DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instruction and Syllabus of

M.E. (Mechanical Engineering)
AUTOMATION & ROBOTICS

With effect from the Academic Year 2023-2024

UNIVERSITY COLLEGE OF ENGINEERING
(Autonomous)
Osmania University
Hyderabad – 500 007, TS, INDIA

Scheme of Instructions & Examination
M.E.(Mechanical Engineering) 4 Semesters (Full Time)

S.No.	Subject	Contact hours per week			Scheme of Examination		Credits
		L	T	P	CIE	SEE	
Semester-I							
1.	Program Core I	3	0	0	40	60	3
2.	Program Core II	3	0	0	40	60	3
3.	Program Core III	3	0	0	40	60	3
4.	Program Elective I	3	0	0	40	60	3
5.	Program Elective II	3	0	0	40	60	3
6.	Program Elective III	3	0	0	40	60	3
7.	Laboratory I	0	0	2	50	--	1
8.	Seminar	0	0	2	50	--	1
	Total	**18**	0	**4**	**340**	**360**	**20**
Semester-II							
1.	Program Core IV	3	0	0	40	60	3
2.	Program Core V	3	0	0	40	60	3
3.	Program Core VI	3	0	0	40	60	3
4.	Program Elective IV	3	0	0	40	60	3
5.	Program Elective V	3	0	0	40	60	3
6.	Open Elective	3	0	0	40	60	3
7.	Laboratory II	0	0	2	50	--	1
8.	Laboratory III	0	0	2	50	--	1
9.	**Mini Project	0	0	4	50	--	2
	Total	**18**	**0**	**8**	**390**	**360**	**22**
Semester-III							
1.	Audit Course-I(Online)	2	0	0	40	60	0
2.	Audit Course-II(Online)	2	0	0	40	60	0
3.	*** Dissertation Phase I	0	0	20	100	--	10
	Total	**4**	**0**	**20**	**180**	**120**	**10**
Semester-IV							
1.	****Dissertation Phase II	0	0	32	100	100	16
	Grand Total	**40**	**0**	**64**	**1010**	**940**	**68**

Total Credits: 20 + 22 + 10 + 16 = 68

Note:

1. *For Audit Course even though the credits are Zero. It is mandatory for the students to secure 50% marks in that particular subject. Audit Courses will be offered in ONLINE mode and SEE will be conducted in Computer Based Test Mode.
2. ** Mini Project total marks 50 out of which 25 marks will be awarded by Guide and 25 marks by internal committee.
3. *** Dissertation Phase I total marks 100 out of which 50 marks will be awarded by Guide and 50 marks by internal committee.
4. ****Dissertation-II has two parts, CIE-I and CIE–II, at the end of 8^{th} week and 16^{th} week respectively for evaluation of 50 marks each.

If the student is selected for Industry Internship, then he/she has to complete the required courses of Program elective V and Open Elective through ***SWAYAM-NPTEL MOOCS*** *Courses for getting the required credits. However, the students are required to consult Head & CBoS (Autonomous) for due approval, before he/ she registers for the course in SWAYAM-NPTEL portal.*

Scheme: M.E. Mechanical Engineering (AUTOMATION & ROBOTICS)

Type of course	Course Code	Course Name	Contact hours per week			Scheme of Examination		Credits
			L	T	P	CIE	SEE	
SEMESTER-I								
Core-I	ME301	Robotic Engineering	3			40	60	3
Core-II	ME302	Drives & Controls for Automation	3			40	60	3
Core-III	ME303	Embedded Systems	3			40	60	3
Program Elective-I	ME311	Finite Element Techniques	3			40	60	3
	ME113	Manufacturing Automation						
	ME312	Computer Control of Mechanical Systems						
	ME313	Bio-Mechanics						
	ME314	Data Analytics						
Program Elective-II	ME315	Vibration Analysis & Condition Monitoring	3			40	60	3
	ME316	Smart Materials						
	ME317	Neural Networks & Fuzzy Logic						
	ME318	Aerial Robots						
	ME115	Industry 4.0						
Program Elective-III	ME106	Additive Manufacturing Technologies and Applications	3			40	60	3
	ME319	VR/AR systems						
	ME320	Robot Motion Planning						
	ME321	Image Processing						
	ME322	Micro Robotics						
Lab-I	ME351	Robotics Lab			2	50	-	1
Seminar	ME361	Seminar			2	50	-	1
TOTAL			**18**	**0**	**4**	**340**	**360**	**20**
SEMESTER-II								
Core-IV	ME304	Fluid Power Systems	3			40	60	3
Core-V	ME305	Planar Multibody Dynamics	3			40	60	3
Core-VI	ME306	Control of Dynamic Systems	3			40	60	3
Program Elective-IV	ME323	Signal Processing for Mechanical systems	3			40	60	3
	ME324	Under Actuated Robots						
	ME325	Modern Control Systems						
	ME326	Rotor Dynamics						
	ME327	Mobile Robots						
Program Elective-V	ME328	Human Computer Interaction	3			40	60	3
	ME329	Nonlinear dynamics and chaos						
	ME330	Machine Learning						

		Applications						
	ME331	Optimization in Engineering Design						
	ME332	Robotic sensing and vision						
Open Elective	OE941BM	Medical Assistive Devices	3			40	60	3
	OE942BM	Medical Imaging Techniques						
	OE941CE	Green Building Technology						
	OE942CE	Cost Management of Engineering Projects						
	OE941CS	Business Analytics						
	OE941EC	Elements of Embedded Systems						
	OE941EE	Waste to Energy						
	OE942EE	Power Plant Control and Instrumentation						
	OE941ME	Operations Research						
	OE942ME	Composite Materials						
	OE943ME	Industrial Safety						
	OE941LA	Intellectual Property Rights						
Lab-II	ME352	Drives & Controls Lab	-	-	2	50	-	1
Lab-III	ME353	Computational Lab for A&R	-	-	2	50	-	1
Core	MC070	Mini Project	-	-	4	50	-	2
TOTAL			**18**	**-**	**8**	**390**	**360**	**22**
SEMESTER-III								
Audit-I (Online)	AC 030 ME	Research Methodology in Mechanical Engineering	2			40	60	0
Audit-II (Online)	AC 031	English for Research Paper Writing	2			40	60	0
	AC 032	Disaster Mitigation & Management						
	AC 033	Sanskrit for Technical Knowledge						
	AC 034	Value Education						
	AC 035	Stress Management by Yoga						
	AC 036	Personality Development Through Life Enlightenment Skills						
	AC 037	Constitution of India						
	AC 038	Pedagogy Studies						
	AC 039	E-Waste Management						
	ME381	Dissertation Phase -I	-	-	20	100	--	10
TOTAL			**04**	**-**	**20**	**180**	**120**	**10**
SEMESTER-IV								
	ME382	Dissertation Phase -II	-	-	**32**	**100**	**100**	**16**
GRAND TOTAL			**40**	**0**	**64**	**1010**	**940**	**68**

CIE : Continuous Internal Evaluation SEE: Semester End Examination

Total Credits: 20+22+10+16 = 68

SEMESTER I

ME 301	**ROBOTIC ENGINEERING**					
(Program Core–I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Familiarize students with various robot configurations.
2	Learn to perform forward and inverse kinematics for general robot configurations
3	Importance of robot dynamics and methods to solve it
4	Familiarize with various trajectory planning and control techniques
5	Will learn to integrate various components in to a robotic system

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify and classify various robot configurations with their workspaces & their usage in industry.
CO-2	Perform forward and inverse kinematics operations & determine singularity conditions for various robot configurations.
CO-3	Compare and contrast various techniques available to find forward and inverse dynamic solutions for various general robot configurations
CO-4	Implement various path planning techniques & control algorithms for computing end effector motions for generalized robotic tasks
CO-5	Interface various hardware and software components to develop robotic systems for industry including the effects of multiple finger kinematics.

Program Articulation Matrix

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	3	1	1	
CO2	3	2	2	2	
CO3	3	3	2	2	
CO4	2	2	3	2	1
CO 5	2	2	2	3	1

UNIT – I

Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability and accuracy, Degrees of freedom of robots, Robot configurations and concept of workspace, Mechanisms and transmission, End effectors and Different types of grippers, vacuum and other methods of gripping. Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots. Rotation matrices, Euler angle and RPY representation, Homogeneous transformation matrices, Denavit-Hartenberg notation, representation of absolute position and orientation in terms of joint parameters, direct kinematics.

UNIT – II

Rotation matrices, Euler angle and RPY representation, Homogeneous transformation matrices, Denavit-Hartenberg notation, representation of absolute position and orientation in terms of joint parameters, direct kinematics.

UNIT – III

Inverse Kinematics, inverse orientation, inverse locations, Singularities, Jacobian, Trajectory Planning: joint interpolation, task space interpolation, executing user specified tasks.

UNIT – IV

Static force analysis of RP type and RR type planar robots, Dynamic analysis using Lagrangian and Newton-Euler formulations of RR and RP type planar robots, , Independent joint control, PD and PID feedback, actuator models, nonlinearity of manipulator models, Computed torque control, force control, hybrid control.

UNIT – V

Multifingured Hand Kinematics: Introduction to Grasping, Force-Closure, Grasp Planning, Grasp Constraints,Lagrange's Equations with Constraints, Robot Hand Dynamics, Redundant and Nonmanipulable Robot Systems,

Suggested Readings:

1. Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and sons, 2008.
2. Nagrath and Mittal, "Robotics and Control", Tata McGraw-Hill, 2003.
3. Fu. K.S, Gonzalez, R.C., Lee, C.S.G, Robotics, control, sensing, Vision and Intelligence, McGraw Hill International, 1987
4. Harry Asada & Slottine "Robot Analysis& Control", Wiley Publications, 2014
5. S K Saha, "introduction to Robotics", 2nd edition, TMH, 2013
6. A Mathematical Introduction to Robotic Manipulations- Richard M. Murray, Zexiang Li, S.Shankar Sastry CRC Press. Inc. 1st edition, 1994

ME302	**DRIVES AND CONTROLS FOR AUTOMATION**					
(Program Core–II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Know the basic principles of drives and controls
2	Understand the various performance characteristics of industrial drives
3	Introduce PLC programming
4	Learn basic programs in PLC
5	Learn to develop applications based on PLC and SCADA

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	To understand working principles of various types of motors, differences.
CO-2	To apply the knowledge in selection of motors, heating effects and braking concepts in various industrial applications
CO-3	To elucidate various linear and rotary motion principles and methods and use the same to application areas
CO-4	To carry out programming using PLC and use of various PLCs to Automation problems in industries.
CO-5	To discuss supervisory control and data acquisition method and use the same in complex automation areas.

Program Articulation Matrix

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	1	1	
CO2	2	2	1	1	
CO3	3	3	1	1	
CO4	2	2	3	3	1
CO 5	2	2	2	3	1

UNIT – I

Introduction: Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle, V/F control, Flux Vector control.

UNIT – II

Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects, electric braking, converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing.

UNIT – III

Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software, programming software tool and interfacing with PC (RS232 & TCP-IP), methods of PLC programming (LD, ST, FBD & SFC), function blocks logical / mathematical operators & data types, array & data structure, PID, types of tasks and configuration, difference between relay logic and PLC, selection of PLC controller (case study)

UNIT – IV

Logic, instructions & Application of PLC: What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, data handling instructions, Sequencer instruction, Visualization Systems, Types of visualization system, PC based Controller, Applications of HMI

UNIT – V

Supervisory control & data Acquisitions: Introduction to Supervisory control & data Acquisitions, distributed Control System (DCS): computer networks and communication in DCS. Different BUS configurations used for industrial automation – GPIB, HART and OLE protocol, Interfacing of SCADA with controllers, Basic programming of SCADA, SCADA in PC based Controller / HMI.

Suggested Readings:

1. Process Control Instrumentation Technology, Johnson Curties, Prentice Hall of India, 8th edition
2. Andrew Parr, Industrial drives, Butterworth – Heineamann
3. G.K.Dubey. Fundamentals of electrical drives
4. Programmable Logic Controllers by W.Bolton
5. A.E. Fitzerald , C.Kingsley and S.D Umans, Electric Machinery - McGraw Hill Int. Student edition
6. Programmable Logic Controllers by Hugh Jack.

ME303	**EMBEDDED SYSTEMS**					
(Programme Elective - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand internal architecture of 8051 and ARM microcontrollers
2	Learn to interface different peripheral devices with 8051 and ARM microcontrollers
3	Learn to write basic programs in microcontrollers (8051 & ARM)
4	Learn to design simple embedded systems
5	Understand the importance of role of embedded systems in industry

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Foster ability to understand the internal architecture and interfacing of different peripheral devices with Microcontrollers.
CO-2	Foster ability to write the programs for microcontroller.
CO-3	Foster ability to understand the role of embedded systems in industry.
CO-4	Foster ability to understand the design concept of embedded systems.
CO-5	Develop real time interface systems for industrial applications

Program Articulation Matrix

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	-	-	-
CO2	3	1	2	-	-
CO3	-	-	1	2	3
CO4	-	2	3	2	-
CO 5	-	-	1	2	3

UNIT- I

Embedded Systems Programming in FPGA:

Embedded System Design Strategies: Microcontroller/DSP/FPGA, FPGA Design Flow, Embedded System Programming in FPGA, Project Design Flow, Overview of Verilog Modeling styles: Structural, Data Flow, Behavioral and switch level Modeling of digital system. Tasks and Functions, Test bench Design Timing Delays, Static timing analysis: Setup time & hold time violations and clock skew and Case studies.

UNIT -II

Embedded Systems Programming in CISC Micro-controller:

Overview of Intel 8051 Architecture, instruction set, Basic Programming: Assembly Language and C programming, I/O port programming, Timer, UART and Interrupt Programming.

UNIT- III

Embedded Systems Programming in RISC Micro-controller: ARM Part I:

ARM architecture versions, Core Architecture, Register Organization, AMBA bus architecture, Instruction Set of ARM, Thumb Instruction set, Cache memory, Introduction to µ Vision IDE, Memory Accelerator Modulator, Interrupt Programming, GIC

UNIT- IV

Embedded Systems Programming in ARM Part II:

Timer Programming, PWM, RTC and Watch dog Timer, Interfaces: UART, I2C, SPI, JEDEC, Memory Management Unit

UNIT -V

Embedded Systems Programming with Real Time World Interface:

ADC, DAC, LED, LCD, Stepper Motor and Sensors

Suggested Reading:

1. Ming-Bo Lin., Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008.
2. Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005.
3. Mohammad Ali Mazidi, Rolin D McKinley, Janice G Mazidi, The 8051 Microcontroller and Embedded Systems, Second Edition, Prentice Hall
4. Andrew N.Sloss, Domnic Symes, Chris Wright, ARM system developers guide, Elsevier publications.

ME311	**FINITE ELEMENT TECHNIQUES**					
(Programme Elective - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
2	To provides a bridge between hand calculations and numerical solutions for more complex geometries and loading states.
3	To study approximate nature of the finite element method and convergence of results are examined.
4	It provides some experience with a commercial FEM code and some practical modeling exercises.
5	To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Summarize the basics of finite element formulation
CO-2	Derive interpolation functions and characteristic matrices for different 1D, 2D and 3D elements.
CO-3	Apply the knowledge in solving one dimension and two-dimensional static stress and dynamic analysis problems.
CO-4	Solve the steady state and transient heat transfer analysis using FEA.
CO-5	Analyze three-dimensional stress analysis and fluid flow problems.

Program Articulation Matrix

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	2	2	
CO2	3	3	2	2	
CO3	3	3	2	2	
CO4	3	3	2	2	
CO 5	3	3	2	2	

UNIT-I

Introduction: Historical Background, General description of the finite element method, Mathematical Modeling of field problems in Engineering, Governing Equations, Discrete and

continuous models, Boundary, Initial and Eigen Value problems, Weighted Residual Methods, Variational Formulation of Boundary Value Problems, Potential energy method, Rayleigh Ritz method, Galerkin's method of finite element formulation. Strain displacement relations, Stress strain relations, Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of local, natural and global coordinates for 1D, 2D, 3D Simplex Elements. Finite element equations, treatment of boundary conditions.

