges

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		3			2	3	2		2		1
CO2		2	3			2	3			2		1
CO3			3			2	3	2		2	2	1
CO4	2						3	2		2		1

Detailed Syllabus:

Biomass Energy, basic concepts, sources of biomass energy, uses of biomass energy, science and engineering aspects of biomass energy, production of biomass electricity, transmission of biomass electricity, storage of biomass electricity.

Energy transformation from source to services; Energy sources, sun as the source of energy; biological processes; photosynthesis; food chains, classification of energy sources, quality and concentration of energy sources; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India’s energy scenario.

Environmental effects of energy extraction, conversion and use; sources of pollution from energy technologies, Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation-, technological/ environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity.

First and second laws of thermodynamics and their applications – Thermodynamic processes - Irreversibility of energy – Entropy. Properties of steam and classification of steam engines. Carnot cycle - Rankine cycle, Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil, Shale, Nuclear energy Option.

Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, Sustainability of biomass fuels, economics of biomass fuels, Fuel stoichiometry and analysis: Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O_2, CO_2, CO, NOx, SOx).

Biomass as a major source of energy in India: Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

Reading:

1. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet's Future Energy Needs, 1st Edition, Springer,2009.
2. Jay Cheng, Biomass to Renewable Energy Processes, 1st Edition, CRC press, 2009.
3. Samir K.Khanal, Rao Y.Surampally, 1st edition, American Society of Civil Engieers,2010.

SM390	MARKETING MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand concepts and scope of marketing and market oriented strategic planning
CO2	Analyze macro level environment
CO3	Identify factors influencing consumer behavior in competitive global business environment
CO4	Identify tools and techniques for marketing management through integrated marketing communication systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					3	2	1		2		3	1
CO2					2	1	2		2		3	1
CO3					2	1	2		2		3	1
CO4					3	2	1		2		3	1

Detailed Syllabus:

Importance of Marketing, Scope of Marketing, Core Marketing concepts company orientation towards market place-production concept, Product concept, selling concept and Marketing concept.

Market oriented Strategic planning – Defining corporate Mission and Vision Statement at Corporate level and at Business unit level. Assigning resources to Strategic Business units through B.C.G Matrix and G.E Model.

Analysing Macro environment-Demographic environment. Economic Environment, Technical Environment, Social-Cultural Environment and political – Legal Environment.

Components of Marketing information systems- Internal Records, Marketing intelligence, Marketing research and Marketing Decision support system.

Consumer Behavior- Buying Decision process and the factors influencing consumer Behavior-Psychological factors, social factors, cultural factors and personal factors.

Importance of Market segmentation, Target market selection and positioning.

Importance of new product development process and the various stages involved.

The concept of product lifecycle and the various strategies used by the marketer in each stage.

Product characteristics and classification, Product mix and product line decisions Branding Decisions, Building Brand Equity.

Importance of Pricing, Factors influencing pricing decisions. Various pricing methods-cost based and demand based methods.

Role of Marketing channels-Channel functions and channel levels channel Design and channel Management Decisions, Managing Retailing. Wholesaling and logistics. Importance of Electronic channels.

Importance of integrated Marketing communication. Advantages and Disadvantages of Various promotional tools- Advertising, Sales promotion, personal selling, publicity and public Relations and Direct marketing.

Reading:

1. Philip Kotler, *Marketing Management* –PHI, 14th Edition.
2. William Stonton & Etzel, *Marketing Management* –TMH, 13th Edition.
3. Rama Swami & Namakumari, *Marketing Management* –McMillan, 2013.

MA390	NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Solve nonlinear differential equations by numerical methods.
CO2	Determine the convergence region for a finite difference method.
CO3	Solve elliptic PDE by finite difference method
CO4	Solve a parabolic PDE by finite difference method
CO5	Solve a hyperbolic PDE by finite difference method

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear nonlinear boundary value problems, Quazilinearization, Shooting methods

Finite difference methods: Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for :

Parabolic equations : Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

Elliptic equations : Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

Reading:

1. M.K. Jain, *Numerical Solution of Differential Equations,* Wiley Eastern, 1984.
2. G.D. Smith, *Numerical Solution of Partial Differential Equations*, Oxford Univ. Press, 2004.
3. M.K.Jain, S.R.K. Iyengar and R.K. Jain, *Computational Methods for Partial Differential Equations*, Wiley Eastern, 2005.

