



JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY - GURAJADA - VIZIANAGARAM
VIZIANAGARAM – 535 003 Andhra Pradesh (India)
 (Established by Andhra Pradesh Act No.22 of 2021)

B.Tech. – III Year I Semester

B.Tech. – III Year I Semester

S.No.	Category	Title	L	T	P	Credits
1	PC	Machine Tools and Metrology	3	0	0	3
2	PC	Thermal Engineering	3	0	0	3
3	PC	Theory of Machines	3	1	0	3
4	PCE-1	Professional Elective – I	3	0	0	3
5	OE-1	1. Sustainable Energy Technologies 2. Applied operation Research 3. Industrial safety 4. Energy Conservation Management	3	0	0	3
6	PC Lab-1	Thermal Engineering Lab	0	0	3	1.5
7	PC Lab-2	Theory of Machines Lab	0	0	3	1.5
8	SEC	Machine Tools & Metrology Lab Mechatronics Lab	0	0	4	2
9	ES	Computational Fluid Dynamics Lab	0	0	2	1.0
10	Evaluation of Community Service Internship	Community Service Internship	-	-	-	2
Total			15	0	12	23

Professional Elective - I

1. Instrumentation & Control Systems
2. Nano Technology
3. Design for manufacturing
4. Thermal management of Electronic Systems
5. Joining Processes



VIZIANAGARAM – 535 003 Andhra Pradesh (India)

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B.Tech. III Year II Semester

Mandatory Industry Internship of 08 weeks duration during summer vacation

1. Industrial robotics
2. Supply chain management
3. Additive manufacturing
4. UnConventional Machining Processes
5. Refrigeration and Air conditioning

1. Automobile Engineering
2. Computer Integrated Manufacturing
3. Smart manufacturing
4. Mechanical Vibrations
5. Composite materials

III Year-II Semester	Professional Core	L	T	P	C
		3	0	0	3
HEAT TRANSFER					

(Heat transfer data book allowed)

Course Objectives:

The students will acquire the knowledge

1. To interpret the different modes of heat transfer and conduction heat transfer through various solid bodies
2. To analyze the one-dimensional steady state heat conduction heat transfer and one-dimensional transient heat conduction
3. To illustrate the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows
4. To analyze the free convection heat transfer concepts and heat transfer processes in heat exchangers
5. To interpret the concepts of film wise condensation, drop wise condensation and radiation heat transfer

UNIT – I:

Introduction

Modes and mechanisms of heat transfer – Basic laws of heat transfer –General discussion about applications of heat transfer.

Conduction Heat Transfer

Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer

Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation. Variable Thermal conductivity – systems with heat sources or Heat Generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature.

UNIT – II:

One Dimensional Transient Conduction Heat Transfer

Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi-infinite body.

Convective Heat Transfer

Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations

UNIT – III:

Forced convection: External Flows:

Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

Internal Flows:

Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this – Use of empirical relations for Horizontal Pipe Flow and annulus flow.

Free Convection:

Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

UNIT – IV:

Heat Transfer with Phase Change:

Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling

Condensation: Film wise and drop wise condensation –Nusselt's Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT V:

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

TEXT BOOKS:

1. Heat Transfer by HOLMAN, Tata McgrawHill
2. Heat Transfer by P.K.Nag, TMH

REFERENCE BOOKS:

1. Fundamentals of Heat Transfer by Incropera& Dewitt, John wiley
2. Fundamentals of Engineering, Heat& Mass Transfer by R.C.Sachdeva, NewAge.
3. Heat& Mass Transfer by Amit Pal – Pearson Publishers
4. Heat Transfer by Ghosh dastidar, Oxford University press.
5. Heat Transfer by a Practical Approach, YunusCengel, Boles, TMH
6. Engineering Heat and Mass Transfer by Sarit K. Das, DhanpatRai Pub

Note: Heat and Mass transfer Data Book by C P Kothandaraman and Subrahmanyam is used to design and analyze various thermal processes and thermal equipment.

Course Outcomes:

At the end of the course, the student should be able to

1. Interpret the different modes of heat transfer and conduction heat transfer through various solid bodies
2. Analyze the one-dimensional steady state heat conduction heat transfer and one-dimensional transient heat conduction
3. Illustrate the basic concepts of convective heat transfer and forced convection heat transfer of external flows and internal flows
4. Analyze the free convection heat transfer concepts and heat transfer processes in heat exchangers
5. Interpret the concepts of film wise condensation, drop wise condensation and radiation heat transfer

III Year-II Semester	Professional Course	L	T	P	C
		3	0	0	3
FINITE ELEMENT METHODS					

Course Objectives:

The students will acquire the knowledge

1. To illustrate basic principles of finite element analysis procedure
2. To analyze the theory and characteristics of finite elements that represent engineering structures of trusses and beams
3. To develop finite element modeling of two-dimensional stress analysis
4. To analyze the finite modelling for high order and isoparametric elements
5. To develop the usage of finite element method for the steady state heat transfer analysis

UNIT-I

Introduction to finite element method, stress and equilibrium, strain –displacement relations, stress–strain relations, plane stress and plane strain conditions, Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

UNIT – II

Analysis of Trusses: Finite element modelling coordinates and shape functions, assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations.

Analysis of Beams: Element stiffness matrix for Hermite beam element, derivation of load vector for concentrated and UDL, simple problems on beams.

UNIT – III

Finite element modelling of two-dimensional stress analysis with constant strain triangles and treatment of boundary conditions, formulation of axi-symmetric problems.

