NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

SYLLABI
FOR B.TECH. PROGRAM

From 2017-18 Batch onwards

DEPARTMENT OF MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION

B.Tech. (Mechanical Engineering) Course Structure

I - Year

Physics Cycle				
Code No.	**Subject**	**No. of Credits**	***L -T-P***	***Cat. Code***
MA101	Mathematics - I	03	*3-0-0*	*BSC*
HS101	English for Technical Communication	03	*2-0-2*	*HSC*
PH101	Physics	03	*3-0-0*	*BSC*
EC101	Basic Electronic Engineering	03	*3-0-0*	*ESC*
CE102	Environmental Science and Engineering	02	*2-0-0*	*ESC*
BT101	Engineering biology	02	*2-0-0*	*ESC*
CS101	Problem Solving & Computer Programming	05	*3-1-2*	*ESC*
PH102	Physics Laboratory	02	*0-1-2*	*BSC*
EA101	EAA: Games and Sports	00	*0-0-3*	*MDC*
	Total	**23**	**29**	

Chemistry Cycle				
Code No.	**Subject**	**No. of Credits**	***L -T- P***	***Cat. Code***
MA151	Mathematics - II	03	*3-0-0*	*BSC*
ME101	Basic Mechanical Engineering	03	*3-0-0*	*ESC*
CY101	Chemistry	03	*3-0-0*	*BSC*
EE101	Basic Electrical Engineering	03	*3-0-0*	*ESC*
CE101	Engineering Mechanics	03	*3-0-0*	*ESC*
ME102	Engineering Graphics	04	*1-1-4*	*ESC*
ME103	Workshop Practice	02	*0-1-2*	*ESC*
CY102	Chemistry Laboratory	02	*0-1-2*	*BSC*
EA151	EAA: Games and Sports	00	*0-0-3*	*MDC*
	Total	**23**	**30**	

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	3	0	0	3	PCC
3	CE235	Fluid Mechanics and Hydraulic Machines	3	1	0	4	PCC
4	CE236	Mechanics of Solids	3	1	0	4	PCC
5	ME201	Thermodynamics	3	1	0	4	PCC
6	ME202	Kinematics of Machinery	3	1	0	4	PCC
7	CE237	Fluid Mechanics and Hydraulics Machines Laboratory	0	1	2	2	PCC
8	CE238	Materials Testing Laboratory	0	1	2	2	PCC
		TOTAL	**18**	**6**	**4**	**26**	

II - Year: II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA261	Numerical and Statistical Methods	3	0	0	3	BSC
2	ME251	Dynamics of Machinery	3	1	0	4	PCC
3	ME252	Turbomachines	3	0	0	3	PCC
4	ME253	Manufacturing Science	3	1	0	4	PCC
5	ME254	Geometric Modeling for CAD	3	0	0	3	PCC
6	ME255	Computer Aided Machine Drawing	1	0	4	3	PCC
7	ME256	Manufacturing Processes Laboratory	0	1	2	2	PCC
8	ME257	Kinematics and Dynamics Laboratory	0	1	2	2	PCC
		TOTAL	**16**	**4**	**8**	**24**	

III - Year: I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME301	Design of Machine Elements	3	0	0	3	PCC
2	ME302	Prime movers for Automobiles	3	0	0	3	PCC
3	ME303	Machine tools and Metrology	3	1	0	4	PCC
4	ME304	Mechanical Measurements	3	0	0	3	PCC
5	ME305	Management Science and Productivity	4	0	0	4	PCC
6		Department Elective I	3	0	0	3	DEC
7	ME306	Thermal Engineering Laboratory	0	1	2	2	PCC
8	ME307	Machining and Metrology laboratory	0	1	2	2	PCC
9	EP349	EPICS	0	0	0	2*	
		TOTAL	**19**	**3**	**4**	**24**	

*Credits are not considered for computation of SGPA and CGPA

III - Year: II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME351	Design of Transmission Elements	3	1	0	4	PCC
2	ME352	Heat and Mass Transfer	3	1	0	4	PCC
3	ME353	Machining Science	3	0	0	3	PCC
4	ME354	Mechatronics	3	0	0	3	PCC
5		Department Elective II	3	0	0	3	DEC
6		Open Elective I	3	0	0	3	OPC
7	ME355	Heat Transfer and Fuels Laboratory	0	1	2	2	PCC
8	ME356	Measurements Lab	0	0	2	1	PCC
9	EP399	EPICS	0	0	0	2*	
		TOTAL	**18**	**3**	**4**	**23**	

*Credits are not considered for computation of SGPA and CGPA

IV - Year: I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	SM413	Engineering Economics and Accountancy	3	0	0	3	HSC
2	ME401	Refrigeration and Air-conditioning	3	0	0	3	PCC
3	ME402	Computer Aided Manufacturing	3	0	0	3	PCC
4		Open Elective II	3	0	0	3	OPC
5		Department Elective III	3	0	0	3	DEC
6	ME403	CAE Lab	0	0	2	1	PCC
7	ME404	CAM Lab	0	0	2	1	PCC
8	ME405	Mechatronics Lab	0	0	2	1	PCC
9	ME449	Project Work - Part A	0	0	4	2	PCC
		TOTAL	**15**	**0**	**10**	**20**	

IV - Year: II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Department Elective IV	3	0	0	3	DEC
2		Department Elective V	3	0	0	3	DEC
3		Department Elective VI	3	0	0	3	DEC
4		Department Elective VII	3	0	0	3	DEC
5	ME451	Mandatory Audit Course (Self Study)*	0	0	0	0	MDC
6	ME499	Project Work - Part B	0	0	8	4	PRC
		TOTAL	**12**	**0**	**8**	**16**	

*****_The result of the Mandatory Audit Course (Self Study) completed by the student either in 6th or 7th semester will be reported in this semester_

List of Department Electives

III Year I Semester

Elective-1

ME311 Mechanical Vibrations
ME312 Design Optimization Methods
ME313 Advanced Thermodynamics
ME314 Gas Dynamics
ME315 Advanced Welding Technology
ME316 Advanced Metal Casting

III Year II Semester

Elective-2

ME361 Finite Element Method
ME362 Theory of Elasticity
ME363 Computational Fluid Dynamics
ME364 Automobile Engineering
ME365 Non-Destructive Testing
ME366 Operations Research
ME367 Production Planning and Control
ME368 Design and Analysis of Experiments

IV Year I Semester

Elective-3

ME411 Condition Monitoring
ME412 Tribology
ME413 Non-conventional Energy Sources
ME414 Advanced IC Engines
ME415 Tool design
ME416 Theory of Plasticity
ME417 Total Quality Management
ME418 Entrepreneurship

IV Year II Semester

Electives - 4, 5, 6 and 7

ME461	Robotics
ME462	Rotor Dynamics
ME463	Engineering Acoustics
ME464	Mechanics of Composite Materials
ME465	Innovative Design
ME466	Convective Heat Transfer
ME467	Alternate Fuels
ME468	Jet Propulsion and Rocketry
ME469	HVAC
ME470	Cryogenics
ME471	Micro-scale Heat Transfer
ME472	Power Plant Engineering
ME473	Combustion
ME474	Advanced Metal forming
ME475	Machine Tool Design
ME476	Micro and Nano Manufacturing
ME477	Design for Manufacturing and Assembly
ME478	Design and Analysis of Engineering Materials
ME479	Additive Manufacturing
ME480	Industrial Automation
ME481	Advanced Operations Research
ME482	Supply Chain Management
ME483	Project Management
ME484	Reliability Engineering
ME485	Theory of Constraints
ME486	Advanced Materials Processing

List of Open Electives

(Offered to Other Department Students)

III Year: II Semester

ME390 Automotive Mechanics
ME391 New Venture Creation

IV Year: I Semester
ME440 Alternate Sources of Energy

ME441 Robust Design

Mandatory Audit Course (Self Study)

Student is required to complete at least one course offered by the following agencies. The student is required to take prior approval from the Department, before registering for any course. The student can register for such a course either in 6th Semester or 7th semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.

ASME: American Society of Mechanical Engineer Certification Program - www.asme.org

SWAYAM:

www.swayam.gov.in

NPTEL:

www.onlinecourse.npt

el.ac.in *Course Era:*

www.coursera.org

Free Online Courses:
www.edx.org

MIT Open Course ware: www.ocw.mit.edu

Points to be noted:

1. Definition of Pre-requisite: The student should have studied that subject which is mentioned as
   Pre-requisite.
2. Course with same name but with different code number indicates that the

subject pertains to different departments and also the syllabus is different.

3. EPICS (Engineering Project in Community Service) Project is offered in two parts as Part-A in III Year I Semester and Part-B in III Year II semester, with Two credits each. The credits earned are not counted for Computation of SGPA and CGPA. The course is not mandatory. It is Optional. Interested students can take it.

4. In first year syllabus, Engineering Biology is included in Physics cycle and Basic Mechanical Engineering is included in Chemistry cycle. This is with effect from 2018-2019 onwards.

DETAILED SYLLABUS

MA101	MATHEMATICS - I	BSC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Solve the consistent system of linear equations
CO2	Apply orthogonal and congruent transformations to a quadratic form
CO3	Determine the power series expansion of a given function
CO4	Find the maxima and minima of multivariable functions
CO5	Solve arbitrary order linear differential equations with constant coefficients
CO6	Apply the concepts in solving physical problems arising in engineering

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO2	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO3	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO4	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO5	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO6	3	3	1	3	1	-	-	-	-	-	-	-	3	-

Detailed Syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigen values and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Asymptotes; Curvature; Curve tracing; Functions of several variables - partial differentiation; total differentiation; Euler's theorem and generalization; Change of variables - Jacobians; maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Ordinary Differential Equations: Geometric interpretation of solutions of first order ODE $y' = f(x, y)$; Exact differential equations; integrating factors; orthogonal trajectories; Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc.

Reading:

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 5th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2015.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.

HS101	ENGLISH FOR TECHNICAL COMMUNICATION	HSC	2-0-2	3 Credits

Pre-requisites: Nil

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

CO1	Understand and learn the nuances of paragraph writing and sample different types of paragraphs that are commonly used; learn to write an effective paragraph using devices of coherence and cohesion; Understand the meaning of idioms and phrasal verbs and use them in context; learn to use sentences unambiguously.
CO2	Learn to construct an effective résumé and cover letter ; learn the finer points and dos and don'ts of résumé writing
CO3	Master the skills and sub skills of reading ; use strategies for reading effectively: skimming, scanning, mapping; Learn to analyze vocabulary through contextual clues, word parts, analogies; demonstrate the ability to employ a range of critical reading skills
CO4	Learn the importance and use of reported speech in a wide range of contexts; use active and passive voice in engineering and scientific contexts when compiling lab reports, project reports, writing technical papers, etc.
CO5	Learn the structure and format of technical reports; distinguish technical reports from other types of reports such as business reports, analytical reports, progress reports, etc. learn to write technical reports on a variety of topics
CO6	Learn to interpret graphs of various kinds and pie charts and diagrams; learn to use terms of comparison and contrast when interpreting charts, bar diagrams and graphs

Course Articulation Matrix:

CO \ PO	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	-	-	-	-	-	1	-	-	-	3	-	1	-	-
CO2	-	-	-	-	-	1	-	-	-	3	-	1	-	-
CO3	-	-	-	-	-	1	-	-	-	3	-	1	-	-
CO4	-	-	-	-	-	1	-	-	-	3	-	1	-	-
CO5	-	-	-	-	-	1	-	-	-	3	-	1	-	-
CO6	-	-	-	-	-	1	-	-	-	3	-	1	-	-

Detailed Syllabus:

1. **Grammar Principles** (Correction of sentences, Concord) and Vocabulary Building (synonyms and antonyms): Idioms and Phrasal verbs--patterns of use and suggestions for effective employment in varied contexts
2. **Effective Sentence Construction** - strategies for bringing variety and clarity in sentences-removing ambiguity - editing long sentences for brevity and clarity
3. **Reported speech**- contexts for use of reported speech - its impact on audiences and readers-active and passive voice- reasons for preference for passive voice in scientific English
4. **Paragraph-writing**: Definition of paragraph and types- features of a good paragraph - unity of theme- coherence- linking devices- direction- patterns of development.
5. **Note-making** - definition- the need for note-making - its benefits - various note formats- like tree diagram, block or list notes, tables, etc.
6. **Letter-Writing**: Its importance in the context of other channels of communication- qualities of effective letters-types -personal, official, letters for various purposes- emphasis on letter of application for jobs - cover letter and resume types -examples and exercises
7. **Reading techniques**: Definition- Skills and sub-skills of reading- Skimming and Scanning - their uses and purposes- examples and exercises.
8. **Reading Comprehension** - reading silently and with understanding- process of comprehension-types of comprehension questions.
9. **Features of Technical English** - description of technical objects and process- Report-Writing-definition- purpose -types- structure- formal and informal reports- stages in developing report-proposal, progress and final reports-examples and exercises
10. **Book Reviews**- Oral and written review of a chosen novel/play/movie- focus on appropriate vocabulary and structure - language items like special vocabulary and idioms used

Language laboratory

1. **English Sound System** -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription of exercises
2. **Stress and Intonation** -word and sentence stress - their role and importance in spoken English-Intonation in spoken English -definition, patterns of intonation- -falling, rising, etc.-use of intonation in daily life-exercises
3. Introducing oneself in formal and social contexts- Role plays- their uses in developing fluency and communication in general.

4. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. **Listening Comprehension** -Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. **Debate/ Group Discussions**-concepts, types, Do's and don'ts- intensive practice.

Reading:

1. English for Engineers and Technologists (Combined Edition, Vol. 1 and 2), Orient Blackswan, 2006.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006.
3. Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice 2nd Edition, Oxford University Press, 2011.

Software:

1. Clear Pronunciation - Part-1 *Learn to Speak English.*
2. Clear Pronunciation - Part-2 *Speak Clearly with Confidence*
3. Study Skills
4. English Pronunciation

PH101	PHYSICS	BSC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Solve engineering problems using the concepts of wave and particle nature of radiant energy.
CO2	Understand the use of lasers as light sources for low and high energy applications
CO3	Understand the nature and characteristics of new Materials for engineering applications.
CO4	Apply the concepts of light propagation in optical fibers, light wave communication systems, holography and for sensing physical parameters.
CO5	Apply the knowledge of Solar PV cells for choice of materials in efficient alternate energy generation.

Course Articulation Matrix:

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	-	3	1
CO2	3	3	1	1	-	-	-	-	-	-	-	-	2	-
CO3	3	3	1	1	-	-	-	-	-	-	-	-	2	-
CO4	3	3	1	`1	-	-	-	-	-	-	-	-	3	1
CO5	3	3	1	1	-	-	-	-	-	-	-	-	3	1

Detailed Syllabus:

Quantum Mechanics: Concepts and Experiments that led to the discovery of Quantum Nature. Heisenberg uncertainty principle; Schrodinger time independent and time dependent wave equations, The free particle problem - Particle in an infinite and finite potential well, Quantum mechanical tunneling. MB, BE and FD distributions.

Wave and Quantum Optics:

Interference and Diffraction: Concept of interference and working of Fabry-perot Interferometer and its application as wavelength filter. Multiple beam diffraction and Working of diffraction Gratings, Application of Grating as wavelength splitter.

Polarization Devices: Principles, Working and applications of Wave Plates, Half Shade Polarimeter, Polariscope, Isolators and Liquid Crystal Displays.

Lasers: Basic theory of Laser, Concept of population inversion and Construction and working of He-Ne, Nd-YAG, CO_2 Lasers, LED, White light LED, Semiconductor Laser, Holography and NDT.

Optical Fibers: Structure, Types, Features, Light guiding mechanism and applications in Communications and Sensing.

Solar Cells: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, applications.

Magnetic and Dielectric Materials:

Magnetic Materials and Superconductors: Introduction - Weiss Theory of Ferromagnetism - Properties - Domains - Curie Transition - Hard and soft magnetic materials - Spinel Ferrites - Structure - Classification - Applications - Meissner effect - Type-I and Type-II Superconductors - Applications.

Dielectric Materials: Introduction to Dielectrics, Dielectric constant - Polarizability - Properties and types of insulating materials **-** Polarization mechanisms in dielectrics(Qualitative) - Frequency and temperature dependence of polarization - Dielectric loss Clausius-Mossotti Equation(Qualitative)- dielectric Breakdown - Applications.

Functional and Nano Materials:

Functional Materials: Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, Bio-materials, high temperature materials and smart materials - Properties and applications.

Nano materials: Introduction, classification, properties, different methods of preparation and applications.

Reading:

1. Halliday, Resnic and Walker, Fundamentals of Physics, John Wiley, 9th Edition, 2011.
2. Beiser A, Concepts of Modern Physics, McGraw Hill International, 5th Edition, 2003.
3. Ajoy Ghatak, Optics, Tata McGraw Hill, 5th Edition, 2012.
4. S.O. Pillai, Solid State Physics, New Age Publishers, 2015.

EC101	BASIC ELECTRONIC ENGINEERING	ESC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Comprehend the characteristics of semiconductor devices, and operational amplifiers
CO2	Understand the principles of working of amplifiers
CO3	Understand and design of simple combinational and basics of sequential logic circuits
CO4	Understand the principles of electronic measuring instruments and Transducers
CO5	Understand the basic principles of electronic communication

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	-	-	1	-	-	-	-	-	-	3	-
CO2	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO3	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO4	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO5	3	3	1	-	-	1	-	-	-	-	-	-	2	-

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. FET and MOSFET characteristics and applications.

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

Integrated Circuits: Operational amplifiers - characteristics and linear applications

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), Introduction to microprocessors and microcontrollers.

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO's).

Electronics Instrumentation: Measurement, Sensors, principles of LVDT, strain guage and thermocouples. Introduction to data acquisition system.

Principles of Communication: Need for Modulation, Definitions of various Modulation and Demodulation techniques, AM radio transmitter and receiver, brief understanding of FM and mobile communications.

Reading:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, Tata McGraw Hill, 2ndEdition, 2013.
2. Malvino and Brown, Digital Computer electronics, McGraw Hill, 3rd Edition, 1993.
3. Keneddy and Davis, Electronic Communication Systems, McGraw Hill, 4th Edition, 1999.
4. Helfrick and Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India, 2011.
5. Salivahanan, N Suresh Kumar, Electronic Devices and circuits, McGraw Hill publications, 3rd Edition, 2012.
6. Neil Storey, Electronics A Systems Approach, Pearson Education Publishing Company Pvt. Ltd, 4th Edition, 2009.

CE102	ENVIRONMENTAL SCIENCE AND ENGINEERING	ESC	2-0-0	2 Credits

Pre-requisites: Nil

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

CO1	Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
CO2	Estimate the population - economic growth, energy requirement and demand.
CO3	Analyze material balance for different environmental systems.
CO4	Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
CO5	Identify the major pollutants and abatement devices for environmental management and sustainable development

Course Articulation Matrix:

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	3	-	-	2	3	1	-	-	-	-	2	-
CO2	3	3	3	-	-	2	3	1	-	-	-	-	2	-
CO3	3	3	3	-	-	2	3	1	-	-	-	-	2	-
CO4	3	3	3	-	-	2	3	1	-	-	-	-	2	2
CO5	3	3	3	-	-	2	3	1	-	-	-	-	2	-

Detailed Syllabus:

Introduction to Environmental Science: Environment and society, major environmental issues: Ozone layer depletion, Acid rains, global climate change etc, sustainable development, Environmental impact assessment, environmental management

Natural Resources Utilization and its Impacts: Energy, minerals, water and land resources, Resource consumption, population dynamics, urbanization.

Ecology and Biodiversity: Energy flow in ecosystem, food chain, nutrient cycles, eutrofication, value of biodiversity, biodiversity at global, national and local levels, threats for biodiversity, conservation of biodiversity

Water Pollution: Sources, types of pollutants and their effects, water quality issues, contaminant transport, self-purification capacity of streams and water bodies, water quality standards, principles of water and wastewater treatment.

Air Pollution: Sources, classification and their effects, Air quality standards, dispersion of pollutants, control of air pollution, automobile pollution and its control.

Solid Waste Management: Sources and characteristics of solid waste, effects, Collection and transfer system, disposal methods

Reading:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.

2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.

3. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, 8th Edition, 2016.

4. M. Chandrasekhar, Environmental science, Hi Tech Publishers, 2009.

BT101	ENGINEERING BIOLOGY	ESC	2 - 0 - 0	2 Credits

Pre-requisites: Nil.