MA391	FUZZY MATHEMATICS AND APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Apply operations on Fuzzy sets
CO2	Solve problems related to Propositional Logic.
CO3	Apply Fuzzy relations to cylindric extensions.
CO4	Apply logic of Boolean Algebra to switching circuits.
CO5	Develop Fuzzy logic controllers

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Crisp set theory (CST): Introduction, Relations between sets, Operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relations on sets.

Fuzzy set theory (FST): Introduction, concept of fuzzy set (FS), Relation between FS, operations on FS, properties of standard operations, certain numbers associated with a FS, certain crisp sets associated with FS, Certain FS associated with given FS, Extension principle.

Propositional Logic (PL1): Introduction, Syntax of PL1, Semantics of PL1, certain properties satisfied by connectives, inference rules, Derivation, Resolution.

Predicate Logic (PL2): Introduction, Syntax of PL2, Semantics of PL2, certain properties satisfied by connectives and quantifiers, inference rules, Derivation, Resolution

Fuzzy Relations (FR): Introduction, Operations on FR, α-cuts of FR, Composition of FR, Projections of FR, Cylindric extensions, Cylindric closure, FR on a domain.

Fuzzy Logic (FL): Introduction, Three-valued logics, N-valued logics and infinite valued logics, Fuzzy logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretations in terms of FR, fuzzy inference, More on fuzzy inference, Generalizations of FL

Switching functions (SF) and Switching circuits (SC): Introduction, SF, Disjunctive normal form, SC, Relation between SF and SC, Equivalence and simplification of circuits, Introduction of Boolean Algebra BA, Identification, Complete Disjunctive normal form.

Applications: Introduction to fuzzy logic controller (FLC), Fuzzy expert systems, classical control theory versus fuzzy control, examples, working of FLC through examples, Details of FLC, Mathematical formulation of FLC, Introduction of fuzzy methods in decision making.

Reading

1. M. Ganesh, *Introduction to Fuzzy Sets and Fuzzy Logic*, PHI, 2001.
2. G.J. Klir and B.Yuan, *Fuzzy sets and Fuzzy Logic–Theory and Applications,* PHI, 1997.
3. T. J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill, 1995.

PH390	MEDICAL INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the origin of bio-potentials and their physical significance.
CO2	Understand anatomy and functioning of human heart and its common problems.
CO3	Analyze ECG, ENG and EMG signals and instrumentation.
CO4	Compare different techniques of measuring blood pressure, blood flow and volume.
CO5	Interpret the principle and operation of therapeutic and prosthetic devices.
CO6	Differentiate between the various techniques for measurement of parameters.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

General Introduction: The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

Origin of Biopotentials: electrical activity of Excitable cells: the resting state, The active state, Volume conductor fields, Functional organization of the peripheral nervous system: Reflex are & Junctional transmission.

The Electroneurogram (ENG): The H-Reflex, The Electromyogram (EMG), The Electrocardiogram (ECG), heart and the circulatory system, Electro conduction system of the heart and heart problems, ECG waveform and Physical significance of its wave features, Electrical behavior of cardiac cells, The standard lead system, The ECG preamplifier, DC ECG Amplier, Defibrillator protection circuit, Electro surgery Unit filtering, Functional blocks of ECG system, Multichannel physiological monitoring system, Common problems encountered and remedial techniques.

Blood Pressure: indirect measurement of blood pressure, korotkoff sounds, auscultatory method using sphygmo manometer, Oscillometric and ultrasonic non invasive pressure measurement, Direct measurement of blood pressure H_2O manometers, electronic manometry, Pressure transducers,. Pressure amplifier designs, Systolic, diastolic mean detector circuits

Blood flow and Volume Measurement: indicator dilution methods, Transit time flow meter, DC flow meter, Electromagnetic flow meter AC electromagnetic flow meter, Quadrature suppression flow meter, Ultrasonic flow meter, Continuous-wave Doppler flow meter, Electric impedance plethysmography, chamber plethysmography, Photo plethysmography.

Pulse Oximetr: Principles of Operation, Absorption Spectrum, Sensor design, Pulse oximeter, Therapeutic and Prosthetic Devices.