UNIT-IV

Higher order and isoparametric elements: One dimensional quadratic and cubic elements in natural coordinates, two dimensional four noded isoparametric elements and numerical integration.

UNIT – V

Steady state heat transfer analysis: one dimensional analysis of a fin and two-dimensional analysis of thin plate, analysis of a uniform shaft subjected to torsion.

Dynamic Analysis: Formulation of finite element model, element consistent and lumped mass matrices, evaluation of Eigen values and Eigen vectors, free vibration analysis.

Text Books:

1. The Finite Element Methods in Engineering /SSRao/Pergamon.

References:

1. Finite Element Method with applications in Engineering / YM Desai, Eldho& Shah /Pearson publishers
2. An introduction to Finite Element Method /JNReddy/McGrawHill

3. The Finite Element Method for Engineers—Kenneth H. Huebner, Donald L. Dewhurst, Douglas E. Smith and Ted G. Byrom/John Wiley & sons (ASIA) Pvt. Ltd.
4. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveni, Pearson Education
5. Finite Element Methods / Chen
6. Finite Element Analysis: for students & Practicing Engineers / G. Lakshmi Narasaiah / BSP Books Pvt. Ltd.

Course outcomes:

Upon successful completion of this course, you should be able to:

1. Illustrate basic principles of finite element analysis procedure
2. Analyze the theory and characteristics of finite elements that represent engineering structures of trusses and beams
3. Develop finite element modeling of two-dimensional stress analysis
4. Analyze the finite modelling for high order and isoparametric elements
5. Develop the usage of finite element method for the steady state heat transfer analysis

III Year-II Semester	Professional Elective -II	L	T	P	C
		3	0	0	3
INDUSTRIAL ROBOTICS					

Course Objectives:

The students will acquire the knowledge:

1. To illustrate various applications of robotics and classification of coordinate system and control systems
2. To build the concepts of components of industrial robotics.
3. To determine kinematic analysis with D-H notation, forward and inverse kinematics and Solve dynamic analysis with Lagrange – Euler and Newton – Euler formulations
4. To model trajectory planning for a manipulator by avoiding obstacles
5. To analyze different types of actuators and applications of robots in manufacturing

UNIT-I

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system.

UNIT – II

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.

UNIT – III

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems. Differential transformation and manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formulations – Problems.

UNIT IV

General considerations in path description and generation. Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion – Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT V

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors.

ROBOT APPLICATIONS IN MANUFACTURING: Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection.

TEXT BOOKS:

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Robotics / John J. Craig/ Pearson

REFERENCE BOOKS:

1. Theory of Applied Robotics /Jazar/Springer.
2. Robotics / Ghosal / Oxford

Course outcomes:

Upon successful completion of this course student should be able to:

1. Illustrate various applications of robotics and classification of coordinate system and control systems
2. Build the concepts of components of industrial robotics.
3. Determine kinematic analysis with D-H notation, forward and inverse kinematics and Solve dynamic analysis with Lagrange – Euler and Newton – Euler formulations
4. Model trajectory planning for a manipulator by avoiding obstacles
5. Analyze different types of actuators and applications of robots in manufacturing

III Year-II Semester	Professional Elective-II	L	T	P	C
		3	0	0	3
SUPPLY CHAIN MANAGEMENT					

Course Objectives:

The students will acquire the knowledge:

1. To explain the importance of Supply chain management frame work in business management
2. To interpret basic concepts of Supply Chain Drivers and Metrics
3. To interpret the Design of Supply Chain Network and factors influencing distribution network design
4. To analyze role of forecasting in a supply chain
5. To analyze aggregate Planning and inventories in supply chain

Unit-I

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Unit-II

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Unit-III

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Unit-IV

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Unit-V

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory. Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Text Books:

1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, 4th Edition, Pearson Education Asia, 2010.
2. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill, 2000.

Course Outcomes:

Up on completion of course students will be able to

1. Explain the importance of Supply chain management frame work in business management
2. Interpret basic concepts of Supply Chain Drivers and Metrics
3. Interpret the Design of Supply Chain Network and factors influencing distribution network design
4. Analyze role of forecasting in a supply chain
5. Analyze aggregate Planning and inventories in supply chain

III Year-II Semester	Professional Elective-II	L	T	P	C
		3	0	0	3
ADDITIVE MANUFACTURING					

Course Objectives:

1. To analyze the principles of prototyping, classification of RP processes and liquid-based RP systems
2. To illustrate and apply different types of solid-based RP systems.
3. To interpret and apply powder-based RP systems.
4. To discuss and apply various rapid tooling techniques.
5. To analyze different types of data formats and to explore the applications of AM processes in various fields.

UNIT– I:

INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.

LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– II:

SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– III:

POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three-dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– IV:

RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.

UNIT– V:

RAPID PROTOTYPING DATA FORMATS: STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

TEXT BOOKS:

1. Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific publications

REFERENCES:

1. Rapid Manufacturing / D.T. Pham and S.S. Dimov/Springer
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates
3. Rapid Prototyping & Manufacturing / Paul F.Jacobs/ASME Press
4. Rapid Prototyping / Chua and Liou

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

1. Analyze the principles of prototyping, classification of RP processes and liquid-based RP systems
2. Illustrate and apply different types of solid-based RP systems.
3. Interpret and apply powder-based RP systems.
4. Discuss and apply various rapid tooling techniques.
5. Analyze different types of data formats and to explore the applications of AM processes in various fields.