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

CO1	Realize the significance of biomolecules for sustaininglife
CO2	Identify the difference between unicellular to multi-cellular organisms
CO3	Understand heredity, variation and central dogma of life
CO4	Analyze and understand the concepts of biology for engineering the cell

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	3	3	1	-	-	-	-	-	-	-	-	1	-
CO2	2	3	3	1	-	-	-	-	-	-	-	-	1	-
CO3	2	3	3	1	-	-	-	-	-	-	-	-	1	-
CO4	2	3	3	1	-	-	-	-	-	-	-	-	1	-

Detailed Syllabus:

Molecules of life, water and carbon - chemical basis of life, protein structure and function, nucleic acids and the RNA world, carbohydrates, lipids, membranes and first cells.

Cell structure and function, inside the cell, cell-cell Interactions, cellular respiration and fermentation, photosynthesis, cell cycle, biological signal transduction.

Gene structure and expression, Mitosis, Meiosis, Mendel and the gene, DNA and the gene: synthesis and repair, how genes work, transcription, RNA processing, and translation, control of gene expression, analyzing and engineering genes, genomics.

Engineering concepts in biology - genetic engineering, disease biology and biopharmaceuticals, stem cell engineering, metabolic engineering, synthetic biology, neuro transmission, bio safety and bioethics.

Reading:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

CS101	PROBLEM SOLVING AND COMPUTER PROGRAMMING	ESC	3 - 1 - 2	5 Credits

Pre-requisites: Nil.

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

CO1	Design algorithms for solving simple mathematical problems including computing, searching and sorting
CO2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO3	Explore the internals of computing systems to suitably develop efficient algorithms
CO4	Examine the suitability of data types and structures to solve specific problems
CO5	Apply control structures to develop modular programs to solve mathematical problems
CO6	Apply object oriented features in developing programs to solve real world problems

Course Articulation Matrix:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO2	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO3	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO4	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO5	3	2	3	2	3	-	-	-	-	-	-	-	2	2
CO6	3	2	3	2	3	-	-	-	-	-	-	-	2	2

Detailed Syllabus:

Theory:

Fundamentals of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques - Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

Number systems and data representation, Basics of C++, Basic data types, Numbers, Digit separation, Reverse order, Writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions-Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

Sorting and searching algorithms, large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions

Magic square and matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays

String processing, File operations.

Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Laboratory:

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 (integer pointers, character pointers).
6. Programs on structures.
7. Programs on classes and objects.

Reading:

1. Walter Savitch, Problem Solving with C++, Pearson, 9th Edition, 2014.
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, 2nd Edition, 2009.
3. R.G. Dromey, How to solve it by Computer, Pearson, 2008.

PH102	PHYSICS LABORATORY	BSC	0 - 1 - 2	2 Credits

Pre-requisites: Nil

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

Course Articulation Matrix:

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	-	3	-	-	-	-	3	2	-	-	2	2
CO2	3	2	-	3	-	-	-	-	3	2	-	-	2	2
CO3	3	2	-	3	-	-	-	-	3	2	-	-	2	2
CO4	3	2	-	3	-	-	-	-	3	2	-	-	2	2

Detailed Syllabus:

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:

1. Physics Laboratory Manual.

MA 151	MATHEMATICS - II	BSC	3-0-0	3 Credits

Pre-requisites: MA101: Mathematics-I

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

CO 1	Analyze improper integrals
CO 2	Evaluate multiple integrals in various coordinate systems
CO 3	Apply the concepts of gradient, divergence and curl to formulate engineering problems
CO 4	Convert line integrals into surface integrals and surface integrals into volume integrals
CO 5	Apply Laplace transforms to solve physical problems arising in engineering

Course Articulation Matrix:

CO \ PO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO2	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO3	3	3	1	2	1	-	-	-	-	-	-	-	3	-
CO4	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO5	3	3	1	2	1	-	-	-	-	-	-	-	3	-

Detailed Syllabus:

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; 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 a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stoke's theorem; Gauss Divergence theorem.

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function.

Convolution theorem; Applications of Laplace transforms - solving certain initial value problems, solving system of linear differential equations, finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc.

Reading:

1. R. K. Jain and S. R. K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishing House, 5th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2015.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.

ME102	ENGINEERING GRAPHICS	ESC	1 - 1- 4	4 Credits

Pre-requisites: Nil.

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

CO1	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
CO2	Classify the systems of projection with respect to the observer, object and the reference planes.
CO3	Construct orthographic views of an object when its position with respect to the reference planes is defined.
CO4	Analyse the internal details of an object through sectional views.
CO5	Develop 3D Isometric View in relation with 2D orthographic views
CO6	Construct 2D (orthographic) and 3D (isometric) views in CAD environment.

Course Articulation Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	2	2	-	1	-	-	-	1	2	-	-	3	-
CO2	2	2	2	-	1	-	-	-	1	2	-	-	3	-
CO3	2	2	2	-	1	-	-	-	1	2	-	-	3	-
CO4	2	2	2	-	1	-	-	-	1	2	-	-	3	-
CO5	2	2	2	-	1	-	-	-	1	2	-	-	3	-
CO6	2	2	2	-	1	-	-	-	1	2	-	-	3	2

Detailed Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales

Orthographic Projection: Principles of Orthographic projection, Four Systems of Orthographic Projection.

Projection of Points: Projections of points when they are situated in different quadrants.

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

Reading:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.
2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23rd Edition, 2016.

CY101	CHEMISTRY	BSC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	The basic knowledge of the organic reaction mechanism and intermediates.
CO2	The basic knowledge of methods of chemical structure analysis and the instrumentation involved.
CO3	The potential energy aspects of fuel cells, rechargeable batteries and new materials for their fabrication.
CO4	About optical fibres, liquid crystals, LCD, LED, OLED, conducting polymers and their applications.
CO5	The quantum and thermodynamic aspects of various types of bonding, coordination complexes and chemical and enzymatic reactions.
CO6	The synthetic methodologies, importance and applications of nanomaterials in different fields.

Course Articulation Matrix:

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

Detailed syllabus:

Quantum Chemistry and Chemical Bonding: Emergence of Quantum Theory; Postulates of Quantum Mechanics, Operators and Observables, Schrodinger Equation, Particle in a One-Dimensional Box and

Colour of Conjugate Molecules, Hetero-diatomic Molecule as Harmonic Oscillator and Rigid Rotor, Hydrogen Atom, LCAO-MO Theory (MO Diagram of CO and NO Molecules).

Chemical Thermodynamics, Equilibrium and Kinetics:Enthalpy and Free Energy Changes in Chemical Reactions; Relevance of C_p and C_v in Gas Phase Reactions, Chemical Potential; Heat Capacity of Solids, Absolute Entropy and Third Law of Thermodynamics, Rates of Enzyme-Catalyzed Homogeneous and Heterogeneous Surface-Catalyzed Chemical Reactions

Electrochemistry and Chemistry of Energy Systems: Electrodes and Electrochemical Cells; Potentiometric and Amperometric Sensors; Li-Ion and Ni-Cd Rechargeable Batteries; Fuel Cells (Methanol-Oxygen); Electrochemical Theory of Corrosion; Factors Affecting Rate of Corrosion; Sacrificial Anodic and Impressed Current Cathodic Protection of corrosion.

Coordination Chemistry and Organometallics: Shapes of Inorganic Compounds; Crystal Field and Molecular Orbital Theories; MO-Diagram for an Octahedral Complex; Metal Ions in Biology; Organometallic Chemistry (Metal Carbonyls).

Basics of Organic Chemistry: Classification of Organic reaction and their mechanisms. Reaction intermediates: formation, structure and properties. Named Reactions: Skraup's synthesis, Diels- Alder reaction, Click Reactions.

Engineering Materials and Application: Introduction to Optical fibres, types of optical fibres, applications of optical fibres. Liquid Crystals: LCD, LED, OLED, Conducting Polymers and applications.

Instrumental Methods of Chemical Analysis: Gas- and Liquid-Chromatographic Separation of Components of Mixtures; UV-Visible, FTIR, NMR and Mass Spectral Methods of Analysis of Structures of Organic Compounds.

Reading:

1. P. Atkins and Julio de Paula, Physical Chemistry, Freeman & Co. 8th Edition, 2017.
2. Atkins and Shriver, Inorganic Chemistry, Oxford University Press, 4th edition, 2008.
3. Clayden, Greaves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2014.
4. Shashi Chawla, Engineering Chemistry, Dhanpat Rai & Co. 2017.
5. Paula Bruce, Organic Chemistry, Pearson, 8th Edition, 2013.

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

Pre-requisites: Nil

Course Outcomes: At the end of the course, the students 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 and requirements of illumination

Course Articulation Matrix:

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

Detailed Syllabus:

DC Circuits: Kirchoff's Voltage and Current Laws, Superposition Theorem, Star-Delta Transformations

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1-ϕ Series & Parallel Circuits, Solution of 3-ϕ circuits and Measurement of Power in 3-ϕ 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 of a 1-ϕ Transformer, Determination of Equivalent circuit parameters, calculation of Regulation & Efficiency of a Transformer

DC Machines: Principle of Operation, Classification, EMF and Torque Equations, Characteristics of Generators and Motors, Speed Control Methods and Applications

Three Phase Induction Motor: Principle of Rotating Magnetic Field, Principle of Operation of 3-ϕ Induction Motor, Torque - Speed Characteristics of 3-ϕ Induction Motor, Applications

Measuring Instruments: Moving Coil and Moving Iron Ammeters and Voltmeters

Illumination: Laws of illumination and luminance.

Reading:

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12th Edition, 2016.
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2nd Edition, 2015.
3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2005.
4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.

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

Pre-requisites: Nil.

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

CO1	Identify Materials for Engineering Applications
CO2	Describe the functions and operations of Conventional, NC, CNC and 3D Printing methods of manufacturing.
CO3	Select a power transmission system for a given application.
CO4	Understand the concepts of thermodynamics and functions of components of a power plant.
CO5	Understand basics of heat transfer, refrigeration, internal combustion engines and automobile engineering.

Course Articulation Matrix:

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

Detailed Syllabus:

Engineering Materials: Introduction to Engineering Materials, Classification and Properties

Manufacturing Processes: Castings - Patterns & Moulding, Hot Working and Cold Working, **Metal Forming processes**: Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing.

Machine Tools: Lathe - Types - Operations, Problems on Machining Time Calculations, Drilling M/c - Types - Operations, Milling M/c - Types - Operations - Up & Down Milling, Shaping M/c -Operations-

Quick Return Mechanism, Planer M/c.- Operations-Shaper Vs Planer, Grinding M/c-Operations. Introduction to NC/CNC Machines, 3D Printing

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains -Simple Problems

Fasteners and Bearings: Fasteners - Types and Applications, Bearings - Types and Selection,

Thermodynamics: Energy Sources - Conventional/Renewable, Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State, C_p, C_v, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

Thermal Power Plant: Layout of Thermal Power Plant & Four circuits - Rankine cycle, T-S & P-V diagrams, Boilers - Babcock & Wilcox, Cochran Boilers, Comparison of Fire Tube &Water Tube Boilers, Steam Turbines - Impulse Vs. Reaction, Compounding - Pressure & Velocity Compounding, Condensers - Jet Condenser and Surface Condenser; Cooling Towers.

I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences

Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants

Heat Transfer: Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient - problems

Automobile Engineering: Layout of an Automobile, Transmission, Clutch, Differential, Internal Expanding Shoe Brake

Reading:

1. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
2. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
3. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
4. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.
5. B.S. Raghuvanshi, Workshop Technology, Vol. 1&2, Dhanpath Rai & Sons, New Delhi, 1989.

CE101	ENGINEERING MECHANICS	ESC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.

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

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

Course Articulation Matrix:

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

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 (Vector approach) - Tension Coefficient method (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system.

Coplanar Force System: 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 and M.I - Arial - Radius of Gyration, Parallel axis-Perpendicular axis theorem - Simple Problems.

Dynamics of Particles: Rectilinear Motion - Kinematics Problems, Kinetics - Problems, Work & Energy - Impulse Moment, Curvilinear Motion - Normal and tangential components.

Reading:

1. J.L. Meriam, L.G. Kraige, Engineering Mechanics, John Wiley &Sons, 7th Edition, 2012.
2. Timoshenko, Young, Engineering Mechanics, McGraw Hill Publishers, 3rd Edition, 2006.
3. Gere, Timoshenko, Mechanics of Materials, CBS Publishers, 2nd Edition, 2011.

ME103	WORKSHOP PRACTICE	ESC	0 - 1 - 2	2 Credits

Pre-requisites: Nil.

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

CO1	Study and practice on 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

Course Articulation Matrix:

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

Detailed Syllabus:

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

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

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaper. Demonstration of the working of CNC and 3D Printing Machines.

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

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

CY102	CHEMISTRY LABORATORY	BSC	0- 1 - 2	2 Credits

Pre-requisites: Nil.

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

CO1	Select a suitable methodology and compare the strategies involved in the estimation of metal content, iodine content, active chlorine or hardness of water for various applications.
CO2	Apply a selective instrumental method in the place of tedious and complex titration processes for repeated and regulated analysis of acids, bases, redox compounds, etc.
CO3	Test and validate optical activity, corrosion inhibitor efficiency and absorption isotherm of selective compounds and processes.

Course Articulation Matrix:

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

Detailed Syllabus:

Cycle-I

1. Standardization $KMnO_4$ solution: Understanding the redox process, electron transfer, importance of qualitative and quantitative analysis.
2. Estimation of Hematite: Understanding the importance on purity of a ore, % of metal content (for Fe).
3. Hardness of Water: Understanding the metal complexes, multi dentate ligands, importance of purity of ground water, (EDTA method; complexometry).
4. Analysis of bleaching powder for available chlorine: Understanding the importance and purity of potable water, back titration (Iodometry).
5. Preparation of nano materials: Understanding the importance of nano materials, their preparation and characterization.

Cycle-II

1. pH metry: Concept of pH, Instrumentation, calibration, determination of the concentrations by instrumental methods
2. Conductometry: Concept of conductivity, importance of conductivity
3. Potentiometry: Determination of the redox potential of the reaction
4. Colorimetry: Importance of Beers and Lamberts law,
5. Photochemical experiment: Importance of visible light and its application for a redox process, importance of coloring agent
6. Preparation of bakelite / polypyrrole: Concepts of organic reactions and application for the organic material preparation.
7. Corrosion experiment: Concept of corrosion, importance of corrosion agents
8. Adsorption experiment: Understanding phenomena of adsorption and absorption
9. Analysis of a drug: Importance of the purity, concentrations of a drug molecule.
10. Preparation of bakelite / red azo dye / Aspirin / Fe(acac) / polypyrrole: Concepts of organic reactions and application for the organic material preparation

Reading:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

MA236	TRANSFORMATION TECHNIQUES	BSC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

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

Course Articulation Matrix:

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

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, 2016.
2. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2017.

MM235	MATERIALS ENGINEERING	PCC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Describe the crystal structure and constitution of alloys.
CO2	Describe methods of determining mechanical properties and their suitability for applications.
CO3	Classify steels and cast irons, and discuss their applications.
CO4	Describe the properties and applications of non-ferrous metals and alloys.
CO5	Differentiate the properties and applications of ceramics, polymers and composites.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to materials engineering, Classification of materials- Metals and alloys, Ceramics, Polymers and Composites

Crystal geometry and Constitution of alloys: Space lattices, Unit cells, Crystal structure, Crystal directions and planes, Crystal imperfections- Point defects, Line defects, Surface defects, Volume defects; Types of solid solutions- substitutional and interstitial; Hume-Rothery rules for solid solutions, Construction and interpretation of binary equilibrium diagrams-isomorphous, eutectic and peritectic-type diagrams, Intermediate phases and phase rule

Mechanical properties: Elasticity and plasticity in materials, Stress-strain curve, Resolved shear stress, Tensile properties, Hardness and hardness measurement, Impact properties, Fatigue, Creep.

Steels and Cast Irons: Iron-carbon phase diagram, Types of steels- low, medium and high carbon steels, stainless steels, alloy steels and their applications; Heat treatment-annealing, normalising, hardening, tempering, surface hardening; Cast irons, types- white, grey, malleable and nodular, Properties and applications of cast irons

Non-ferrous metals and alloys: Properties and applications of - Cu and its alloys, Al and its alloys, Age hardening, Ti and its alloys, Ni-based alloys.

Ceramics, Polymers and Composites: Ceramics - Crystalline ceramics, Glasses, Properties and applications of ceramics; Polymers - Polymerization, Thermoplastics and thermosetting plastics, Properties and applications of polymers; Composites - Concept of composites, Matrix and reinforcement, Rule of mixtures, Classification of composites, Applications of composites

Reading:

1. W.D. Callister (Adapted by R. Balasubramaniam), Materials Science and Engineering, 2nd ed. (2014), Wiley India, New Delhi (ISBN: 978-8126541607)
2. M.F. Ashby and D.R.H. Jones, Engineering Materials 1-An Introduction to Properties, Applications and Design, 4th ed. (2011), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978-0080966656)
3. M.F. Ashby and D.R.H. Jones, Engineering Materials 2-An Introduction to Microstructures and Processing, 4th ed. (2012), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978-0080966687)
4. S. H. Avner, Introduction to Physical Metallurgy, 2nd ed. (1997), McGraw-HillEducation Publishers, New York, USA (ISBN: 978-0074630068)
5. V. Raghavan, Physical Metallurgy: Principles and Practice, 2nd ed. (2012) Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120330122)
6. V. Raghavan, Materials Science and Engineering: A First Course, 6thed.(2015), Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120350922)
7. D.S. Clark and W. Varney, Physical Metallurgy for Engineers, 2nd ed. (2004) CBS Publishers and Distributors, New Delhi (ISBN: 978-8123911786)

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

Pre-requisites: Nil

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

Course Articulation Matrix:

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

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 machine 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.

Course Articulation Matrix:

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

ME201	THERMODYNAMICS	PCC	3 - 1 - 0	4 Credits

Pre-Requisites: Nil

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	2	1	2	-	-	2	1	1
CO2	3	3	2	3	3	1	2	-	2	-	-	2	2	2
CO3	3	2	1	2	1	1	1	-	2	-	-	2	2	2
CO4	3	3	3	-	1	1	1	-	2	-	-	2	2	2
CO5	3	3	1	3	1	1	2	-	2	-	-	2	2	2
CO6	3	3	1	3	2	1	2	-	1	-	-	2	2	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, thermodynamic definition of work, different forms of work, path function, Heat, temperature and zeroth law of thermodynamics, thermometry.

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. 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.

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. 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.

Pure Substance: Behavior 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.

Air Standard Cycles: Assumptions for air standard cycles, Analysis of Otto, Diesel, Dual combustion, Joule/Brayton cycles.

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 - 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 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 design requirements.
CO4	Evaluate gear tooth geometry and select appropriate gears for the required applications.
CO5	Design cams and followers for specified motion profiles.

Course Articulation Matrix:

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

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 center method, Kennedy's theorem, locating instantaneous centers, 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: Classification and application of cams. SVAJ diagrams. Analysis of Uniform velocity, Harmonic and cycloidal motion profiles. Graphical and analytical synthesis of planar cams with knife edge, roller and flat faced followers.

Reading:

1. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, 3rd edition, East West Press Pvt. Ltd., New Delhi (Reprint 2017)

2. S.S.Rattan, Theory of Machines, 3rdedition, McGraw-Hill Publications, New Delhi (2011)

3. Shigley J. E. and John Joseph Uicker, Theory of Machines and Mechanisms, 2ndedition McGraw-Hill international edition (2003)

4. 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.

CE237	FLUID MECHANICS & HYDRAULIC MACHINES LABORATORY	PCC	0 - 1 - 2	2 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

Detailed Syllabus:

a. Calibration of Venturi meter, Orifice meter (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. "Engineering Fluid Mechanics" Experiments, Eurasia Publishing House, 1997

2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995

CE238	MATERIAL TESTING LAB	PCC	0 - 1 - 2	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

Course articulation Matrix:

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

MA261	NUMERICAL AND STATISTICAL METHODS	BSC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Interpret an experimental data using interpolation/curve fitting.
CO2	Solve numerically algebraic / transcendental and ordinary differential equations.
CO3	Understand the concepts of probability and statistics.
CO4	Test the hypothesis for large and small samples.

Course Articulation Matrix:

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

Detailed Syllabus:

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-Seidel 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 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.

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.

Reading:

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

ME251	DYNAMICS OF MACHINERY	PCC	3 - 1- 0	4 Credits

Pre-Requisites: Nil

Course Outcomes: At the end of the course, the student shall 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.

Course Articulation Matrix:

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

Detailed Syllabus:

Vibrations:

Introduction, elements of a vibrating system, free vibrations of undamped system, natural frequency, phase, degree of freedom, applications of energy methods, namely, energy method and Rayleigh's method. Studying the effect of parameters on vibrations. Excitation sources, kinds of excitations. Vibration of undamped system under harmonic excitation. Effect of frequency of excitation on the amplitude of vibrations. Magnification Factor. Vibrations under resonance.