UNIT-II

One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for 1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Analysis of plane truss with number of unknowns not exceeding two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node. Analysis of Beams: Element stiffness matrix for two noded, two degrees of freedom per node for beam element. Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

UNIT-III

Finite element modeling of two dimensional stress analysis problems with constant strain triangles and treatment of boundary conditions. Two dimensional four noded iso-parametric elements and numerical integration. Plane stress, plane strain and axisymmetric problems, Body forces and temperature effects. Stress calculations, Plate and shell elements. Elements. Convergence requirements and geometric isotropy. Application to Field Problems, Thermal problems, Analysis of a uniform shaft subjected to torsion using Finite Element Analysis. Quadrilateral elements and Higher Order Elements.

UNIT-IV

Steady state heat transfer analysis: One dimensional analysis of a fin, composite walls and two dimensional conduction analysis of thin plate. Time dependent field problems: Application to one dimensional heat flow in a rod. Dynamic analysis: Formulation of finite element modeling of Eigen value problem for a stepped bar and beam. Evaluation of Eigen values and Eigen vectors.

UNIT-V

Finite element formulation of three dimensional problems in stress analysis. Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works. Finite Element formulation of an incompressible fluid. Potential flow problems Bending of elastic plates. Introduction to non-linear problems and Finite Element analysis software.

Suggested Readings:

1. Tirupathi R Chandraputla and Ashok .D. Belegundu, Introduction of Finite Element in Engineering, Prentice Hall of India, 1997.
2. Rao S.S., The Finite Element Methods in Engineering, Pergamon Press,1989.
3. Segerland. L.J., Applied Finite Element Analysis, Wiley Publication,1984.
4. Reddy J.N., An Introduction to Finite Element Methods, Mc Graw Hill Company,1984.
5. P.Seshu, Text book of Finite Element Analysis, PHI Learning Pvt. Ltd., 20

ME113	MANUFACTURING AUTOMATION					
(Programme Elective - I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To learn the concepts and principles of manufacturing automation
2	To understand the components of automation and their practical use in manufacturing application
3	Learn principles of assembly systems and material handling systems.
4	Understand quality control and other support systems used in automated system
5	To provide information integration and data warehousing

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand the concepts and the effect of manufacturing automation strategies
CO-2	Apply the principles of automation
CO-3	Design automated material handling and storage systems
CO-4	Analyze automated flow lines and assembly systems, and balance the line.
CO-5	Make use of automated inspection methods.

Course Outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	
CO2	3	2	1	1	
CO3	3	3	1	2	
CO4	3	3	2	2	
CO 5	3	3	2	2	

UNIT – I

Introduction: Definition of automation, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models, Automation Strategies, Production Economics: Costs in Manufacturing, Break-Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

UNIT – II

Automation Production Lines: Automated Flow lines, Methods of Work part Transport, Transfer Mechanism, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Simulation of Automated Flow Lines.

UNIT – III

Assembly Systems and Line Balancing: The Assembly Process, Assembly Systems, Manual Assembly Lines, Methods of Line Balancing, Other ways to improve the Line Balancing, The Line Balancing Problem, Flexible Manual Assembly Lines. Automated Assembly Systems: Design for Automated Assembly, Types of Automated Assembly Systems, Part Feeding Devices, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine.

UNIT –IV

Automated Materials Handling: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.

UNIT – V

Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. The Future Automated Factory: Trends in Manufacturing, The Future Automated Factory, Human workers in the Future Automated Factory and the social impact.

Suggested Readings:

1. Mikell P.Grover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education Asia.
2. Ray Asfahl, Robots and manufacturing automation, John Wiley and Sons New York.
3. Viswanadham and Y.Narahari, Performance Modeling of Automated Manufacturing Syetms, Printice Hall India Pvt. Ltd.
4. Stephen J. Derby, Design of Automatic Machinery, Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai.
5. Nanua Singh, System Approach to Computer Integrated Manufacturing, Wiley & Sons Inc., 1996

ME312	COMPUTER CONTROL OF MECHANICAL SYSTEMS					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand various levels of automation
2	Understand various features of NC and CNC machines
3	Learn the basics of NC and CNC programming for machining operations like turning, drilling machining etc
4	Understand the tooling and control systems used in CNC machines
5	Learn the basics of adaptive control in CNC machines

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify Levels of Automation. & Explain the concept of Computer Process Control.
CO-2	Describe the features of NC Machine tools & Apply the knowledge in selection of control l loops, drives, feedback devices and actuation systems.
CO-3	Differentiate CNC Machining centres, CNC Turning centres and Tool Changing Systems
CO-4	Develop part programs for given component on turning and milling machine
CO-5	Explain CNC concept, Reference-pulse Technique, sampled-Data technique, Microcomputers in CNC & Adaptive Control Systems

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	2	2	1	2	
CO3	2	2	2	1	
CO4	3	2	3	2	1
CO 5	2	2	1	1	

UNIT -I

Automation and Control technologies: Levels of Automation, Continuous Versus Discrete Control - Continuous Control Systems -Discrete Control Systems Computer Process Control - Control Requirements - Capabilities of Computer Control. Computer Process Control: Forms of Computer Process Control - Computer Process Monitoring - Direct Digital Control - Numerical Control and Robotics - Programmable Logic Controllers - Supervisory Control - Distributed Control Systems and Personal Computers in process control, Enterprise - Wide

Integration of Factory Data.

UNIT –II

Features of NC Machine tools: Fundamentals of numerical control, advantages and limitations of N.C systems-classification of N.C systems, Design consideration of N.C machine tools, Methods of improving machine accuracy, increasing productivity with N.C machines, Machining centers, MCU Functions. Control loops of N C Systems and CNC hardware basics: Introduction, control of point-to point systems, Control Loops in Contouring systems. CNC Hard ware Basics: Structure of CNC machine tools, Drives, Actuation systems, Feedback devices, Axes-standards.

UNIT- III

CNC Machine tools and control systems: CNC Machining centres, CNC Turning centres, Highspeed machine tools, Machine control unit, Support systems, Touch trigger probes. Tool Changing Systems: Turning-tool geometry, Milling Tooling Systems, Tool Presetting, Methods of optimizing output from NC machine tools, Automatic Tool Changers, Work holding.

UNIT –IV

CNC programming: Part Programming Fundamentals – Manual Part Programming methods using ISO codes, Preparatory functions, Miscellaneous functions, Tool length compensation, canned cycles, Cutter radius compensation, canned cycles, Part Programs on milling, Drilling and Tapping operations. Turning centre Programming: Comparisons between machining centre and turning centres, Tape format, Axes system, General programming functions, motion commands, cut planning, Thread cutting, canned cycles, Part programs on turning.

UNIT -V

Computerized Numerical Control: CNC concepts, advantages of CNC, Digital computer, Reference-pulse Technique, sampled-Data technique, Microcomputers in CNC. Adaptive Control Systems: Introduction, Adaptive control with optimization, Adaptive control with constraints, variable- gains AC systems, Adaptive control of Grinding.

Suggested textbooks:

1. Y. Koren, "Computer Controls of Manufacturing Systems," McGraw Hill,1983.
2. P.N. Rao, "CAD/CAM Principles and Applications,"3 rd Edition, McGraw Hill, Education Pvt. Ltd., New Delhi,26 May 2010, ISBN: 978-0070681934.
3. M.P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing," Prentice Hall India Pvt. Ltd.,3rd Edition, 24 July 2007, ISBN: 978-0132393218.
4. Martin J, "Numerical Control of Machine Tools," Butterworth-Heinemann, 20th May 1991, ISBN:9780750601191.
5. Y. Koren& J. Ben-Uri, "Numerical Control of Machine Tools," Khanna Publishers, Delhi, 19

ME313	BIO-MECHANICS					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the importance of composition & properties with respect to structure of bones
2	Learn to develop viscoelastic models of soft tissues
3	Learn to determine the mechanical behavior of passive muscles
4	Understand the behavior of muscle force production and transmission
5	Learn to optimse the production of muscle force and transmission

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify various bones with their composition & elastic properties and understand their importance with respect to structural strength of human skeleton
CO-2	Determine the viscoelastic constitutive models of soft tissues and further modifying the muscle models as fibre composite materials
CO-3	Determine the mechanical properties of muscles and tendons
CO-4	Develop functional relationships between force applied and length & velocity developed in muscles
CO-5	Optimise the muscle force production & transmission

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	
CO2	3	3	3	2	
CO3	3	2	2	2	
CO4	3	2	2	2	
CO 5	3	2	2	2	

UNIT-I

Introduction to Biomechanics – Terminology – Anthropometry – Skeletal Mechanics – Structureof bones – Composition and properties of bones and relationship to structure – Elasticproperties of bones – Characterizing elastic anisotropy – Modeling and Remodeling of bones(Wolfe's law of bone remodeling)

Viscoelasticity of soft tissues – Models of viscoelasticity (Maxwell, Voigt, Kelvin)Muscle mechanics – Muscle architecture and mechanics – Muscle fascicles and theirarrangement – Fiber architecture in fascicles – Muscle as a fiber reinforced composite – Musclecentroids – Muscle Cross sectional areas (Physiological & Anatomical)

UNIT-III

Properties of tendons and passive muscles – Viscoelastic behavior of tendons – Tendon interaction with surroundingtissues – Mechanical properties of passive muscles

UNIT-IV

Mechanics of Active muscle: Muscle force production and transmission – Functional relations(Force – length, Force – Velocity curves), History effects in muscle mechanics – Hill's model(derivation) – Sliding filament theory

UNIT-V

Muscle coordination – Problem of motor redundancy – Approach to studying muscle force production using optimization (forward and inverse)Exemplary behavior: Dynamics of Reaching – Inverse dynamic modeling

Suggested Readings:

1. Principles of Biomechanics by Robert L.Huston, CRC Press
2. Berne & Levy Physiology, 6th Updated Edition, Bruce M. Koeppen and Bruce A. Stanton, Mosby, 2009 edition.

ME314	DATA ANALYTICS					
(Programme Elective - I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Know various methods of data characterization and management
2	Learn the basics of R programming
3	Learn to solve statistical analysis using R software
4	Understand the basic of data analytics using R software
5	Learn to use data analytics for data sets of practical applications

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Classify various techniques and statistical measures used in data analysis
CO-2	Find various statistical measures using R/python software
CO-3	Apply various hypothetical testing methods for data analysis with and without software
CO-4	Perform various regression and clustering techniques on the data provided
CO-5	Apply the regression and clustering techniques for various case studies using Python and R software

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	2	
CO2	2	2	3	2	
CO3	2	2	3	3	
CO4	2	2	2	2	1
CO 5	1	1	2	2	1

UNIT-I

Data Definitions and Analysis Techniques

Elements, Variables, and Data categorization, Levels of Measurement, Data management and indexing, Introduction to statistical learning and R-Programming

Descriptive Statistics: Measures of central tendency, Measures of location of dispersions, Practice and analysis with R

UNIT-III

Basic analysis techniques: Statistical hypothesis generation and testing, Chi-Square test, t-Test, Analysis of variance, Correlation analysis, Maximum likelihood test, Practice and analysis with R

UNIT-IV

Data analysis techniques: Regression analysis, Classification techniques, Clustering, Association rules analysis, Practice and analysis with R

UNIT-V

Case studies and projects: Understanding business scenarios, Feature engineering and visualization, Scalable and parallel computing with Hadoop and Map-Reduce, Sensitivity Analysis

Suggested Readings:

1. Peter Bruce , Andrew Bruce, Practical Statistics for Data Scientists, June 2017
2. Hadley Wickham, Garrett Grolemund, R for data science : Import, Tidy, Transform, Visualize, And Model Data , January 2017
3. Anil Maheshwari, Data Analytics Paperback, July 2017
4. Seema Acharya, Data Analytics Using R Paperback, April 2018
5. U Dinesh Kumar Manaranjan Pradhan, Machine Learning using Python, January 2019.

ME315	VIBRATION ANALYSIS & CONDITION MONITORING					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the theoretical basis for single and multi-degree freedom systems
2	Learn to derive the mathematical models for free and forced vibration systems
3	Understand the importance of various methods to solve multi degree freedom systems
4	Know the working principles of various condition monitoring equipment
5	Learn various methods of recording and displaying data

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Fully understand importance of vibrations in mechanical design of machine parts that operate under vibratory conditions.
CO-2	Write differential equation of motion of vibratory system and understand free and forced modes of vibration
CO-3	Obtain linear vibratory models of dynamic systems of varying complexity (SDOF,MDOF)
CO-4	Apply various condition monitoring techniques available in the literature.
CO-5	Classify and use various devices available to record interpret and understand the vibration data.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	-	-	-
CO2	3	1	2	-	-
CO3	-	-	1	2	3
CO4	-	2	3	2	-
CO 5	-	-	1	2	3

UNIT-I

Causes and effects of vibration. Vibrations of Single Degree of freedom systems. Free, Damped and Forced vibrations

Two Degree of freedom systems. Bending vibrations of two degree of freedom systems, Steady state and transient characteristics of vibration, vibration absorber and vibration isolation.

UNIT-III

Multi degree of freedom systems: Dunkerley method, Rayleigh method, stodola method and holzers method. Modal analysis.

UNIT-IV

Introduction to Condition Monitoring, Failure types, investigation and occurrences. Causes of failure, Vibration measuring instruments, vibration transducers, signal conditioning elements. Display and recording elements. Vibration meters and analyzers. Condition Monitoring through vibration analysis.

Frequency analysis, Filters, Vibration signature of active systems, vibration limits and standards.

UNIT-V

Contaminant analysis, SOAP and other contaminant monitoring techniques. Special vibration measuring techniques – Change in sound method, Ultrasonic measurement method, Shock pulse measurement, Kurtosis, Acoustic emission monitoring, Cepstrum analysis, Modal analysis, critical speed analysis, Shaft –orbit & position analysis.

Suggested Readings:

1. Rao S .S Mechanical Vibrations , 5th Edition, Prentice Hall, 2011
2. V.P. Singh, Mechanical vibrations, Dhanpat Rai Publications, 2015
3. Collacott, R.A., Mechanical Fault Diagnosis and Condition Monitoring, Chapman & Hall, London, 1982.
4. John S. Mitchell, Introduction to Machinery Analysis and Monitoring, Penn Well Books, Penn Well Publishing Company, Tulsa, Oklahoma, 1993.
5. J S Rao, Vibration condition monitoring of machines, CRC Press, 2000
6. Nakra, B.C. Yadava, G.S. and Thuested, L., Vibration Measurement and Analysis, National Productivity Council, New Delhi, 1989.

ME316	SMART MATERIALS					
(Programme Elective - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60Marks	**CIE**		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn the physics behind the use of certain materials for sensing and actuation
2	Understand the constitute equations developed for smart materials like piezo, SMA, EAP, IPMC, Magneto resistive
3	Learn how to select smart materials for an application
4	Understand the use of smart materials for precision equipment in industries
5	Learn to use smart materials for developing cost effective systems

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Classify and identify various smart materials with their applications
CO-2	Illustrate the working principles of various smart materials like SMA,EAP & Magneto restrictive , IPMC
CO-3	Develop constitutive models for various smart materials like SMA,EAP , IPMC & Magneto restrictive
CO-4	Investigate design and control issues in Smart materials
CO-5	Apply smart materials to develop cost efficient systems

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	1	1	
CO2	3	3	2	2	
CO3	2	3	3	2	
CO4	2	2	2	2	1
CO 5	2	2	2	1	2

UNIT-I

Introduction: Smart materials and their application for sensing and actuation, Mechatronics aspects, Piezoelectric materials: Piezoelectricity and piezoelectric materials, Constitutive equations of piezoelectric materials, Piezoelectric actuator types, Control of piezoelectric actuators, Applications of piezoelectric actuators for precise positioning and scanning.