III Year-II Semester	Professional Elective-II	L	T	P	C
		3	0	0	3
UNCONVENTIONAL MACHINING PROCESSES					

Course Objectives:

The students will acquire the knowledge

1. To Analyze basic concepts of modern machining processes and ultrasonic machining.
2. To interpret the principles and procedure of principles of electro chemical machining.
3. To apply the principles and procedure of thermal metal removal processes.
4. To illustrate the principles and procedure of electron beam machining, laser beam machining and plasma machining.
5. To interpret the principles and procedure of abrasive jet machining.

UNIT – I

INTRODUCTION: Need for non-traditional machining methods-classification of modern machining processes considerations in process selection, applications.

Ultrasonic machining – Elements of the process, mechanics of material removal, MRR process parameters, economic considerations, applications and limitations.

UNIT – II

ELECTRO – CHEMICAL MACHINING: Fundamentals of electro chemical machining, electrochemical grinding, electro chemical honing and deburring process, metal removal rate in ECM, Tool design, Surface finish and accuracy, economic aspects of ECM – Simple problems for estimation of metal removal rate, fundamentals of chemical, machining, advantages and applications.

UNIT - III

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

UNIT – IV

Electron Beam Machining, Laser Beam Machining - Basic principle and theory, mechanics of material removal, process parameters, efficiency & accuracy, applications

Plasma Machining: Application of plasma for machining, metal removal mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries.

UNIT – V

Abrasive jet machining, Water jet machining and abrasive water jet machining: Basic principles, equipment, process variables, mechanics of material removal, MRR, application and limitations, magnetic abrasive finishing, abrasive flow finishing, Electro stream drilling, shaped tube electrolytic machining.

Text Books:

1. Fundamentals of Machining Processes-Conventional and non – conventional processes/Hassan Abdel – Gawad El-Hafy/CRCPress-2016.

References:

1. Modern Machining Process / Pandey P.C. and Shah H.S./TMH.
2. New Technology / Bhattacharya A/ the Institution of Engineers, India1984.
3. Non-Traditional Manufacturing Processes / Benedict

Course Outcomes

At the end of the course the students shall be able to:

1. Analyze basic concepts of modern machining processes and ultrasonic machining.
2. Interpret the principles and procedure of principles of electro chemical machining.
3. Apply the principles and procedure of thermal metal removal processes.
4. Illustrate the principles and procedure of electron beam machining, laser beam machining and plasma machining.
5. Interpret the principles and procedure of abrasive jet machining.

III Year-II Semester	Professional Elective-II	L	T	P	C
		3	0	0	3
REFRIGERATION AND AIR CONDITIONING					

(Refrigeration and Psychrometric tables and charts allowed)

Course Objectives:

The students will acquire the knowledge:

1. To illustrate the operating cycles and different systems of refrigeration
2. To analyze cooling capacity and coefficient of performance of vapor compression refrigeration systems and understand the properties of refrigerants
3. To identify VCR system components and calculate coefficient of performance by conducting test on vapor absorption and steam jet refrigeration systems
4. To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
5. To describe different component of refrigeration and air conditioning systems

UNIT – I

INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT – II

VAPOUR COMPRESSION REFRIGERATION: Working principle and essential components of the plant – simple vapor compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.

VCR SYSTEM COMPONENTS: Compressors – general classification – comparison – advantages and disadvantages. condensers – classification – working principles evaporators – classification – working principles expansion devices – types – working principles

REFRIGERANTS – Desirable properties – classification - refrigerants used – nomenclature – ozone depletion – global warming

UNIT III

VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH₃ – water system and Li Br –water (Two shell & four shell) System, principle of operation three fluid absorption system, salient features.

STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components. Principle and operation of thermoelectric refrigerator and vortex tube.

UNIT IV

INTRODUCTION TO AIR CONDITIONING: Psychrometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF- problems, concept of ESHF and ADP temperature.

Requirements of human comfort and concept of effective temperature- comfort chart –comfort air conditioning – requirements of industrial air-conditioning, air-conditioning load calculations.

UNIT – V

AIR CONDITIONING SYSTEMS: Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits

Text Books:

1. A Course in Refrigeration and Air conditioning / SC Arora & Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora / TMH.

References:

1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration / Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH

Course Outcomes:

Upon successful completion of this course the student should be able to:

1. Illustrate the operating cycles and different systems of refrigeration (BL-2)
2. Analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the properties of refrigerants (BL-3)
3. Identify VCR system components and calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems (BL-3)
4. Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning. (BL-2)
5. Demonstrate different component of refrigeration and air conditioning systems. (BL-2)

III Year-II Semester	Professional Elective-III	L	T	P	C
		3	0	0	3
AUTOMOBILE ENGINEERING					

Course Objectives:

The students will acquire the knowledge

1. To Illustrate basic components and functions of automobile
2. To analyze the various elements and working of transmission system of automobile
3. To Interpret the working of steering system, suspension system and braking system of automobile
4. To analyze the concepts involved in the electrical system of automobile, engine specifications and safety systems
5. To illustrate the concepts involved in the emission control and engine service of different parts

UNIT – I

INTRODUCTION: Components of four-wheeler automobile – chassis and body – power unit – power transmission – rear wheel drive, front wheel drive, 4-wheel drive – types of automobile engines, engine construction, turbo charging and super charging – engine lubrication, splash and pressure lubrication systems, oil filters, oil pumps – crank case ventilation – engine service, reboring, decarbonization, Nitriding of crank shaft.