Free vibrations of spring mass damper system, concepts of critical damping coefficient and damping factor, under damping, critical damping and over damping. Vibrations of spring mass damper system under harmonic excitation. Magnification Factor. Phase difference between excitation and motion.

Rotating unbalance, 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, vibration isolation. Concepts of normal mode vibrations, natural frequencies, mode shapes, nodes. Practical problems

Balancing: Balancing and its types, Rotor balancing, 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. Balancing of reciprocating machines: primary, secondary and higher order unbalanced forces. Balancing of in line, V and radial engines.

Flywheels: 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: Principle of gyroscope, Roll, Yaw and pitch motions, Gyroscopic effect in a two wheeler, car, ship and aeroplane. Practical problems

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 Int. Edition, 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.
3. Venkatachalam, R., Mechanical Vibrations, PHI, 2014.

ME252	TURBOMACHINES	PCC	3 - 0 - 0	3 Credits

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

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

CO1	Apply thermodynamic concepts to understand the working of turbo machines.
CO2	Differentiate ideal and practical gas turbine cycles.
CO3	Understand the working of gas turbine plant components and analyse their performance.
CO4	Analyse the steam power plant cycles
CO5	Design steam nozzles and steam turbines.

Course Articulation Matrix:

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

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.

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.

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

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

Steam Turbines: Steam Turbines - Impulse and reaction Turbines, Compounding of steam turbines, multistage reaction Turbines, Reheat factor and Efficiency.

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.

Learning Resources/ Readings/ Video lectures:

1. Lecture series on Turbomachinery Aerodynamics by Prof. Bhaskar Roy and Prof. A M Pradeep IIT, Bombay. For more details on NPTEL visit http://nptel.ac.in

ME253	MANUFACTURING SCIENCE	PCC	3 - 1 - 0	4 Credits

Pre-requisites: ME101: Basic Mechanical Engineering, MM235: Materials Engineering

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

CO1	Design core, core print and gating system in metal casting processes.
CO2	Develop process-maps for metal forming processes using plasticity principles
CO3	Design near net shaped components from metal and ceramic powders
CO4	Develop joints using solid state and fusion joining, brazing and soldering techniques

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to Manufacturing, Net and near-net shape manufacturing and their evolution

Near-Net and Net Shaped Manufacturing:

Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design, Shell Casting, Investment Casting, Centrifugal Casting.

Powder Metallurgy: (Metals and Ceramics) Techniques of near net shape manufacturing, techniques of powder manufacturing, characterization of powders, powder compaction methods, introduction to sintering, Sintering phenomenon, post sintering operations.

Rapid Manufacturing: Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing.

Deformation Processes:

Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axi-symmetric bulk deformation processes.

Joining Processes:

Operating principle, basic equipment, merits and applications of Fusion and Solid state welding processes: V-I Characteristics, Solidification Phenomenon in Welding - Microstructural Evolution - Different Zones of Weld Region and their Microstructural Evolution - Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining.

Reading:

1. Amitabha Ghosh and Mallick A. K., Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
2. M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
3. S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
4. G. K. Lal and S. K. Choudhury, Fundamentals of Manufacturing Process, 2009. Boca Raton, FL: CRC Press, 2011.
5. J.P. Holman, Experimental Methods for Engineers, McGraw Hills Int. Edition.
6. P. C. Angelo and R. Subramanian, “Powder Metallurgy- Science, Technology and Applications“, PHI, New Delhi, 2010.

References:

1. Gowri P. Hariharan, A. Suresh Babu, "Manufacturing Technology I", Pearson Education, 2014
2. Roy. A. Lindberg, "Processes and Materials of Manufacture", PHI / Pearson education, 2006
3. Paul Degarmo E, Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice -Hall of India, 1997.
4. Sharma, P.C., "A Text book of production Technology", S. Chand and Co. Ltd., 2014.
5. P.L.JAIN. "Principles of Foundry Technology", TMH, 2014
6. Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 2ndEdition, TMH; 2017

ME 254	GEOMETRIC MODELLING FOR CAD	PCC	3 - 0- 0	3 Credits

Pre-requisites: Nil

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

CO1	Apply geometric transformations and projection methods in CAD.
CO2	Develop geometric models to represent curves.
CO3	Design surface models for engineering design.
CO4	Model engineering components using solid modelling techniques for design.
CO5	Apply geometric modelling techniques in design and analysis.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, geometric modelling.

Transformations in Geometric Modeling: Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations. Computer-Aided assembly of rigid bodies, applications of transformations in design and analysis of mechanisms, etc. Implementation of the transformations using computer codes.

Projections: Projective geometry, transformation matrices for Perspective, Axonometric projections, Orthographic and Oblique projections. Implementation of the projection formulations using computer codes.

Introduction to Geometric Modeling for Design: Introduction to CAGD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modelling.

Curves in Geometric Modeling for Design: Differential geometry of curves**,** Analytic Curves, PC curve, Ferguson's Cubic Curve, Composite Ferguson, Curve Trimming and Blending. Bezier segments, de Castegliau's algorithm, Bernstein polynomials, Bezier- subdivision, Degree elevation, Composite Bezier. B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS. Conversion of one form of curve to other. Implementation of the all the curve models using computer codes in an interactive manner.

Surfaces in Geometric Modeling for Design: Differential geometry of surfaces, parametric representation, Curvatures, Developable surfaces. Surfaces entities (planar, surface of revolution, lofted etc). Free-form surface models (Hermite, Bezier, B-spline surface). Boundary interpolating surfaces (Coon's). Implementation of the all the surface models using computer codes.

Solids in Geometric Modeling for Design: Solid entities, Boolean operations, Topological aspects, Invariants. Write-frame modeling, B-rep of Solid Modelling, CSG approach of solid modelling. Popular modeling methods in CAD software. Data Exchange Formats and CAD Applications**:**

Reading:

1. Michael E. Mortenson, Geometric Modeling, Tata McGraw Hill, 2013.
2. A. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005.
3. Rogers, David F., An introduction to NURBS: with historical perspective, Morgan Kaufmann Publishers, USA, 2001.
4. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

ME255	COMPUTER AIDED MACHINE DRAWING	PCC	1 - 0 - 4	3 Credits

Pre-requisites: Nil

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

CO1	Develop the surfaces of different solids
CO2	Draw the machine elements including keys, couplings, and cotters, riveted, bolted and welded joints following the conventions for engineering materials.
CO3	Construct an assembly drawing using part drawings of machine components.
CO4	Create part drawing of machine components using machine assembly

Course Articulation Matrix:

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

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, tolerances, sectional views, Screw threads.

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

Assembly Drawing Practice: Draw the assembly drawings of Stuffing Box, Eccentric, Swivel bearing, Drill jig, Tail stock, Toolpost, Tool head for shaping machine, machine vice, screw jack, using the component drawings,Draw the component drawings using the assembly drawings, Machine Drawing practice using AutoCAD and CREO

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.

ME256	MANUFACTURING PROCESSES LABORATORY	PCC	0 - 1 - 2	2 Credits

Pre-requisites: Nil

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

CO1	Fabricate weldments using gas and arc welding.
CO2	Evaluate the quality of welded joints and cast components using non-destructive testing methods.
CO3	Test the properties of moulding sands.
CO4	Perform formability studies on sheet metals.

Course Articulation Matrix:

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

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 butt joint in the given samples by using gas welding, SAW, TIG and MIG welding.
5. Join metal plates in the given samples using resistance spot welding
6. Join rectangular cross section plates in the given samples by flash butt welding
7. Identify welding defects by liquid penetration test in the welded sample
8. Demonstration on sweep pattern and core making in mould preparation

9. Calculate the amount of the clay content in the given moulding sand
10. Find the grain fineness number of the given moulding sand
11. Find the green and dry shear strength, compression strength and permeability of the given moulding sand.
12. Find shatter index of the given moulding sand
13. Demonstration on sand casting of at least two products.
14. Perform formability studies on sheet metals.
15. Evaluate coefficient of friction using ring compression test.

Reading:

1. Manufacturing Technology Lab manual

ME257	KINEMATICS AND DYNAMICS LABORATORY	PCC	0-1-2	2 Credits

Pre-requisites: Nil

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

CO 1	Analyse the kinematics of different mechanisms.
CO 2	Identify the essential system properties and physically visualize the concepts of frequency and time period of vibrations under free vibration
CO 3	Explain the mechanism of forced vibration to analyse the damping properties.
CO 4	Evaluate the mechanism of forced vibration to analyse the different mode shapes and critical speed of shaft.

Course Articulation Matrix:

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

Detailed Syllabus:

Cycle 1: KINEMATICS

1. To determine the link lengths of four bar chain, Single slider crank chain, and Double slider crank chain mechanisms.
2. To study the belt, rope and chain drives
3. To identify the motion of cam and follower mechanism
4. Basic ideas concerning to clutch drive and gear and gear trains

Cycle 2: DYNAMICS

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 the center of mass G and the moment of inertia about I_G of a given connecting rod (Compound pendulum).
6. To determine the viscous damping coefficient of a given viscous damper
7. To estimate the damping in given vibrating system through Logarithmic decrement.
8. To determine the viscous damping coefficient of a viscous damper by observing free vibrations of Spring-Mass-Damper system.
9. To determine the coefficient of friction between two surfaces.
10. To determine the natural frequencies of the Coupled pendulum (Two degree freedom) through (a) Normal mode vibrations (b) Beat phenomenon and then calculate the stiffness of the coupling spring
11. To determine the first and second natural frequencies of a Cantilever beam (Vibration of Continuous system)
12. To estimate the Critical speed of shafts

ME301	DESIGN OF MACHINE ELEMENTS	PCC	3 - 0 - 0	3 Credits

Pre-requisites: CE101: Engineering Mechanics and CE236: Mechanics of Solids

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

CO1	Identify the preferred sizes and codes, and selection of proper material for design of machine element.
CO2	Design the machine element under static and dynamic loading conditions.
CO3	Design the temporary and permanent joints required to assemble the machine elements.
CO4	Design the required spring for the given application.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	-	-	-	-	-	-	2	2	1
CO2	3	3	3	2	2	-	-	-	-	-	-	2	2	1
CO3	3	3	3	2	3	-	-	-	-	-	-	2	2	1
CO4	3	3	3	2	2	-	-	-	-	-	-	2	2	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, Mechanical properties of engineering materials, Selection of materials, Manufacturing considerations and their selection.

Static Loading: Basics- Stresses in members subjected to different types of loads, Modes of failure, Principal stresses, Theories of failure- Rankine theory, Guests theory and Von Mises theory, Selection of failure theories to design simple machine parts.

Dynamic Loading: Stress concentration and its Importance in design, Methods to reduce stress concentration, Stress concentration factor-Theoretical and actual stress concentration factors, Notch sensitivity, Design of stress concentrated members subjected to various loads-Problems, Types of variable/Cyclic loads, Mean & amplitude Stresses, Fatigue Failure, Endurance Limit & Strength, S-N Diagram, Goodman and Soderberg criterion, Modifying factors: Size effect, surface effect, Reliability, stress concentration effects etc., Problems on design of members for finite & infinite life in members subjected to individual & combined loading, Cumulative damage in fatigue.

Design of Temporary Joints: Types of temporary joints- cotter joints, knuckle joint and fasteners, Design of cotter and knuckle joint, Forms of screw threads, Nomenclature of screw thread, Thread series and its designation, Power screws and their advantages over v-threads, Stress in screwed threads, Design of bolts based on uniform strength, Empirical relation for initial tightening, Design of screw & Nut for power screw-Problems.

Design of Permanent Joints: Types of permanent joints-Riveted and Welded 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, Welding process, merits and demerits of welded joint over riveted joints, weld symbols, Strength of parallel and fillet weld, Eccentrically loaded welded joints, Weld subject to bending moment and torsional moment, Problems.

Design of Springs: Types of Springs, Spring materials, terminology - Stresses in Helical coil springs of circular and non-circular cross sections, Compression-spring surge, Springs under eccentric loading and fluctuating loads, - Energy stored in springs, torsion, Belleville springs. Leaf Springs: Stresses in leaf springs, Nipping. Equalized stresses.

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, McGraw Hill Book Company, Inc., New York, USA., 2007.
5. Kannaiah, P., Machine Design, 2/e, Scitech Publication Pvt. Ltd., 2009.

ME302	PRIME MOVERS FOR AUTOMOBILES	PCC	3 - 0 - 0	3 Credits

Pre-Requisites: ME201: Thermodynamics

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

CO1	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion processes.
CO2	Estimate engine performance and emission parameters.
CO3	Identify harmful IC engine emissions and use viable alternate fuels in engines.
CO4	Classify electric vehicles based on batteries, electric motors and alternate power sources.
CO5	Analyze batteries and electric motors commonly used in electric/hybrid vehicles.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to IC engines: Overview of the course, Examination and Evaluation patterns-Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-s cycle engines based on scavenging, Differences between 2-s and 4-s cycle engines, Differences between SI and CI engines.

Two-stroke engines: Definition of parameters-Scavenging Efficiency, Delivery ratio and trapping Efficiency, Theoretical Scavenging Processes-Practical Scavenging Systems- Kadenacy effect-Numerical problems on 2-stroke cycle engines

Spark Ignition Engines: Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines

Compression Ignition Engines: Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI).Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI),Fuel Injectors-Nozzle types, Electronic Control Unit(ECU)-Numerical problems on fuel injection

Supercharging of IC Engines: Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen(NO-NOX) and Particulate Matter.Mechanism of formation of pollutants, Factors affecting pollutant formation.Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

Performance of IC Engines: Classification of engine performance parameters-Measurement of brake power, indicated power and friction power.Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors

Hybrid vehicles: Configurations of hybrids-Series and Parallel, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability-Hydrogen: Production-Hydrogen storage systems-reformers

Batteries: Battery: lead-acid battery, cell discharge and charge operation, construction, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell

Reading:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
2. W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd 2002
3. Seth Leitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
4. F.Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press-2005.

ME303	MACHINE TOOLS AND METROLOGY	PCC	3 - 1 - 0	4 Credits

Pre-requisites: Nil

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

CO1	Analyse the kinematic motions in a machine tool.
CO2	Estimate machining times for various machining operations
CO3	Design speed and feed gear boxes for a given configuration.
CO4	Select methods and devices for the measurement of machining and geometric features of components.
CO5	Design limit gauges for verifying the component tolerances.

Course Articulation Matrix:

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

Detailed syllabus:

Machine Tools: Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Machining time calculations for various machining operations, Accessories and Attachments, Thread Cutting on Lathe, Methods of indexing - Dividing head.

Regulation of Speed and Feed Rates: Methods of Speed and Feed Regulation, Stepped Regulation of Speeds, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

Finishing Processes: Grinding, Lapping, Honing & Broaching Processes.

Metrology:

Linear and Angular Measurements: Linear Measuring Instruments, Angle measuring instruments, Comparators, Calibration of Instruments.

Limits, Fits, Tolerances and Gauging: Interchangeability, Types of fits, Basic-Hole System, Basic-Shaft System, Types of Assemblies, Design of limit gauges, Introduction to GD&T.

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-wiremethods).

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

Interferometry: Principle of Interference, Optical Flat, Fringe Patterns, NPL Interferometer.

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. N.K. Mehta, Machine Tool Design, Tata McGraw Hill, 2012
4. I.C. Gupta, Engineering Metrology, DhanpatRai& Sons, 2003
5. R. K. Jain, Engineering Metrology, Khanna Publishers, 19/e, 2005.

ME304	MECHANICAL MEASUREMENTS	PCC	3 - 0 - 0	3 Credits

Pre-Requisites: Nil

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

CO1	Understand the measurement terminologies and the concept of generalized measurement system.
CO2	Estimate errors and uncertainty in measurements using statistical analysis.
CO3	Analyzezeroth, first and second order measurement systems.
CO4	Classify sensors for measurement of specific parameters with required accuracy.
CO5	Design experiments by combining measuring devices to acquire desired outputs.

Course Articulation Matrix:

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

Detailed Syllabus:

Basics of Measurements: Introduction, Generalized 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, Thermo-electric 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 and gas composition.

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 thermos-physical properties of micro and Nano fluidics

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

Reading:

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

ME305	MANAGEMENT SCIENCE AND PRODUCTIVITY	PCC	4 - 0 - 0	4 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	2	-	-	2	-	3	3	3	2	2	3	2
CO2	-	-	2	-	-	2	2	2	2	2	2	2	3	2
CO3	2	2	2	2	-	2	-	2	2	-	2	2	3	3
CO4	2	2	-	-	-	-	-	-	-	-	-	-	2	2
CO5	2	3	2	3	-	-	-	2	2	-	-	2	3	3
CO6	2	-	2	-	-	-	2	2	2	2	3	-	2	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, Market segmentation, Targeting and Positioning, 4 P's of marketing mix, Product Life Cycle and marketing strategies.

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

Productivity and Work study: Productivity and its role in the economy, Techniques for improving productivity, Method study, Principles of motion economy, Stopwatch 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", 10^{th} Edition, McGraw-Hill, New York, 2015.
2. Kotler P.,"Marketing Management", 15^{th} Edition, Prentice Hall of India/Pearson, New Delhi2017.
3. Chase, Shankar and Jacobs, "Operations and Supply Chain Management", 14^{th} Edition, Tata McGraw Hill, New Delhi, 2017.

ME306	THERMAL ENGINEERING LABORATORY	PCC	0 - 1 - 2	2 Credits

Pre-Requisites: Nil

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

CO1	Conduct constant speed and emission tests on IC engines and interpret their performance.
CO2	Estimate energy distribution by conducting heat balance test on IC engines.
CO3	Determine the friction power of an IC engine by motoring, Morse and retardation tests.
CO4	Evaluate performance parameters of steam power plant.
CO5	Evaluate the performance of turbomachines.

Course Articulation Matrix:

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

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. Heat Balance Test on steam condenser
11. Demonstrationof boiler

Reading:

1. Vasandhani V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand & Co Publishers, New Delhi, 2015.
2. Ganesan, V., Gas Turbines 3rd Edition, Tata McGraw Hill Book Company, New Delhi, 2015.

ME307	MACHINE TOOLS AND METROLOGY LABORATORY	PCC	0-1-2	2 Credits

Pre-requisites:

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

CO1	Perform different operations on a lathe.
CO2	Evaluate the effect of process parameters on shear angle, cutting forces and surface finish in machining.
CO3	Evaluate the effect of process parameters on MRR and surface finish in EDM.
CO4	Perform indexing to machine spur and helical gears on milling machine.
CO5	Evaluate internal and external taper angles, straightness and flatness of a given surface.
CO6	Evaluate dimensional and form accuracies of thread and gear profiles.

Course Articulation Matrix:

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

List of Experiments:

Machining Cycle:

1. Turning, Taper turning, Facing, Thread cutting and chamfering on lathe (Demo: Split-half nut).

2. Eccentric turning (Demo: Different types of chucks, Belt, Chain and Geardrives).
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. Measurement of cutting forces and surface finish in turning (Demo: Dynamometer and its setup).

Metrology Cycle:

1. Internal and external taper measurement.
2. Thread measurement using floating carriage diameter measuring machine.
3. Straightness measurement using auto-collimator.
4. Measurement of Thread and Gear profiles for their form and geometrical accuracies.
5. Demonstration Coordinate Measuring Machine for the evaluation of form errors.

Reading:

1. Kalpakjian S. and Steven R. Schmid, “Manufacturing, Engineering & Technology”, Pearson, 2007
2. I.C. Gupta, “Engineering Metrology”, DhanpatRai and Sons, 2003.

ME311	MECHANICAL VIBRATIONS	DEC	3-0-0	3 Credits

Pre-requisites: Nil.

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

CO1	Develop schematic models for physical systems and formulate governing equations of motion.
CO2	Analyse rotating and reciprocating systems and compute critical speeds.
CO3	Analyse and design machine supporting structures, vibration isolators and absorbers.
CO4	Calculate free and forced vibration responses of multi degree freedom systems using modal analysis.

Course Articulation Matrix:

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

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, Undamped Free vibration response and 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 strings, bars and beams.

Reading:

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

ME 312	DESIGN OPTIMIZATION METHODS	DEC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Formulate a design task as an optimization problem
CO2	Solve unconstrained optimization problems
CO3	Formulate constrained optimization problem and solve using corresponding methods
CO4	Solution of discontinuous optimization problems using special methods
CO5	Solve the nonlinear optimization problems with evolutionary methods

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to optimization in design: Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization

Single-variable Optimization: Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

Multiple-variable Optimization: Optimal criteria, direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies.