Cardiac Pacemakers: Lead wires and electrodes, Synchronous Pacemakers, rate responsive pacemaking, Defibrillators, cardioverters, Electrosurgical unit, Therapeutic applications of laser, Lithotripsy Hemodialysis.

Reading:

1. John G Webster, *Medical Instrumentation: Application and Design* , John Wiley,3rd Ed. 2012.
2. Joseph J. Carr & John M. Brown , *Introduction to biomedical Equipment Technology*, 4th Ed., Prentice Hall India, 2001.

PH391	ADVANCED MATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Understand modeling of composite materials by finite element analysis
CO4	Differentiate superconducting materials
CO5	Understand the characteristics and uses of functional materials

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Nano Materials: Origin of nano technology, Classification of nano materials, Physical, chemical, electrical, mechanical properties of nano materials. Preparation of nano materials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon nano tubes(CNT).Synthesis, preparation of nanotubes, nano sensors, Quantum dots, nano wires,nano biology, nano medidcines.

Biomaterials: Overview of biomaterials. Biomaterials, bioceramics, biopolymers, tissue grafts, soft tissueapplications, cardiovascular implants, biomaterials in ophthalmology, orthopeadiacimplants, dental materials.

Composites: General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

Optical materials: Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices(CCD), laser materials.

Super conducting materials: Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high T_c superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

Smart materials: An introduction, principles of smart materials, input – output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials.

Surface Acoustic Wave (SAW) Materials and Electrets: Delay lines, frequency filters, resonators, Pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets.

Reading:

1. T.Pradeep, *Nano: The Essentials*; TaTa McGraw-Hill,2008.
2. B.S. Murthy et al., *Textbook of Nano science and Nanotechnology*, University press
3. Krishan K Chawla, *Composite Materials;* 2^{nd} Ed., Springer 2006.

CY390	INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Characterize materials using ultraviolet and visible absorption and fluorescence techniques
CO2	Analyze materials, minerals and trace samples using the atomic absorption, emission and X-ray fluorescence techniques
CO3	Analyze environmental, industrial, production-line materials by liquid, gas and size-exclusion chromatographic techniques.
CO4	Characterize interfaces and traces of surface adsorbed materials using electro analytical techniques
CO5	Understand the principles of thermogravimetry and differential thermal analyses.
CO6	Characterize chemical, inorganic and engineering materials by selecting analytical technique.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

UV-Visible Spectrophotometry and Fluorescence: Beer-Lambert’s law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, applications.

Atomic spectrometry, atomic absorption, X-ray fluorescence methods: Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, Instrumentation, quantitative analysis.

Separation techniques: Solvent extraction, Principle, Extraction of solutes, Soxhlet extraction Chromatography methods: Gas chromatography, High performance liquid chromatography, Size exclusion chromatography, Principle, Basic instrumentation, Capillary Electrophoresis: Principle and application.

Thermoanalytical methods: Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations.

Electroanalytical methods: Coulometric methods, Polarography, Pulse voltammetric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric sensors, Applications.

Spectroscopic methods: Molecular absorption, Woodward rules, applications, Infra red absorption, functional group analysis, qualitative analysis, 1H- and 13C-NMR spectroscopy, Principle, Basic instrumentation, terminology, Interpretation of data, Quantitative applications.

Mass spectrometry: Principles, Instrumentation, Ionization techniques, Characterization and applications.

Reading

1. Mendham, Denny, Barnesand Thomas, Vogel: Text book of Quantitative Chemical Analysis, Pearson Education, 6th Edition, 2007.
2. Donald L. Pavia, Gary M Lanyman, Introduction to Spectroscopy, 3rd Edition,Thompson Pubs, 2008
3. Krishan K Chawla, Composite Materials; 2nd Edition, Springer 2006.