UNIT – II

TRANSMISSION SYSTEM: Clutches, principle, types, cone clutch, single plate clutch, multi plate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh, construct mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. propeller shaft – Hotch – Kiss drive, Torque tube drive, universal joint, differential rear axles – types – wheels and tyres.

UNIT – III

STEERING SYSTEM: Steering geometry – camber, castor, king pin rake, combined angle toein, centre point steering. types of steering mechanism – Ackerman steering mechanism, Davis steering mechanism, steering gears – types, steering linkages.

SUSPENSION SYSTEM: Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, independent suspension system.

UNIT – IV: BRAKING SYSTEM: Mechanical brake system, hydraulic brake system, master cylinder, wheel cylinder tandem master cylinder requirement of brake fluid, pneumatic and vacuum brakes.

ELECTRICAL SYSTEM: Charging circuit, generator, current – voltage regulator – starting system, bendix drive mechanism solenoid switch, lighting systems, horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.

UNIT – V

ENGINE SPECIFICATION AND SAFETY SYSTEMS: Introduction- engine specifications with regard to power, speed, torque, no. of cylinders and arrangement, lubrication and cooling etc.

SAFETY: Introduction, safety systems - seat belt, air bags, bumper, anti lock brake system (ABS), wind shield, suspension sensors, traction control, mirrors, central locking and electric windows, speed control

ENGINE EMISSION CONTROL: Introduction – types of pollutants, mechanism of formation,

concentration measurement, methods of controlling-engine modification, exhaust gas treatment-thermal and catalytic converters-use of alternative fuels for emission control – National and International pollution standards

ENGINE SERVICE: Introduction, service details of engine cylinder head, valves and valve mechanism, piston-connecting rod assembly, cylinder block, crank shaft and main bearings, engine reassembly-precautions.

Text Books:

1. Automotive Mechanics – Vol. 1 & Vol. 2 / Kirpal Singh/standard publishers
2. Automobile Engineering / William Crouse/TMH Distributors
3. Automobile Engineering/P.S Gill/S.K. Kataria& Sons/New Delhi.

References:

1. Automotive Engines Theory and Servicing/James D. Halderman and Chase D. Mitchell Jr.,/ Pearson education inc.
2. Automotive Engineering / K Newton, W.Steeds& TK Garrett/SAE
3. Automotive Mechanics : Principles and Practices/ Joseph Heitner/Van Nostrand Reinhold
4. Automobile Engineering / C Srinivasan/McGrawHill

Course Outcomes:

At the end of the course the students shall be able to:

1. Illustrate basic components and functions of automobile
2. Analyze the various elements and working of transmission system of automobile
3. Interpret the working of steering system, suspension system and braking system of automobile
4. Analyze the concepts involved in the electrical system of automobile, engine specifications and safety systems
5. Illustrate the concepts involved in the emission control and engine service of different parts

III Year-II Semester	Professional Elective-III	L	T	P	C
		3	0	0	3
COMPUTER INTERGRATED MANUFACTURING					

Course Outcome

Students will be able to

1. Apply manufacturing concepts and management principles.
2. Classify and compare different manufacturing processes and systems.
3. Develop part program for manufacturing of different machine components.
4. Analyze the behavior of manufacturing system using simulation.

UNIT-I

Introduction:

Introduction, evolution of CIM, types of manufacturing system, components of CIM, CIM Wheel, role of management in CIM. Impact of CIM on personnel, Levels of Automation, Lean Production and Just-In Time Production.

UNIT-II

Group Technology & CAPP Introduction, part families, visual inspection, part classification and coding techniques – chain type, hierarchical structure, hybrid & Opitz coding, product flow analysis, rank order clustering, composite part concepts.

Introduction, Approaches to Computer Aided Process Planning – Variant, Generative and Hybrid method, applications and benefits.

UNIT-III

Flexible Manufacturing System Introduction & component of FMS, needs of FMS, general FMS consideration, objectives, types of flexibility, FMS layout and advantages. Automated material handling system: Types and Application, Automated Storage and Retrieval System, Automated Guided Vehicles, Automated Tool Management and supply system, Tool Monitoring System, Flexible Fixturing, Flexible Assembly Systems.

UNIT-IV

Robot Technology Introduction: Robot Anatomy, Laws of Robot, human System and robotics, coordinate system, specifications of robot, different configurations of robots, power sources, actuators and transducers, robotic sensors, grippers, robot safety, applications, economic considerations of robotics system. Concepts of Computer Vision and Machine Intelligence.

UNIT-V

NC/CNC Machine Tools Types, Classification, Specification and components, Construction Details, Controllers, Sensors and Actuators, CNC hardware: Re circulating ball screw, antifriction slides, step/servo motors. Axis designation, NC/CNC tooling. Fundamentals of manual Part programming, absolute and incremental dimensioning Types of formats, Part Programming for drilling, lathe and milling operations, subroutines, canned Cycles, parametric sub routines.

Software based programming cycles: • Turning Cycles Stock Removal, Groove, Undercut, Thread-OD,

Cut-off, contour and plunge turning operations • Milling Cycles Face Milling, Pocket, Multi-edge spigot, slot, Thread Milling, Engraving) • Drilling Cycles Centering, Drilling, Deep Hole Drilling, Boring, Threading

Programmable Logic Controllers Introduction, Programmable controller architecture, relay device components, programming a programmable controller, tools for PLC logic design.