Shape memory alloys (SMA): Properties of shape memory alloys, Shape memory effects, Pseudo-elasticity in SMA, Design of shape memory actuator, selection of materials, Smart actuation and control, Applications of SMA in precision equipments for automobiles, trains and medical devices.

UNIT -III

Electro-active polymers (EAPs): Ionic polymer metal composites (IPMC), Conductive polymers, Carbon nanotubes, Dielectric elastomers, Design & control issues for EAP actuators, Applications of EAP for biomemetic, tactile display and medical devices.

UNIT-IV

Magnetostrictive materials: Basics of magnetic properties of materials, magnetostriction: constitutive equations, types of magnetostrictive materials, Design & control of magnetostrictive actuators, Applications of magnetostrictive materials for active vibration control. Summary, conclusion and future outlook: Comparative analysis of different smart materials based actuators,

UNIT - V

Conclusions, Future research trend and applications trends of smart materials and smart materials based actuator technology.

Suggested Text books:

1. Jose L. Pons, Emerging Actuator Technologies, a Micro mechatronics Approach, John Wiley & Sons Ltd, 2005.
2. Ralph Smith, Smart Material Systems: Model Development, SIAM, Society for Industrial and Applied Mathematics, 2005.
3. F. Carpi, D. De Rossi, R. Kornbluh, R. Pelrine, P. Sommer-Larsen, Dielectric Elastomers as Electromechanical Transducers, Elsevier, Hungry, 2008.
4. Y. B. Cohen, Electroactive Polymer (EAP) Actuators as Artificial Muscles Reality, Potential and Challenges, SPIE press, USA, 2004

ME317	NEURAL NETWORKS & FUZZY LOGIC					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basics of Fuzzy and Neural networks
2	Know when to apply Fuzzy logic and Neural network
3	Understand the importance of various neural network models
4	Learn to solve supervised problems using ML
5	Learn to solve unsupervised problems using DL

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate between randomness and fuzziness and Apply the concept of fuzziness in real time systems
CO-2	Differentiate between Neural nets and fuzzy logic based systems and specify their merits and demerits.
CO-3	Use various models of supervised learning for classification problems
CO-4	Use various models of unsupervised learning for clustering problems
CO-5	Apply the concepts of deep learning in real time systems

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	2	1
CO2	3	3	1	2	
CO3	3	2	3	3	1
CO4	2	2	3	2	1
CO 5	1	1	2	2	1

UNIT-I

Concepts of fuzzy sets: Introduction – Crisps sets, notation of fuzzy sets, basic concepts of fuzzy sets, operation, fuzzy compliment, union, intersection, Binary relation, Equivalence and similarity relations, belief and plausibility measures, probability measures, computability, relations, ordering morphisms, possibility and necessary measures. Uncertainty and information: Types of uncertainty, measures of dissonance, measures of confusion, measures of nonspecificity, uncertainty and information. Complexity, Principle of uncertainity.

UNIT-II

Adaptive fuzzy systems: Neural and Fuzzy intelligence, Fuzziness as multivalent, fuzziness in probabilistic world, randomness verses ambiguity. Fuzzy association memories: Fuzzy and neural function estimates, FAN mapping, neural verses fuzzy representation of structural knowledge, FAM as mapping, Fuzzy hebb FAM's Bidirectional FAM theorem, Super imposition FAM Rules, FA System architecture.

UNIT-III

Introduction to Neural networks: Knowledge base information processing, general view of knowledge based algorithm, neural information processing, Hybrid intelligence, and artificial neurons.

UNIT-IV

Characteristics of artificial Neural Networks: Single Neural Networks, Multi Layer Neural Networks, Training of ANN – objective, supervise training, unsupervised training, overview of training. Neural networks Paradigms: Perception meculloch and Pitts Model, back propagation algorithm and deviation, stopping criterion, Hopfield nets, Boldman's machine algorithm, Neural networks applications.

UNIT-V

Deep Learning:Principal Component Analysis and its interpretations, Singular Value Decomposition Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders. Regularization: Bias Variance Tradeo-, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying. Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

Suggested Reading:

1. Deep Learning, Ian Goodfellow, YoshuaBengio, Aaron Courville, MIT Press
2. Neural Networks: A Comprehensive Foundation, Simon S. Haykin, Prentice Hall, 1999
3. Neural networks using matlab, Deepa and Sivanandham, TMH,
4. Fuzzy Logic with Engineering Applications, By Timothy J. Ross, Wiley Publications

ME 318	AERIAL ROBOTS					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basic concepts, identify parts and classify aerial robots.
2	Able to understand fundamentals of aerial robots
3	Understand and apply knowledge on modelling and dynamics for aerial robot applications
4	Understand and apply navigation & path planning in aerial robots
5	Understand system integration for aerial robots

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Classify aerial robots & Identify the basic components with their functioning.
CO-2	Develop dynamic models, derive controllers, and synthesize planners for operating in dynamic conditions.
CO-3	Demonstrate the design process of UAVs fixed wing multicopter and flapping wing
CO-4	Describe the navigation and guidance of Aerial Robot.
CO-5	Apply methods of system integration for aerial robots.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	1	
CO2	2	3	2	2	
CO3	3	2	3	2	1
CO4	2	2	2	2	1
CO 5	2	2	1	2	1

UNIT I:

Introduction: Fundamentals of Aerial Robot – Classification – Applications – Design considerations

UNIT II:

Sensors And Actuators: Sensors for Aerial robots – Sensor Characteristics – Inertial Sensors – Classification of Sensors – Electric Actuators – DC Motors – Servo motor – Encoders – Motor Drives.

UNIT III:
Modeling And Dynamics: Frame Rotations and Representations – Dynamics of a Multirotor Micro Aerial Vehicle – Dynamics of a Fixed-Wing Unmanned Aerial Vehicle

UNIT IV:
Flight Controls and Motion Planning: PID Control – LQR Control – Linear Model Predictive Control – An Autopilot Solution

UNIT V:
Case Study Of Aerial Robots: Holonomic Vehicle Boundary Value Solver – Dubins Airplane model Boundary Value Solver – Collisionfree Navigation – Structural Inspection Path Planning

Suggested Readings:

1. Kenzo Nonami, Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro Aerial Vehicles, Springer, 2010
2. Yasmina Bestaoui Sebbane, Planning and Decision Making for Aerial Robots, Springer, 2014
3. Roland Siegwart, Introduction to Autonomous Mobile Robots, 2nd Edition, MIT Press, 2011
4. Woo-Kyung Choi, Hong-Tae Jeon, Seong-Joo Kim, "Multiple Sensor Fusion and Motion Control of Snake Robot Based on Soft-Computing", INTECH Open Access Publisher, 2007

ME115	INDUSTRY 4.0					
(Programme Elective - II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basic concepts, identify parts and classify aerial robots.
2	Able to understand fundamentals of aerial robots
3	Understand and apply knowledge on modelling and dynamics for aerial robot applications
4	Understand and apply navigation & path planning in aerial robots
5	Understand system integration for aerial robots

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Interpret the meaning and scope of Industry 4.0.
CO-2	Illustrate the role of Data Analytics and IoT in a Manufacturing Industry.
CO-3	Recognise the role of Robotics and Augmented Reality in the implementation of Industry 4.0
CO-4	Identify the role of Additive Manufacturing Technology in Industry 4.0 and interpret the working of various AM technologies and their applications.
CO-5	Analyse the role of virtual factory, digital traceability and Cyber Security in the implementation of Industry 4.0.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	3	1	2	3	
CO3	2	2	3	3	
CO4	3	1	2	3	
CO 5	2	1	3	2	

UNIT – I

Introduction: Definition, Main concepts and components of Industry 4.0, Proposed Framework of Industry 4.0, Smart and Connected Product Business Models, Smart Manufacturing, Lean Production Systems for Industry 4.0, The changing role of Engineering Education in Industry 4.0 Era, Industry 4.0 laboratories, Opportunities and Challenges of Industry 4.0, Future Skills required by Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

UNIT – II

Data Analytics and Internet of Things in Manufacturing: Introduction to data analytics, Techniques used for Predictive Analytics, Forecast Accuracy Calculations, A real world Case Study; Introduction to IoT, Examples for IoTs Value Creation in Different Industries. IoTs Value Creation Barriers: Standards, Security and Privacy Concerns.

UNIT – III

Robotics and Augmented Reality in Industry 4.0: Introduction, Recent Technological Components of Robots: Advanced Sensor Technologies, Artificial Intelligence, Internet of Robot Things, Cloud Robotics, Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications. Introduction to Augmented Reality: Augmented Reality Hardware and Software Technology, Industrial Applications of Augmented Reality

UNIT–IV: Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies: Stereolithography, 3DP, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Laser Engineered Net shaping, Advantages and Disadvantages of Additive Manufacturing. Applications of Additive Manufacturing in Medical, Surgical Planning, Implant and Tissue Design, Automotive, Aerospace, Electronics, Education and Oceanography. Impact of AM Technologies on society: Impact on health care, Environment, Manufacturing and Supply Chain.

UNIT–V: Virtual Factory, Digital Traceability and Cyber Security: Introduction to Virtual Factory, Virtual Factory Software, Limitations of Commercial Software; Introduction to Digital Traceability, Digital Traceability Technologies, Architectural Framework, Applications, Project Management in Digital Traceability; Introduction to Cyber Security, Security Threats and Vulnerabilities of IoT, Industrial Challenges, Evolution of Cyber Attacks, Cases on Cyber Attacks and Solutions, Strategic Principles in Cyber Security, Cyber Security Measures.

Suggested Readings:

1. Alp Ustundag and Emre Cevikcan, Industry 4.0: Managing The Digital Transformation Springer Series, 1st edition, 2018.
2. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, 1st edition, 2019.
3. DrIng. Klaus Schwab, The fourth Industrial Revolution, Penguin Publisher; 1st edition, 2017.
4. Pascual D G, Handbook of Industry 4.0 and Smart Systems, Taylor and Francis, 2020
5. Kumar K, Digital Manufacturing and Assembly Systems in Industry 4.0**,** Taylor and Francis, 2020

ME 106	ADDITIVE MANUFACTURING TECHNOLOGIES AND APPLICATIONS					
(Programme Elective - III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To know the fundamentals of Additive Manufacturing (AM) and compare it with conventional CNC technology
2	To understand the working principle, advantages, limitations and applications of various AM Technologies and also various types of data formats and errors.
3	To know the role of AM in Topology optimization and understand the applications of AM in various fields like Biomedical, Aerospace, Automobile and other domains.
4	To know the fundamentals of Additive Manufacturing (AM) and compare it with conventional CNC technology
5	To understand the working principle, advantages, limitations and applications of various AM Technologies and also various types of data formats and errors.

CO's	Description
CO1	Interpret the features of Additive Manufacturing and compare it with conventional CNC Technology
CO2	Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies and Rapid Tooling systems
CO3	Interpret various types data formats and STL file errors used in AM and identify the role of Topology optimization in AM
CO4	Analyze the features of different types of software's used in 3D Printing
CO5	Apply the knowledge of various AM technologies for developing new and innovative applications

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	3	2	1	2	
CO3	3	2	1		1
CO4	2	2	3	2	1
CO 5	3	2	2	2	1

UNIT – I

Introduction: Prototyping fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies. Role of AM in Industry 4.0.

UNIT – II

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies

VatPhotopolymerization AM Systems: Photopolymers, photo polymerization Stereo lithography Apparatus (SLA), Direct Light Processing (DLP) and Continuous Direct Light Processing (CDLP).

Material Jetting AM Systems: Material Jetting, Nano particle jetting and Drop-On-Demand (DOD) material jetting **Binder Jetting AM Systems:** Three-dimensional Printing (3DP).

Material Extrusion AM Systems: Fused Deposition Modeling (FDM

UNIT – III

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies

Powder Bed Fusion AM Systems: Selective laser sintering (SLS), Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM).

Direct Energy Deposition (DED) AM Systems: Laser Engineered Net Shaping (LENS) and Electron Beam Additive Manufacturing (EBAM).

Sheet Lamination AM Systems: Laminated Object Manufacturing (LOM) and Ultrasonic Additive Manufacturing (UAM).

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods.

UNIT – IV

Reengineering in AM: Reengineering Engineering (RE) Methodologies and Techniques, Selection of RE systems, RE software, RE hardware, RE in product development

AM Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Slicing Algorithms: Rock Algorithm, Crawford's algorithm, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques, Topology optimization and Additive Manufacturing.

AM Software's: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor, SurgiGuide, 3-matic, Simplant, MeshLab.

UNIT –V

AM Applications: Application – Material Relationship, Application in Design, Engineering Analysis and Planning, Aerospace, Automotive, Jewelry, Coin, GIS, Arts, Architecture. Medical and Bioengineering Applications, Forensic Science and Anthropology, Visualization of Biomolecules. **Cost Estimation in AM:** Cost Model, Build Time Model, Laser Scanning Vat Photopolymerization Example, Life-Cycle Costing.

Suggested Readings:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing- Ian Gibson, David W Rosen, Brent Stucker, Springer, Second Edition, 2010.
2. Chee Kai Chua and Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" Fifth Edition, World scientific.
3. Rapid Prototyping & Engineering Applications – Frank W.Liou, CRC Press, Taylor & Francis Group, 2011.
4. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.
5. NPTEL Course on Rapid Manufacturing

ME 319	VR/AR SYSTEMS					
(Programme Elective - III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn the basics of VR and AR
2	Learn how to build objects in Unity IDE
3	Learn to build controllers in Unity IDE
4	Learn to build environment in Unity IDE
5	Learn to generate animated walk in Unity IDE

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate Virtual and Augmented Realities.
CO-2	Understand Virtual reality concepts.
CO-3	Develop VR applications using Unity3D.
CO-4	Move around the 3D world.
CO-5	Run Unity 3D application in VR on a smart phone

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2		
CO2	3	2	2		
CO3	2	2	3	2	1
CO4	2	2	3	2	
CO 5	1	2	2	2	1

UNIT-I:

Introduction To Virtual Reality : Virtual Reality – Types – Virtual Reality Vs Augmented Reality – Applications – Technical skills required

UNIT-II:

Building Simple Scenes: Introduction to Unity IDE – Objects and Scale – Creating a simple diorama – VR Device integration

UNIT-III:

Gaze Based Control: First person Controller – Third person controller – Navigation in VR application – World space User Interface

UNIT-IV:

Physics & Environment: Physics component – physics materials – Raycast – particle effects

UNIT -V:

Walk-Throughs: Assembling scenes – Adding photos – Animated walkthrough – optimizing for performance – Using all 360 degrees

Suggested Textbooks

1. 1.Tony Parisi, Learning Virtual Reality, O'Reilly Media, 2016
2. Jason Jerald, The VR Book – Human Centered Design for Virtual Reality, Morgan & Claypool, 2015
3. John Williamson, Charles Palmer, Virtual Reality Blueprints: Create compelling VR experiences for mobile and desktop, Packt Publishing, 2018

ME 320	ROBOT MOTION PLANNING					
	(Programme Elective - III)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Refresh the basics of robotic engineering
2	Learn to use and integrate sensors and actuation in mobile robot systems
3	Understand various robot path and motion planning algorithms
4	Learn the basics of object grasping and manipulation
5	Learn to implement these algorithms in real robots

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify Configuration spaces of mobile vehicles and manipulators,
CO-2	Use Geometric modelling and sensor based map building.
CO-3	Develop Path planning and obstacle avoidance methods and algorithms
CO-4	Perform Object manipulation and grasping
CO-5	Design of user interfaces and simulation and Algorithms for assembly and biological aspects of motion and intelligence.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	2	2	2	3	
CO3	2	3	3	2	1
CO4	2	2	2	3	1
CO 5	2	2	2	2	1

UNIT-I

Review of robotics basics, transformations, kinematics etc, Concept of configuration space of mobile and arm manipulators**.**

UNIT-II

Sensors and actuators as used in mobile robotics**,** Geometrical modeling and map building

UNIT-III

Path planning and obstacle avoidance**,** Object manipulation and grasping

UNIT-IV

Design of user interface and simulation**,** Algorithms for applications, assembly, etc

UNIT-V

Intelligence in motion planning and optimization

Suggested Readings

1. Robot motion planning algorithms, stevelavelle
2. Robot motion planning, lacoumbe
3. Motion planning algorithms, choset

ME 321	IMAGE PROCESSING					
	(Programme Elective - III)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the fundamentals of image processing and transforms
2	Learn various methods of Image enhancement
3	Know various methods of image compression and restoration
4	Learn video processing and perform 2d motion estimation
5	Learn various methods of multi object tracking

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	To understand fundamentals and mathematical transforms necessary for image processing.
CO-2	To apply various techniques used for image enhancement
CO-3	Use appropriate techniques for both image restoration and compression procedures
CO-4	Learn video processing techniques and perform 2d motion estimation
CO-5	Perform human tracking based on multiple object tracking concepts

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	-
CO2	1	3	2	1	1
CO3	1	2	2	2	-
CO4	1	3	2	1	-
CO 5	1	3	1	2	-

UNIT I

Fundamentals of Image Processing and Image Transforms; Basic steps of Image Processing System, Monochrome and color vision models**,** Image acquisition and display, Sampling and Quantization of an image – Basic relationship between pixels Image Transforms: 2 D- Discrete Fourier Transform, Discrete Cosine Transform (DCT), Wavelet Transforms: Continuous Wavelet Transform, Discrete Wavelet Transforms.