CY391	CHEMICAL ASPECTS OF ENERGY SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand traditional and alternative forms of energy
CO2	Understand energy production, storage, distribution and utilization.
CO3	Model environmental impacts of energy generation and conservation
CO4	Apply concepts of engineering design to energy challenges

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1		2		2					2
CO2	3	3	2		2		2					2
CO3	3	3	1		2	1	3					2
CO4	3	3	2		2		2					2

Detailed Syllabus:

Energy as the Key of Civilization; Thermo chemistry of Energy Sources and Kinetics of Energy Tapping; Conventional and Finite Energy Sources; Coal Based Energy Sources and Coal Carbonization; Petroleum and Natural Gas; Biomass and Gobar Gas; Primary and Secondary Batteries, Reserve Batteries, Solid State and Molten Solvent Batteries, Lithium Ion Batteries;, Solar Energy Harnessing, Photo galvanic and Photovoltaic Energy Storage; Fuel Cells; Hydrogen as Future Fuel; Photochemical Water Cleavage; Green Energies.

Reading

1. Tokio Ohta, Energy Systems, Elsevier Science, 2000.
2. R. Narayan and B. Viswanathan, Chemical and Electrochemical Energy Systems, Universities Press, 1998.

HS390	SOFT SKILLS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand corporate communication culture
CO2	Prepare business reports and proposals expected of a corporate professional
CO3	Use fluent and appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire appropriate corporate email, mobile and telephone etiquette

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

English Language Enhancement: Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English

Art of Communication, Communication process- Non-verbal Communication- Effective Listening-

Interpersonal and Intra Personal Communication Skills- Self-Awareness- Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles-Leadership

Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette- Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills- Interview Handling skills- Effective Resume-- Common Interview Mistakes- Body-language- Content Aid, Visual Aids- Entrepreneurial Skills Development

Reading:

1. Robert M.Sherfield, Developing Soft Skills, Montgomery and Moody Fourth Edn. 2009 Pearson Publishers.
2. K.Alex, Soft Skills: Know Yourself & Know The world, S. Chand ; 2009
3. Robert Bramson , Coping with Difficult People, Dell 2009

CE440	BUILDING TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Apply basic principles to develop stable, sustainable and cost-effective building plans.
CO2	Identify effective measures for fire proofing, damp proofing, and thermal insulation.
CO3	Adopt standard building provisions for natural ventilation and lighting.
CO4	Identify different materials, quality and methods of fabrication & construction.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1				1		2		1	1
CO2	3	2	1				1				1	1
CO3	2	2	1				1		1		1	1
CO4	2	2	1				1		2		1	1

Detailed Syllabus:

Overview of the course, basic definitions, Buildings – Types, components, economy and design, Principles of planning of buildings and their importance.

Definitions and importance of Grouping and circulation; Lighting and ventilation; How to consider these aspects during planning of building

Termite proofing: Inspection, control measures and precautions, Lighting protection of buildings: General principles of design of openings, Various types of fire protection measures to be considered while planning a building.

General requirements and extra requirements for safety against fire, special precautions, Vertical transportation in building – types of vertical transportation, Stairs, different forms of stairs, planning of stair cases, Other modes of vertical transportation – lifts, ramps, escalators.

Prefabrication systems in residential buildings – walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication.

Planning and designing of residential buildings against the earthquake forces, Principles, Seismic forces and their effect on buildings.

Air conditioning – process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation.

Acoustics, effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation – importance and measures.

Plumbing services – water supply system, maintenance of building pipe line, Sanitary fittings, principles governing design of building drainage.

Reading:

1. Building Construction - Varghese, PHI Learning Private Limited, 2008
2. Building Construction - Punmia, B C, Jain, A J and Jain A J, Laxmi Publications, 2005
3. Building Construction by S.P. Arora and S.P. Bindra – Dhanpatrai and Sons, New Delhi, 1996.
4. Building Construction – Technical Teachers Training Institute, Madras, Tata Mc Graw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005

MM440	MATERIALS FOR ENGINEERING APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Correlate processing, microstructure and properties of materials.
CO2	Understand behaviour of materials under various conditions.
CO3	Characterize modes of failure of engineering materials and design new materials with better properties and cost effective processes.
CO4	Identify suitable materials for engineering applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1		2		2					1
CO2	3	3	2		2		2					1
CO3	3	3	1		2		2					1
CO4	3	3	2		2		2					1

Detailed Syllabus:

Materials Science and Engineering Materials, Classification of Materials and Properties: Mechanical, Dielectric, Magnetic and Thermal