Textbooks:

1. Principles of Computer-integrated Manufacturing by S. Kant Vajpayee
2. Automation, Production Systems and Computer Integrated Manufacturing by Mikell P Groover
Pearson Education

Reference Books:

1. Robotics Technology and Flexible Automation, by S R Deb, S Deb, McGraw Hill Education
2. Private Limited
3. Flexible Manufacturing Cells and System -William. W. Luggen
4. CNC Machines by B.S. Pabla
5. CNC Machines and Automation by J.S. Narang

III Year-II Semester	Professional Elective-III	L	T	P	C
		3	0	0	3
SMART MANUFACTURING					

Course Objectives:

- 1) To interpret the basics of smart manufacturing
- 2) To describe advanced automation and smart design and manufacturing technologies
- 3) To apply machine learning in manufacturing
- 4) To illustrate the applications of smart manufacturing
- 5) To illustrate the elements of IIoT

UNIT-I Introduction to Smart Manufacturing

Definition, objectives, benefits of Smart Manufacturing, Evolution of manufacturing systems, Key components and technologies in Smart Manufacturing, Industrial Automation and Control Systems. Basic principles and technologies of a Smart manufacturing, Digitalization and the Networked Economy, Globalization and Emerging Issues. Cyber-Physical Systems and Cyber-Physical Production Systems, smart work piece, Digital Twins in production, Assistance systems for production.

UNIT-II: Smart Design & Fabrication

Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices. Online Predictive modelling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities.

UNIT-III : ML in Manufacturing

ML - Concept of AI, Conceptual Learning, AI & Augmented reality in Manufacturing. ANN in Manufacturing-Biological Neuron, Artificial Neuron, Types NNs, ML Applications in Manufacturing. Human-Robot Collaboration. Communication Systems in Cloud Manufacturing, Cloud Applications in Manufacturing, and allied factory.

UNIT- IV: Application

Factories and Assembly Line, Food Industry, Medical, Power Plants, Inventory Management & Quality. Data Acquisition and Analysis

UNIT-V: Elements of IIoT

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

Textbooks:

1. Masoud Soroush, McKetta Michael Baldea, & Thomas Edgar (2020). "Smart Manufacturing: Concepts and Methods", Elsevier, 2020.
2. Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence Luo, Z. ed., 2014 IGI Global.
3. Smart Manufacturing: Integrating Transformational Technologies for Competitiveness and Sustainability. Shemwell, S.M. and Quazi, H.A., CRC press
4. Gilchrist, A., "Industry 4.0: the industrial internet of things", A press, 2016
5. Automation, Production Systems and CIM/Groover M.P./PHI/2007

Reference Books:

1. Rawat, D. B., Brecher, C., Song, H., & Jeschke, S. (2017)., "Industrial Internet of Things: Cybermanufacturing Systems", Springer, 2017.
2. M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, 1st edition, Morgan Kaufmann, 2010, ISBN-10: 0123748992.

Course Outcomes:

- 1) Interpret the basics of smart manufacturing
- 2) Describe advanced automation and smart design and manufacturing technologies
- 3) Apply machine learning in manufacturing
- 4) Illustrate the applications of smart manufacturing
- 5) Illustrate the elements of IIoT

III Year-II Semester	Professional Elective -III	L	T	P	C
		3	0	0	3
MECHANICAL VIBRATIONS					

Course Objectives:

The students will acquire the knowledge

1. To analyze basic principles of mathematical modeling of vibrating systems
2. To illustrate the basic concepts free and forced multi degree freedom systems
3. To interpret concepts involved in the torsional vibrations
4. To analyze the principles involved in the critical speed of shafts
5. To illustrate the basic concepts of transient vibrations

UNIT-I: INTRODUCTION

Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modelling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT-II: MULTI DEGREE FREEDOM SYSTEMS

Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality Principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT-III: CONTINUOUS SYSTEMS

Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non linear and random vibrations.

UNIT-IV: CRITICAL SPEEDS OF SHAFTS: Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT-V: TRANSIENT VIBRATIONS:

Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method.

Text books:

1. S.S.Rao, “Mechanical Vibrations ”, 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, “Elements of vibration Analysis”, 2nd Edition, McGraw-Hill, New York, 1985.

References:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, “Theory of Vibration with Applications”, 5th Edition, Pearson Education, 2008.
2. M.L.Munjal, “Noise and Vibration Control”, World Scientific, 2013.
3. Beranek and Ver, “Noise and Vibration Control Engineering: Principles and Applications”, JohnWiley and Sons, 2006.

4. Randall F. Barron, “Industrial Noise Control and Acoustics”, Marcel Dekker, Inc., 2003.

Course Outcomes:

1. Analyze basic principles of mathematical modeling of vibrating systems
2. Illustrate the basic concepts free and forced multi degree freedom systems
3. Interpret concepts involved in the torsional vibrations
4. Analyze the principles involved in the critical speed of shafts
5. Illustrate the basic concepts of transient vibrations

III Year-II Semester	Professional Elective-III	L	T	P	C
		3	0	0	3
COMPOSITE MATERIALS					

Course Objectives

The students will acquire the knowledge:

1. To classify the composite materials and identify the applications
2. To illustrate strengthening mechanisms of fiber composites
3. To analyze Major composite classes and role of interfaces in composites
4. To interpret the Fabrication of PMC's, CMC's and MMC'S
5. To analyze applications of advanced composite materials.