UNIT II

Image Processing Techniques Image Enhancement Spatial domain methods: Histogram processing, Fundamentals of Spatial filtering, Smoothing spatial filters, Sharpening spatial filters. Frequency domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, Selective filtering. Laplacian of Gaussian (LOG) filters. **Image Segmentation:** Segmentation concepts, Point, Line and Edge Detection, Thresholding, Region Based segmentation. Hough Transform, boundary detection, chain coding,

UNIT III

Image Compression Image compression fundamentals - Coding Redundancy, Spatial and Tempora redundancy, Compression models: Lossy & Lossless, Huffman coding, Arithmetic coding, LZW coding, Run length coding, Bit plane coding, Transform coding, Predictive coding, Wavelet coding, JPEG standards. **Basic steps of Video Processing** Analog Video, Digital Video. Principles of color video processing, composite versus component video, Time-Varying Image Formation models Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Video signals, Filtering operations.

UNIT IV

2-D Motion Estimation Optical flow, General Methodologies, Pixel Based Motion Estimation, Block-Matching Algorithm, Mesh based Motion Estimation, Global Motion Estimation, Region based Motion Estimation, Multi resolution motion estimation, Waveform based coding, Block based transform coding, Predictive coding, Application of motion estimation in Video coding, Content dependent video coding and Joint shape and texture coding ,MPEGs and H.26x standards.

UNIT V

Multi-Object Tracking- Classification of multiple interacting objects from video, Region-based Tracking, Contour-based Tracking, Feature-based Tracking, Model-based Tracking, Hybrid Tracking, Particle filter based object tracking, Mean Shift based tracking, Tracking of multiple interacting objects. Human Activity Recognition- Template based activity recognition, Sequential recognition approaches using state models (Hidden Markov Models), Human Recognition Using Gait, HMM Framework for Gait Recognition, Description based approaches, Human interactions, group activities, Applications and challenges.

Suggested Readings

1. Gonzaleze and Woods Digital Image Processing –, 3rd ed., Pearson.
2. Yao Wang, Joem Ostermann and Ya–quin Zhang Video processing and communication –. 1st Ed., PH Int.
3. M. Tekalp, "Digital Video Processing, Prentice Hall International

ME 322	MICRO ROBOTICS					
	(Programme Elective - III)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Provide brief introduction to micromachining and the principles of microsystems
2	Understand the various flexures, actuators and sensor systems.
3	Discuss the methods of implementation of micro robots.

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Describe the principles of microsystems and Analyze the effects of scaling laws on physical and electrical properties of materials to be used in MEMS.
CO-2	Specify the characteristics of various flexures, actuators and sensor systems
CO-3	Provide a task specification of micro robots and its applications based on the knowledge about micro robots
CO-4	Outline the various methods of implementation of micro robots.
CO-5	Discuss about the principle of micro fabrication and micro assembly

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	-
CO2	1	3	2	1	1
CO3	1	2	2	2	-
CO4	1	3	2	1	-
CO 5	1	3	1	2	-

UNIT I

Introduction to MST (Micro System Technology) – Micromachining - Working principles of Microsystems - Applications of Microsystems. Introduction to Scaling laws - Scaling effect on physical properties, scaling effects on Electrical properties, scaling effect on physical forces. Physics of Adhesion - Silicon-compatible material system - Shape memory alloys - Material properties: Piezo resistivity, Piezoelectricity and Thermoelectricity.

UNIT II

Elemental flexures - Flexure systems - Mathematical formalism for flexures. Electrostatic actuators, Piezoelectric actuators, Magneto-strictive actuators. Electromagnetic sensors, Optical-based displacement sensors, Motion tracking with microscopes.

UNIT III

Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

UNIT IV

Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro-grippers and other micro-tools - Micro conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication.

UNIT V

Micro fabrication and Micro assembly (7 hrs) Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

Suggested Readings

1. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, New York, 2002.
2. Yves Bellouard, "Microrobotics Methods and Applications", CRC Press, Massachusetts, 2011.

ME351	ROBOTICS LAB					
Pre-requisites			L	T	P	C
			-	-	3	1
Evaluation	SEE	00Marks	CIE		50Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basics of robot analysis using RobotDK software
2	Learn to Simulate simple mechanisms using MSC Adams software
3	Learn to perform robot analysis using Articulated robot
4	To build various robot systems using ROS

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Ability to perform simulations/ experiment and understand the phenomenon involved in Automation Robotics lab
CO-2	Critically evaluate and interpret the results
CO-3	Prepare a well-organized record

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	1
CO2	2	2	3	3	1
CO3	2	2	3	2	1

List of Experiments

Using 6 axis articulated robot

1. To perform a pick and place operation
2. To perform a path planning operation

Using Msc Adams Software

1. Kinematic analysis of Single Link Pendulum
2. Impact test of a falling stone body
3. Kinematic and dynamic analysis of a 4 bar mechanism
4. Kinematic and dynamic analysis of a slider crank mechanism
5. Dynamic analysis of a linear and non linear spring
6. Kinematic and dynamic analysis of a RR Type 2 link robot

Using Robot DKS OF TW ARE

1. Introduction to Robot DK Software.
2. Installation and execution of first program.
3. To perform a pick and place operation

4. To perform a robot machining operation
5. To perform a robot welding operation
6. To perform a robot painting operation
7. To perform a robot cutting operation

Using ROS

1. Introduction to Robot Operating System development studio
2. Installing and Configuring ROS Environment
3. Navigating the ROS Filesystem
4. Creating a ROS Package
5. Building a ROS Package
6. Understanding ROS Nodes
7. Understanding ROS Topics
8. Writing a Simple Publisher and Subscriber (Python)
9. ROS simulation and visualisation
10. To create Custom Robot and integrate with Gazebo and Rviz
11. To perform a Localization, Navigation and path planning in ROS

ME361	SEMINAR					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	3	1
Evaluation	**SEE**	00Marks	**CIE**		50 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the purpose of seminar
2	Learn the resources available at the college and outside for pursuing project
3	Importance of literature review
4	Learn to document results and arrive at required conclusions

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify engineering problems reviewing available literature.
CO-2	Study the different techniques adopted to solve the problem.
CO-3	Understand the usage of related techniques and software's
CO-4	Investigate the procedure adopted and Interpret the results and conclusions obtained
CO-5	Document the findings as a technical report with proper references.

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	1		
CO2	3	3	1	1	
CO3	2	3	3	2	
CO4	2	2	2	2	

The seminar must be clearly structured and Power point presentation should include the following:

1. Introduction
2. Literature survey
3. Consolidation of available information
4. Objectives and Methodology
5. Results and Discussions
6. Conclusions
7. References

Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

The seminar must be clearly structured and the power point presentation shall include following aspects:

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Objectives and Methodology
5. Results and Discussions & Summary
6. Conclusions
7. References

Each student is required to:

1. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
2. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the Department.

Guidelines for awarding marks		
S. No.	**Description**	**Max. Marks**
1	Contents and relevance	10
2	Presentation skills	10
3	Preparation of PPT slides	05
4	Questions and answers	05
5	Report in a prescribed format	20

Note:

1. The seminar presentation should be a gist of few research papers from Peer-reviewed or UGC recognized journals.
2. The seminar report should be in the following order: Background of work, literature review, techniques used, prospective deliverables, discussion on results, conclusions, critical appraisal and references
3. At least two faculty members will be associated with the seminar presentation to evaluate and award marks.
4. Attendance of all the students for weekly seminar presentations is compulsory.

SEMESTER - II

ME304	FLUID POWER SYSTEMS					
	(Programme Core - IV)					
Pre-requisites		L	T	P	C	
		3	-	-	3	
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	The course will develop the students' knowledge and understanding of hydraulic and pneumatic devices and systems.
2	The students should be able to understand the principles of operation and the design details of hydraulic pumps, motors, valves, actuators, and systems.
3	The student should be able to analyze both the steady-state and the dynamic performance of individual hydraulic components and systems.
4	The student should also be able to relate the theory with the practical applications of these principles
5	The course will develop the students' knowledge and understanding of hydraulic and pneumatic devices and systems.

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate between Hydraulic and Pneumatic systems and Identify various hydraulic and pneumatic elements with their symbols.
CO-2	Classify various hydraulic, pneumatic fluids with their properties & applications and Illustrate the working principles of various positive displacement pumps and motors.
CO-3	Generate and solve mathematical models for various hydraulic & pneumatic components like valves, pumps and motors.
CO-4	Integrate all hydraulic & pneumatic components and solve the corresponding mathematical models for generating various fluidic circuits.
CO-5	Apply the concept of fluidics in developing various fluidic circuits.

Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	
CO2	3	2	2	2	
CO3	3	2	2	2	1
CO4	2	2	2	3	1
CO 5	2	1	1	2	1

UNIT - I

Advantages and Disadvantages of Fluid control, Types of Hydraulic Fluids, physical, chemical and thermal properties of hydraulic fluids, selection of hydraulic fluid, fluid flow fundamentals. Hydraulic Pumps and Motors: Basic Types and constructions, ideal pump and motor analysis, Performance curves and parameters

UNIT - II

Hydraulic Control Valves- Valve configurations, general valve analysis, critical center, open center, three way spool valve analysis and Flapper valve analysis, pressure control valves, single and two stage pressure control valves, flow control valves, introduction to electro hydraulic valves.

UNIT - III

Hydraulic Power Elements: Valve controlled motor, valve controlled piston, three way valve controlled piston, pump controlled motor, pressure transients in power elements.

UNIT - IV

Characteristics of Pneumatics, Applications of Pneumatics, Basic Pneumatic elements, Pneumatic servomechanisms, pneumatic servo, ram equations, load sensitivity, method of stabilization, stabilization using auxiliary tanks. Some practical aspects of servo testing and design

UNIT - V

Control of pressure and speed in Hydraulic and Pneumatic Systems, Fluidics: proportional amplifier, bistable amplifier, vortex amplifier, turbulence amplifier, impact modulator, Boolean algebra, fluid logics, manipulation of logic expressions, special circuits and sequential circuits.

Suggested Reading:

1. Herbert E. Merritt, "Hydraulic Control Systems", John Wiley & Sons, 1967.
2. D McCloy & H R Martin," The control of fluid power" Longman publications.1980
3. Anthony Esposito, "Fluid power with applications", Prentice Hall, 7th Edition, 2002.
4. Arthur Akers, Max Gassman, Richard Smith, "Hydraulic Power System Analysis", Taylor and Francis Group, 2006.
5. John Pippenger & Tyler Hicks, "Industrial Hydraulics", 3rd edition McGraw Hill , 1979
6. A.B. Goodwin, Fluid Power Systems, Macmillan, 1976.

ME 305	PLANAR MULTIBODY DYNAMICS					
(Programme Core - VI)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn the fundamentals of planar kinematics & dynamics
2	Learn to draw FBD for various mechanical systems
3	Understand the analysis based on body, joint and point formulation
4	Understand the effect of contact and impact on the dynamic analysis of systems
5	Use numerical methods to derive forward and inverse dynamics of dynamic systems

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand the importance of kinematics and dynamics in the analysis of mechanical systems
CO-2	Draw free body diagrams for mechanical systems under different loading conditions
CO-3	Develop dynamic models for mechanical systems based on Joint, point and body coordinate formulation
CO-4	Use numerical methods to solve the dynamics effects in mechanical systems
CO-5	Apply numerical methods to analyse various mechanisms

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	
CO2	3	3	2	2	
CO3	3	3	3	2	
CO4	2	2	3	2	
CO 5	2	2	3	2	

UNIT-I

Multibody Systems: Introduction, Multibody Mechanical Systems, Types of Analyses, **Fundamentals of Planar Kinematics**: Kinematics of a Particle, Rigid Body, Velocity and Acceleration of a Body, Degrees of Freedom, Constraint Equations, Kinematic Joints, **Fundamentals of Planar Dynamics**: Newton's Laws of Motion, Particle Dynamics, Dynamics of a System of Particles, Rigid body Dynamics, Moment of a Force and Torque, Centroidal Equations of Motion, Noncentroidal Equations of Motion Multibody Dynamics, Applied Forces, Reaction Forces

Friction Force, Wheel and Tire, Motor and Driver, Work and Energy

UNIT -II

Vector Kinematics: Types of Vectors, Open-Chain Systems, Closed-Chain Systems, Slider-Crank Mechanism, Four-Bar Mechanism, Six-Bar Quick-Return Mechanism, Six-Bar Dwell Mechanism, Complete Kinematic Analysis Free-Body Diagram, FBD Examples, Two-Body System (Unconstrained), Two-Body System (Constrained), Sliding Pendulum, Slider-Crank

Mechanism, Four-Bar Mechanism, Equations of Motion, Force Analysis, Slider-Crank Mechanism, Four-Bar Mechanism, Generalization of Force Analysis,

UNIT-III

Body-Coordinate Formulation: General Procedure, Kinematic Joints, Revolute (Pin) Joint, Translational (Sliding) Joint, Revolute–Revolute Joint, Revolute–Translational Joint, Rigid Joint, Simple Constraints, Circular Disc, Driver Constraints, System Jacobian, Unconstrained Equations of Motion, Constrained Equations of Motion, Reaction Forces and Lagrange Multipliers, Total Energy, Body coordinate simulation examples: Double A-Arm Suspension, MacPherson Suspension, cart, Conveyor Belt and Friction, Rod Impacting Ground Joint-Coordinate Formulations,

Joint coordinate Formulation: Joint Coordinate and Joint Reference Point, Recursive Kinematics, Open-Chain Systems, Closed-Chain Systems, Cut-Joint Constraints, Equations of Motion, Jacobian Matrix, Initial Conditions, Reaction Forces, Driver Constraint,

UNIT-IV

Point-Coordinate Formulation: Classical Method, Primary and Stationary Points, Constraints, Length angle, simple Constraints, Equations of Motion, Force and Torque Distribution, Mass Distribution, Mass Condensation, Two Primary Points, Three Primary Points, Force and Mass Addition.

Contact and Impact: Piecewise Analysis, Momentum, Impact of Particles, Unconstrained Bodies, Constrained Bodies, Impact with Friction, Continuous Analysis, A Body Contacting a Rigid Surface, Two-Body Contact.