Constrained Optimization: KKT conditions, Penalty method, and Sensitivity analysis, direct search methods for constrained optimization, quadratic programming, GRG method, Formulation and Case studies.

Specialized algorithms: Integer programming (Penalty function and branch-and-bound method), Geometric programming.

Evolutionary Optimization algorithm: Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization.

Multi-objective Optimization: Terminology and concepts, the concepts of Pareto optimality and Pareto optimal set, formulation of multi-objective optimization problem, NSGA.

Case studies and Computer Implementation: Representative case studies for important methods and development of computer code for the same to solve problems.

Readings:

1. Jasbir Arora, Introduction to Optimum Design, Academic Press, 2004
2. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI, 2004.
3. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley, 2001.

ME313	ADVANCED THERMODYNAMICS	DEC	3 - 0 - 0	3 Credits

Pre-Requisites: ME201: Thermodynamics

Course Outcomes: At the end of the course, 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	Analyze 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.

Course Articulation Matrix:

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

Detailed Syllabus:

Revision of Thermodynamics: I Law of Thermodynamics, II Law of Thermodynamics, Entropy, and 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, 8^{th} Ed, TMH, 2017.
2. Borgnakke, C & Sonntag, R.E., Fundamentals of Thermodynamics, 7^{th} Ed, Wiley, 2009.
3. Nag, P.K., Basic and Applied Thermodynamics, 2^{nd} Ed, TMH, 2017.
4. Smith, J.M. etal, Introduction to Chemical Engineering Thermodynamics, 7^{th} Ed, TMH, 2009.
5. Mcquarrie, D.A., and Simon, J.D., Molecular Thermodynamics, Viva Books, 2010.

ME314	GAS DYNAMICS	DEC	3 - 0 - 0	3 Credits

Pre-Requisites: ME201: Thermodynamics

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Review of basic fluid dynamic and thermodynamic principles, Conservation equations for inviscidflows.

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.

ME315	ADVANCED WELDING TECHNOLOGY	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME253 - Manufacturing Science

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

CO1	Understand solid state welding processes such as friction stir welding and explosive welding and their applications
CO2	Apply laser beam welding processes to join metals
CO3	Analyze the welded jointsfabricated through hybrid welding process
CO4	Examine weldability of cast iron, steel and Aluminum alloys.
CO5	Analyze the welded joint fabricated through cold metal transfer welding process
CO6	Develop plastic components using ultrasonic welding process.

Course Articulation Matrix:

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

Detailed Syllabus:

Solid state welding processes : Classification of solid state welding processes, Review of Friction stir welding, Selection of tool design, Fixture design, modification of tool and features, modeling of friction stir welding, submerged friction stir welding. Friction stir processing, Process variables, Surface modification by friction stir processing, Production of composite by friction stir processing. Adhesive bonding, vacuum brazing, Explosive welding: Process description, process parameters, joint design, advantages and limitations applications.

Laser Beam welding (LBW): Laser Beam welding, process parameters, and Laser Beam welding of steels. Hybrid welding processes: GMAW and Laser welding , process, advantages and Limitations, GTAW and Laser beam welding, Cold Metal Transfer welding process, advantages, limitations and applications.

Weldability studies of cast iron and steel. Welding of dissimilar materials: Aluminum to steel, Aluminum to copper.

Ultrasonic welding, ultrasonic spot welding, line welding, continuous seam welding , welding of plastic and Induction welding of plastics, process description, application, advantages and limitations.

Reading:

1. Nadkarni S.V., “Modern Welding Technology”, Oxford IBH Publishers, 2015.
2. Parmar R. S., “Welding Engineering and Technology”, Khanna Publishers, 2014.
3. D. L. Olson, T. A. Siewert, “Metal Hand Book”, Vol 06, Welding, Brazing and Soldering, ASM International Hand book Metals Park, Ohio USA, 2015.

ME316	ADVANCED METAL CASTING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME253: Manufacturing Science

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

CO1	Recommend remedies for the defects in castings.
CO2	Model components for castings using CAD tools.
CO3	Design gating system for metal casting processes
CO4	Perform economic and castability analysis using Auto-CAST software.

Course Articulation Matrix:

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

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.

Reading:

1. B.Ravi, "Metal casting: CAD and Analysis", PH Publication, 2014.
2. P.L.Jain, "Principles of Foundry Technology", 2012.
3. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2010.

ME351	DESIGN OF TRANSMISSION ELEMENTS	PCC	3 - 1 - 0	4 Credits

Pre-requisites: ME301: Design of Machine Elements

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

CO1	Design the required size of shaft, key and coupling for the given application.
CO2	Select the appropriate gear and Design the gear for the given operating conditions.
CO3	Identify the suitable bearing and design the required size of bearing.
CO4	Design the flexible elements required to transmit the desired power.
CO5	Design the suitable size of I.C. engine parts, clutch and brake.

Course Articulation Matrix:

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

Detailed Syllabus:

Design of Shafts, Keys 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 in Shaft Design, Practical examples, Purpose of Key, Different types of keys, Design - square and flat keys, Kennedy keys and splines, Purpose of shaft couplings, Different types of couplings, Design of rigid couplings - muff coupling, split muff coupling and flanged coupling, Design of Flexible couplings - bushed-pin flexible coupling, Oldhams coupling and Universal coupling.

Design of Gears: Classification of Gears, Law of gearing, Terminology of spur gear, Standard Systems of gear tooth, Interference and undercutting, backlash, 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, Design of spur gear tooth based on strength, Checking the design under dynamic loading conditions and wear loading conditions, Terminology and Force analysis - Helical gears, Worm gears and Bevel gears (self-study)

Design of Friction Bearings: Conditions of proper lubrication, Mechanism of dry friction, Petroff's law, Assumptions involved in Petrof's law, Hydrodynamic lubrication, Practical examples, hydrodynamic conditions 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, Introduction of hydrostatic bearings and magnetic bearings.

Design of Antifriction Bearings: Advantages and disadvantages over friction bearings, Different types of antifriction bearings, A qualitative comparison of performance of antifriction bearings with journal bearings, Basic static and dynamic load ratings, Equivalent radial load, Selection of bearings from manufacturers catalogue, bearings design.

Design of Flexible Elements: Belts and their construction, Flat belts versus V- belts, Open and cross belt arrangement, Ratio of belt tensions, Centrifugal tension, Effect of centrifugal tension, Design of flat belts and V-belts, Selection of wire rope and Pulleys, Introduction to Chain drive - its merits and demerits, Constructional features of a chain drive.

Design of Brakes and Clutches: Different types of brakes, Concept of self-energizing and self-locking of brakes, Practical examples, Design of band brakes, block brakes and internal expanding brakes, Necessity of a clutch in an automobile, Types of clutch, friction materials and its properties, Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.

Design of I.C. Engine parts: Design of engine parts such as Piston, Connecting rod and Crank shaft.

Reading:

1. Richard G. Budynas, J Keith Nisbett, *Shigley's Mechanical Engineering Design*, McGraw Hill, Ninth edition, 2011.
2. Robert L Norton, *Machine design an integrated approach*, Pearson Education, Second edition, 2009.
3. V B Bhandari, *Design of Machine Elements*, Tata McGraw Hill Education Private Limited, Third Edition, 2012.
4. Black and Adams, *Machine Design*, McGraw Hill and Co, New Delhi, 2002.

ME352	HEAT AND MASS TRANSFER	PCC	3 - 1 - 0	4 Credits

Pre-Requisites: ME201: Thermodynamics

Course Outcomes: At the end of the course, 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	Analyze heat transfer through extended surfaces.
CO4	Interpret forced and free convection heat transfer.
CO5	Understand the principles of radiation heat transfer and basics of mass transfer.
CO6	Design and analyze heat exchangers using LMTD and NTU methods.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Heat Transfer - Different Modes, Governing Laws, Applications to Heat Transfer, Numerical Problems.

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, Numerical Problems.

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, Numerical Problems.

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, Numerical Problems.

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.

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 two-body enclosures, Radiation Shield, Numerical problems.

Heat Exchangers: Definition, Classification, LMTD method, Effectiveness - NTU method, Analytical Methods, Numerical Problems, Chart Solution for 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 isothermal equi-molal counter diffusion of ideal gases, Mass diffusivity.

Reading:

1. M. NecatiOzisik, Heat Transfer - A Basic Approach, McGraw Hill, New York.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York.
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi.
4. Alan J. Chapman, Heat Transfer, Macmillan, New York.

ME353	MACHINING SCIENCE	PCC	3 - 0 - 0	3 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:

C01	Develop interrelations among ASA, ORS and NRS systems of tool geometry.
C02	Analyze the stresses, cutting forces, temperature, power and specific energy in metal cutting with single point cutting tool.
C03	Select cutting fluids, tool materials and coatings to control temperature and tool wear to improve tool life and machinability
C04	Evaluate cutting speed to minimize production cost and maximize production rate.
C05	Analyze the cutting forces, temperature, power and specific energy in machining with multi point cutting tool.
C06	Select a modern machining process based on the effect of various process parameters on the required performance criteria.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, Classification of Manufacturing 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: Sourcesofheatgeneration,Effectsoftemperature,Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature.

Tool wear, Tool life, Machinability: 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.

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 A.K. Mallik, "Manufacturing Science", 2nd Edition East-West Press,2010
4. V. K. Jain, "Advanced manufacturing Processes", Allied Publishers Pvt. Ltd, 2002.
5. B L Juneja and G S Sekhon, "Fundamentals of metal cutting and machine Tools", New Age International publishers, 2001.
6. K. C. Jain and A. K.Chitale, "Production Engineering", PHI, 2014.

ME354	MECHATRONICS	PCC	3 - 0 - 0	3 Credits

Pre-requisites: EC101: Basic Electronic Engineering

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

CO1	Model and analyze mechatronic systems for an engineering application
CO2	Identify sensors, transducers and actuators to monitor and control the behavior of process or product.
CO3	Develop PLC programs for an engineering application.
CO4	Evaluate the performance of mechatronic systems.

Course Articulation Matrix:

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

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

Actuators: ElectricalActuators: 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, Feedback, 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.

Industry 4.0 Concepts: Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Reading:

1. W. Bolton, "Mechatronics", 5th 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

ME355	HEAT TRANSFER AND FUELS LABORATORY	PCC	0 - 1 - 2	2 Credits

Pre-Requisites: ME201: Thermodynamics

Course Outcomes: At the end of the lab, 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 and compare with theoretical and empirical values.
CO4	Measure heat transfer coefficient in free convection and compare with empirical values.
CO5	Estimate the efficiency and effectiveness of a pin-fin and equivalent thermal resistance of a composite slab.
CO6	Determine surface emissivity of a test plate and demonstrate working of a Heat Pipe.

Course Articulation Matrix:

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

List of Experiments:

1. **Abel's apparatus:** Determination of flash and fire points of a given oil sample.
2. **Redwood Viscometer No. 1:** Determination of kinematic and absolute viscosities of a given oil sample.
3. **Distillation apparatus:** Determination of distillation characteristic of a given sample of gasoline.

4. **Two-Stage Reciprocating Air-Compressor:** Determination of volumetric efficiency of the compressor as a function of receiver pressure.
5. **Pin-Fin Apparatus:** Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment.
6. **Natural Convection Apparatus:** Determination of experimental and empirical values of free convection heat transfer coefficient from a Heated Vertical Cylinder.
7. **Composite Slab Apparatus:** Determination of theoretical end experimental values of equivalent thermal resistance of a composite slab.
8. **Forced Convection Apparatus:** Determination of theoretical, experimental and empirical values of forced convection heat transfer coefficient for flow through a circular pipe.
9. **Emissivity Apparatus:** Determination of surface emissivity of a given test plate at a given absolute temperature.
10. **Heat Pipe Demonstrator:** Demonstration of isothermal characteristic exhibited by a heat pipe in comparison to other pipes.
11. **Parallel and Counter flow Heat Exchanger:** Determination of LMTD of parallel and counter flow heat exchanger.

Reading:

1. M. NecatiOzisik, Heat Transfer - A Basic Approach, McGraw Hill, New York., 1980
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York, 2013
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi, 2011

ME356	MEASUREMENTS LABORATORY	PCC	0 - 0 - 2	1 Credit

Pre-Requisites: ME304: Mechanical Measurements

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

CO1	Estimate errors and uncertainty in measurements using statistical analysis.
CO2	Calibrate measuring instruments with standards.
CO3	Identify sensors for measurement of specific parameters with required accuracy.

Course Articulation Matrix:

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

List of Experiments:

1. Calibrate strain gauge pressure sensor with Bourdon gauge.
2. Determine the mass flow rate of air using hot wire anemometer and pitot tube.
3. Demonstrate the working principle of LVDT and compare with micro meter.
4. Compare the temperature reading recorded by thermocouples, RTD, thermometers.
5. Demonstrate the working of IR thermal transducer and recording high temperatures.
6. Demonstrate torque measurement and do regression analysis.
7. Compare venturi meter, orifice meter and rotameter for flow measurement.

Reading:

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

ME361	FINITE ELEMENT METHOD	DEC	3-0-0	3 Credits

Pre-Requisites: Nil

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

CO1	Apply finite element method to solve problems in solid 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 analyse plain stress, plain strain, and axi-symmetric and plate bending problems.
CO4	Implement and solve the finite element formulations using MATLAB.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Overview of the course, examination and evaluation patterns, history and basic concept of finite element method and direct FEM.

Fundamental concepts: Calculus of variation and solving differential equations, Ritz method, Galerkin method, Least squares, collocation and subdomain methods, Case studies for Ritz and Galerkin methods, Ritz FEM formulation, Galerkin FEM formulation.

One-Dimensional Problems: Finite element formulation for 1-D problems, elimination method, penalty method, computer implementation and case studies.

Trusses: Introduction, fem formulation, plane trusses, three dimensional trusses, frames and case studies.

Two-Dimensional Problems: Finite element formulation for 2-D problems, constant strain triangle, various elements, iso parametric, sub parametric and super parametric elements, interpolation functions, computer implementation and case studies.

Numerical Integration and 2-D problems of Elasticity: Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems.

Thermal Applications: Two - dimensional heat conduction analysis, formulation of functional, element matrices and case studies.

Fluid Mechanics Applications: Stream function formulation, velocity potential formulation and torsional analysis of a prismatic bar.

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

Reading:

1. Seshu P., Textbook of Finite Element Analysis, PHI, 2009
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. Zeincowicz, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.

ME362	THEORY OF ELASTICITY	DEC	3-0-0	3 Credits

Pre-Requisites: Nil

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

CO1	Formulate the stress strain relations in elastic body.
CO2	Develop the governing equation and apply boundary conditions for 2D elastic problems.
CO3	Apply the general theorems to the 3D elastic continuum problems.
CO4	Analyse the stress in the Prismatic Beams of rectangular and circular cross-section

Course Articulation Matrix:

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

Detailed Syllabus:

Elasticity: Two dimensional stress analysis - Deformation and Strain Tensor, Traction and Stress Tensor Plane stress - Plane strain - Equations of compatibility - Stress function - Boundary conditions.
Rectangular Coordinates System: Stress, Strain and Displacement Transformations, Solution by polynomials - Saint Venent's principles - Determination of displacement - Simple beam problems, Problems in polar coordinates - General equations in polar coordinates - Stress distribution symmetrical about axis - Strain components in polar coordinates - Simple and symmetric problems.
Three-Dimensional Classical Elasticity Problems: Principle stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain.
General Theorems: Differential equations of equilibrium and compatibility - Displacement - Uniqueness of solution - Reciprocal theorem, Boussinesq's Problem, Mindlin's Problem.
Bending of Prismatic Bars and Elasto dynamics: Stress function - Bending of cantilever beam - Beam of rectangular cross-section - Beams of circular cross-section, Helmholtz Decomposition, Elastic Wave Propagation in Solids
Reading:

1. Theory of Elasticity by Timoshenko, S.P. and Goodier, J.N.McGraw-Hill, 1970.
2. An Engineering Theory of Plasticity by E.P. Unksov.Butterworths, 1961
3. A Treatise on the mathematical Theory of Elasticity, Love. FB & C Limited, 2017
4. Fundamentals of Fracture Mechanics, T. Kundu, Taylor and Francis, 2008

ME363	COMPUTATIONAL FLUID DYNAMICS	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:CE235: Fluid Mechanics and Hydraulic Machines

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

CO1	Explain the differential equations for flow phenomena and numerical methods for their solution.
CO2	Critically analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.
CO3	Solve computational problems related to fluid flows and heat transfer.
CO4	Analyze the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
CO5	Evaluate forces in both internal and external flows.

Course Articulation Matrix:

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

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 - Lasonen, 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, McCormack 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 tetrahedral Elements, 2-D Heat conduction with Triangular Elements.

Reading:

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.

ME364	AUTOMOBILE ENGINEERING	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME101: Basic Mechanical Engineering, ME302: Prime Movers for Automobiles

Course Outcomes: At the end of the course, 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 restraint system.
CO5	Study latest developments in automobiles.

Course Articulation Matrix:

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

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, Ignition System and Electrical system: Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburetor, 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 system: 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, steering 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 axle 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.

Automotive Restraint Systems: Seat belt, automatic seat belt tightener system, collapsible steering column and air bags.

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.

ME365	NON DESTRUCTIVE TESTING	DEC	3- 0 - 0	3 Credits

Pre-requisites: NIL

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

CO1	Understand general principles of NDT techniques
CO2	Conduct NDT techniques and interpret the results
CO3	Select appropriate NDT techniques in practical applications
CO4	Apply codes and standards used in NDT techniques

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to NDT, Liquid Penetrant Test: Physical Principles, Procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages and limitations.

Thermography: Basic principle, Detectors and equipment, techniques, applications.

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.

Magnetic Particle Inspection: Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

Practical NDT: Principles, procedures, applications, limitations, codes and standards widely used in non-destructive testing (NDT) techniques. Reliability in NDT.

Reading:

1. Peter J Shull, "Nondestructive Evaluation: Theory, Techniques and Applications", Marcel Dekkar, 2002.
2. P. McIntire (Ed.), "Non Destructive Testing Hand Book", Vol. 4, American Society for Non Destructive Testing, 2010
3. ASM Metals Hand Book, "Non Destructive Testing and Quality Control", Vol. 17, ASM, 1989.
4. Baldev Raj, M. Thavasimuthu, T. Jaya kumar, "Practical Non-Destructive Testing", 3rd Edition, Narosa Publishing House, 2009.

ME366	OPERATIONS RESEARCH	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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 engineering and managerial situations as LPP, transportation and Assignment problems.
CO3	Solve LPP, Transportation and Assignment problems
CO4	Formulate multi-stage applications into a dynamic programming framework.
CO5	Solve Integer programming problems.

Course Articulation Matrix:

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

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", 10^{th}Edition, Prentice Hall of India, New Delhi, 2017.
2. Hillier F.S.and Lieberman G.J., "Introduction to Operations Research", 7th Edition, TMH, 2009.

ME367	PRODUCTION PLANNING AND CONTROL	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME305: Management Science and Productivity.

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

CO1	Explain production systems and their characteristics.
CO2	Evaluate MRP and JIT systems against traditional inventory control systems.
CO3	Evaluate 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	Apply theory of constraints for effective management of production systems.

Course Articulation Matrix:

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

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, 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.

Theory of Constraints: Concept of bottleneck, Local and global optima, Five steps of TOC approach, Performance measures.

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 W. J. and Spearman M. L. "Factory Physics: Foundations of Manufacturing Management", McGraw Hill International Edition, 3rd Edition, 2008.
4. Mukhopadhyay S.K., "Production Planning and Control", 2nd Edition, PHI, Eastern Economy Edition, 2013.

ME368	DESIGN AND ANALYSIS OF EXPERIMENTS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil
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	Analyse 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.

Course Articulation Matrix:

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

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 D. C. "Design and Analysis of Experiments", 7th Edition, John Wiley & Sons, 2008.
2. Ross P. J. "Taguchi Techniques for Quality Engineering", McGraw-Hill, NY, 2008.
3. Madhav S. Phadke, "Quality Engineering using Robust Design", Prentice Hall, 1989

SM413	ENGINEERING ECONOMICS AND ACCOUNTANCY	HSC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand various methods of Economic Analysis and apply.
CO2	Calculate Depreciation using various methods.
CO3	Sensitize the student to Macro Economic Environment.
CO4	Analyze the financial statements with ratios for investment decisions.
CO5	Analyze costs and their role in pricing
CO6	Develop effective presentation skills

Course Articulation Matrix:

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

Detailed Syllabus:

Engineering Economics

1. Introduction to Engineering Economics, Fundamental concepts, Time value of money, Cash flow and Time Diagrams, Nominal Rate of Interest Vs effective rate of interest, choosing between alternative investment proposals, Methods of Economic analysis (Pay back, ARR, NPV, IRR and B/C ratio).