UNIT-I

Introduction to Composites: Matrices, Reinforcements, Classifications, Applications, Comparison with Metals and Importance over other materials, design fabrication and economic consideration, General requirements. Classification of composites on the basis of reinforcement and matrix, Classification of Reinforcement, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fiber-reinforced composites. Fibres and resin materials.

UNIT-II

Strengthening mechanisms, Aspect Ratio, Rule of Mixture, discontinuous and continuous fiber composites and their comparison, Characteristics and materials of reinforcements and matrices. Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation.

UNIT-III

Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites. Hybrid composites, Laminated composites. Polymer composites, thermoplastics, thermosetting plastics, manufacturing of PMC, MMC & CCC and their applications.

Role of interfaces in composites, Interfacial Bonding Mechanisms. Pullout & Push-out Testing. Control of Bond Strength. Toughening mechanisms in PMCs, MMCs, and CMCs.

UNIT-IV

Fabrication of PMC's:- Fabrication of Fibers, Plastic Fiber Forms, Prepregs, Molding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, and Recycling. ; Matrix –Reinforcement Interface, Wettability.

Fabrication of CMC's: Hot-Pressing, Infiltration, In Situ Chemical Reaction Techniques. CVD & CVI, Sol-gel.

Fabrication of MMC'S: Liquid Infiltration- Casting, Solid State Processes-Diffusion Bonding & In Situ Technique.

UNIT-V

Applications of advanced composite materials. Environmental effects in Composites, Green composites, Synthesis and Properties of Nanocomposites. Surface Composites & Surface metal matrix composites: Need, Synthesis, Properties and applications

Text Books:

1. Nano material /A.K. Bandyopadhyay/New age Publishers
2. Material science and Technology: A comprehensive treatment/Robert W.Cahn,/VCH
3. Engineering Mechanics of Composite Materials / Isaac and M Daniel/Oxford University Press

References:

1. Mechanics of Composite Materials / R. M. Jones/ Mc Graw Hill Company, New York, 1975.
2. Analysis of Laminated Composite Structures / L. R. Calcote/Van Nostrand Reinhold, NY 1969
3. Analysis and performance of fibre Composites /B. D. Agarwal and L. J. Broutman /Wiley-Interscience, New York, 1980
4. Mechanics of Composite Materials - Second Edition
(Mechanical Engineering) /Autar K.Kaw / CRC Press

Course Outcomes:

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

1. Classify the composite materials and identify the applications
2. Illustrate strengthening mechanisms of fiber composites
3. Analyze Major composite classes and role of interfaces in composites
4. Interpret the Fabrication of PMC's, CMC's and MMC'S
5. Analyze applications of advanced composite materials.

III Year-II Semester	Open Elective-II	L	T	P	C
		3	0	0	3
ELECTRICAL VEHICLES					

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

1. To Illustrate electric vehicles.
2. To Interpret drive-train topologies.
3. To Classify various electrical drives
4. To Classify energy storage technologies.
5. To Classify different energy management strategies.

UNIT-I:

INTRODUCTION TO ELECTRIC VEHICLES

History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies. Comparison by efficiency of Conventional, Hybrid, Electric and Fuel cell Vehicles.

UNIT-II:

ELECTRIC DRIVE-TRAINS

Basic concept of electric traction, Introduction to various electric drive-train topologies, Power flow control in electric drive-train topologies.

UNIT-III:

ELECTRIC DRIVES & CONTROL

Introduction to electric components used in electric vehicles, Control of Induction Motor Drive, Permanent Magnet (PM) motor Drive & Switched Reluctance Motor (SRM) Drive.

UNIT-IV:

ENERGY STORAGE

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its modeling, SOC, Different Types of Batteries, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices.

UNIT-V:

ENERGY MANAGEMENT STRATEGIES & CHARGING INFRASTRUCTURE 10 Lectures

Introduction to energy management strategies used in electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies, Types of EV charging Infrastructure & Standardized Communication protocols for EV charging.

TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2 nd Edition, 2017. (Unit-I, II)

2. Ali Emadi, “Advanced Electric Drive Vehicles (Energy, Power Electronics, and Machines)”, CRC Press, 2015. (Unit-III)
3. John G. Hayes and A. Goodarzi, “Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles”, Wiley, 2018. (Unit-IV & V)

References:

1. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 2 nd Edition 2012.

Course Outcomes:

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

1. Illustrate electric vehicles.
2. Interpret drive-train topologies.
3. Classify various electrical drives
4. Classify energy storage technologies.
5. Classify different energy management strategies.

III Year-II Semester	Open Elective-II	L	T	P	C
		3	0	0	3
SUPPLY CHAIN MANAGEMENT					

Course Objectives:

The students will acquire the knowledge:

1. To explain the importance of Supply chain management frame work in business management
2. To illustrate basic concepts of Supply Chain Drivers and Metrics
3. To interpret the Design of Supply Chain Network and factors influencing distribution network design
4. To analyze role of forecasting in a supply chain
5. To analyze aggregate Planning and inventories in supply chain

Unit-I

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Unit-II

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Unit-III

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Unit-IV

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Unit-V

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory. Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Text Books:

1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, 4th Edition, Pearson Education Asia, 2010.
2. David Simchi-Levi, Philip Kaminsky and Edith Simchi Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill, 2000.

Course Outcomes:

Up on completion of course students will be able to

1. Explain the importance of Supply chain management frame work in business management
2. Illustrate basic concepts of Supply Chain Drivers and Metrics

3. Interpret the Design of Supply Chain Network and factors influencing distribution network design
4. Analyze role of forecasting in a supply chain
5. Analyze aggregate Planning and inventories in supply chain

Note: The students who already opted the subject name- Supply Chain Management in Professional elective need to opt for a different subject.