UNIT-V

Kinematics and Inverse Dynamics: Kinematic Analysis, Nonlinear Algebraic Equations **Forward Dynamics**: Unconstrained Formulation, Initial Value Problems, Runge–Kutta Algorithm, General Procedure, Constrained Formulation, Constraint Violation Stabilization Method, Coordinate Partitioning Method, Penalty Method,

Joint-Coordinate Method: Momentum Method, Contact and Impact, Combined Analyses, **Complementary Analyses**: Static Analysis, Static Equilibrium, Initial Condition Correction, Redundant Constraints,

Applications: Film-Strip Advancer, Web-Cutter Mechanism, Six-Bar Quick-Return Mechanism, Six-Bar Dwell Mechanism, Windshield Wiper Mechanism, Double A-Arm Suspension, MacPherson Strut Suspension, Half-Car, Mountain Bike, Creeping Robot,

Suggested Readings:

1. Parviz Nikravesh, Planar Multibody Dynamics, Taylor & Francis, 2nd edition
2. Computational dynamics, Shabana A. A., John Wiley & Sons.
3. Dynamics of multibody systems, Roberson R. E., and Richard S., Springer-Verlag.
4. Dynamics of multibody systems, Shabana A. A., Cambridge University press.
5. Flexible multibody dynamics, Bauchau O. A., Vol. 176. Springer.
6. Dynamics and balancing of multibody systems, Chaudhary H., and S K Saha. Springer

ME306	CONTROL OF DYNAMIC SYSTEMS					
	(Programme Core - III)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn to develop mathematical models for first and second order systems.
2	Understand the importance of transient and steady state analysis of multi degree freedom systems.
3	Understand the concept of observability and controllability in solve problems in MIMO systems.
4	Learn to develop stability plots based on time and frequency response techniques.
5	Learn to draw phase plane plots for non linear systems and determine the stability analysis of linear and non linear systems using Lyapunov analysis.

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate between linear, non linear systems & classify features of linear and non-linear systems. Enumerate the merits and demerits of classical and modern control systems.
CO-2	Develop mathematical models for various physical systems.
CO-3	Determine the transient effects, steady state errors and stability analysis using the frequency and time response plots.
CO-4	Determine stability of MIMO systems using State Space variables.
CO-5	Sketch phase plane plots for non-linear systems and determine the non linear stability analysis using Lyapunov method.

Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	2	
CO2	3	3	3	2	1
CO3	3	2	2	2	
CO4	3	3	3	2	1
CO 5	3	2	2	2	

UNIT-I

Mathematical Modeling of physical systems, 1st, 2nd order and higher order systems, transient, steady stateanalysis, steady state errors, Performance Indices.

UNIT-II
Poles, zeros, zero and pole placements, Routh‟s criteria, Root locus Technique, Bode plots, Nyquist criterion, Compensation circuits.

UNIT-III
State space method, state transition matrix, canonical forms, Diagonalisation, solutions of homogeneous sand non homogenous equations, zero and pole placement using state space techniques, controllability and observability, state controllability matrix, state observability matrix.

UNIT-IV
Non-Linear Systems Phase plane analysis: Phase portraits, Singular points characterization. Analysis of non-linear systems using phase plane techniques, Existence of limit cycles.

UNIT-V
Stability Analysis Concept of stability, Stability in the sense of Lyapunov and absolute stability, autonomous systems, the invariance principle, linear systems and linearization, non autonomous systems, linear time varying systems and linearization.

Suggested Readings:

1. K. Ogata, “Modern Control Engineering”, Pearson India, 3rd Edition.
2. Norman Nise, “Control System Engineering”, Prentice Hall India, Fourth Edition
3. Anand Kumar, “Control System Theory”, Prentice Hall India.
4. M.Vidyasagar, "Nonlinear systems analysis", Second Edition, Prentice Hall, 1993
5. H.Khalil, "Nonlinear Systems", Macmillan Publishing Company, NY, 1992.
6. A. Isidori, “Nonlinear Control Systems” 3rd edition, Springer Verlag, London, 1995.
7. B. Brogliato, R. Lozano, B. Maschke, O. Egeland, "Dissipative Systems Analysis and Control", Springer Verlag, London, 2nd edition, 2007.

ME 323	SIGNAL PROCESSING FOR MECHANICAL SYSTEMS					
(Programme Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To study the DFT and FFT algorithms.
2	To understand the concept of FIR and IIR filters.
3	To study the types of filters.
4	To understand Multi rate signal processing.
5	To study the architecture of TMS processor

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Able to find DFT of a given signal through Fast Fourier Transform techniques.
CO-2	Able to design FIR and IIR type digital filters
CO-3	Able to identify filter structures and evaluate the coefficient quantization effects.
CO-4	Able to understand sample rate conversion techniques.
CO-5	Able to compare the architectures of DSP and general purpose Processors

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3		1	
CO2	2	2	2	1	
CO3	2	1	1	1	1
CO4	3	3		1	
CO 5	2	1	1	1	2

UNIT-I

Introduction: Review of Discrete Time Fourier Transform, Concept of frequency in continuous and discrete time signals, DFT and its properties, linear convolution, circular convolution. Computational complexity of direct Computation of DFT, Fast Fourier Transform, DIT and DIF, FFT algorithms for RADIX-2 case, in-place computation, Bit reversal, Finite word length effects in FFT algorithms, Use of FFT in Linear Filtering.

UNIT-II

FIR Filters: FIR digital filter design techniques. Properties of FIR digital filters, design of FIR filters using windows and frequency sampling techniques, linear phase characteristics. Realization diagrams for IIR and FIR filters, finite word length effects.

UNIT-III

IIR Filters: Analog filter design – Butterworth and Chebyshev approximations, IIR digital filter design techniques, impulse invariant technique. Bilinear transform technique. Comparison of FIR and IIR filters, frequency transformations.

UNIT- IV

Multirate signal processing: Introduction, decimation by a factor D, interpolation by a factor I, sampling rate conversion by a rational factor I/D, design of practical sampling rate converter, S/W implementation of sampling rate converter, application of Multirate signal processing.

UNIT-V

DSP Processors: Introduction to Fixed point Digital Signal Processors, TMS 320C54XX processor- architecture, addressing modes, instruction set, Assembly programming, programming issues, Applications of DSP processors.

Suggested Readings:

1. John G.Proakis and Dimitris G. Manolakis, "Digital Signal Processing principles, Algorithms and Applications", 3rd Edition, Prentice-Hall of India Private Limited, NewDelhi, 1997.
2. Alan V. Oppenheim and Ronald W. Schafer, "Discrete Time Signal Processing", 3rd edition, Prentice Hall, Upper Saddle River, NJ,2010
3. Sanjit K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 4/e, McGraw-Hill, New York,2011
4. Avatar sing and S.Srinivasan, "Digital Signal Processing implementation using DSP Microprocessors with Examples from TMS320C54XX", Thomson Books Icole, 2004.

ME 324	UNDER ACTUATED ROBOTICS					
	(Programme Elective-IV)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the differences between fully and under actuated robot systems
2	Learn the various methods of walking models
3	Learn how to model systems with uncertainty
4	Introduce the concept of Optimal control
5	Understand the importance of various motion planning algorithms

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate between fully and under actuated systems
CO-2	Understand the effectiveness of various walking models
CO-3	Determine the effects of non linearity in the equations, systems and models
CO-4	Apply the concepts of optimal control and other techniques to robot control
CO-5	Apply various path and motion control algorithms

UNIT-I

Fully v/s under actuated systems, non linear dynamics of the simple pendulum, Acrobot and cart-pole controllability, partial feedback linearization (PFL), energy shaping

UNIT-II

Simple walking models- rimless wheels, compass gait, kneed compass gait, feedback control for simple walking models. Simple running models-spring loaded inverted pendulum (SLIP), Raibert hoppers, swimming and flapping flight.

UNIT-III

Function approximation and system identification, model systems with uncertainty, state distribution dynamics and state estimation

UNIT-IV

Introduction to optimal control, double integrator and pendulum examples, dynamic programming and value integration, grid world, quadratic regulator (Hamilton –Jacobi-Bellman sufficiency), min-time control (pontryagin), open loop optimal control, direct and indirect methods., trajectory stabilization, iterative linear quadratic regulator (ILQR).

UNIT-V

Motion planning: Dijkstra‟s algorithm, A-star algorithm, randomized motion planning, rapidly exploring randomized trees, and probabilistic road maps, feedback motion planning-planning with funnels, linear quadratic regulator (LQR) trees

Suggested Reading:

1. Strogatz steven.H, Non linear Dynamics and Chaos: with applications to physics, biology, chemistry and Engineering, Boulder, CO: west view press, 2001
2. Slotine, Jean-Jacques and Weiping Li, Applied Nonlinear control, Upper Saddle River, NJ, Prentice Hall, 1991
3. Fantoni, Isabelle and Rogelio Lozano, Non linear control for under actuated mechanical systems, Newyork, NY, Springer verlag, 2002
4. Bertsekas, Dimitri , Dynamic Programming and Optimal control 3rd edition, vol I and II Nausha, NH, Athena Scientific, 2007
5. Lavalle steven, Planning Algorithms, New york, NY, Cambridge University Press, 2006

ME 325	MODERN CONTROL SYSTEMS					
	(Programme Elective-IV)					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basics of linear and non-linear control systems
2	Learn the concepts of stability in linear and non linear systems
3	Understand the concept of phase plane plots and their importance
4	Learn to apply Lyapunov analysis of linear and non linear systems
5	Understand the basics of optimal control

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Differentiate between classical and modern control system and their importance in solving real time problems.
CO-2	Determine controllability and observability conditions for multi-input and multi-output systems.
CO-3	Understand characteristics of non linear systems and Interpret Phase plane plots for various stability conditions.
CO-4	Apply the concepts of Liaponov stability conditions for linear and nonlinear systems.
CO-5	To apply the comprehensive knowledge of optimal theory for Control Systems

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	3	3	3	2	1
CO3	2	3	2	3	
CO4	3	3	3	2	1
CO 5	2	2	2	2	1

UNIT–I: Mathematical Preliminaries:
Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen-values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Non-uniqueness of state model – State diagrams for Continuous-Time State models.

UNIT-II: State Variable Analysis:
Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time

State Equations – State transition matrix and its properties. General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

UNIT-III: Non Linear Systems: Introduction – Non Linear Systems – Types of Non-Linearities – Saturation – Dead-Zone – Backlash – Jump Phenomenon etc;– Singular Points – Introduction to Linearization of nonlinear systems, Properties of Non-Linear systems – Describing function–describing function analysis of nonlinear systems – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

UNIT-IV: Stability Analysis:
Stability in the sense of Lyapunov, Lyapunov's stability, and Lypanov's instability theorems – Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method Generation of Lyapunov functions – Variable gradient method – Krasooviski's method. State feedback controller design through Pole Assignment – State observers: Full order and Reduced order.

UNIT-V: Optimal Control:
Introduction to optimal control – Formulation of optimal control problems – calculus of variations – fundamental concepts, functional, variation of functional – fundamental theorem of theorem of Calculus of variations – boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator.

Suggested Readings:

1. Modern Control System Theory by M.Gopal – New Age International -1984
2. Control System Engineering, Nagrath and Gopal – New Age International – Fourth Edition
3. Optimal control by Kirck , Dover Publications
4. Advanced Control Theory A. NagoorKani, RBA Publications, 1999
5. Modern Control Engineering by Ogata. K – Prentice Hall – 1997

ME 326	ROTOR DYNAMICS					
(Programme Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the fundamentals of vibrations under free and forced vibrations
2	Learn to determine mode shapes and critical speeds
3	Learn to solve multi degree systems using various methods
4	Learn to determine torsional vibrations in rotary machinery
5	Understand the effect of rotor placed in fixed rotors, rotor with overhangs and flexible supports

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand the fundamentals of free and damped vibrations
CO-2	Importance of Eigen values determination, and critical speeds determination
CO-3	Solve multi degree freedom systems using various methods
CO-4	Determine the causes and effects of vibrations in torsional vibration systems
CO-5	Determination of effects of vibrations for rotating bodies due to various supports

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	1	
CO2	2	3	2	3	
CO3	2	3	2	2	
CO4	2	3	2	2	
CO 5	2	2	2	2	

UNIT-I

Single degree of freedom system – Free vibrations. Damped vibrations and forced vibrations, Two degree of freedom systems – Undamped vibration, absorbers, Forced Damped vibrations, Vibration isolation.

UNIT-II

Close coupled systems – Eigenvalue problem. Orthogonality of mode shapes. Modal analysis Critical speeds.

UNIT-III

Vibrations of multi rotor systems – Matrix method, Influence coefficient methods, Transfer matrix analysis and Holzers method.

UNIT-IV

Torsional vibrations in rotating machinery – Equivalent discrete system, transient response, branched system.

UNIT-V

Out-of-rotors in rigid supports, simply supported rotor with overhangs. Gyroscopic effects. Rotor mounted on fluid film bearings – Transfer matrix analysis of turbine rotor by distributed elements, Dual rotor system analysis. Balancing of rotors.

Suggested Reading:

1. J.S. Rao, *Rotor dynamics*.
2. J.S. Rao, K. Gupta, *Mechanical Vibration*

ME 327	MOBILE ROBOTS					
(Programme Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	This course covers fundamentals of mobile robotics that include the mechanical, motor, sensory, perceptual and cognitive aspects of the robots.
2	Students will learn the basic principles in the design and analysis of mobile robotic systems.
3	Topics to be covered are: locomotion, mobile robot kinematics, perception, mobile robot localization, SLAM, planning and navigation

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Introduced to the fundamental concepts of computational mobile robotics and human-robot interaction.
CO-2	understand the algorithmic approach towards designing intelligent systems
CO-3	learn about computational human-robot interaction, experiment design and interface evaluation
CO-4	Learn about a variety of robotic platforms, their applications and uses.
CO-5	learn the basics mechanical and electrical systems of these robots, including sensors, locomotion and manipulation hardware

Course outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1		1		2	
CO2	2				
CO3		1		2	
CO4		2		2	
CO5			3		3

Unit-1

Introduction to Mobile Robots and Manipulators, introduction to Locomotion and Types of Locomotion, Introduction to Mobile Robot Kinematics, Degree of Maneuverability and Types of Wheels, Kinematic Simulation of a Mobile Robot (Land-based), Kinematic Simulation and Motion Animation of a Mobile Robot (Land-based),A Generalized Wheel (Kinematic) Model Examples related to the Generalized Wheel (Kinematic) Model, Holonomic and Non-holonomic Mobile Robots

Unit-II

Kinematic Simulation of Wheeled Mobile Robots, Mobile Robot Dynamics - Equation of Motion and Dynamic Simulation of a Mobile Robot, Dynamic Models of Wheeled Mobile Robots with Wheel Configurations, Kinematic and Dynamic Models of a Mobile base with Four-Independent Steerable Power Wheels

Unit-III

Sensing and Perception, Sensors and Sensing, Commonly used sensors, Sensor Errors and Error modelling, Mobile Robot Localization, Map based Localisation, Markov, Localization, Kalman Filter Localization ,SLAM

Unit-IV

Mobile Robot Navigation, Path Planning: Graph Construction, Graph Search Methods, Path Planning and Obstacle avoidance, Introduction to Motion Control of Mobile Robots ,Kinematic control of Land-based Mobile Robots ,Simulation of Land-based Mobile Robots along with Kinematic Control

Unit-V

Dynamic Control of Mobile Robots, Cascaded or Back-stepping Control of Mobile Robots Modern Robotics and Challenges, Multiple Mobile Robotic Systems, Autonomous Mobile Robots and Mobile Manipulators, Legged and Hybrid Robots, Underwater and Aerial Robots, Healthcare Robots

Suggested Reading:

1. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh, MIT Press, 2004.
2. Computational Principles of Mobile Robotics, Gregory Dudek, Michael Jenkin, Cambridge University Press, 2010.
3. Autonomous Robots, George A. Bekey, MIT Press, 2005
4. Mobile Robotics: Mathematics, Models, and Methods , A Kelly, Cambridge university press, USA, 2013
5. Introduction to Mobile robot controls , S G Tzafestas, Elsevier, USA, 2014
6. U. Nehmzow, Mobile Robotics - A Practical Introduction, 2nd Ed, Springer, 2003.
7. Autonomous Robot Vehicles. Cox and Wilfong. Springer-Verlag.
8. Probabilistic Robotics. S. Thrun, W. Burgard, D. Fox. MIT Press, 2006.
9. Fundamentals of robotic mechanical systems: theory, methods, and algorithms. Jorge Angeles. New York, Springer, 2003.
10. Robot Modeling and Control. Mark W. Spong, Seth Hutchinson and M. Vidyasagar. John Wiley and Sons, 2006.