Metallurgical Aspects of Materials: Structure of Metals and Alloys, Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals, Significance of microstructural features

Heat Treatment: effect of cooling and heating rates and ageing materials for mechanical load bearing applications

Corrosion Resistant Materials: Some important Metals, Alloys, Ceramics and Polymers

Materials for Electrical Applications: Conductors, Dielectrics, insulators

Materials for Civil Engineering Applications

Materials for Biomedical applications: Steels, Ti and its alloys, Ni-Ti alloys, bioceramics, porous ceramics, bioactive glasses, calcium phosphates, collagen, thin films, grafts and coatings, biological functional materials Latex products

Reading:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, Butterworth Heinemann, 2005.
3. ASM Publication Vol. 20, Materials Selection and Design, ASM, 1997
4. Pat L. Mangonon: The Principles of Materials Selection and Design, Prentice Hall International, Inc, 1999.

CH440	INDUSTRIAL POLLUTION CONTROL	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Analyze the effects of pollutants on the environment.
CO2	Understand meteorological aspects of air pollution
CO3	Understand air pollution control methods
CO4	Select treatment technologies for water/wastewater/solid waste.
CO5	Design unit operations for pollution control.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction: Biosphere, hydrological cycle, nutrient cycle, consequences of population growth, pollution of air, water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, emission sources, behavior and fate of air pollutants, effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, wind velocity and turbulence, plume behavior, dispersion of air pollutants, estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, ambient air sampling, stack sampling, analysis of air pollutants.

Air pollution control methods & equipment: Control methods, source correction methods, cleaning of gaseous effluents, particulate emission control, selection of a particulate collector, control of gaseous emissions, design methods for control equipment.

Water pollution: Water resources, origin of wastewater, types of water pollutants and there effects.

Waste water sampling, Analysis and Treatment: Sampling, methods of analysis, determination of organic matter, determination of inorganic substances, physical characteristics, bacteriological measurement, basic processes of water treatment, primary treatment, secondary treatment, advanced wastewater treatment, recovery of materials from process effluents.

Solid Waste Management: Sources and classification, public health aspects, methods of collection, disposal Methods, potential methods of disposal.

Hazardous Waste Management: Definition and sources, hazardous waste classification, treatment methods, disposal methods.

Reading:

1. Rao C.S. – Environmental Pollution Control Engineering- Wiley Eastern Limited, India, 1993.
2. Noel de Nevers- Air Pollution and Control Engineering- McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke - Environmental Science and Engineering, 2^{nd} Edition, Prentice Hall of India, 2004.
4. Rao M.N. and Rao H.V.N - Air Pollution, Tata – McGraw Hill Publishing Ltd., 1993.
5. De A.K - Environmental Chemistry, Tata – McGraw Hill Publishing Ltd., 1999.

CH441	FUEL CELL TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand fuel cell fundamentals.
CO2	Analyze the performance of fuel cell systems.
CO3	Understand construction and operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2			1				1
CO2	2	2	1		2			1				1
CO3	1	3	1		1	1	1	1				1
CO4	3	1	1		3	1	1	1				1

Detailed Syllabus:

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuels for Fuel Cells: Fossil fuels, Basics of fuel processing, Biofuels, Hydrogen, Hydrogen storage.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal , Using renewable fuels for SOFCs

Reading:

1. Gregor Hoogers, Fuel Cell Technology Hand Book, CRC Press, 2003.

2. Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: Theory and Practice (2nd Ed.) Elsevier/Academic Press, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications

CS440	MANAGEMENT INFORMATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Determine key terminologies and concepts including IT, marketing, management, economics, accounting, finance in the major areas of business.
CO2	Design, develop and implement Information Technology solutions for business problems.
CO3	Analysis of computing systems and telecommunication networks for business information systems.
CO4	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions.
CO5	Plan projects, work in team settings and deliver project outcomes in time.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Organization and Information Systems, Foundation Concepts, Information Systems in Business, The Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage.

Changing Environment and its impact on Business, Kinds of Information Systems.

Computer Fundamentals, Computer Hardware, Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Telecommunication and Networks, Telecommunications and Networks, The Networked Enterprise, Telecommunications Network Alternatives

System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems

Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT,

Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology

Reading:

1. Kenneth J Laudon, Jane P. Laudon, *Management Information Systems*, 10th Edition, Pearson/PHI, 2007.
2. W. S. Jawadekar, *Management Information Systems*, 3rd Edition, TMH, 2004.