2. The Effect of borrowing on investment, Equity Vs Debt Financing, Concept of leverage, Income tax and leverage
3. Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method, declining Balance Method, Annuity Method, Sinking Fund method).
4. National Income Accounting, Methods of Estimation, Various Concepts of National Income, Significance of National Income Estimation and its limitations.
5. Inflation, Definition, Process and Theories of Inflation and Measures to Control,
6. Balance of payments and its impact on exchange rate.
7. New Economic Policy 1991, LPG.
8. Basics of Union Budget, various deficits such as fiscal deficit and revenue deficit.

Accountancy

9. Analysis of financial statements, income statements and balance sheet (simple ratios).
10. Cost accounting, classification of costs, cost sheet and preparation of cost sheet, breakeven analysis meaning& limitations.

Presentations/ Group Discussions on current topics.

Reading:

1. D N Dwivedi "Managerial Economics", Vikas Publishing House Private Limited, 2010
2. Agrawal AN, "Indian Economy" Wiley Eastern Ltd, New Delhi, 2015
3. R.K Sharma and Sashi K Gupta," Financial Management", Kalyani Publications, 2014
4. Arora, M.N." Cost Accounting", Vikas Publication, 2013

Source- Internet

- Capitaline Plus Database - http://www.capitaline.com/
- Ministry of Finance - http:/finmin.nic.in/
- Database of Indian Economy - http://dbie.rbi.org.in
- Statistics of India -www.indiastat.com/ or http://mospi.nic.in/
- The Economist Magazine.

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

Pre-Requisites: ME201: Thermodynamics

Course Outcomes: At the end of the course, 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.*

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Introduction to Refrigeration - Basic Definition.

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 McGraw - Hill, New Delhi.
3. Stoecker, W. F., and Jones, J. W., Refrigeration and Air-Conditioning, McGraw - Hill, New Delhi.

Data Book: Refrigerant and Psychrometric Properties - Tables and Charts [SI Units], Mathur, M. L., and Mehta, F. S., Jain Brothers.

ME402	COMPUTER AIDED MANUFACTURING	PCC	3 - 0 - 0	3 Credits

Pre-requisites: Nil
Course Outcomes: At the end of the course, student will be able to:

CO1	Develop part programs with G codes and M codes for typical components
CO2	Develop part programs with APT language
CO3	Understand the elements of an automated manufacturing environment
CO4	Apply the knowledge of AM to manufacture custom specific components

Course Articulation Matrix:

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

Detailed syllabus:

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

CNC Control Systems: CNC Machining Centers, CNC turning centers, High-speed machine tools, machine control unit, support systems, touch-trigger probe, Adaptive Control, Introduction to FANUC, SINUMERIC controllers, DNC.

CNC Programming: Part programming fundamentals, Process planning, Axes selection, Tool selection, Steps involved in Development of Part Program, Job and Tool Set up Planning, Machining path planning.

Manual Part Programming: Manual part programming Methods, Preparatory functions, G- Codes, Miscellaneous Functions M Codes, Writing Part programs for typical components, Tool length compensation, Canned cycles, Cutter radius compensation,

Computer Aided Part Programming: Concept of CAP, APT Language, Geometry Commands, Motion Commands like point to point Continuous path commands, Post processor commands, Compilation of control commands, Writing complete Part programs for typical components with APT.

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 coding systems, production flow analysis.

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.

Computer Aided Inspection and Quality Control: Inspection and testing Coordinate Measuring Machine, Non-Contact Inspection, and Machine Vision

Additive Manufacturing (AM): Introduction to Additive Manufacturing (AM), Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Reading:

1. P.N. Rao, "CAD/CAM Principles and Applications", 3rd Edition, Tata McGraw Hill, New Delhi, 2010.
2. Grover M. P. and Zimmers E.W. "CAD/CAM: Computer Aided Design and Manufacturing", Prentice Hall of India, 2010.
3. YoramKoren, "Computer Control of Manufacturing Systems", McGraw Hill Publications, 2005.
4. T.C. Chang, R.A. Wysk, H.P. Wang "Computer Aided Manufacturing", 3rd Edition, Pearson Prentice Hall, 2006.
5. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.

ME403	CAE Lab	PCC	0 - 0 - 2	1 Credit

Pre-requisites: Nil
Course Outcomes: At the end of the course, the student shall be able to:

CO1	Generate code in MATLAB software to solve various engineering problems
CO2	Develop programs for simulation and visualization of mathematical models and experimental results
CO3	Solve different structural engineering elements using FEA software
CO4	Execute mini projects involving programming knowledge, modelling and analysis

Course Articulation Matrix:

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

Detailed syllabus:

a. **Computer Aided Simulation Exercises:**
   1. Arithmetic operations, control loops and functions
   2. Solving Linear, non-linear equations, curve fitting and interpolation
   3. Visualization and plotting
   4. Solving engineering problems involving ODE' s and PDE's
   5. Solve problems involving Vibrations, Optimization
   6. Solve problems involving FEM, and Heat transfer
   7. Introduction to Simulink

b. **Computer Aided Analysis Exercises:**
   1. Introduction to FEA software-Ansys
   2. Solving truss problems using Ansys
   3. Solving problems of Beams and Frames using Ansys
   4. Solving problems involving triangular elements
   5. Analysing 3D Problems using Ansys
   6. Harmonic analysis of a Cantilever beam
   7. Mini Project

ME404	CAM Lab	PCC	0 - 0 - 2	1 Credits

Pre-requisites: Nil

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

CO1	Develop manual part programs for 2D-complex profiles for Fanuc and Siemens controller using CNC Simulator and Sinutrain Software.
CO2	Generate CNC program for turning and milling of component using Master CAM and Edge CAM software.
CO3	Generate and verify CNC code using Virtual CNC software.
CO4	Machine complex profiles on CNC machine using auto generated CNC code.
CO5	Verify STL files and print 3D parts by AM machines

Course Articulation Matrix:

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

Detailed syllabus:

Manual Part programming for Fanuc and Siemens Controller using CNC Simulator and Sinutrain,

CNC programming for turned and milled components using Edge CAM, Sinutrain and Master CAM, Training on CNC machines.

List of experiments:

Simulation of turn components on CNC Simulator. (3-4 Exercises)

Turning of components on spinner.com Lathe. (3-4 Exercises)

Turning of components on VDF lathe. (3-4 Exercises)

Milling simulation of 2D profiles on CNC Simulator. (3-4 Exercises)

Milling Simulation of Turbine blade on CNC Simulator.

Milling of 2D profiles on Max Mill CNC milling Machine. (2-4 Exercises)

Milling of 2D / 3D profiles using Master Cam. (2-4 Exercises)

Milling of 2D / 3D profiles using Edge Cam. (2-4 Exercises)

Generate and visualize CNC code using Virtual CNC Software. (2-4 Exercises)

Design and fabrication of components using 3D printer.

Reading:

1. NITW CNC Lab Manual,
2. John Stenerson and Kelly Curran, “Computer Numerical Control: Operation and Programming”, PHI, New Delhi, 2009.
3. T. C. Chang, R.A.Wysk and H. P. Wang, “Computer Aided Manufacturing”, PHI, New Delhi, 2009.

ME405	MECHATRONICS LAB	PCC	0 - 0 - 2	1 Credits

Pre-requisites: Nil

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 microcontroller programming to guide a robot.
CO4	Simulate and analyze PID controllers for a physical system using MATLAB.
CO5	Develop pneumatic and hydraulic circuits using Automation studio.

Course Articulation Matrix:

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

List of Experiments:

1. **DYNA 1750 Transducers Kit:-**
    1. Characteristics of LVDT
    2. Principle & Characteristics of Strain Gauge
    3. Characteristics of Summing Amplifier
    4. Characteristics of Reflective Opto Transducer
2. **Mobile Robot with P89V51RD2microcontroller**
    1. Program for Operating Buzzer Beep

2. Program for Operating Motion control
3. Program for Operating Direction control
4. Program for Operating White line follower for the given arena

3. PLC PROGRAMMING

1. Ladder programming on Logic gates, Timers &counters
2. Ladder Programming for digital & Analogy sensors
3. Ladder programming for Traffic Light control, Water level control and Lift control Modules

4. AUTOMATION STUDIO software

1. Introduction to Automation studio & its control
2. Draw & Simulate the Hydraulic circuit for series & parallel cylinders connection
3. Draw & Simulate Meter-in, Meter-out and hydraulic press and clamping.

5. MATLAB Programming

1. Sample programs on Matlab
2. Simulation and analysis of PID controller using SIMULINK

ME411	CONDITION MONITORING	DEC	3-0-0	3 Credits

Pre-requisites: Nil
Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand effective maintenance schemes in industries
CO2	Diagnose the mechanical systems by applying vibration monitoring techniques
CO3	Apply oil analysis technique to diagnose the wear debris.
CO4	Identify nonconventional methods for machine diagnoses.
CO5	Develop modern technologies for effective plant maintenance.

Course Articulation Matrix:

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

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, 2012
5. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

ME412	TRIBOLOGY	DEC	3 - 0 - 0	3 credits

Pre-Requisites: Nil

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

CO1	Analyze properties of lubricant and selection of proper lubricant for the given application.
CO2	Identify the lubrication regime for the given mechanical application.
CO3	Determine tribological performance parameters of sliding contact in hydrodynamic lubrication regimes.
CO4	Evaluate the friction and wear behavior of the given materials.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: History and basic concept of friction wear and lubrication, Types of lubricants, Objectives and selection of lubricant, Physical properties of lubricants.

Lubrication: Regimes of lubrication - hydrodynamic, Elasto-hydrodynamic, mixed and boundary lubrication, Reynolds' equation, Hydrodynamic lubrication of roughened surfaces.

Theories of other Lubrication: Externally pressurized lubrication, Squeeze-film lubrication, Elasto-hydrodynamic lubrication, Rheological lubrication regime, Functional lubrication regime.

Applications of hydrodynamic lubrication theory - Journal bearing, inclined thrust pad bearing, Rayleigh step bearing.

Friction and Wear: Origin of sliding friction, Causes of Friction, Laws of Rolling Friction. Friction Instability, Contact between two bodies in relative motion, Wear classification - Wear between solids - Wear between solid and liquid - Factors affecting wear - Measurement of wear, Types of wear and their mechanisms - Adhesive wear-adhesion junction growth, Abrasive wear, Wear due to surface fatigue and wear due to chemical reactions, wear of metallic materials.

Reading:

1. Stachowaik, G.W., Batchelor, A.W., *Engineering Tribology*, 3rd Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., Wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.
4. Stolarski TA, *Tribology in Machine Design*, Butterworth Heinemann, 2000.

ME413	NON-CONVENTIONAL ENERGY SOURCES	DEC	3 - 0 - 0	3 Credits

PreRequisites: Nil

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

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

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Basic concepts of energy; Introduction to Renewable Energy Technologies; Energy and Environment: Global warming, acid rains, Depletion of ozone layer; Global and Indian Scenario of renewable energy sources

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.

ME414	ADVANCED IC ENGINES	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics, ME302: Prime Movers for Automobiles

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

CO1	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion process.
CO2	Identify harmful IC engine emissions and use viable alternate fuels in engines.
CO3	Analyze and evaluate engine performance and adopt improvement devices and new combustion concepts.
CO4	Classify and analyze alternate power sources for automobiles.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to IC engines: Overview of the course, Examination and Evaluation patterns-Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-S cycle engines based on scavenging, Differences between 2-S and 4-S cycle engines, Differences between SI and CI engines.

Spark Ignition Engines: Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines.

Compression Ignition Engines: Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI).Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI), Fuel Injectors-Nozzle types, Electronic Control Unit (ECU)-Numerical problems on fuel injection.

Supercharging of IC Engines: Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOx) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

Performance of IC Engines: Classification of engine performance parameters-Measurement of brake power, indicated power and friction power. Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

Batteries: Battery: lead-acid battery, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradability.

Hybrid vehicle: Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradability-Hydrogen: Production-Hydrogen storage systems-reformers.

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

Reading:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988.
2. W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd 2002.
3. SethLeitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
4. F.Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press-2005.

ME415	TOOL DESIGN	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME253: Manufacturing Science, ME301: Design of Machine Elements, ME303: Machine Tools and Metrology, ME353: Machining Science

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

CO1	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.
CO2	Select and design progressive, compound or combination dies for producing a given component.
CO3	Design single point and multipoint cutting tools for conventional and CNC Machining.
CO4	Design jigs and fixtures for conventional and NC machining.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: 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 ofcenterofpressure,Designofpiercingdie,Designofblankingdie,Progressive,Compoundand Combination dies.

Design of cutting tools: Introduction to cuttingtools, 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 NCMachine, Cutting toolsforNCMachine,Tool holding methods for NC Machine, ATC and APC for NC Machine, Tool presetting for NCMachine.

Reading:

1. F. W. Wilson, "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
3. Prakash Joshi, "Jigs and Fixtures Design Manual", 2nd Edition, McGraw-Hill Professional, 2002.
4. K. Venkataraman, "Design of Jigs, Fixtures and Press Tools", 1st Edition, Wiley; Athena Academic, 2015.

ME416	THEORY OF PLASTICITY	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME253: Manufacturing Science

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

CO1	Differentiate elastic and plastic behavior from stress-strain curves
CO2	Identify plastic yield criteria to establish constitutive modeling
CO3	Interpret material constants in mathematical formulation of constitutive relationship
CO4	Analyze boundary value problems with elasto-plastic properties

Course ArticulationMatrix:

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

Detailed syllabus:

Introduction to the concept of plastic deformation-Role of microstructure and thermodynamics in plastic deformation - Constitutive responses: elastic, viscoelastic, plastic, visco plastic, anisotropy etc.

Physical overview of crystal plasticity, plasticity of granular media, plasticity in rubber-like materials, etc. (Rate independent plastic deformation) - Rate dependent and rate independent plasticity - Plastic strain, incremental strain, objective rates, and hardening variables - Yield criteria - Plastic work (Drucker's postulate) - Maximum dissipation and normality rule (Associated flow rules) - Hardening rules (isotropic and kinematic) - Non-associated flow rules

Axisymmetric problems in plasticity - Basic equations of plane strain and plane stress - Slip lines and their properties - Limit analysis and shakedown theorems (Plastic stability and waves) - Concept of plastic stability - Global stability criteria according to Hill - Elastoplastic column buckling - Local stability criteria (localization, shear bands, ellipticity)

Introduction to dynamic plasticity - One-dimensional - Phase transformation and plasticity, strain-gradient plasticity, dislocation plasticity, crystal plasticity.

Reading:

1. J. Lubliner, “Plasticity Theory”, Dover Publishing, 2008.
2. L. M. Kachanov, “Fundamentals of the theory of plasticity”, Dover Publishing, 1990.
3. D. Bigoni, “Nonlinear Solid Mechanics”, Cambridge University Press, 2012
4. P. M. Dixit and U. S. Dixit, “Plasticity: Fundamentals and applications”, CRC Press; (2014)
5. J. Chakrabarty, “Theory of Plasticity”, 3rd Edition, Butterworth-Heinemann, 2006.
6. R Narayanasamy and R Ponalagusamy, “Theory of Engineering Plasticity”, Ahuja Book Company, 2000.

ME417	TOTAL QUALITY MANAGEMENT	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand quality management philosophies, techniques, and frameworks
CO2	Adopt TQM methodologies for continuous quality improvement
CO3	Identify the areas of improvement through measurement of cost of poor quality, effectiveness and efficiency of processes
CO4	Apply TQM process and concepts to enhance the performance of systems
CO5	Understand the implications of quality management standards and systems

Course Articulation Matrix

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

Detailed syllabus:

Introduction: Definition of Quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs - Analysis, Techniques for Quality Costs, and 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, Taguchi Quality Philosophy- Robust Design Concept, Orthogonal Arrays, 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.

ME418	ENTREPRENEURSHIP	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

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

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 Enterprise: 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. G.G. Meredith, R.E.Nelson and P.A. Neek, “The Practice of Entrepreneurship”, ILO, 1982.
2. Dr. Vasant Desai, “Management of Small Scale Enterprises”, Himalaya Publishing House, 2004.
3. “A Handbook for New Entrepreneurs”, Entrepreneurship Development Institute of India, Ahmedabad, 1998.
4. Bruce R Barringer and R Duane Ireland, “Entrepreneurship: Successfully Launching New Ventures”, 3rd Edition, Pearson Education, 2013.

ME449	PROJECT WORK PART - A	PRC	0 - 0 - 4	2 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

RUBRICS

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide
	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it	Splitting the project into small tasks and scheduling them to finish it in	Splitting the project into small tasks is not sufficient and sharing different	Not able to split the project into small tasks. Needs lot of work to be done.

		in time and division of the work among the members of the team is good and coordination in the team is good.	time and different tasks of the job shared among the members of the team with satisfactory coordination.	tasks among the team members needs some more attention	
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Team Work	Coordinates team efforts and communication among members is good.	Coordinates team efforts and communication among members is satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation in incomplete in all aspects.
	Understanding	Understanding the task fully. Knowing all the tasks of the project. 100%.	Ability of correlating the theoretical aspects with the practical aspects is in between 60-80%	Ability of correlating the theoretical aspects with the practical aspects is in between 50-60%	Ability of correlating the theoretical aspects with the practical aspects is less than 50%

Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project	Answering, less than 50% of the questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor

ME461	ROBOTICS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.

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

CO1	Understand the basic components of robots, classification and robot grippers.
CO2	Model forward and inverse kinematics of robot manipulators.
CO3	Analyze forces in links and joints of a robot.
CO4	Programme a robot to perform tasks in industrial applications.
CO5	Design intelligent robots using sensors.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: 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 andInverse Kinematics for industrial robots for Position and orientation.

Statics & dynamics: 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, Adaptivecontrol, and Servo system for robot control.

Robot programming: Programming of Robots and Vision System- overview of various programming Languages.

Applications: 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. Craig, J.J., *Introduction to Robotics Mechanics and Control*, AddisonWesley, 1999.
2. Saha, Subir Kumar. Introduction to robotics. Tata McGraw-Hill Education, 2014.
3. Spong, Mark W., Seth Hutchinson, and MathukumalliVidyasagar. Robot modeling and control. Vol. 3. New York: Wiley, 2006.

ME462	ROTOR DYNAMICS	DEC	3-0-0	3 credits

Pre-Requisites: ME251: Dynamics of Machinery

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

CO1	Model the Rotor bearing systems and formulate the governing equations.
CO2	Understand the role of damping, gyroscopic, centrifugal, stiffness and inertial effects on rotors.
CO3	Compute the critical speeds and stability limits for rotors under axial, transverse and torsional modes.
CO4	Analyse the rotor bearing systems using transfer matrix method and Finite Element Method.
CO5	Compute the transient response of rotors.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Introduction to rotor dynamics & smart rotor systems, Review of momentum principles, Hamilton's principle and Lagrange's equations, Rotating and reciprocating unbalances, Classification of Discrete and continuous systems, Review of free and forced vibrations of single and multi-degree of freedom systems.

Linear Rotor Dynamics: Equation of motion, Rotating systems, Complex coordinate representation, Undamped Jeffcott Rotor - Free whirling, Unbalance response, Shaft Bow Jeffcott Rotor with viscous damping - Free whirling, Unbalance response, Shaft Bow With structural damping - Free whirling, Unbalance response, frequency dependent loss factors with non-synchronous damping, Effect of Bearing Compliance, Stability in supercritical region.

Modelling with Four Degrees of Freedom:

Generalised coordinates and equations of motion in real and complex coordinates, Static and couple unbalance and their effects, uncoupled gyroscopic systems, Free whirling of coupled undamped systems, Unbalance response and Shaft bow. Model uncoupling of gyroscopic systems, Configuration and state space approaches. Disc gyroscopic, synchronous and nonsynchronous whirl, forward and backward whirl.

Discrete multi-degree of freedom:

Introduction, Transfer matrix approach for undamped systems, Damped systems, the finite element method for rotors, Beam elements, spring elements, Mass elements, Assembly and constraints, damping matrices, Choice of coordinates: fixed Vs Rotating and Real Vs Complex coordinates, Computation of critical speeds, Computation of unbalance response. Campbell and root locus diagrams, Reduction of DOF: Nodal reduction, model reduction and component mode synthesis.

Transmission Shafts: Modelling of rotors as continuous systems, Euler-Bernoulli and Timoshenko beam models, Dynamic stiffness, Analytical and approximate solutions.

Anisotropy of rotors and supports:

Isotropic rotors on Anisotropic supports - Influence of damping, non-isotropic rotors on isotropic supports.