ME 328	Human Computer Interaction					
(Programme Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To gain an overview of Human-Computer Interaction (HCI), with an understanding of user interface design in general
2	become familiar with the vocabulary associated with sensory and cognitive systems as relevant to task performance by humans.
3	be able to apply models from cognitive psychology to predicting user performance in various human-computer interaction tasks and recognize the limits of human performance
4	appreciate the importance of a design and evaluation methodology that begins with and maintains a focus on the user
5	be familiar with a variety of both conventional and non-traditional user interface paradigms

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Ability to apply HCI and principles to interaction design.
CO-2	Ability to design certain tools for blind people
CO-3	Ability to design certain tools for differently abled people
CO-4	Apply models to predict and recognize the limitations of human performance
CO-5	Use effectively both conventional and nontraditional user interface paradigms

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3		1	
CO2	2	2	2	1	1
CO3	2	1	1	1	1
CO4	3	3		1	
CO 5	2	1	1	1	1

UNIT-I:
Introduction: Importance of user Interface – definition, importance of good design. Benefits of good design. A brief history of Screen design. The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics, Web user – Interface popularity, characteristics- Principles of user interface.

UNIT-II:
Design process – Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds, understanding business junctions.
Screen Designing: Design goals – Screen planning and purpose, organizing screen elements, ordering of screen data and content – screen navigation and flow – Visually pleasing composition – amount of information – focus and emphasis – presentation information simply and meaningfully – information retrieval on web – statistical graphics – Technological consideration in interface design.

UNIT-III:
Windows – New and Navigation schemes selection of window, selection of devices based and screen based controls. Components – text and messages, Icons and increases – Multimedia, colors, uses problems, choosing colors.

UNIT-IV:
HCI in the software process, The software life cycle Usability engineering Iterative design and prototyping Design Focus: Prototyping in practice Design rationale Design rules Principles to support usability Standards Golden rules and heuristics HCI patterns Evaluation techniques, Goals of evaluation, Evaluation through expert analysis, Evaluation through user participation, Choosing an evaluation method. Universal design, Universal design principles Multi-modal interaction

UNIT -V:
Cognitive models Goal and task hierarchies Design Focus: GOMS saves money Linguistic models The challenge of display-based systems Physical and device models Cognitive architectures Ubiquitous computing and augmented realities Ubiquitous computing applications research Design Focus: Ambient Wood – augmenting the physical Virtual and augmented reality Design Focus: Shared experience Design Focus: Applications of augmented reality Information and data visualization Design Focus: Getting the size right.

Suggested Textbooks

1. The essential guide to user interface design, Wilbert O Galitz, Wiley Dream Tech.
2. Human – Computer Interaction. Alan Dix, Janet Fincay, GreGoryd, Abowd, Russell Bealg, Pearson Education
3. Designing the user interface. 3rd Edition Ben Shneidermann, Pearson Education Asia.
4. Interaction Design Prece, Rogers, Sharps. Wiley Dreamtech.
5. User Interface Design, Soren Lauesen , Pearson Education.
6. Human –Computer Interaction, D. R. Olsen, Cengage Learning.
7. Human –Computer Interaction, Smith - Atakan, Cengage Learning.

ME 329	NON-LINEAR DYNAMICS AND CHAOS					
(Programme Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the concept of autonomous and non-autonomous systems
2	Learn to solve one dimensional and two dimensional bifurcations
3	Learn to develop chaotic maps
4	Understand the concept of fractals in dynamic systems
5	Understand the effect of these non-linear dynamics in mechanical systems

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand the concept of stability related linear and non-linear systems andidentify the basic classes of nonlinear systems.
CO-2	Understand the concept of a bifurcation and bifurcation diagrams and be familiar with the most common types of bifurcations
CO-3	Specify how and why a dynamical system becomes chaotic
CO-4	Develop chaotic solutions for continues systems
CO-5	Determine numerical solutions for dynamic systems using various methods

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	1	
CO2	3	3	2	2	
CO3	3	2	2	2	
CO4	2	2	3	2	
CO 5	2	2	3	2	

UNIT-I:

Introduction to dynamical systems: Discrete time systems-continuous time systems-autonomous and nonautonomous systems-phase space and flows-attracting sets-concepts of stability-fixed point-limit cycle

UNIT-II:

Local and global bifurcations- static and dynamic bifurcation- bifurcation of maps. Types of bifurcation- Chaos-period doubling-quasiperiodic and intermittency routs to chaos. Quasiperiodic solutions: Poincare' maps-circle map

UNIT-III

Chaotic solutions of maps, Chaotic solutions of continuous systems, period doubling and intermittency mechanisms.

UNIT-IV:

Fractals and dynamical systems: Fractal dimension-measures of fractal dimension-Tools to identify and analyze motions-Fourier spectra- Poincare' sections and maps- Lyapunov exponents. Computational aspects-Numerical integration-cell mapping-Galerkin-Harmonic Balancing-Shooting method-parameter continuation and path following

UNIT-V

Applications to mechanical systems-gear with backlash, Clutch springs-bearings, buckled beams etc.

Suggested Readings

1. Ali H. Nayfeh and B Balachandran, Applied nonlinear dynamics, John Wiley & Sons
2. Thomson, J M T and Stewart, H B, Nonlinear dynamics and chaos, John Wiley & Sons
3. Francis C.Moon, Chaotic and Fractal dynamics, John Wiley & Sons
4. S.H.Strogatz, Nonlinear dynamics and chaos, Perseus books publishing, LLC, 2000

ME 330	MACHINE LEARNING APPLICATIONS					
(Programme Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the importance of data preparation & management in Machine learning applications
2	Learn the basics of various statistical tools required in machine learning
3	Learn to solve using regression and clustering techniques
4	Learn to use concept of ANN and CNN for solving problems
5	Learn to use ML and DL for mechanical applications

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Distinguish between supervised and unsupervised problem statements
CO-2	Compare and contrast various Machine Learning and Deep Learning algorithms
CO-3	Apply the concepts of Supervised & Unsupervised Learning to obtain the required results
CO-4	Evaluate the importance of different algorithms used for Machine & Deep learning
CO-5	Apply the concepts of ML and DL to the real-time data for mechanical applications and arrive at the required results.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2			
CO2	3	2			
CO3	3	3	3	2	
CO4	3	2	2	2	
CO 5	2	2	2	2	

UNIT I

Data Preparation: Introduction, types of data, Data preparation -Data selection, Data Pre-processing-Formatting, cleaning and sampling, Data Transformation-Scaling, Decomposition and Aggregation. **Regression:** Linear regression, Logistic regression, Multiple regression, Stepwise, overfitting, Regularization

UNIT II

Supervised Learning: Gradient Descent, Bias and Variance Support Vector Machine: Hyperplanes, Kernels, Regularization, Large margin classification

UNIT III

Unsupervised learning: Clustering, k-means algorithm, Principal Component Analysis, Missing Data, choosing clusters

UNIT IV

Neural Networks: Neurons and biological motivation. Linear threshold units. Perceptrons: representational limitation and gradient descent training. Multilayer networks and backpropagation. Hidden layers and constructing intermediate, Overfitting, learning network structure. Shallow neural networks, problems with shallow networks, importance of Deep Learning, key concepts in Deep Learning, Practical Considerations of Deep neural networks: hyper parameter tuning, initialisation, regularisation, gradient checking, optimisation algorithms, Convolutional Neural Networks, step by step procedure, Recurrent Neural Networks- step by step procedure, ALEXNET, Autoencoders

UNIT V

Mechanical Applications of Machine Learning: ANOVA Analysis of manufacturing processes like forming, welding, Abrasive machining, Condition Monitoring of rotary and reciprocating equipment, Condition monitoring of wind turbine, bearing fault diagnostics, Automatic car detection.

Suggested Readings:

1. Tom Mitchell, *Machine Learning*, McGraw Hill
2. Ian Good fellow, Yoshua Bengio, and Aaron Courville, Deep Learning
3. Christopher M. Bishop, Pattern Recognition and Machine Learning
4. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning
5. Kevin Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press
6. Richard Sutton and Andrew Barto, *Reinforcement Learning: An Introduction*, MIT Press.
7. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

ME 331	OPTIMISATION OF ENGINEERING DESIGN					
(Programme Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn to classify and formulate optimization problems
2	Understand the importance on unconstrained minimization
3	Learn to use various direct and indirect optimization methods
4	Learn to optimize various mechanical components with respect parameters like cost, weight
5	Learn to use optimization for springs and absorbers

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand the definition of parameter optimization.
CO-2	Classify and formulate optimization problem
CO-3	Explain evolutionary computation techniques and methodologies set in the context of modern heuristic methods.
CO-4	Apply various evolutionary computation methods and algorithms for particular classes of problems
CO-5	Develop evolutionary algorithms for real-world applications

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2			
CO2	3	3			
CO3	3	3	2	2	
CO4	2	2	2	2	
CO 5	2	2	2	2	

UNIT- I

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints, classification of optimization problems. Single and multivariable optimization techniques (structural, size, shape, topology optimisation)

UNIT- II:

Technique of unconstrained minimization. Golden section, Random, Pattern and Gradient search methods, interpolation methods, equality and inequality constraints. Direct methods and indirect methods using penalty function, Lagrange multipliers.

UNIT-III:

Evolutionary Optimisation Techniques (single and multi) : **Genetic algorithms**: introduction, terminology, features, representation, mutation, crossover, selection mechanism, applications, **Differential Evolution Algorithm**: introduction, terminology, initialisation, mutation, crossover/recombination, selection, examples and applications of NSGA II and NSGA III algorithms, **Artificial Immune Optimisation**: Biological Immune systems, immunity, antigens, innate immunity, adaptive immunity, immune network model, negative selection algorithm, clonal selection algorithm, danger theory, Applications.

UNIT-IV:

Swarm Optimisation techniques (single and Multi) **: Particle Swarm Optimisation**: introduction, terminology, fitness function, updation of global best, applications, **Ant Colony Optimisation**: introduction, features, terminology, fitness function, evaluation of fitness function, applications, **Grey Wolf Optimisation**: Wolf behaviour, social behaviour, hunting behaviour, Algorithm development, encircling prey- its mathematical model, hunting, applications **Spider monkey Optimisation**: introduction, fusion -fission swarm, initialisation, local leader phase, global leader phase, learning of local and global phase, local and global leader decision phase, applications, **Bacterial Foraging Optimisation**: foraging theory, optimal foraging, run/swim and tumble, decision making in foraging, chemotaxis, swarming, reproduction, elimination and dispersion, examples.

UNIT-V:

Engineering applications, structural-design application axial and transverse loaded members for minimum cost, maximum weight. Design of shafts and torsion members, design optimization of springs.

Dynamics applications for two-degree freedom system. vibration absorbers. Application in mechanisms.

Suggested Textbooks:

1. Engineering Optimization -Theory and Practice/ Singerusu S. Rao/ New Age.
2. Optimum Design of Mechanical elements/ Johnson Ray C/ Wiley, John & Sons
3. Genetic Algorithms in search, Optimization and Machine/ Goldberg D. E. Addison/Wesley / NewYork.
4. Optimization for Engineering Design Algorithms and Examples/ Kalyanamoy Deb/Prentice Flail of India.
5. Introduction to Optimum Design/Jasbir S. Arora/ Academic Press/ Everest/ 3rd Edition.
6. P. Y. Papalambros, Principles of optimal design, Cambridge University Press, 2000
7. O. de Weck and K. Willcox, Multidisciplinary System Design Optimization, MIT lecture note, 2003

ME 332	ROBOT SENSING AND VISION					
(Programme Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60Marks	CIE		40Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn the basics of robot vision and their interfacing
2	Learn the basics of computer vision
3	Understand the basics of position and orientation
4	Understand various methods of localisation and navigation
5	Understand the concepts of recognition and interpretation

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Understand various principles of robot vision
CO-2	Interface various sensors with robotic devices
CO-3	Determine the location and orientation of robotic devices
CO-4	Estimate the motion, track and map robotic devices.
CO-5	Develop real time applications using various sensor interfaces

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3		1	
CO2	2	2	2	1	1
CO3	2	1	1	1	1
CO4	3	3		1	1
CO 5	2	1	1	1	

UNIT-I

Robotic vision sensors and their interfacing

UNIT-II

Fundamentals of Computer Vision: Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC

UNIT-III

Position and Orientation: Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment

UNIT-IV

Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (Mono SLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies.

UNIT -V

Recognition and Interpretations: Concepts of machine learning and deep learning, sequence modeling, Learning for robotic vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics

Suggested Textbooks

4. 1.Tony Parisi, Learning Virtual Reality, O'Reilly Media, 2016
5. Jason Jerald, The VR Book – Human Centered Design for Virtual Reality, Morgan & Claypool, 2015
6. John Williamson, Charles Palmer, Virtual Reality Blueprints: Create compelling VR experiences for mobile and desktop, Packt Publishing, 2018

OE 941 BM	MEDICAL ASSISTIVE DEVICES					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

Unit – II
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

Unit – III
Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

Unit – IV
Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

Unit – V
Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

Suggested Reading:

1	Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, HisaichiOhnabe, Douglas A. Hobson, *Series in medical physics and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

OE 942 BM	MEDICAL IMAGING TECHNIQUES					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.

Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment,

Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

Unit – II

Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of

sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

Unit – III

Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging.
Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

Unit – IV

Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion.
Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

Unit – V

Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera.
Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested Reading:

1	Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2	S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5	Stewart C.Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

OE 941 CE	GREEN BUILDING TECHNOLOGY					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicial use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of energy use and energy processes in building.
CO-2	Identify the energy requirement and its management.
CO-3	Know the Sun-earth relationship vis-a-vis its effect on climate.
CO-4	Be acquainted with the end-use energy requirements.
CO-5	Be familiar with the audit procedures of energy

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	3	3	2	1	2
CO-2	3	2	3	2	1	1
CO-3	3	2	3	2	1	2
CO-4	3	2	3	2	1	2
CO-5	3	2	3	2	1	1

Unit – I

Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

Unit – II

Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

Unit – III

Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and

solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

Unit – IV
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

Unit – V
Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

Suggested Reading:

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

OE 942 CE	COST MANAGEMENT OF ENGINEERING PROJECTS					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
CO-2	Ability to appreciative detailed engineering activities of the project and execution of projects
CO-3	Preparation of project report and network diagram
CO-4	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
CO-5	Applications of various quantitative techniques for cost management

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

Unit – II

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

Unit – III

Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Unit – IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets-Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit – V
Quantitative techniques for cost management, Linear Programming, PERT/CPM,-Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Suggested Reading:

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

OE 941 CS	BUSINESS ANALYTICS					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	To understand the basic concepts of business analytics
CO-2	Identify the application of business analytics and use tools to analyze business data
CO-3	Become familiar with various metrics, measures used in business analytics
CO-4	Illustrate various descriptive, predictive and prescriptive methods and techniques
CO-5	Model the business data using various business analytical methods and techniques

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction to Business Analytics: Introduction to Business Analytics, needand science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

Unit – II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

Unit – III

Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto

regression models, auto-regressive moving process, ARIMA, Theil's coefficient

Unit – IV
Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering**: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics**- Linear Programming (LP) and LP model building.