BT440	BIOSENSORS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand biosensing and transducing techniques
CO2	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
CO3	Demonstrate appreciation for the technical limits of performance of biosensor
CO4	Apply principles of engineering to develop bioanalytical devices and design of biosensors

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1		2		2					1
CO2	2	3	2		2		2					1
CO3	2	3	1		2		2					1
CO4	2	3	2		2		2					1

Detailed Syllabus:

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; Piezoelectric transducers.

Biorecognition systems: Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Tissue and organelles (animal and plant tissue); Cell culture; Immunoreceptors; Chemoreceptors; Limitations & problems. Immobilization of biomolecules.

Biosensor Engineering: Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, microcontact printing, MEMS. Engineering concepts for mass production.

Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.

Reading:

1. Donald G. Buerk, Biosensors: Theory and Applications, 1^{st} Edition, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1998.
3. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003.

SM440	HUMAN RESOURCE MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand principles, processes and practices of human resource management.
CO2	Apply HR concepts and techniques in strategic planning to improve organizational performance.
CO3	Understand tools to manage HR systems and procedures.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Introduction to Human Resource Management, Objectives, Scope and Significance of HRM, Functions of HRM, Problems and Prospects in HRM, Environmental scanning.

Human Resource Planning, Demand Forecasting Techniques, Supply Forecasting Techniques, Analyzing work and designing jobs, Recruitment and Selection, Interviewing Candidates.

Human Resource Development, Orientation, Training and Development, Management Development, Performance Appraisal and Employee Compensation, Factors Influencing Employee Remuneration and Challenges of Remuneration.

Industrial Relations, Industrial Disputes and Discipline, Managing Ethical Issues in Human Resource Management, Workers Participation in Management, Employee safety and health, Managing Global Human Resources and Trade Unions

International HRM, Future of HRM and Human Resource Information Systems

Reading:

1. Aswathappa ,*Human Resource Management* — TMH., 2010.
2. Garry Dessler and Biju Varkkey ,*Human Resource Management*, PEA., 2011.
3. Noe & Raymond ,*HRM: Gaining a Competitive Advantage*, TMH, 2008.
4. Bohlander George W, Snell Scott A ,*Human Resource Management*, Cengage Learning., 2009.

MA440	OPTIMIZATION TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Formulate and solve linear Programming Problems
CO2	Determine the optimum solution to constrained and unconstrained
CO3	Apply dynamic programming principle to Linear programming problems.
CO4	Determine the integer solutions to Linear Programming Problems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		1	2	1					1	1
CO2	3	2		1	2	1					1	1
CO3	3	2		1	3	1					1	1
CO4	3	2		1	2	1					1	1

Detailed Syllabus:

Linear Programming: Introduction and formulation of models, Convexity, Simplex method, Big-M method, Two-phase method, Degeneracy, non-existent and unbounded solutions, revised simplex method, duality in LPP, dual simplex method, sensitivity analysis, transportation and assignment problems, traveling salesman problem

Nonlinear Programming: Introduction and formulation of models, Classical optimization methods, equality and inequality constraints, Lagrange multipliers and Kuhn-Tucker conditions, quadratic forms, quadratic programming problem, Wolfe's method

Dynamic Programming: Principle of optimality, recursive relations, solution of LPP

Integer Linear Programming: Gomory's cutting plane method, Branch and bound algorithm, Knapsack problem, linear 0-1 problem

Reading:

1. Kanti Swarup, Man Mohan and P.K.Gupta, *Introduction to Operations Research*, S.Chand & Co., 2006
2. J.C.Pant, *Introduction to Operatins Research*, Jain Brothers, New Delhi, 2008.
3. N.S.Kambo : Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

MA441	OPERATIONS RESEARCH	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Formulate and solve linear programming problems
CO2	Determine optimum solution to transportation problem
CO3	Determine average queue length and waiting times of queuing models.
CO4	Determine optimum inventory and cost in inventory models.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2		2		2		1	1	2	1
CO2	3	2	1		2		2		1	1	2	1
CO3	3	2	1		2		2		1	1	1	1
CO4	3	2	1		2		2		1	1	1	1

Detailed Syllabus:

Linear Programming: Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

Transportation Problems: Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions. Degenracy in Transportation problems.