III Year-II Semester	Open Elective-II	L	T	P	C
		3	0	0	3
DESIGN OF EXPERIMENTS					

Course Objectives:

The students will acquire the knowledge:

1. To interpret Probability laws, Baye's theorem and Probability distributions.
2. To analyze normal and t-distributions and Central limit theorem.
3. To interpret randomization, blocking with paired comparisons and Analysis of variance
4. To develop analyze two-way factorial designs and understand Yate's algorithm
5. To interpret simple modeling with least squares

UNIT-I:

Introduction to probability, Probability laws, Baye's theorem, Probability distributions, Parameters and statistics.

UNIT-II:

Normal and t-distributions, Central limit theorem, Random sampling and declaration of independence significance tests.

UNIT-III:

Randomization and blocking with paired comparisons significance tests and confidence interval for means, variances, proportions and frequencies. Analysis of variance, Experiments to compare k-treatment means.

UNIT-IV:

Two-way factorial designs, blocking, Yate's algorithm Fractional factorial designs at two levels, Concept of design resolution.

UNIT-V:

Simple modeling with least squares (Regression analysis), Matrix versions of normal equations.

Text Book

1. Statistics for Experimenters, G.E.P. Box, William G. Hunter and J.S. Hunter, John Wiley & Sons.

Reference Books

1. Design and Analysis of Experiments, D.C. Montgomery, 2nd Edition John Wiley and Sons.
2. Design of Experiments in Chemical Engineering: A Practical Guide, Zivorad R. Lazic, Wiley-VCH publications.

Course Outcomes

After completing this course students will be able to:

- 1) Interpret Probability laws, Baye's theorem and Probability distributions.
- 2) Analyze normal and t-distributions and Central limit theorem.
- 3) Interpret randomization, blocking with paired comparisons and Analysis of variance
- 4) Develop analyze two-way factorial designs and understand Yate's algorithm
- 5) Interpret simple modeling with least squares

III Year-II Semester	Open Elective-II	L	T	P	C
		3	0	0	3
TOTAL QUALITY MANAGEMENT					

Course Objectives

The students will acquire the knowledge:

1. To analyze the concepts of TQM, Quality and Business performance
2. To illustrate importance of customer satisfaction and loyalty
3. To analyze Organizing for quality implementation
4. To interpret the concept of cost of quality
5. To analyze ISO 9000 universal standards of quality

UNIT – I:

INTRODUCTION: The concept of TQM, Quality and Business performance, attitude and involvement of top management, communication, culture and management systems. Management of Process Quality: Definition of quality, Quality Control, a brief history, Product Inspection vs, Process Control, Statistical Quality Control, Control Charts and Acceptance Sampling.

UNIT – II:

CUSTOMER FOCUS AND SATISFACTION: The importance of customer satisfaction and loyalty-Crating satisfied customers, Understanding the customer needs, Process Vs. Customer, internal customer conflict, quality focus, Customer Satisfaction, role of Marketing and Sales, Buyer – Supplier relationships. Bench Marketing: Evolution of Bench Marketing, meaning of Bench marketing, benefits of bench marketing, the bench marketing process, pitfalls of bench marketing.

UNIT – III:

ORGANIZING FOR TQM: The systems approach, organizing for quality implementation, making the transition from a traditional to a TQM organizing, Quality Circles. Productivity, Quality and Reengineering: The leverage of Productivity and Quality, Management systems Vs. Technology, Measuring Productivity, Improving Productivity Re-engineering.

UNIT – IV:

THE COST OF QUALITY: Definition of the Cost of Quality, Quality Costs, Measuring Quality Costs, use of Quality Cost Information, Accounting Systems and Quality Management.

UNIT – V:

ISO9000: Universal Standards of Quality: ISO around the world, The ISO9000 ANSI/ASQCQ-Series Standards, benefits of ISO9000 certification, the third-party audit, Documentation ISO9000 and services, the cost of certification implementing the system.

TEXT BOOKS:

1. Total Quality Management / Joel E.Ross/Taylor and Franscis Limited
2. Total Quality Management/P.N.Mukherjee/PHI

REFERENCES:

1. 1 Beyond TQM / Robert L.Flood
2. 2 Statistical Quality Control / E.L. Grant / McGraw Hill.
3. 3 Total Quality Management- A Practical Approach/H. Lal
4. 4 Quality Management/KanishkaBedi/Oxford University Press/2011
5. 5 Total Engineering Quality Management/Sunil Sharma/Macmillan

Course Outcomes:

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

1. Analyze the concepts of TQM, Quality and Business performance
2. Illustrate importance of customer satisfaction and loyalty
3. Analyze Organizing for quality implementation
4. Interpret the concept of cost of quality
5. Analyze ISO 9000 universal standards of quality

III Year-II Semester	Open Elective-II	L	T	P	C
		3	0	0	3
INDUSTRIAL ROBOTICS					

Course Objectives:

The students will acquire the knowledge:

1. To Analyze various applications of robotics and classification of coordinate system and control systems
2. To interpret the concepts of components of industrial robotics.
3. To analyze kinematic analysis with D-H notation, forward and inverse kinematics and solve dynamic analysis with Lagrange – Euler and Newton – Euler formulations
4. To Interpret trajectory planning for a manipulator by avoiding obstacles
5. To analyze different types of actuators and applications of robots in manufacturing

UNIT-I

INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system.