Unit – V
Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process,cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

Suggested Reading:

1	U Dinesh Kumar, "Data Analytics", Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015

Web Resources:

1	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

OE 941 EC	ELEMENTS OF EMBEDDED SYSTEMS					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand Embedded Design Strategies and architecture of Arduino Board
CO-2	Program using various onboard components of Arduino
CO-3	Design real time interfacing with Arduino
CO-4	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
CO-5	Implement combinational and sequential circuits using verilog HDL

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

Unit – II

Interfacing: Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

Unit – III

Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor**,** USB programming

Unit – IV

FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling,

Structural Modelling, Hierarchal Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

Unit – V
Modelling of Circuits: Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite Sate Machine Design, Tasks and Functions, Introduction to Test Benches

Suggested Reading:

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

Web Resources:

1	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

OE 941 EE	WASTE TO ENERGY					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of conservation of waste
CO-2	Identify the different forms of wastage.
CO-3	Chose the best way for conservation to produce energy from waste.
CO-4	Explore the ways and means of combustion of biomass.
CO-5	Develop a healthy environment for the mankind.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	-	3	2	3	1
CO-2	3	-	3	2	3	1
CO-3	3	-	3	2	3	1
CO-4	3	-	3	2	3	1
CO-5	3	-	3	2	3	1

Unit – I
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit – II
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit – III
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit – IV
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit – V
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Reading:

1	Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

OE 942 EE	POWER PLANT CONTROL AND INSTRUMENTATION					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
CO-2	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
CO-3	Identify the different types of analyzers used for scrutinizing boiler steam and water.
CO-4	Model different types of controls and control loops in boilers.
CO-5	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	3	1	-	-	-	2
CO-2	3	1	-	-	-	2
CO-3	3	1	-	-	-	2
CO-4	3	1	-	-	-	2
CO-5	3	1	-	-	-	2

Unit – I
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.

Unit – II
Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature,

steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

Unit – III
Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

Unit – IV
Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

Unit – V
Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

Suggested Reading:

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering“, Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, “Standard Boiler Operations”, Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, “Power Plant Engineering”, Tata McGraw-Hill, 1st Edition, 1984.

OE 941 ME	**OPERATION RESEARCH**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To understand the dynamic programming to solve problems of discrete and continuous variables
2	To apply the concept of non-linear programming and carry out sensitivity analysis
3	To understand deterministic and probabilistic inventory control models.

Course Outcomes:	
After the completion of this course, the students shall be able to:	
CO-1	To understand the basics of OR, including mathematical modeling, feasible solutions and optimization.
CO-2	Able to carry out sensitivity analysis.
CO-3	Apply PERT/CPM in project management.
CO-4	Select appropriate inventory control model.
CO-5	Able to apply dynamic programming and understand the concept of non-linear programming.

Course Outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	1	1	3	2	1	2
CO-2	3	1	2	3	2	-
CO-3	1	3	3	1	2	2
CO-4	3	2	1	3	1	1
CO-5	2	1	3	2	2	2

Unit – I
Development, Different Phases, Characteristics, Operations Research models and applications. Linear Programming Problem: Introduction, Basic Assumptions, Formulation, graphical method, simplex method: Big M and Two Phase method.

Unit – II
DUALITY: Duality theory, primal-dual relationships, Economic interpretation, Dual simplex method, Post optimal or sensitivity analysis.

Unit – III
Project Management: Introduction to PERT and CPM, critical Path calculation, float calculation and its importance. Cost reduction by Crashing of activity. **Inventory models** – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

Unit – IV
Sequencing Models: Introduction, General assumptions, processing n jobs through 2 machines, processing 'n' jobs through m machines. **Game Theory**: Introduction, Characteristics of Game Theory, Dominance theory, Mixed strategies (2 x 2, m x 2), Algebraic and graphical methods. **Nonlinear programming problem:** - Kuhn-Tucker conditions.

Unit – V
Queuing models - Queuing systems and structures – Notation parameter – Single server and multi server models – Poisson arrivals – Exponential service times – with finite population – Infinite population. Dynamic Programming: Characteristics, principle of optimality, deterministic problems.

Suggested Reading:

1	H.A. Taha, Operations Research, An Introduction, PHI,2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi,2010
3	J.C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, Delhi,2008.
4	Frederick S. Hillier, Gerald J. Lieberman, Operations Research, 10thEdition, McGraw Hill Pub. 2017.
5	Panner selvam, Operations Research: Prentice Hall of India, 2010.
6	Ronald L. Rardin, Optimization in Operations Research, First Indian Reprint, Pearson Education Asia. 2002,

OE 942 ME	**COMPOSITE MATERIALS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study the concepts of composite construction.
2	Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.
3	Apply the concepts for design of multi-storey composite buildings.
4	Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of composite construction, and analysis and designs of composite beams.
CO-2	Analyse and design the composite floors
CO-3	Select suitable materials for composite columns,
CO-4	Analyse composite trusses and understand connection details.
CO-5	Analyse and design the multi-stored composite buildings

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions.
Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

Unit – II

Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

Unit – III

Composite columns: Materials - Concrete filled circular tubular sections - Non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of

members to axial compressions - Composite column design - Fire resistance.

Unit – IV
Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

Unit – V
Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

Suggested Reading:

1	R.P. Johnson, "Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings", Blackwell Publishing, Malden, USA, 2004.
2	"INSDAG Teaching Resources for Structural Steel Design", Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	"INSDAG Handbook on Composite Construction – Multi-Storey Buildings", Institute for Steel Development and Growth Publishers, Calcutta, India.
4	"INSDAG Design of Composite Truss for Building", Institute for Steel Development and Growth Publishers, Calcutta, India.
5	"INSDAG Handbook on Composite Construction – Bridges and Flyovers", Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, "Code of Practice for Composite Construction in Structural Steel and Concrete", Bureau of Indian Standards, New Delhi, 1985.

OE943 ME	**INDUSTRIAL SAFETY**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Identify the causes for industrial accidents and suggest preventive measures.
CO-2	Identify the basic tools and requirements of different maintenance procedures.
CO-3	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
CO-4	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
CO-5	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes, Fire prevention and firefighting, equipment and methods.

Unit – II

Fundamentals of Maintenance Engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit – III
Wear and Corrosion and their Prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, corrosion prevention methods.

Unit – IV
Fault Tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

Unit – V
Periodic and Preventive Maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of Machine tools, Pumps, Air compressors, Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Suggested Reading:

1	H. P. Garg, "Maintenance Engineering", S. Chand and Company
2	Audels, "Pump-hydraulic Compressors", Mcgraw Hill Publication
3	Higgins & Morrow, "Maintenance Engineering Handbook", Da Information Services.
4	Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

OE 941 LA	**INTELLECTUAL PROPERTY RIGHTS**					
(OPEN ELECTIVE)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the concept of intellectual property rights.
CO-2	Develop proficiency in trademarks and acquisition of trade mark rights.
CO-3	Understand the skill of acquiring the copy rights, ownership rights and transfer.
CO-4	Able to protect trade secrets, liability for misappropriations of trade secrets.
CO-5	Apply the patents and demonstration of case studies.

Course outcome	**Program Outcome**					
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

Unit – I

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit – II

Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Unit – III

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer**.**

Unit – IV
Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

Unit – V
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Suggested Reading:

1	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
2	"Mayall, "Industrial Design", McGraw Hill,1992
3	"Niebel, "Product Design", McGraw Hill,1974.
4	"Asimov, "Introduction to Design", Prentice Hall,1962.
5	"Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age",2016.
6	T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand,2008

ME 352	DRIVES AND CONTROLS LAB					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	3	1
Evaluation	**SEE**	00Marks	**CIE**		50Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the working principles of various sensors
2	Learn to write embedded programs using KEIL software
3	Learn to integrate peripheral devices to 8051, Arduino and Arm micro controller
4	Understand the working of hydraulic and pneumatic trainer kits
5	Learn to develop hydraulic and pneumatics circuits for simple applications

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Ability to perform simulations/ experiment and understand the phenomenon involved in Automation Robotics lab
CO-2	Critically evaluate and interpret the results
CO-3	Prepare a well-organized record

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	2	3	1
CO2	2	2	3	3	1
CO3	1	2	3	3	1

Using Various Sensors

1. Familiarization of various sensors
2. Sensor behavior and calibration
3. Measurement of position, velocity , temperature, force, pressure and strain

Using 8051 Microcontroller

1. LCD interfacing with 8051MC
2. Interfacing of PMW with DC motor using 8051 MC interface
3. 16 ADC and DAC interfacing with 8051 MC
4. Temperature control using 8051 MC interface
5. Traffic Light control using 8051 MC interface.
6. Servo motor Interfacing with 8051MC
7. Basic Experiments using Use Hydraulic, Pneumatic and Electro-pneumatic circuits

Using Arduino Microcontroller

1. LCD interfacing with Arduino Microcontroller
2. Interfacing of PMW with DC motor using Arduino Microcontroller interface
3. 16 ADC and DAC interfacing with Arduino Microcontroller
4. Temperature control using Arduino Microcontroller interface
5. Traffic Light control using Arduino Microcontroller interface.
6. Servo motor Interfacing with Arduino Microcontroller

Using Arm Microcontroller

1. LCD interfacing with Arm Microcontroller
2. Interfacing of PMW with DC motor using Arm Microcontroller interface
3. 16 ADC and DAC interfacing with Arm Microcontroller
4. Temperature control using Arm Microcontroller interface
5. Traffic Light control using Arm Microcontroller interface.
6. Servo motor Interfacing with Arm Microcontroller

ME353	**COMPUTATION LABORATORY FOR A&R**					
Pre-requisites		**L**	**T**	**P**	**C**	
		-	-	3	1	
Evaluation	**SEE**	00Marks	**CIE**		50Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Learn to use Matlab for solving basic problems
2	Learn to develop simple applications using matlab and simulink
3	Learn to use python programming and solve simple problems
4	Learn to use various matlab tool boxes like robotics tool box, Neural nets tool box, global optimization, control tool box for solving engineering problems

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Ability to perform simulations/ experiment and understand the phenomenon involved in Automation Robotics lab
CO-2	Critically evaluate and interpret the results
CO-3	Prepare a well-organized record

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	2	2	3	3	
CO2	2	2	3	2	1
CO3	2	2	3	2	1

List of Experiments:

Using MATLAB software

1. Evaluate the mathematical expressions in Matlab
2. Write scripts to make the following single-index arrays
3. Basic syntax and command-line exercises, Basic array exercises, Relational and logical operations
4. Control of flow: if-blocks , Loop constructs: for and while
5. Problems on generating various kinds of 2D & 3DPlots
6. Solving ordinary differential equations
7. Solving non-linear algebraic equations
8. Applications of Curve fitting and interpolation
9. Introduction to Simulink
10. Pid control using Simulink
11. Usage of Data Analysis and statistics
12. Introduction to optimization methods like GA, Fuzzy, Neural &PSO

13. Modeling of problems related to kinematics and dynamics of robot using MATLAB
14. To simulate a 2R Robotic Arm Manipulator

Using Python Software

1. Running Python scripts
2. Using Python as a calculator
3. Computing trigonometric functions, arrays, strings, functions, methods, conditional expressions, loops, lists, modules.
4. Solving problems on statistics
5. Working with data: lists, sorting, tuples, sets, files, comprehensions, dictionaries
6. Working with modules, object oriented programming (state, classes, objects, inheritance, errors, exceptions, iterators, generators)

*Students are advised to do any 10 experiments

ME 070	**MINI PROJECT**					
Pre-requisites			**L**	**T**	**P**	**C**
			-	-	6	3
Evaluation	**SEE**	00Marks	**CIE**		50Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the purpose of doing mini project
2	Learn the resources available at the college and outside for pursuing project
3	Importance of literature review
4	Learn to select appropriate software and procedure
5	Learn to document results and arrive at required conclusions

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify engineering problems reviewing available literature
CO-2	Study different techniques used to analyze complex systems.
CO-3	Use related techniques and software's for solving the problem
CO-4	Interpret the results and arrive at the relevant conclusions.
CO-5	Document the findings as a technical report with proper references

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1			3	2	1
CO2			3	3	1
CO3			3	3	1
CO4			3	3	1
CO 5			3	3	1

Guidelines

1. Guide allocation will be done at the beginning of the semester. Identification of mini project work will be done with Guides consultation

2. Mini project presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.

3. Evaluation of Mini project will be done by the Departmental Committee. Half of the marks are awarded by the Guide and the remaining half of the marks will be awarded by Departmental Committee.

SEMESTER-III

AC030 ME	**RESEARCH METHODOLOGY IN MECHANICAL ENGINEERING**					
AUDIT - I						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
1	Learn to focus on research related activities.
2	Learn methods to devise and develop the various research designs
3	Learn basic principles of data collection and analysis techniques
4	Learn the style and format of writing a report for technical papers

Course Outcomes: After completion of the course student will be able to	
CO-1	Motivate the orientation towards research related activities
CO-2	Formulate the research problem, analyze research related information
CO-3	Identify various sources for literature review and design an experimentation set-up
CO-4	Apply the basic principles of data collection and analysis techniques
CO-5	Improve the style and format of writing a report for technical / Journal articles

UNIT – I

Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem

UNIT – II

Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. **Literature Review**: Need of Review, Guidelines for Review, Record of Research Review.

UNIT – III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

UNIT – IV

Data Collection: Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software.

Data Analysis: Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F-test, Time Series analysis, Autocorrelation and Autoregressive modeling

UNIT –V

Research Report Writing: Format of the Research report, Synopsis, Dissertation, Thesis its Differentiation, References/Bibliography/Webliography, Technical paper writing/Journal report writing, making presentation, Use of visual aids. **Research Proposal Preparation**: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

Suggested Reading:

1	C.R Kothari, Research Methodology, Methods & Technique; Revised Edition, New Age International Publishers, 2004
2	R. Ganesan, Research Methodology for Engineers, 1st Edition, MJP Publishers, 2011.
3	Ratan Khananabis and Suvasis Saha, Research Methodology, 1st Edition, Universities Press, Hyderabad, 2015
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, 1st Edition, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5	Vijay Upagade and Aravind Shende, Research Methodology, 1st Edition, S. Chand & Company Ltd., New Delhi, 2009
6	G. Nageswara Rao, Research Methodology and Quantitative methods, 2nd Edition, BS Publications, Hyderabad, 2012.

AC 031	ENGLISH FOR RESEARCH PAPER WRITING					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand that how to improve your writing skills and level of readability
2	Understand the nuances of language and vocabulary in writing a Research Paper.
3	Develop the content, structure, format of writing a research paper and produce original research papers without plagiarism

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Interpret the nuances of research paper writing.
CO-2	Differentiate the research paper format and citation of sources.
CO-3	To review the research papers and articles in a scientific manner.
CO-4	Avoid plagiarism and be able to develop their writing skills in presenting the research work.
CO-5	Create a research paper and acquire the knowledge of how and where to publish their original research papers

Unit – I

Academic Writing: Meaning & Definition of a research paper– Purpose of a research paper – Scope – Benefits, Limitations – outcomes.

Unit – II

Research Paper Format: Title – Abstract – Introduction – Discussion – Findings, Conclusion – Style of Indentation – Font size/Font types – Indexing – Citation of sources.

Unit – III

Research Methodology: Methods (Qualitative – Quantitative) Review of Literature. Criticizing, Paraphrasing & Plagiarism.

Unit – IV

Process of Writing a research paper: Choosing a topic - Thesis Statement – Outline – Organizing notes - Language of Research – Word order, Paragraphs – Writing first draft – Revising/Editing - The final draft and proof reading.