Torsional and Axial Dynamics:

Free and forced Torsional vibrations and critical speeds, Axial Vibration of rotors

Rotor-Bearing Interaction:

Rigid body and flexural modes, Linearization of bearing Characteristics, Rolling element bearings, Fluid film bearings, Magnetic bearings, bearing alignment in multi rotor bearings

Reading:

1. Giancarlo Genta, Dynamics of Rotating Systems, Springer, 2009

2. Rao, J.S., Rotor Dynamics, 3 Ed. New Age International, 2003

3. Maurice L. Adams, Jr., Rotating Machinery Vibrations, Marcel Dekker, Inc., New York, 2001

4. Chong-Won Lee, Vibration Analysis of Rotors, Kluwer Academic Publishers, London, 1995

5. Muszynska A, Rotor dynamics, Taylor & Francis, New York, 2005

ME463	ENGINEERING ACOUSTICS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Review of vibrations, resonance and frequency, Sound pressure, power and intensity and its measurement, Concept of Monopoles, Dipoles and Quadrupoles, Sound Power measurement, Transmission loss, Longitudinal and Transverse wave equations, Spherical and cylindrical wave equation, Acoustic intensity, decibel scales, Sound wave generators.

Acoustic wave propagation: Transmission/reflection of waves in different media, radiation and reception of acoustic waves, absorption and attenuation of sound, Cavities and waveguides. Wave types in fluids and solids. Modes of vibrations in solids.

Pipes, Resonators, and Filters: Resonance in pipes, standing waves, Absorption of sound, Helmholtz resonator, acoustic impedance, 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, Noise measurement and instrumentation standards. Noise Control approaches.

Reading:

1. Robert D Finch. Introduction to acoustics, PHI2008
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.

ME464	MECHANICS OF COMPOSITE MATERIALS	DEC	3-0-0	3 Credits

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

CO1	Understand the industrial need for composite materials.
CO2	Identify suitable processes to develop fiber reinforced composite materials.
CO3	Apply the micro and macro mechanics for fiber reinforced composite materials.
CO4	Develop governing equation for Bending, Buckling, and Vibration of Laminated plates.
CO5	Design the composite structures with the help of computers.

Course Articulation Matrix:

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

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, Nonlinear behaviour, Inter-laminar 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

ME465	INNOVATIVE DESIGN	DEC	3-0-0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Modern product development and design, State of art, Understanding the opportunity, Develop a concept, implement a concept, Reverse engineering and redesign methodology, Comparison between scientific method and design method.

Need Identification and Problem definition: Wheelwright Clark model, constructing a survey instrument, Kano diagram, Establishing Engineering Characteristics, Benchmarking, Evaluating Customer Requirements, Quality Function Deployment (QFD) and Product Design Specification (PDS).

Information Gathering: types, sources, Copy rights and Intellectual property systems, Journals and patent writing, Codes and Standards.

Concept generalization: Creativity and problem solving, Models of brain, Creative methods and barriers, Theory of Inventive Problem Solving (TRIZ), Physical and Functional Decomposition, Morphological analysis, Axiomatic design.

Concept evaluation and decision making- Decision Theory, Evaluation methods, Pugh's concept, weighted decision matrix, Analytic hierarchy process (AHP)

Embodiment design: Phases, Significance, Product architecture, Configuration and Parametric design, detailed design, Design for X: Manufacturing, Assembly, Environment, Robustness

Ethical Issues and Team Management: Ethical issues during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.

Reading:

1. Engineering Design by George E Dieter
2. GenrichAltshuller, The Innovation Algorithm, Technical Innovation Centre, 2011.
3. Nigel Cross, Engineering Design Methods, John Wiley, 2009.

ME466	CONVECTIVE HEAT TRANSFER	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics; ME352: Heat and mass transfer

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

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

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 heatflux. Sidewalls, triangular enclosures, heated from below, inclineden closures, annular space between horizontalcylinders.

Turbulent boundary layer flow: Boundary layer equations, mixing length model, flow over single cylinder, crossflow 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, 2001.

ME467	ALTERNATE FUELS	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics, ME302: Prime Movers for Automobiles

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

CO1	Categorize, interpret and understand the essential properties of fuels for IC engines.
CO2	Identify the need for alternate fuels and characterize prospective alternate fuels.
CO3	Evaluate the storage and dispensing facility requirements.
CO4	Analyze the implement limitations with regard to performance, emission and materials compatibility.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Estimation of petroleum reserve - Need for alternate fuels - Availability and properties of alternate fuels, ASTM standards.

Alcohols: General Use of Alcohols - Properties as Engine fuel - Gasoline and alcohol blends - Performance in SI Engine - Methanol and Gasoline blend - Combustion Characteristics in engine - emission characteristics.

Vegetable oils: Soyabeen, Jathropa, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils.

Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines - performance and emission characteristics of CNG using LPG in SI & CI engines.

Hydrogen: Hydrogen production, Hydrogen as an alternative fuel, fuel cell

Automobile emissions & its control: need for emission control -Classification/ categories of emissions -Major pollutants -control of emissions - Evaluating vehicle emissions - EURO I, II, III, IV standards - Indian standards.

Reading:

1. Richard L. Bechhold, P.E.Alternate Fuels Guide Book, Society of Automotive Engineers, 1997.
2. Joseph M Norbeck, Hydrogen fuel for surface transportation, Society of Automotive Engineers, 1996.
3. Earnest Henry Wakefield, History of the Electric Automobile: Hybrid Electric Vehicles, Society of Automotive Engineers, 1998.
4. Pundir B.P., Engine Emissions: Pollutant formation and advances in control Technology, Narosa Publishing House, 2007.
5. S.C. Bhatia, Air Pollution and its Control, Atlantic Publications, 2008.
6. James D. Halderman, James Linder. Automotive Fuel and Emission Control system, Prentice Hall, 2005.

ME468	JET PROPULSION AND ROCKETRY	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics, ME252: Turbomachines

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

CO1	Understand the applications of jet and rocket propulsion and their energy requirements.
CO2	Identify propellants available and factors influencing their burn rate and performance.
CO3	Classify nozzles and their requirementsfor the development of thrust and impulse.
CO4	Understand the principles of rocket propulsion, staging and boosting.
CO5	Evaluate burn rate, propulsive power, thrust and energy requirements in ideal cases of propulsion devices.

Course Articulation Matrix:

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

Detailed Syllabus:

Motion In Space-Requirements of Orbit: Introduction, Motion of Bodies in Space and Laws of Motion; Parameters describing Motion of Bodies, Newton's laws of Motion, Universal Law of Gravitational Force, Gravitational Field; Requirements for Motion in Space, Geosynchronous and Geostationary Orbits, Eccentricity and Inclination of Orbits, Energy and Velocity Requirements to reach a Particular Orbit; Escape Velocity, Freely Falling Bodies, Means of Providing the Required Velocities, small problems.

Theory of Rocket Propulsion: Illustration by an Example of Motion of Sled Initially at Rest, Motion of Giant Squid in Deep Seas; Rocket Principle and the Rocket Equation, Mass Ratio of a

Rocket, Desirable Parameters of a Rocket, Propulsive Efficiency of a Rocket, Performance Parameters of a Rocket, Staging and Clustering of Rockets, Classification of Rockets, problems.

Rocket Nozzle and Performance: Expansion of gas from a high pressure chamber, Shape of the Nozzle, Nozzle area Ratio, Performance loss in a conical Nozzle, Flow Separation in Nozzles Contour or Bell Nozzles, Unconventional Nozzles Mass Flow rates and characteristic Velocity, Thrust developed by a Rocket; Thrust Coefficient Efficiencies, Specific Impulse and Correlation with C* and CF General Trends.

Chemical Propellants: Small Values of Molecular Mass and Specific Heat Ratio, Energy Release during Combustion of Propellants, Criterion for Choice of Propellants, Solid Propellants, Liquid Propellants, Hybrid Propellants.

Solid Propellant Rockets: Mechanism of Burning and Burn Rate, Choice of Index n for Stable Operation of Solid Propellant Rockets, Propellant Grain Configuration, Ignition of Solid Propellant Rockets, Pressure Decay in the chamber after propellant Burns Out, Action time and Burn Time, Factors influencing Burn RateComponents of a Solid Propellant Rocket.

Liquid Propellant Rockets: Propellant Feed system, Thrust Chamber, Performance and Choice of Feed System Cycle, Turbo-pumps, Gas requirements for draining of propellants from storage tanks, draining under microgravity conditions, Complexity of Liquid Propellant Rockets and simulation, Trends in the development of liquid propellant rockets.

Liquid Monopropellant rockets: Hydrazine, Monopropellant rockets, Catalyst bed loading, Performance and applications.

Hybrid Rockets: Working Principle, Choice of Fuels and Oxidizers, Future of Hybrid Rockets.

Combustion Instability: Bulk and wave modes of Combustion Instability, Analysis procedure for bulk mode of combustion, Instability in liquid propellant rockets, Bulk mode of combustion instability in solid Propellant Rockets, Wave mode of combustion instability, Wave mode instability in solid propellant rockets, Evaluation of the growth constant of solid propellant using T burner, Conversion of growth constant derived from T burner for application in a solid propellant rocket, Wave mode instability in liquid propellant rockets, Non-linear combustion instability, Process induced combustion instability, Pogo instability due to interaction of propulsion and structure, Combustion Instability: Suppression and Control.

Reading:

1. Barrere, M., Rocket Propulsion, EIsevier Pub. Co., 1990.
2. Sutton, G. P., Rocket Propulsion Elements, John Wiley, New York, 1993.
3. Ramamurthi K., Rocket Propulsion, Macmillan Publishers India Ltd., 2010.
4. Feedesiev, V. I. and Siniarev, G. B., Introduction to Rocket Technology, Academic Press, New York, 2000.
5. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 6th Edition, Pearson Prentice Hall, 2008.

ME469	HEATING, VENTILATION & AIR-CONDITIONING	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics

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

CO1	Understand the fundamentals of Psychrometry
CO2	Apply human comfort indices and comfort chart to design indoor conditions of HVAC systems.
CO3	Estimate heating and cooling loads for buildings according to ASHRAE procedures/standards.
CO4	Design and evaluate complete air distribution system including fan, duct, and installation requirements for a typical HVAC system.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Brief history of air conditioning and impact of air conditioning. HVAC systems and classifications, Heat Pumps

Psychrometryof Air Conditioning Processes: Thermodynamic properties of moist air, Important Psychrometry properties, Psychometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, air conditioning processes, air washers.

Comfort Air Conditioning: Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism. Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration. Selection of outside and inside design conditions.

Heat Transfer Through Building Structures: Solar radiation; basic concepts, sun-earth relationship, different angles, measurement of solar load, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag method. Infiltration, stack effect, wind effect. CLTD/ETD method - Use of tables, Numerical and other methods, Heat transfer through penetration - Governing equations, SHGF/SC/CLF Tables

Load Calculation: Types of air-conditioning systems, General consideration, internal heat gains, system heat gain, cooling and heating load estimate.

Ventilation System: Introduction- Fundamentals of good indoor air quality, need for building ventilation, Types of ventilation system, Air Inlet system. Filters heating & cooling equipment, Fans, Duct design, Grills, Diffusers for distribution of air in the work place.

Reading:

1. F.C. McQuiston& J.D. Parker, "Heating Ventilating and Air Conditioning- Analysis and Design", 5th Ed., John Wiley & Sons, 2001.
2. J.L. Threlkeld, "Thermal Environmental Engineering", 2nd Ed., Prentice-Hall, Inc., 1970.
3. ASHRAE Handbooks: Fundamentals, HVAC Applications, HVAC Systems & Equipment.
4. R.C. Arora, "Refrigeration & Air conditioning", PHI, 2010.

ME470	CRYOGENICS	DEC	3 - 0 - 0	3 Credits

Pre-Requisites: Nil

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

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

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. MamataMukhopadhyay, Fundamentals of Cryogenic Engineering, PHI, 2010.
2. Thomas Flynn, Cryogenic Engineering, Revised and Expanded, CRC, 2004.
3. Arora and Domukundwar, Refrigeration and Air-conditioning, Dhanpat Roy & Co., 2018.
4. A. R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005.
5. Timmerhaus et. al., Cryogenic Engineering, Fifty Years of Progress, Springer, 2007.

ME471	MICRO-SCALE HEAT TRANSFER	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:CE235: Fluid mechanics and Hydraulic Machines,
ME352: Heat and Mass Transfer

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

CO1	Apply scaling laws for heat transfer and flow phenomenon.
CO2	Analyse surface tension dominated flows.
CO3	Analyse systems with micro-scale heat conduction and micro-scale heat convection.
CO4	Apply microfabrication techniques for the manufacture of micro-scale systems.
CO5	Identify techniques for measuring micro-scale flow and heat transfer

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Historical Perspectives, Definition, Biological Systems, Analogy with computational platforms, Benefits, Application Examples: Micro Electro-Mechanical Systems (MEMS), Lab on a Chip, Micro reactor, Micro heat pipes, Micro sensors, Micro actuators, Micro Pumps, Drug delivery systems.

Scaling Analysis: Natural systems, Parallel plate capacitor for sensor, Micro droplets, Micro resonator, Micro reactor, Micro heat exchangers

Channel Flow: N-S equations, Dimensional Analysis, Hydraulic resistance, arbitrary shaped channel flow, Elliptic, Equilateral and Rectangular channel flow, Dissipation effect, Compliance of channel wall.

Transport Laws: Boundary slip, Momentum accommodation coefficient, Thermal accommodation coefficient, Thermal creep, Knudsen Compressor, Slip flow boundary condition in liquids and gases, Physical parameters affecting Slip, Slip Model Derivation, Compressibility effect, Slip flow between parallel plates and Couette flow, Introduction to molecular modeling, Deterministic molecular modeling, Statistical molecular modeling, Boltzmann Equation, Direct Simulation Monte-Carlo (DSMC) Method.

Diffusion, Dispersion and Mixing: Random walk model of diffusion, Stokes-Einstein Law, Fick's law, governing equation of multicomponent system, Characteristic non-dimensional parameters, fixed planar source diffusion, Constant planar source diffusion, Convection-diffusion equation, Taylor dispersion, Micromixer examples, Soluble or rapidly reacting wall, Reverse osmosis channel flow.

Surface Tension Dominated Flows: Microscopic model of surface tension, Gibbs free energy, Young-Laplace equation, Contact angle (Static and Dynamic), Wetting, Super hydrophobicity and hydrophilicity, Coating flows, Thermo-capillary flows, Thermo capillary pump, Diffuso-capillary flows, Electro-wetting, Taylor flows, Two-phase liquid flows, Clogging pressure, Digital microfluidics, Marangoni convection and instability.

Microscale Heat Conduction: Energy Carriers, Time and length scales, Scale effects, Fourier's law, Hyperbolic heat conduction, Kinetic theory, Electron thermal conductivity in metals, Lattice thermal conductivity, Scale effects of thermal conductivity, Boltzmann transport theory, Heat transport in thin films and at solid-solid interfaces, Heat conduction in semiconductor devices and interconnects, Laser heating.

Microscale Convection: Scaling laws, Temperature jump boundary condition, Convection in parallel plate channel flow and Couette flow with and without viscous dissipation, Similarity and dimensionless parameters, Flow boiling in micro channels, Mini-channel versus micro-channel, Nucleate and convective boiling, Dryout incipience quality, Saturated and sub-cooled flow boiling, Condensation heat transfer in mini-micro channels, Micro heat pipes.

Micro Fabrication: Functional materials, Lithography, Subtractive technique, Etching, Wet etching, Dry etching, Deep reactive ion etching, Additive techniques, Physical vapor deposition, Chemical vapor deposition, PDMS based molding, Bonding, Laser micro fabrication technique.

Measurements: Micro scale velocimetry, Microscale thermometry.

Reading:

1. P. Tabeling “Introduction to Microfluidics”, Oxford University Press, 2005.
2. G. Karniadakis, A. Beskok and N. Aluru, “Microflows&Nanoflows: Fundamental and Simulation”, Springer Publication, 2005.
3. J. Berthier and P. Silberzan, “Microfluidics for Biotechnology”, Artech House, 2006.
4. H. Bruus, “Theoretical Microfluidics”, Oxford University Press, 2008.
5. N.T. Nguyen and S.T. Wereley, “Fundamentals and Applications of Microfluidics”, 2nd edition, Artech House, 2006.

ME472	POWER PLANT ENGINEERING	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics

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

CO1	Understand functions of the components of power plant.
CO2	Understand the working of nuclear, thermal and gas based power plants.
CO3	Evaluate the design layout and working of hydroelectric power plants.
CO4	Evaluate economic feasibility and its implications on power generating units.

Course Articulation Matrix:

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

Detailed Syllabus:

Analysis of Steam Cycles: Introduction to the course, Power plant layout and essential feature Rankine cycle, Reheating and regeneration, Problems on Rankine Cycle, Combined cycle power generation, Binary vapour cycles.

Fuels and Combustion: Basics on fuels and combustion, Mass and energy balance of steam generator, Draught system, Enthalpy of combustion.

Steam generators, accessories and Condensers: Different types of boilers, description, working procedures, High pressure Boilers, Accessories, fluidized bed boiler. Direct Contact Condenser Surface Condensers, Effect of various parameters on condenser performance, Design of condensers, cooling towers and cooling ponds.

Hydroelectric power plant: Introduction, Hydrological Cycle and hydrographs, Design construction and operation.

Nuclear power plants: Introduction, concepts of nuclear fusion and nuclear fission, types of reactors and their operation.

Energy storage: Need of storage, types of energy storage, options and limitations.

Non-conventional power generation: Basics of different non-conventional power generation types, operation, limitations.

Power plant economics and other issues: Load duration curves, Power plant economics, estimation of tariff. Diesel and gas plants, Pollution and control, Greenhouse effect and control, Peak load plants.

Reading:

1. Arora & Domkundwar, “Power plant engineering‘’, Dhanpat Rai & Sons, New Delhi, 2008.
2. M.M.Ei-Wakil, “Power plant Technology‘’, McGraw Hill Com., 1985.
3. P C Sharma, “Power plant engineering‘’, S.K. Kataria & Sons, New Delhi, 2010.

ME473	COMBUSTION	DEC	3 - 0 - 0	3 Credits

Pre-Requisites:ME201: Thermodynamics

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

CO1	Understand the concepts of combustion phenomena in energy conversion devices.
CO2	Apply the knowledge of adiabatic flame temperature in the design of combustion devices.
CO3	Identify the phenomenon of flame stabilization in laminar and turbulent flames.
CO4	Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Overview of the course-Thermo chemistry of combustion-Concept of Adiabatic Flame Temperature-Numerical Problems

Chemical Kinetics: Differences between equilibrium and rate controlled reactions- Global versus Elementary Reactions. Elementary reaction rates, bimolecular reactions and collision theory, other elementary reactions, Relation between rate coefficients and equilibrium constants, Steady-state Approximation. The mechanism for Uni-molecular reactions, Chain and Chain-Branching reactions.

Introduction to species Mass Transfer: Rudiments of Mass Transfer, Mass Transfer Rate Laws, Species Conservation. The Stefan Problem, Liquid-vapor interface boundary conditions, Droplet evaporation, Numerical.

Simplified Conservation Equations for Reacting Flows: Overview-Overall Mass Conservation (Continuity) Species mass Conservation (Species Continuity) Momentum

Conservation,1-D and 2-D forms, Energy Conservation-General 1-D Form, Shvab- Zeldovich Forms, Definition of Mixture Fraction.

Laminar Premixed Flames: Physical Description, Definition, Principal characteristics, Typical Laboratory Flames. Simplified Analysis, Assumptions, Conservation Laws, Solution, Factors Influencing flame velocity and Thickness: temperature, pressure, Equivalence ratio, fuel type, Flame speed Correlations for Selected fuels, Quenching, Flammability, and Ignition Flame lift-off (Blow-off) and flash back, Concept of Flame stretch-Karlovitz number, Flame Stabilization.

Introduction to Turbulent Flames: Turbulent length and time scales, Weak turbulent flames. Wrinkled Reaction Sheets, Distributed Reaction zones.

Pollutant Emissions: Effects of emissions, Quantification of Emissions, Emission Indices, Corrected concentrations, Various Specific emission measures-Emissions from Premixed Combustion: Oxides of Nitrogen, Carbon Monoxide, Unburned Hydrocarbons, Catalytic After-treatment, Particulate Matter.Emissions from non-Premixed Combustion: Oxides of Nitrogen, Unburned Hydrocarbons and Carbon Monoxide, Particulate Matter and Oxides of Sulfur, Numerical Problems.