Queueing Theory: Poisson process and exponential distribution. Poisson queues - Model (M/M/1):(∞/FIFO) and its characteristics.

Elements of Inventory Control: Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

Reading:

1. Kanti Swarup, Man Mohan and P.K.Gupta, *Introduction to Operations Research*, S.Chand & Co., 2006
2. J.C.Pant, *Introduction to Operatins Research*, Jain Brothers, New Delhi, 2008.
3. N.S.Kambo : Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

PH440	NANOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the synthesis and properties of nano-structured materials.
CO2	Analyze magnetic and electronic properties of quantum dots
CO3	Understand the structure, properties and applications of Fullerenes and Carbon nano-tubes.
CO4	Understand applications of nanoparticles in nanobiology and nanomedicine

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									1
CO2	3	2	1			1	2					1
CO3	2	2	1			1						1
CO4	3	2	2		2	1	2					1

Detailed Syllabus:

General properties of Nano materials : Origin of nanotechnology. Classification of nanomaterials. Fullerene,carbon, Nanotubes (CNT's) , Nanoparticles. Physical ,Chemical, Electrical, Optical, Magnetic and mechanical properties of nanomaterials.

Fullerenes and Carbon Nanotubes (CNT's): Introduction: Synthesis and purification. Preparation of fullerenes in the condensed phase ,Transport, mechanical, physical properties of CNT's.

Investigation and manipulating materials in the Nanoscale: Electron microscope, scanning probe microscopes, optical microscopes for Nanoscience and Technology, X-Ray Diffraction.

SAMs and clusters: Growth process. Patterning monolayers. Types of clusters. Bonding and properties of clusters.

Semi conducting Quantum Dots: Introduction: Synthesis of Quantum Dots. Electronic structure of Nanocrystals, properties.

Nanobiology: Interaction between Biomolecules and Nanoparticle surgaces. Different types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies. Nanoprobes for Analytical Applications.

Nanosensors: Nanosensors based on optical properties. Nanosensors based on quantum size effects. Nanobiosensors.

Nanomedicines: Developments of nanomedicines. Nanotechnology in Diagnostic Applications, materials for use in Diagnostic and therapeutic Applications.

Reading:

1. T.Pradeep, *Nano: The Essentials*; TaTa McGraw-Hill,2008.
2. W.R.Fahrner,*Nanotechnology and Nanoelectronics*;Springer,2006.
3. Rechard Booker and Earl Boysen, *Nanotechnology*;Willey, 2006.

PH441	BIOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the structure and properties of biomaterials
CO2	Classify implant biomaterials
CO3	Evaluate the biocompatibility of implants
CO4	Identify appropriate biomaterials for specific medical applications

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									1
CO2	3	2	1			1	2					1
CO3	3	2	2			1		2	1	1		1
CO4	3	2	2		2	1	2			1		1

Detailed Syllabus:

Overview of biomaterials: Historical developments, impact of biomaterials, interfacial phenomena, tissue responses to implants

Structure and properties of biomaterials: Crystal structure of solids, phase changes, imperfections in solids, non crystalline solids, surface properties of solids, mechanical properties, surface improvements

Types of biomaterials: Metallic implant materials, ceramic implant materials, polymeric implant materials composites as biomaterials

Characterization of materials: Electric properties, optical properties, X-ray absorption, acoustic and ultrasonic properties

Bio implantation materials: Materials in ophthalmology, orthopedic implants, dental materials and cardiovascular implant materials

Tissue response to implants : Normal wound healing processes, body response to implants, blood compatibility, structure – property relationship of tissues

Reading:

1. Joon park, R.S. Lakes , *Biomaterials an introduction*; 3rd Ed., Springer 2007
2. Sujatha V Bhat , *Biomaterials*; 2nd Ed., Narosa publishing house, 2006

CY440	CORROSION SCIENCE	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the electrochemical principles of corrosion.
CO2	Apply eight forms of corrosion to industrial problems.
CO3	Evaluate corrosion rates for industrial problems
CO4	Evaluate the corrosion rates of steel in RCC under corrosive environments.
CO5	Perform case studies using microbially induced corrosion (MIC) of metals.
CO6	Perform case studies using appropriate methods of corrosion control of metals and alloys