Unit – V

Research Paper Publication: Reputed Journals – National/International – ISSN No, No. of volumes, Scopus Index/UGC Journals – Free publications - Paid Journal publications – Advantages/Benefits

Presentation Skills: Developing Persuasive Presentations, Structure of Presentation,

Presentation Slides, Presentation Delivery, role of the audience, what to search and cite, how to establish credibility.

Suggested Reading:

1	C. R Kothari, Gaurav, Garg, "*Research Methodology Methods and Techniques*", 4/e, New Age International Publishers.
2	Day R, "*How to Write and Publish a Scientific Paper*", Cambridge University Press, 2006
3	"*MLA Hand book for writers of Research Papers*", 7/e, East West Press Pvt. Ltd, New Delhi
4	Lauri Rozakis, Schaum's, "*Quick Guide to Writing Great Research Papers*", Tata McGraw Hills Pvt. Ltd, New Delhi.

AC 032	DISASTER MITIGATION AND MANAGEMENT					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Introduction of various types of disasters and its effect on structures.
2	Learning of quality assurance and damage assessment of structures
3	Educate different types of repair, strengthening, rehabilitation and retrofitting techniques.
4	Awareness about flood characteristics and flood forecasting systems
5	Description of Flood mitigation, adjustment, and regulation

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Understand the fundamentals of disaster and seismic performance of buildings
CO-2	Able to assess various damages in structures and give assurance of quality of concrete
CO-3	Decide the appropriate repair, strengthening, rehabilitation and technique required for a case study of building.
CO-4	Applications of flood routing, flood forecasting and space time characteristics of rainfall.
CO-5	Advanced understanding of flood plain adjustments and employment of appropriate technologies for flood mitigation.

Unit – I
Disaster: Classifications - Causes - Impacts including social, economical, political, environmental, health, psychosocial, etc.
Seismic performance of buildings :case studies of major earthquakes in the country, damage to buildings, damage patterns, performance of non-engineered buildings-Introduction to repair and rehabilitation of structures.

Unit – II
Quality assurance for concrete – Strength, Durability and Thermal properties of concrete. Damage Assessment**:** - Condition assessment and distress, Purpose of assessment, Rapid assessment - diagnostic techniques, Investigation of damage, , Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems, Procedure for evaluating damaged of structure.

Unit – III
Repair, Rehabilitation And Retrofitting Techniques: Repair materials, Common types of repairs – Repair in concrete structures – Repairs in under water structures – Guniting – Shot create –Underpinning, Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake, Retrofitting techniques

Unit – IV
Introduction to Disasters: Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.
Flood characteristics and forecasting: Measureable features of a flood (Elevation, discharge, volume, and duration), flood forecasting (unit hydrograph method, meteorological and snow data, and snow field air temperatures), operation of flood forecasting systems.
Space-time characteristics of rainfall: Policy criteria for design flood of a major and minor reservoir, spillways, diversion dams and barrages, design flood criteria for dams and other hydraulic structures (CWC recommendations).

Unit – V
Flood Routing: Mathematics of flood routing, various methods of flood routing, Hydrologic and Hydraulic routing.
Flood mitigation: flood ways, channel improvement, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation.
Flood plain adjustments and regulations: Results of controlling floods, alternatives to controlling floods, range of possible adjustments, practical range of choice, critical characteristics of flood hazards.

Suggested Reading:

1	Barry A. Richardson, "Defects and Deterioration in Buildings", E &FN Spon Press, London, 1991.
2	J. H. Bungey, "Testing of Concrete in Structures", Chapman and Hall, New York, 1989.
3	"A.R. Santakumar, "Concrete Technology", Oxford University Press, New Delhi, 2006.
4	"Pankaj Agarwal and Manish Shrihkande (2006). "Earthquake Resistance Design of Structures." Prentice Hall of India.
5	"Ravishankar.K., Krishnamoorthy.T.S, "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers, 2004. New Technological Age",2016.
6	CPWD and Indian Buildings Congress, Hand book on Seismic Retrofit of Buildings, Narosa Publishers, 2008.

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AC 033	**SANSKRIT FOR TECHNICAL KNOWLEDGE**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2	To make the novice Learn the Sanskrit to develop the logic in mathematics, science & other subjects
3	To explore the huge knowledge from ancient Indian literature

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Develop passion towards Sanskrit language
CO-2	Decipher the latent engineering principles from Sanskrit literature
CO-3	Correlates the technological concepts with the ancient Sanskrit history.
CO-4	Develop knowledge for the technological progress
CO-5	Explore the avenue for research in engineering with aid of Sanskrit

Unit – I

Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)

Unit – II

Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).

Unit – III

Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):

Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

Unit – IV
Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology): Computer languages and the Sanskrit languages-computer command words and the vediccommand words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

Unit – V
*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):*Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthiyanthram

Suggested Reading:

1	M Krishnamachariar, *"History of Classical Sanskrit Literature",* TTD Press, 1937.
2	M.R. Kale, "*A Higher Sanskrit Grammar: For the Use of School and College Students*", Motilal Banarsidass Publishers, 2015.
3	Kapail Kapoor, "*Language, Linguistics and Literature: The Indian Perspective",* ISBN- 10: 8171880649, 1994.
4	"*Pride of India*", Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, "*Vedas the source of ultimate science",* Nag publishers, 2005.

AC 034	VALUE EDUCATION					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the need and importance of Values for self-development and for National development.
2	Imbibe good human values and Morals
3	Cultivate individual and National character.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Gain necessary Knowledge for self-development
CO-2	Learn the importance of Human values and their application in day to day professional life.
CO-3	Appreciate the need and importance of interpersonal skills for successful career and social life
CO-4	Emphasize the role of personal and social responsibility of an individual for all-round growth.
CO-5	Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.

Unit – I

Human Values, Ethics and Morals: Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

Unit – II

Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

Unit – III

Spiritual outlook and social values: Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.

Unit – IV

Values in Holy Books: Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

Unit – V
Dharma, Karma and Guna: Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

Suggested Reading:

1	Chakroborty, S.K., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	Jaya Dayal Goyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

AC 035	STRESS MANAGEMENT BY YOGA					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Creating awareness about different types of stress and the role of yoga in the management of stress.
2	Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).
3	Prevention of stress related health problems by yoga practice.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	To understand yoga and its benefits.
CO-2	Enhance Physical strength and flexibility.
CO-3	Learn to relax and focus.
CO-4	Relieve physical and mental tension through Asanas
CO-5	Improve work performance and efficiency.

Unit – I
Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

Unit – II
Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

Unit – III
Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

Unit – IV
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

Unit – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati- Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.
Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT).

Suggested Reading:

1	"Yogic Asanas for Group Training - Part-I": Janardhan Swami Yogabhyasi Mandal, Nagpur
2	"Rajayoga or Conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
3	Nagendra H.R nadNagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda Yoga Prakashan

Web resource:

1	https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2	https://freevideolectures.com/course/3539/indian-philosophy/11

AC 036	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To learn to achieve the highest goal happily
2	To become a person with stable mind, pleasing personality and determination
3	To awaken wisdom in students

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Develop their personality and achieve their highest goal of life.
CO-2	Lead the nation and mankind to peace and prosperity.
CO-3	To practice emotional self-regulation.
CO-4	Develop a positive approach to work and duties.
CO-5	Develop a versatile personality.

Unit – I
Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

Unit – II
Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

Unit – III
Introduction to Bhagavad Geetha for Personality Development - Shrimad Bhagawad Geeta: Unit 2 – Verses 41, 47, 48 - Unit 3 – Verses 13,21,27,35 - Unit 6 – Verses 5,13,17,23,35 - Unit 18 – Verses 45, 46, 48 Unit – 6: Verses 5, 13, 17, 23, 35; Unit – 18: Verses 45, 46, 48.

Unit – IV
Statements of basic knowledge - Shrimad Bhagawad Geeta: Unit 2- Verses 56, 62,68 - Unit 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

Unit – V
Role of Bahgavadgeeta in the present scenario - Unit 2 – Verses 17 – Unit 3 – Verses 36, 37, 42 - Unit 4 – Verses 18, 38, 39 - Unit 18 – Verses 37, 38, 63.

Suggested Reading:

1	"Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit, Sansthanam, New Delhi.

Web resource:

1	NTPEL:http://nptel.ac.in/downloads/109104115

AC 037	CONSTITUTION OF INDIA					
	(AUDIT COURSE - II)					
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	The history of Indian Constitution and its role in the Indian democracy.
2	Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3	Have knowledge of the various Organs of Governance and Local Administration.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the making of the Indian Constitution and its features.
CO-2	Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.
CO-3	Have an insight into various Organs of Governance - composition and functions
CO-4	Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.
CO-5	Understand Electoral Process, special provisions.

Unit – I

History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

Unit – II

Contours of Constitutional Rights and Duties Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties

Unit – III

Organs of Governance": Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

Unit – IV

Local Administration - District's Administration head: Role and importance. Municipalities: Introduction, ayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions and role. Block level: Organizational Hierarchy (Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

Unit – V
Election commission: Election Commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women**.**

Suggested Reading:

1	The Constitution of India", 1950 (Bare Act), Government Publication
2	Dr. S. N. Busi, Dr. B. R. Ambedkar, "Framing of Indian Constitution", 1st Edition, 2015.
3	M. P. Jain, "Indian Constitution Law", 7th Edn., Lexis Nexis, 2014
4	D.D. Basu, "Introduction to the Constitution of India", Lexis Nexis, 2015.

Web resource:

1	http://www.nptel.ac.in/courses/103107084/Script.pdf

AC 038	PEDAGOGY STUDIES					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To present the basic concepts of design and policies of pedagogy studies.
2	To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.
3	To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
CO-2	Examine the effectiveness of pedagogical practices.
CO-3	Understand the concept, characteristics and types of educational research and perspectives of research.
CO-4	Describe the role of classroom practices, curriculum and barriers to learning.
CO-5	Understand Research gaps and learn the future directions.

Unit – I

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.

Unit – II

Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

Unit – III

*Evidence on the Effectiveness of Pedagogical Practices***:** Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches – Teachers attitudes and beliefs and pedagogic strategies.

Unit – IV

Professional Development: alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

Unit – V
Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

Suggested Reading:

1	Ackers J, Hardman F, *"Classroom Interaction in Kenyan Primary Schools, Compare*", 31 (2): 245 – 261, 2001.
2	Agarwal M, *"Curricular Reform in Schools: The importance of evaluation*", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.
3	Akyeampong K, "*Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)",* Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, *"Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?"* International Journal Educational Development, 33 (3): 272- 282, 2013.
5	Alexander R J, *"Culture and Pedagogy: International Comparisons in Primary Education",* Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: *"A mass scale, rapid, learning to read campaign",* 2003

AC 039	**E-WASTE MANAGEMENT**					
(AUDIT COURSE - II)						
Pre-requisites			**L**	**T**	**P**	**C**
			2	-		0
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Introduction to E-Waste management
2	Understanding on resource efficiency and circular economy
3	E-waste Management rules 2016
4	RoHS compliances/directives to EEE

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Complete understanding on E-Waste management
CO-2	Understanding on effective recycling methodologies for e-waste management
CO-3	Overall understanding about E-waste Management rules 2016 and strategies for e-waste management
CO-4	Understanding on RoHS compliances for EEE products

Unit – I

Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities and Management, a Global Scenario; The Importance of Waste Management; Types of Waste- Solid and Liquid; Criteria for EEE/E-Waste Classification; Multivariate Model for E-Waste Estimation; Environmental and Health Effects of Waste Management, Inventorisation of E-Waste and Emerging trends in E-waste disposal with bench marks for depollution - global scenario; Dumping, Burning and Landfill: Impact on the Environment

Unit – II

Effective Waste Management and Disposal Strategies; Legislative Influence on Electronics Recycling; Waste Management Rules and Their Amendments; Extended Producer Responsibility (EPR) in E-Waste Management; The Role of Collective versus Individual Producer Responsibility in E-Waste Management

Unit – III

Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products

Unit – IV

Recycling and Resource Management: Ecological and Economical Valuation; Life Cycle Assessment (LCA) Approach to Waste Management System; Environmental Incentives for Recycling and Life Cycle Analysis of Materials Recycling Electronic Waste: Challenges and Opportunities for Sustainable Management; Resource Recovery from E-waste: Efficiency and Circular Economy;

Integrated Approach to E-Waste Recycling: Recycling and Recovery Technologies, Recycling and Recovery Technologies.

Unit – V
Cases studies: E-waste Generation, collection and recycling

Suggested Reading:

1	Electronic Waste Management and Treatment Technology, Editors: Majeti Narasimha Vara Prasad Meththika Vithanage
2	Electronic Waste Management, Edited by R. E. Hester, R. M. Harrison, RSC Publishing 2009
3	Solid Waste Technology & Management, Christensen, T., Ed., Wiley and Sons., 2011
4	Electronics Waste Management: An India Perspective. Front Cover. Sandip Chatterjee. Lap Lambert Academic Publishing GmbH KG, 2010 - Electronic
5	Handbook of Electronic Waste Management, International Best Practices and Case studies, Elsevier, 2019
6	E-waste: Implications, regulations, and management in India and current global best practices. Author(s): Rakesh Johri, TERI Press

ME 381	**DISSERTATION PHASE - I**					
Pre-requisites			**L**	**T**	**P**	**C**
			20	-	-	10
Evaluation	**SEE**	00Marks	**CIE**		100Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the purpose of Project work
2	Learn the resources available at the college and outside for pursuing project
3	Importance of literature review
4	Learn to select appropriate software and procedure
5	Learn to document results and arrive at required conclusions

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Identify suitable engineering problems reviewing available literature.
CO-2	Study different techniques used to analyze complex systems.
CO-3	Use related techniques and software's for solving the problem
CO-4	Interpret the results (if available) and defend work in front of technically qualified audience
CO-5	Document the findings as a technical report with proper references

Course Outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1			2	3	1
CO2			2	3	1
CO3			2	3	1
CO4			2	3	1
CO 5			2	3	1

Guidelines

1. The Major Project Phase-I Work should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
2. Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M.E.

3. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review.
4. The preliminary results (if available) of the problem may also be discussed in the report.
5. The work has to be presented in front of the examiners panel set by Head and Faculty Advisor
6. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

SEMISTER - IV

ME 382	**DISSERTATION PHASE - II**					
Pre-requisites			**L**	**T**	**P**	**C**
			32	-	-	16
Evaluation	**SEE**	100 Marks	**CIE**		100 Marks	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the purpose of doing project work
2	Learn the resources available at the college and outside for pursuing project
3	Importance of literature review
4	Learn to select appropriate software and procedure
5	Learn to document results and arrive at required conclusions

Course Outcomes:	
On completion of this course, the student will be able to do:	
CO-1	Use different Simulation models /experimental techniques/ software/ computational /analytical tools.
CO-2	Design and develop Simulation model/Mathematical model/ experimental set up/ equipment/ test rig.
CO-3	Conduct tests and draw logical conclusions from the results after analyzing them.
CO-4	Work in either in research environment or in an industrial environment and Conversant with technical report writing.
CO-5	Present and defend their work to the evaluation committee

Course outcome	**Program outcome**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1			2	3	1
CO2			2	3	1
CO3			2	3	1
CO4			2	3	1
CO 5			2	3	1

GUIDELINES

1. It is a continuation of Major Project Phase I work started in semester III.
2. The project work should be presented in standard format as provided by the department.
3. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) adopted& Result analysis.
4. The report must bring out the conclusions of the work and future scope for the study and also should be properly referenced.
5. Student has to submit the report in prescribed format and also present a seminar.
6. Student should present a Seminar in front of Internal committee consisting of Head, CBoS, Guide, Subject expert, Faculty Advisor. Further the suggestions of the committee have to be incorporated in the final Report.
7. The final work has to be presented in front of the examiners panel consisting of an approved external examiner and a guide, co-guide etc. as decided by the Head and Faculty advisor.
8. The candidate has to be in regular contact with his guide.