Reading:

1. Stephen, R. Turns., Combustion, McGraw Hill, 2005.
2. Mishra, D.P., Introduction to Combustion, Prentice Hall, 2009.
3. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
4. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
5. Warnatz, Ulrich Maas and Robert W. Dibble Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation, 1999.

ME474	ADVANCED METAL FORMING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME253: Manufacturing Science

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	Analyze the deformation process parameters for different engineering components.

Course Articulation Matrix:

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

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 equipment, 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-Upper Bound - Slip-Line-Slab Analysis - Problems.

Bulk Forming Processes: Forging; open-dieforging, closed-dieforging, coining, nosing, upsetting, heading, extrusion andtooling, 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. R. Narayanasamy, R Ponalagusamy, “Theory of Engineering Plasticity”, Ahuja Book Company, 2000.
2. Henry S. Valberg, “Applied Metal Forming - Including FEM Analysis”, Cambridge University Press, 2010.
3. G.K. Lal, P.M. Dixit and N.Venkat Reddy, “Modeling Techniques for Metal Forming Processes“, Alpha Science, 2011

ME475	MACHINE TOOL DESIGN	DEC	3 - 0 - 0	3 Credits

Pre-requisites: ME301: Design of Machine Elements, ME303: Machine Tools and Metrology, ME353: Machining Science

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

CO1	Design and analyze kinematic motions in a machine tool.
CO2	Design and analyze speed and feed gear boxes.
CO3	Design machine tool structures for strength and rigidity.
CO4	Analyze machine tool vibration and chatter.
CO5	Select alignment tests to be performed on a machine tool for quality assurance.

Course Articulation Matrix:

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

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: Alignment tests on lathe, drilling and milling machines.

Reading:

1. N.K. Mehta, **"**MachineTool 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.

ME476	MICRO AND NANO MANUFACTURING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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	Create and characterize nanostructures for a particular industrial application
CO3	Select appropriate manufacturing methods to create micro sized components
CO4	Design and select industrially-viable processes, equipment and manufacturing tools for specific industrial products

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology.

Nano materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultra-fine 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 CondensationProcessing (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).

Microfabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding. MEMS Fabrication Techniques, Bulk Micromachining: Processes used for shaping and sizing of microproducts and macro products and Nano finishing techniques , 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 servosystems.

Reading:

1. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture,” McGraw- Hill, 2008.
2. V. K. Jain, “Introduction to Micromachining”, 2nd Edition, Alpha Science, 2014.
3. Mark James Jackson, “Microfabrication and Nanomanufacturing”, CRC Press, 2005.
4. Gabor L. Hornyak, H.F.Tibbals, Joydeep Dutta & John J Moore, “Introduction to Nanoscience and Nanotechnology”, CRC Press, 2009.
5. Ray F. Edgerton, “Physical Principles of Electron Microscopy: An Introduction toTEM, SEM, and AEM”, Springer, 2005.
6. B.D. Cullity, “Elements of X-Ray Diffraction”, 3rd Edition, Prentice Hall, 2002.

ME477	DESIGN FOR MANUFACTURING AND ASSEMBLY	DEC	3-0-0	3 Credits

Pre-requisites: MM 235: Materials Engineering, ME303: Machine Tools and Metrology

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

CO1	Utilize Design-for-Manufacturing concepts for effective product development
CO2	Estimate the cost of dies, molds and machined components based on die life.
CO3	Formulate appropriate design rules for forging, sheet metal forming, machining and powder metallurgy processes
CO4	Propose manual and automated assembly sequences using appropriate design rules

Course Articulation Matrix:

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

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

Designfor Casting: Basic characteristics and Mold preparation, Sand casting alloys, Design rules for and castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cast, 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 ofcavities, Assembly techniques, Design Guidelines.

Designfor Hot Forging: Characteristics of the forging process, forging allowances, flash removal, die cost estimation, die life and tool replacement costs.

Designfor Sheet metal working: Pressselection, press brakeoperations, Designrules.

Designfor Powder Metal processing: Powder metallurgy, tooling and presses for Compaction, Sintering, materials, heat treatments, Design guidelines.

Designfor machining: Machining using single point cutting tools, multipoint cutting tools, abrasive wheels, Assembly, cost estimation for machined components, Design guidelines.

Design for Assembly: Historical Development, Choice of Assembly method, Social effects of automation, Design guidelines for Manual assembly, Analysis of an assembly, Development of a systematic DFA analysis method, DFA index, classification system for manual handling, Manual insertion and Fastening.

Reading:

1. Geoffrey Boothroyd, Dewhurst P., Knight W., “Product design for manufacture and assembly”, CRC press, 2002
2. George E. Dieter, “Engineering Design - A material processing approach”, 5th Edition, McGraw Hill International, 2003.
3. ASM Handbook, “Design for manufacture”, 2000.

ME478	DESIGN AND ANALYSIS OF ENGINEERING MATERIALS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the principles of materials selection and design.
CO2	Design components using appropriate attribute limits and material indices.
CO3	Establish the criteria for material qualification and acceptance.
CO4	Apply design principles for manufacturing of different engineering components.

Course ArticulationMatrix:

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

Detailed Syllabus:

Introduction: The families of engineering materials. The Design process, types of design, Design tools and materials data.

Material Selection-The basic and case studies: Introduction and synopsis, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, the structural index, summary and conclusions, case studies.

Selection of material and shape, case studies: Introduction and synopsis, shape factors, Microscopic or Micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, summary and conclusions, case studies.

Designing Hybrid Materials and case studies: Introduction and synopsis, filling holes in material property space, hybrids of type 1, 2, 3, 4. Summary and conclusions, case studies.

Reading:

1. G.S. Ramaswamy, “Design and Construction of Concrete Shell Roofs”, 1st Edition, CBS Publishers, 2005.
2. R. Szilard, “Theory and Analysis of Plates - Classical and Numerical Methods”, Prentice Hall, 1974.
3. Timoshenko and Krierger, “Theory of Plates and Shells”, 2nd Edition, Tata McGraw Hill, 2010.

ME479	ADDITIVE MANUFACTURING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the working principle and process parameters of AM processes
CO2	Apply the suitable process for fabricating a given product
CO3	Use suitable post processes based on product application
CO4	Explore the applications of AM processes in various fields

Course ArticulationMatrix:

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

Detailed syllabus:

Introduction to Additive Manufacturing (AM): Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Vat Photopolymerization AM Processes: Stereolithography (SL), Materials, SL resin curing process, Micro-stereolithography, Process Benefits and Drawbacks, Applications of Photopolymerization Processes.

Material Jetting AM Processes: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.

Binder Jetting AM Processes: Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, Technical challenges in printing, Applications of Binder Jetting Processes.

Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Sheet Lamination AM Processes: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Directed Energy Deposition AM Processes: Process Description, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques

AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.

Reading:

1. Ian Gibson, David W Rosen, Brent Stucker, “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015.
2. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles& Applications”, 4th Edition, World Scientific, 2015.
3. Ali K. Kamrani, EmandAbouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer, 2006.
4. D.T. Pham, S.S. Dimov, “Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling”, Springer 2001.
5. RafiqNoorani, “Rapid Prototyping: Principles and Applications in Manufacturing”, John Wiley & Sons, 2006.

ME480	INDUSTRIAL AUTOMATION	DEC	3-0-0	3 Credits

Pre-requisites: Nil

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

CO1	Understand principles, strategies andadvantagesofindustrial automation.
CO2	Designmaterial handlingandmaterial storagesystemsforanautomatedfactory.
CO3	Devise automated shopfloorcontrolsandpartidentificationmethods.
CO4	Outline the IoT Technologies used in a manufacturing plant and their role in Industry.

Course Articulation Matrix:

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

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, Merits and Demerits of automation.

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 AIDCTechnologies.

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. Control system components-Sensors, Actuators, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Input/output Devices for Discrete Data.

Industry 4.0: Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

Reading:

1. Groover M. P., "Automation production Systems and Computer Integrated Manufacturing", Pearson Education, 2013.
2. Krishna Kant, "Computer Based Industrial Control", Prentice Hall of India, New Delhi, 2010.
3. Tiess Chiu Chang and Richard A. W., "An Introduction to Automated Process Planning Systems", Tata McGraw-Hill Publishing Company, New Delhi, 2012.
4. Klafter, R.D., Chmielewski, T. A. and Negin M., "Robot Engineering-An Integrated Approach", Prentice Hall of India, New Delhi, 2012.
5. Craig J. J., "Introduction to Robotics Mechanics and Control", 3rd Edition, Pearson Higher Education, 2014.

ME481	ADVANCED OPERATIONS RESEARCH	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

Course Articulation Matrix:

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

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: Meta-heuristics, Tabu search, simulated annealing, genetic algorithms.

Reading:

1. Taha H.A., “Operations Research”, 10th Edition, Prentice Hall of India, New Delhi, 2016.
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.

ME482	**SUPPLY CHAIN MANAGEMENT**	**DEC**	**3 - 0 - 0**	**3 Credits**

Pre-requisites: Nil
Course Outcomes: At the end of the course, the student will be able to

CO1	Relate competitive and supply chain strategies.
CO2	Identify drivers of supply chain performance.
CO3	Analyze factors influencing network design.
CO4	Analyze the influence of forecasting in a supply chain.
CO5	Evaluate the role of aggregate planning, inventory, IT and coordination in a supply chain.

Course Articulation Matrix:

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

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", 6th Edition, Pearson Education Asia, 2016.
2. David Simchi-Levi, PhilpKamintry and Edith Simchy Levy, "Designing and Managing the Supply Chain - Concepts Strategies and Case Studies", 3rd Edition, TMH, 2008.

ME483	PROJECT MANAGEMENT	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

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 and Samuel J., Jr. Mantel, “Project Management - A Managerial Approach”, John Wiley, 6th Edition, 2011.

ME484	RELIABILITY ENGINEERING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.
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

Course Articulation Matrix:

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

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 C. E. "An Introduction to Reliability and Maintainability Engineering", TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, "Practical Reliability Engineering", Wiley, 2012.

ME485	THEORY OF CONSTRAINTS	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil
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

Course ArticulationMatrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	3	-	-	-	-	2	-
CO2	3	3	-	-	-	-	-	3	-	-	2	-	3	-
CO3	3	3	3	-	-	-	-	2	3	-	-	-	2	-
CO4	3	3	3	-	-	3	-	3	3	-	3	-	2	-
CO5	3	-	-	-	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, Pre-requisite tree, transition tree.

Reading:

1. Dettmer H. W., "Goldratt'sTheory 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.

ME486	ADVANCED MATERIALS PROCESSING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Manufacturing Science

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

CO1	Understand the different processing techniques for engineering materials.
CO2	Analyze the principles of casting for the manufacturing of MMC.
CO3	Utilize appropriate manufacturing methods for powder metallurgical components.
CO4	Apply laser for processing of engineering materials.
CO5	Analyze the processing of ceramics.

Course Articulation Matrix:

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

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, Production of MMC through stir casting and centrifugal 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.

Ceramics: Classification of ceramics, Applications, fabrication and Processing of ceramics, Rheological behavior of composites, Characterization of composites before and after processing.

Laser processing of materials: Laser hardening, laser heat treatment, and laser forming

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, 2017.
2. Y. Waseda, A. Muramatsu and Yoshio Waseda, "Morphology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization", Springer, 2014.

Mandatory Audit Course (Self Study)

Student is required to complete at least one course offered by the following agencies. The student is required to take prior approval from the Department, before registering for any course. The student can register for such a course either in 6^{th} Semester or 7^{th} semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.

ASME: American Society of Mechanical Engineer Certification Program - www.asme.org
SWAYAM: www.swayam.gov.in
NPTEL: www.onlinecourse.nptel.ac.in
Course Era: www.coursera.org
Free Online Courses: www.edx.org
MIT Open Course ware: www.ocw.mit.edu

ME499	PROJECT WORK PART - B	PRC	0 - 0 - 6	4 Credits

Pre-requisites: Nil.

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.

Course Articulation Matrix:

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

RUBRICS:

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide

	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it in time and division of the work among the members of the team is good and coordination in the team is good.	Splitting the project into small tasks and scheduling them to finish it in time and different tasks of the job shared among the members of the team with satisfactory coordination.	Splitting the project into small tasks is not sufficient and sharing different tasks among the team members needs some more attention	Not able to split the project into small tasks. Needs lot of work to be done.
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Team Work	Coordinates team efforts and communication among members is good.	Coordinates team efforts and communication among members is satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation in incomplete in all aspects.

	Understanding	Understanding the task fully. Knowing all the tasks of the project. 100%.	Ability of correlating the theoretical aspects with the practical aspects is in between 60-80%	Ability of correlating the theoretical aspects with the practical aspects is in between 50-60%	Ability of correlating the theoretical aspects with the practical aspects is less than 50%
Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project	Answering, less than 50% of the questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor

OPEN ELECTIVES

(Offered to Other Department Students)

ME390	AUTOMOTIVE MECHANICS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
CO2	Understand operation of engine cooling system, lubrication system, electrical system and ignition system.
CO3	Understand fuel supply systems in an diesel and petrol vehicles
CO4	Analyze current and projected future environmental legislation and its impact on design, operation and performance of automotive power train systems.
CO5	Understand operation and performance of suspension, steering and braking system.
CO6	Understand layout of automotive electrical and electronics systems.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Layout of an automotive chassis, engine classification.

Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc.

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto and Electronic, Engine Starting drives

Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems.

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

Transmission: Clutch**-** Single and multi-plate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

Engine service: Engine service procedure.

Reading:

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M.Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H.Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

ME391	NEW VENTURE CREATION	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO2	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO3	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO4	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO5	-	-	-	-	-	3	1	3	2	2	3	-	-	-
CO6	-	-	-	-	-	3	1	3	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 Enterprise: 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 Edition, Pearson Education, 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 Edition, S Chand & Company Ltd., 2012.
4. Dr. Vasant Desai, “Management of Small Scale Enterprises”, Himalaya Publishing House, 2004.

ME440	ALTERNATIVE SOURCES OF ENERGY	OPC	3 - 0 - 0	3 Credits

(Offered to Other Department Students)

Pre-requisites: Nil

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

CO1	Identify renewable energy sources and their utilization.
CO2	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
CO3	Understand working of solar cells and its modern manufacturing technologies.
CO4	Understand concepts of Fuel cells and their applications
CO5	Identify methods of energy storage.
CO6	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

Course Articulation Matrix:

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

ME441	ROBUST DESIGN	OPC	3 - 0 - 0	3 Credits

(Offered to Other Department Students)

Pre-requisites: Nil

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

CO1	Understand stages in engineering design and concept of robust design.
CO2	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
CO3	Identify control and noise factors for a given product or process.
CO4	Conduct experiments using DOE concepts to decide the optimal setting of parameters
CO5	Apply quality loss function approach for fixing the component tolerances.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Taguchi's quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause and effect diagram.

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

Parameter Design: Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

Tolerance Design: Experiments, selection of tolerances to be tightened, fixing the final tolerances.

Reading:

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

CE390	ENVIRONMENTAL IMPACT ANALYSIS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

Course Outcomes: At the end of the course, 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.

Course Articulation Matrix:

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

Course Outcomes: At the end of the course, 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 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

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Control system, types, feedback and its effects-linearization
Mathematical Modeling of Physical Systems: Block diagram Concept and use of Transfer function. Signal Flow Graphs, Mason's gain formula.
Time Domain Analysis of Control Systems - BIBO stability, absolute stability, Routh-Hurwitz Criterion.
P, PI and PID controllers. Root Locus Techniques - Root loci theory, application to system stability studies.
Introduction to state variables technique, Analysis of R-L, R-L-C networks.
Frequency Domain Analysis of Control Systems - polar plots, Nyquist stability criterion, Bode plots, application of 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.

EE391	SOFT COMPUTING TECHNIQUES	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the concepts of population based optimization techniques
CO2	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution
CO3	Evaluate the importance of parameters in heuristic optimization techniques
CO4	Apply for the solution of multi-objective optimization

Course Articulation Matrix:

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

Detailed syllabus:

Fundamentals Of Soft Computing Techniques: Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Classification of meta-heuristic techniques - Single solution based and population based algorithms - Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

Genetic Algorithm And Particle Swarm Optimization: Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques-Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling - anatomy of a particle- equations based on velocity and positions - PSO topologies - control parameters. Application to SINX maximization problem.

Ant Colony Optimization And Artificial Bee Colony Algorithms: Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating-local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.

Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm: Bat Algorithm-Echolocation of bats- Behavior of microbats- Acoustics of Echolocation-Movement of Virtual Bats-Loudness and Pulse Emission-Shuffled frog algorithm-virtual population of frogs-comparison of memes and genes-memeplex formation-memeplex updation.

Application to multi-modal function optimization

Introduction to Multi-Objective optimization; Concept of Pareto optimality.

Reading:

1. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation”, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb “Multi-Objective Optimization using Evolutionary Algorithms”, John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, “Swarm Intelligence”, The Morgan Kaufmann Series inEvolutionary Computation, 2001.
4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, “Swarm Intelligence-From natural to Artificial Systems”, Oxford university Press, 1999.
5. David Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, PearsonEducation, 2007.
6. Konstantinos E. Parsopoulos and Michael N. Vrahatis, “Particle Swarm Optimization and Intelligence: Advances and Applications”, Information science reference, IGI Global, 2010.
7. N P Padhy, “Artificial Intelligence and Intelligent Systems”, Oxford University Press, 2005.

EC390	COMMUNICATION SYSTEMS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

Course Outcomes: At the end of the course, 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 design tradeoffs and performance of communications systems.

Course Articulation Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO2	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO3	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO4	1	1	-	-	1	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.

Amplitude (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. S. Haykin, Communication Systems, 4thEdn, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, 3rd Edition, Oxford University Press, Chennai, 1998.
3. Leon W. Couch II, Digital and Analog Communication Systems, 6th Edition, Pearson Education Inc., New Delhi, 2001.
4. A Bruce Carlson, PB Crilly, J C Rutledge, Communication Systems, 4th Edition, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

Course Outcomes: At the end of the course, 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 applications

Course Articulation Matrix:

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

Detailed syllabus:

Microcomputer Organization: CPU, Memory, I/O, Operating System, Multiprogramming, Multithreading, 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.

MM364	FUNDAMENTALS OF MATERIALS PROCESSING TECHNOLOGY	OPC	3 - 0 -0	03 Credits

Pre-requisites: Nil

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

CO1	Describe engineering materials.
CO2	Appreciate material processing techniques.
CO3	Select material processing technique for a given material and application.
CO4	Explain surface engineering techniques and their engineering significance.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to engineering materials: Metals, alloys and phase diagrams, ferrous metals, non-ferrous metals, super alloys, guide to processing of metals; ceramics-structure and properties of ceramics, traditional ceramics, new ceramics, glass, some important elements related to ceramics; polymers-fundamentals of polymer science and technology, thermoplastic and thermosetting polymers, elastomers; composite materials-classification of composite materials, metal matrix, polymer matrix and ceramic matrix composites.

Fundamental properties of materials: mechanical properties-stress-strain relationships, hardness, tensile properties, effect of temperature on properties, visco-elastic behaviour of polymers, thermal properties and electrical properties of metals, polymers, ceramics and composites.

Metal casting fundamentals and metal casting processes: Overview of casting technology, melting and pouring, solidification and casting, sand casting, other expendable-mold casting processes, permanent-mold casting processes, casting quality, metals for casting.

Particulate processing of metals and ceramics: Powder metallurgy-characterization of engineering powders, production of metallic powders, conventional processing and sintering, alternative processing and sintering techniques, materials and products for powder metallurgy, design considerations in powder metallurgy, processing of traditional ceramics, processing of new ceramics, cermets and their processing.

Fundamentals of metal forming and shaping processes (rolling, forging, extrusion, drawing, sheet metal forming) : Overview of metal forming, friction and lubrication in metal forming; bulk deformation processes in metal forming-rolling, other deformation processes related to rolling, forging, other deformation processes related to forging, extrusion, wire and bar drawing; cutting and bending operations, sheet-metal drawing, other sheet metal forming operations, dies and presses for sheet-metal processes, sheet-metal operations not performed in presses.

Fundamentals welding: Overview of welding technology, the weld joint, physics of welding, features of a fusion-welded joint; Welding processes-arc welding, resistance welding, oxy-fuel gas welding, other fusion welding processes, solid-state welding, weld quality, weldability; brazing, soldering and adhesive bonding.

Surface engineering and tribology: Importance of surface engineering, classification of surface engineering processes, introduction to thermal, mechanical, thermo-chemical and electro-chemical surface engineering processes with their advantages, limitations and applications.