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Understanding Corrosion:

Types of corrosion: uniform corrosion, Galvanic corrosion, pitting corrosion, stress corrosion cracking, corrosion fatigue, stray current corrosion, selective leaching, microbial corrosion Pourbaix potential-pH diagrams for iron, for aluminium, limitations of Pourbaix diagram Passivity- characteristics of passivation and the Flade potential, Theories of passivity, passive-active cells, critical pitting potential, Anodic protection and transpassivity.

Methods of corrosion monitoring:

Polarisation and corrosion rates, polarisation diagrams of corroding metals, calculation of corrosion rates from polarization data. Electrochemical impedance spectroscopy: Nyquist plots, Bode plots, simple equivalent circuits for fitting the impedance data, calculation of corrosion parameters from impedance measurements. Electrochemical cell assembly for polarization and impedance studies. Gravimetric method of determination of corrosion rates.

Measurement of corrosion rates of carbon steel in reinforced cement concrete, Corrosion rates of metals due to micriobially induced corrosion .

Methods of corrosion prevention and control:

Cathodic protection; By impressed current, By the use of sacrificial anodes, combined use with coatings, Advances in cathodic protection.

Metallic coatings: Methods of application, Electroplating, Electroless plating, specific metal platings like Cu, Ni and Cr.

Inhibitors and passivators: Picking inhibitors, vapour phase inhibitors, Inhibitors for cooling water systems, understanding of action of inhibitors through polarization and impedance.

Corrosion prevention and control strategies in different industries – case studies

Reading:

1. R. Winston Revie, Herbert H. Uhlig, Corrosion and Corrosion Control, 4th Edition, Wiley Interscience, 2007.
2. Mc Caffety, Edward, Introduction to Corrosion Science, 1st Edition, Springer, 2010.

CY441	CHEMISTRY FOR NANOMATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand the state of art synthesis of nano materials
CO2	Characterize nano materials using ion beam, scanning probe methodologies, position sensitive atom probe and spectroscopic ellipsometry.
CO3	Analyze nanoscale structure in metals, polymers and ceramics
CO4	Analyze structure-property relationship in coarser scale structures
CO5	Understand structures of carbon nano tubes.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Synthesis, characterization, properties and applications of the following Nanomaterials, Fullerenes, Carbon nanotubes, Core-Shell Nanoparticles, Nanoshells, Self-assembled monolayers and Monolayer Protected Metal Nanoparticles, Nanocrystalline materials, Magnetic Nanoparticles and Important properties in relation to nanomagnetic materials, Thermoelectric materials, Non-linear optical materials, liquid crystals.

Reading:

1. T Pradeep, NANO: The Essentials, MaGraw-Hill Edu., 2007.
2. Sulabha K. Kulakarni, Nanotechnology (Principles, Properties and Applications), Capital Publications House, 2009.
3. C. N. R. Rao, Nanomaterials Chemistry, Achim Muller, K.Cheetham, Wiley-VCH, 2007

HS440	CORPORATE COMMUNICATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None.

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

CO1	Understand corporate communication culture
CO2	Prepare business letters, memos and reports
CO3	Communicate effectively in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Practice corporate email, mobile and telephone etiquette
CO6	Develop good listening skills and leadership qualities

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Importance of Corporate communication - Introduction to and definition of corporates – Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

Oral Communication- Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion – Debate and oral presentations.

Written Communication- Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

Corporate responsibility- Circulating to employees vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

Corporate Ethics and Business Etiquette- Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing – Etiquette in e-mail, mobile and telephone.

Listening Skills - Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

Leadership Communication Styles - Business leadership -Aspects of leadership-qualities of a leader- training for leadership-delegation of powers and ways to do it-humour-commitment.

Reading:

1. Raymond V. Lesikar, John D. Pettit, Marie E. Flatley Lesikar's Basic Business Communication - 7th Edition: Irwin, 1993
2. Krishna Mohanand Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000
3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: – 3rd Edition Tata McGraw-Hill, 2008
4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.
5. Shirley Taylor, Communication for Business, Longman, 1999