Reading:

1. Kalpakjian and Schmid, Manufacturing Engineering and Technology, Prentice Hall, New Jersey, 2013.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc, New Jersey, 2010.
3. DeGarmo, Black, and Kohser, Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York, 2011.
4. R. S. Parmar, Welding processes and Technology, Khanna Publishers, 2010.
5. H.S. Bawa, Manufacturing Technology-I, Tata McGraw Hill Publishers New Delhi, 2007.
6. SeropeKalpakjian, Manufacturing processes for Engineering Materials, Addison Wesley, 2001.

CH390	NANOTECHNOLOGY AND APPLICATIONS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the properties of nanomaterials
CO2	Synthesize nanoparticles
CO3	Characterize nanomaterials.
CO4	Scale up the production of nanoparticles
CO5	Evaluate safety and health related issues of nanoparticles

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nanosizes and properties comparison with the bulk materials, Different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach Grinding, Planetary 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 bucky-balls, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones.

Quantum mechanics: Quantum 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 Semi-conductor quantum dots

Nanomaterials characterization: Fractionation principles of Particle size measurements, Particle size and its distribution, 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: Self-assembly and molecular manufacturing, Surfactant based system Colloidal system applications, Functional materials Applications, commercial processes of synthesis of nanomaterials.

Nanoinroganic materials of $CaCO_3$ synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices,

Nanobiology: Biological synthesis of nanoparticles and applications in drug delivery, Nanocontainers and Responsive Release 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. KulkarniSulabha K, 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, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
5. Davies, J.H., The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press, 1998.

CH391	INDUSTRIAL SAFETY MANAGEMENT	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.

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 prevention.
CO4	Assess the risks using fault tree diagram.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, the Nature of the Accident Process, Inherent Safety.

Industrial Hygiene: Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Toxic Release and Dispersion Models-Parameters Affecting Dispersion, Neutrally Buoyant Dispersion Models, Dense Gas Dispersion, Toxic Effect Criteria, Effect of Release Momentum and Buoyancy, Release Mitigation.

Fires and Explosions: The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Risk Assessment: Review of Probability Theory, Event Trees, Fault Trees.

Safety Procedures: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures-Operating, Procedures-Permits, Procedures-Safety Reviews and Accident Investigations.

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, Elsevier India, Volume 6, 2006.

CH392	INDUSTRIAL POLLUTION CONTROL	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Analyze the effects of pollutants on the environment.
CO2	Distinguish air pollution control methods
CO3	Assess treatment technologies for wastewater
CO4	Identify treatment technologies for solid waste
CO5	Select treatment methodologies for hazardous and E-waste

Course Articulation Matrix:

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

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.Control of specific gaseous pollutants: Control of NOx emissions, Control of hydrocarbons and mobile sources.

Water pollution: Water resources, Origin of wastewater, types of water pollutants and their 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.

E-waste: Sources, environmental and social issues, management practices

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, Prentice Hall of India, 2^{nd} Edition, 2004.
4. Rao M.N., Rao H.V.N, Air Pollution, Tata McGraw Hill Publishing Ltd., 1993.
5. De A.K., Environmental Chemistry, Tata McGraw Hill Publishing Ltd., 1999.
6. George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy, Inc., Franklin Burton, Waste Water Engineering: Treatment and Reuse, McGraw Hill Education; 4^{th} Edition, 2003.
7. E-waste recycling, NPCS Board of consultants and Engineers, Asia pacific business press Inc. 2015

CS390	OBJECT ORIENTED PROGRAMMING	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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 codeAPI documentations.
CO5	Create GUI based applications.

Course Articulation Matrix:

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

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, 2000.
2. Herbert Schildt, "The complete reference Java 2", TMH, 2017.

BT390	GREEN TECHNOLOGY	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Chemistry

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

CO1	Address smart energy, green infrastructure and non-renewable energy challenges
CO2	Build models that simulate sustainable and renewable green technology systems
CO3	Understand history, global, environmental & economic impacts of green technology
CO4	Explore the usage of microorganism for the bioremediation
CO5	Synthesis the nanoparticles by various biological methods
CO6	Apply the green techniques for the production of renewable fuels

Course Articulation Matrix:

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

Detailed Syllabus:

Green Technology definition, factors affecting green technologies, co/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies); design for sustainability reuse, recovery, recycle, raw material substitution, cleaner production, ISO 14000, wealth from waste, case studies.

Clean Technology: Biotechnology and Microbiology of Degradation of coal - Aerobic and Anaerobic pathway of coal degradation, Biogas technology, Microbial and biochemical aspects, Operating parameters for biogas production, kinetics and mechanism - Dry and wet fermentation. Digesters for rural application - High rate digesters for industrial waste water treatment.

Biomass energy: Concept of biomass energy utilization, types of biomass energy, conversion processes, Wind Energy, energy conversion technologies, their principles, equipment and suitability in Indian context; tidal and geothermal energy, Design and operation of Fixed and Fluidized Bed Gasifiers. 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.

Nano particles preparation techniques, Greener Nano synthesis: Greener Synthetic Methods for Functionalized Metal Nan particles, Greener Preparations of Semiconductor and Inorganic Oxide Nano particles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods, Green materials: biomaterials, biopolymers, bioplastics, and composites. Nanomaterials for Fuel Cells and Hydrogen; Generation and storage, Nano-structures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electro-catalysts in Fuel Cells, Nanowires as Hydrogen Sensors.

Reading:

1. Ristinen, Robert Kraushaar, Jack J.A Kraushaar, Jack P. Ristinen, Robert A.,Energy and the Environment, 2nd Edition, John Wiley, 2006.
2. B. R Wilson & W J Jones, Energy, Ecology and the Environment, Academic PressInc, 2005.
3. Sarkar S, Fuels and combustion, 2nd ed., University Press, 2009.

SM390	MARKETING MANAGEMENT	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

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.

Analyzing 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, 2013.
2. William Stonton & Etzel, Marketing Management, TMH, 13th Edition, 2013.
3. Rama Swamy & Namakumari, Marketing Management, McMillan, 2013.

MA390	NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

Course Articulation Matrix:

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

Detailed Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear and nonlinear boundary value problems, Quasi-linearization, 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 forParabolic 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: Nil

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

Course Articulation Matrix:

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

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, 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: Nil

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.

Course Articulation Matrix:

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

Detailed Syllabus:

General Introduction: The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

Origin of Bio potentials: 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 noninvasive pressure measurement, Direct measurement of blood pressure H2O 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 Oximeter: 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, Electro surgical unit, Therapeutic applications of laser, LithotripsyHaemodialysis.

Reading:

1. John G Webster, Medical Instrumentation: Application and Design, John Wiley, 3rd Edition, 2012.
2. Joseph J. Carr & John M. Brown, Introduction to biomedical Equipment Technology, 4thEdition, Prentice Hall India, 2001

PH391	ADVANCED MATERIALS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

Course Articulation Matrix:

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

Detailed Syllabus:

Nano Materials: Origin of nanotechnology, Classification of nanomaterials, Physical, chemical, electrical, mechanical properties of nanomaterials. Preparation of nanomaterials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon-nano tubes(CNT).Synthesis, preparation of nanotubes, nanosensors, Quantum dots, nanowires, nanobiology, nanomedicines.

Biomaterials: Overview of biomaterials. Biomaterials, bio ceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedic implants, 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 Tc 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, 2012.
3. Krishan K Chawla, Composite Materials; 2nd Edition, Springer 2006.

CY390	INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the concepts of ultraviolet and visible absorption and fluorescence techniques for material characterization.
CO2	Understand the various liquid, gas and size-exclusion chromatographic techniques the automated continuous analysis of environmental, industrial, production-line materials
CO3	Understand the concepts of various electroanalytical techniques for characterization of interfaces and traces of surface adsorbed-materials.
CO4	Understands the principles of thermogravimetry and differential thermal analyses (TGA and DTA) for applications into pharmaceuticals, drugs, polymers, minerals, toxins and in Finger Print Analysis
CO5	Identification of suitable analytical technique for characterization of chemical, inorganic and engineering materials

Course Articulation Matrix:

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

Chromatography methods: Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications.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 voltametric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric Sensors, Applications.

Spectroscopic methods: Molecular absorption, Woodward rules, applications, Infrared 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. Gurdeep Chatwal and Sham Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 1986.
2. Skoog, Holler and Kouch, Instrumental methods of analysis, Thomson, 2007.
3. Mendham, Denny, Barnes and Thomas, Vogel: Text book of quantitative chemical analysis, Pearson, 6Edotion, 2007.
4. William Kemp, Organic spectroscopy, McMillan Education, UK, 1991.
5. Instrumental methods of analysis - Willard, Meritt and Dean, PHI, 2005.

HS390	SOFT SKILLS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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	Employ appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire corporate email, mobile and telephone etiquette

Course Articulation Matrix

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

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 4th Edition, Pearson, 2009.
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: Nil.

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 different materials, quality and methods of fabrication & construction.
CO3	Adopt standard building provisions for natural ventilation and lighting.
CO4	Identify effective measures for fire proofing, damp proofing, and thermal insulation.

Course Articulation Matrix:

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

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, Lightning 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 McGraw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005.

EE440	NEW VENTURE CREATION	OPC	3-0- 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
CO3	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
CO4	Expose the students with the functional management issues of running a new venture

Course Articulation Matrix:

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

Detailed syllabus:

Entrepreneur and entrepreneurship**: Entrepreneurship and Small Scale Enterprises (SSE), Role in Economic Development, Entrepreneurial Competencies, and Institutional Interface for SSE.**

Establishing the Small Scale Enterprise: Opportunity Scanning and Identification, Market Assessment for SSE, Choice of Technology and Selection of Site, Financing the New/Small Enterprises, Preparation of the Business Plan, Ownership Structures and Organizational Framework.

Operating the Small Scale Enterprises: Financial Management Issues in SSE, Operational Management Issues in SSE, Marketing Management Issues in SSE, and Organizational Relations in SSE.

Reading:

1. Holt, Entrepreneurship: New Venture Creation, PHI (P), Ltd., 2001.
2. Madhulika Kaushik: Management of New & Small Enterprises, IGNOU course material, 1995
3. B S Rathore S Saini: Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
4. P.C. Jain: A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
5. J.B. Patel, D.G Allampalli: A Manual on How to Prepare a Project Report, EDII, Ahmedabad, 1991.
6. J B Patel, S SModi, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

EE441	PRINCIPLES OF ELECTRIC POWER CONVERSION	OPC	3-0- 0	3 Credits

Pre-requisites: Nil

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

CO1	Understand the basics in the electric power conversion using power switching devices
CO2	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives
CO3	Analyze the different energy storage systems
CO4	Identify the various Industrial and domestic applications

Course Articulation Matrix:

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

Detailed syllabus:

Power Electronic Devices and Converters: V-I characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

Applications to Electric Drives: Speed control of DC motor, Induction motors, PMSM and BLDC drives

Applications to Renewable Energy: Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

Energy Storage Systems: Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

Domestic And Industrial Applications: Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers

Reading:

1. M.H.Rashid: Power Electronics-circuits, Devices and applications, Prentice Hall India, New Delhi, 2009.
2. P.S.Bhimbra: Power Electronics, Khanna publishers, New Delhi, 2012.
3. Ned Mohan, Undeland and Robbin: Power electronics converters, applications and design, John Willey & Sons, Inc. New York, 2006.

EC440	ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Apply knowledge of instruments for effective use
CO2	Select suitable instruments for typical measurements.
CO3	Identify various transducers to measure strain, temperature and displacement.
CO4	Understand data acquisition system and general purpose interfacing bus.

Course Articulation Matrix:

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

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. Oliver and Cage, Electronic Measurements and Instrumentation, McGraw Hill, 2009
2. Helfrick Albert D. and Cooper William D., Electronic Instrumentation & Measurement Techniques, PHI, 2008.
3. D.A. Bell, Electronic Instrumentation and Measurements, 3rd Edition, Oxford, 2013.

MM499	METALLURGY FOR NON-METALLURGISTS	OPC	3-0-0	03 Credits

Pre-requisites: Nil

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

CO1	Discuss the characteristics and applications of metals and alloys.
CO2	Explain different fabrication techniques.
CO3	Correlate the microstructure, properties, processing and performance of materials.
CO4	Select metal/alloy for engineering applications.

Course Articulation Matrix:

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

Detailed syllabus:

Introduction to Metallurgy: Metals and Alloys classification, engineering applications of metals/alloys.

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

Fabrication and Finishing of metal products: Metal Working and Machining

Testing of Metals: Destructive and Non-Destructive Testing, Inspection and Quality Control of Metals.

Engineering Alloys: Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, selective non-ferrous metals and alloys.

Heat Treatment: Annealing, Normalizing, Hardening and Tempering.

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. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, Physical Metallurgy Principles, East-West Press, 2009.
4. V Raghavan, Elements of Materials Science and Engineering- A First Course, 5th Edition, PHI Publications, 2011

CH440	DATA DRIVEN MODELLING	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Identify disturbance models
CO2	Estimate parametric and non-parametric models
CO3	Determine the model structure
CO4	Validate the developed models

Course Articulation Matrix:

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

Detailed syllabus:

System Identification - Motivation and Overview. Models of Discrete-Time LTI Systems - Convolution equation. Difference equations, Transfer functions, State-space models, Discretization, Sampling and Hold operations, sampling theorem.

Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX, OE, BJ and PEM - structures and their applicability in real-time.

Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation and properties.

Estimation of non-parametric models - impulse / step response coefficients, frequency response models.

Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method.
Model Structure Selection and Diagnostics -estimation of delay and order, residual checks, properties of parameter estimates, model comparison and selection, model validation.

Reading:

1. Arun K. Tangirala. System Identification: Theory and Practice, CRC Press, 2014.
2. Karel J. Keesman, System Identification - An Introduction, Springer, 2011.
3. Nelles, O. Nonlinear System Identification, Springer-Verlag, Berlin, 2001.
4. Zhu, Y. Multivariable System Identification for Process Control, Pergamon, 2001.
5. Ljung, L. System Identification: Theory for the User, Prentice-Hall, 2^{nd} Edition, 1999.
6. J. R. Raol, G. Girija, J. Singh, Modeling and Parameter Estimation of Dynamic Systems, The Institution of Electrical Engineers, 2004.
7. Rolf Johansson, System Modeling and Identification, Prentice Hall, 1993.

CH441	FUEL CELL TECHNOLOGY	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil.

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	Demonstratethe operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems

Course Articulation Matrix:

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

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: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

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, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs

Reading:

1. Hoogers G, Fuel Cell Technology Hand Book, CRC Press, 2003.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, 2006.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2nd Edition, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications
5. Laminie J, Dicks A, Fuel Cell Systems Explained, 2nd Edition, John Wiley, New York, 2003.

CH442	DESIGN OF EXPERIMENTS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Design experiments for a critical comparison of outputs
CO2	Propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments.

Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

Experiments with Single Factor: An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparametric methods in the analysis of variance, Problems.

Design of Experiments: Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments, Parameter Estimation.

Response Surface Methods: Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

Design and Analysis: Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

Reading:

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5th Edition, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH443	CARBON CAPTURE, SEQUESTRATION AND UTILIZATION	DEC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Identify the necessity of CO_2 capture, storage and utilization
CO2	Distinguish the CO_2 capture techniques
CO3	Evaluate CO_2 Storage and sequestration methods
CO4	Assess Environmental impact of CO_2 capture and utilization

Course Articulation Matrix:

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

Detailed syllabus:

Introduction: Global status of CO_2 emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

CO_2 capture technologies from power plants: Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

CO_2 capture agents and processes: Capture processes, CO_2 capture agents, adsorption, ionic liquids, metal organic frameworks

CO_2 storage and sequestration: Geological sequestration methods, Biomimetic carbon sequestration

CO_2 Utilization: CO_2 derived fuels for energy storage, polymers from CO_2, CO_2 based solvents, CO_2 to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

Environmental assessment of CO_2 capture and utilization: Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA, Method of conducting an LCA for CO_2 capture and Utilization.

Reading:

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.
2. Goel M,Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.
3. AmitavaBandyopadhyay, Carbon Capture and Storage, CO_2 Management Technologies, CRC Press, 1st Edition, 2014.
4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO_2) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.
5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 1st Edition, 2014.

CS440	MANAGEMENT INFORMATION SYSTEMS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

Detailed syllabus:

Organization and Information Systems, Foundation Concepts, Information Systems in Business, 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: Nil

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

CO1	Understand bio-sensing 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 bio-analytical devices and design of biosensors

Course Articulation Matrix:

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

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 and Biosensor Engineering: Enzymes; Oligonucleotides and Nucleic Acids; Membrane receptors, Cells; Immunoreceptors; Limitations & problems.

Immobilization of biomolecules, Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS.

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, 1st Edition, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley & Sons, 1998.

   Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley & Sons, 2003.

SM440	HUMAN RESOURCE MANAGEMENT	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	2	1	2	-	-	1
CO2	2	2	-	-	-	-	-	-	2	1	2	-	-	1
CO3	2	2	-	-	-	-	-	-	2	1	2	-	-	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 BijuVarkkey, 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, 2009.

MA440	OPTIMIZATION TECHNIQUES	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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.

Course Articulation Matrix:

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

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.

Course Articulation Matrix:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	2	-	-	-	-	-	-	-	1	1
CO2	3	3	1	1	2	-	-	-	-	-	-	-	2	1
CO3	3	3	1	1	2	-	-	-	-	-	-	-	2	1
CO4	3	3	1	1	2	-	-	-	-	-	-	-	2	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. Degeneracy in Transportation problems. Queuing 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. K. Swarup, Manmohan & P.K.Gupta, Introduction to Operations Research, S.Chand & Co., 2006
2. J.C. Pant, Introduction to Operations 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: Nil

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

CO1	Understand synthesis and properties of nanostructured materials.
CO2	Analyze magnetic and electronic properties of quantum dots.
CO3	Understand structure, properties and applications of Fullerenes and Carbon nanotubes.
CO4	Understand applications of nanoparticles in nanobiology and nanomedicine.

Course Articulation Matrix:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	-	-	-	-	-	-	-	-	1	-
CO2	3	1	1	1	-	-	-	-	-	-	-	-	2	-
CO3	3	1	1	1	-	-	-	-	-	-	-	-	1	-
CO4	3	1	1	1	-	-	-	-	-	-	-	-	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, Nano technology 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: Nil

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 biocompatibility of implants
CO4	Identify appropriate biomaterials for specific medical applications

Course Articulation Matrix:

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

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. JoonPark, R.S. Lakes, Biomaterials an introduction; 3rd Edition, Springer, 2007
2. Sujatha V Bhat, Biomaterials; 2nd Edition, NarosaPublishing House, 2006.

CY441	CHEMISTRY OF NANOMATERIALS	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

CO1	Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials.
CO2	Review critically the potential impact, in all classes of materials, of the control of nanostructure
CO3	Describe the methods for the synthesis and nano structural characterization of such materials.
CO4	Identify the possible opportunities for nanomaterials in society development and enhancement.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Review the scope of nanoscience and nanotecnology, understand the nanoscience in nature, classification of nanostructured materials and importance of nano materials.

Synthetic Methods: Teach the basic principles for the synthesis of Nanostructure materials by Chemical Routes (Bottom-Up approach):-Sol-gel synthesis, microemulsions or reverse micelles, solvothermal synthesis, microwave heating synthesis and sonochemical synthesis and Physical methods (Top-Down approach):- Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.

Techniques for characterization: Learning of characterization method by various techniques like, Diffraction Technique:-Powder X-ray diffraction for particle size analysis, Spectroscopy Techniques:-Operational principle and applications of spectroscopy techniques for the analysis of nano materials, UV-VIS spectro photometers and its application for band gap measurement, Electron Microscopy Techniques:-Scanning electron microscopy (SEM) and EDAX analysis, transmission electron microscopy (TEM), scanning probe microscopy (SPM) BET method for surface area determination and Dynamic light scattering technique for particle size analysis.

Studies of nano-structured Materials: Synthesis, properties and applications of the following nanomaterials: fullerenes, carbon nanotubes, core-shell nanoparticles, nanoshells, self- assembled monolayers, and monolayer protected metal nanoparticles, nanocrystalline materials.

Reading:

1. T Pradeep, NANO: The Essentials, McGraw-Hill, 2007.
2. B S Murty, P Shankar, Baldev Rai, B B Rath and James Murday, Textbook of Nanoscience and nanotechnology, Univ. Press, 2012.
3. Guozhong Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Imperial College Press, 2007.
4. M.A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology, Narosa Pub., 2010.
5. Manasi Karkare, Nanotechnology: Fundamentals and Applications, IK International, 2008.
6. C.N.R. Rao, Achim Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.

HS440	CORPORATE COMMUNICATION	OPC	3 - 0 - 0	3 Credits

Pre-requisites: Nil

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

Course Articulation Matrix:

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