UNIT – II

COMPONENTS OF THE INDUSTRIAL ROBOTICS: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.

UNIT – III

MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.

MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems. Differential transformation and manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formulations – Problems.

UNIT IV

General considerations in path description and generation. Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion –straight line motion – Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT V

ROBOT ACTUATORS AND FEED BACK COMPONENTS:

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors.

ROBOT APPLICATIONS IN MANUFACTURING: Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection.

TEXT BOOKS:

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Robotics / John J. Craig/ Pearson

REFERENCE BOOKS:

1. Theory of Applied Robotics /Jazar/Springer.
2. Robotics / Ghosal / Oxford

Course outcomes:

Upon successful completion of this course student should be able to:

1. Analyze various applications of robotics and classification of coordinate system and control systems
2. Interpret the concepts of components of industrial robotics.
3. Analyze kinematic analysis with D-H notation, forward and inverse kinematics and solve dynamic analysis with Lagrange – Euler and Newton – Euler formulations
4. Interpret trajectory planning for a manipulator by avoiding obstacles
5. Analyze different types of actuators and applications of robots in manufacturing

Note: The students who already opted the subject name- Industrial Robotics in Professional elective need to opt for a different subject.

III Year-II Semester	Professional Core	L	T	P	C
		0	0	3	1.5
HEAT TRANSFER LAB					

Course objectives:

The student will acquire

The laboratory course is aimed to provide the practical exposure to the students with regard to the determination of amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

1. Determination of overall heat transfer co-efficient of a composite slab
2. Determination of heat transfer rate through a lagged pipe.
3. Determination of heat transfer rate through a concentric sphere
4. Determination of thermal conductivity of a metal rod.
5. Determination of efficiency of a pin-fin
6. Determination of heat transfer coefficient in natural and forced convection
7. Determination of effectiveness of parallel and counter flow heat exchangers.
8. Determination of emissivity of a given surface.
9. Determination of Stefan Boltzman constant.
10. Determination of heat transfer rate in drop and film wise condensation.
11. Determination of critical heat flux.
12. Determination of Thermal conductivity of liquids and gases.
13. Investigation of Lambert's cosine law.

Course Outcomes:

At the end of the course the students shall be able to:

1. Find the thermal conductivity of different materials, composite slabs and powders.
2. Solve heat transfer coefficient for free and forced convection and pin fin efficiency for forced and free convection
3. Examine the Stefan Boltzmann Constant and emissivity of grey body
4. Compare parallel and counter flow heat exchanger performance characteristics and investigation of Lambert's cosine law
5. Solve the heat transfer rate through lagged pipes and heat transfer rate in film and drop wise condensation

III Year-II Semester	Skill Oriented Course	L	T	P	C
		0	1	2	2
ROBOTICS & DRONE TECHNOLOGY					

Course Objectives: This course aims to

1. To develop the students' knowledge in various robot and drone structures and their workspace.
2. To develop multidisciplinary robotics that have practical importance by participating in robotics Competitions
3. To develop students' skills in performing spatial transformations associated with rigid body motions, kinematic and dynamic analysis of robot systems.
4. Through projects done in lab, increase the true hands-on student learning experience and enhance their conceptual understanding, increase students' ability, competence and teamwork skills on dealing with real life engineering problems

Lab Experiments:

1. Assembling of robot mechanical components, mounting of motors, sensors, electronic circuits to the chassis.
2. Connecting to electronic circuitry: motor drivers, incremental encoders proximity sensors, micro controller,
3. Different types of batteries, selection of suitable battery for application, safety precaution.
4. Introduction to Linux Command Line Interface: basic file and directory management and other useful commands
5. Controlling robot using Python: i) Move robot using Python code, ii) Make robot move in patterns using Python
6. Robot programming with Sensor inputs: i) Read sensor data using Python, ii) Visualize sensor data using Python, iii) Code robot to avoid obstacles by using sensor data
7. Open CV: i) Create an Image and display an image; ii) Read and change pixel values; iii) Create colored shapes and save image; iv) Extract the RGB values of a pixel; v) Reading and Writing Videos
8. Open CV: i) Extraction of Regions of Interest; ii) Extraction of RGB values of a pixel
9. Coding robot to work with colors, follow colored objects, identifying shape of the object-oriented
10. Projects: i) Making a line follower robot using a Camera; ii) Writing code for a complex function
11. Assembly of a drone

Course Outcomes: After completion of this course, students will be able to

1. Demonstrate knowledge of the relationship between mechanical structures of robotics and their operational workspace characteristics
2. Interpret mechanical components, motors, sensors and electronic circuits of robots and build robots.
3. Demonstrate knowledge of robot controllers.
4. Use Linux environment for robotic programming.
5. Write Python scripts to control robots using Python and Open CV

III Year-II Semester	Skill Oriented Course	L	T	P	C
		0	1	2	2
COMPUTER AIDED MANUFACTURING LAB					

Course Objectives:

The students will acquire the knowledge

- To model of simple machine parts and assemblies from the part drawings using standard CAM packages.
- To generate CNC Turning codes for different operations using standard CAM packages.
- To generate CNC Milling codes for different operations using standard CAM packages.
- To learn various fields of engineering where these tools can be effectively used to improve the output of a product.
- To impart knowledge on how these tools are used in Industries by solving some real time problems using 3-D printing equipment.

List of Experiments:

1. Study and prepare the Manual Part program for CNC Turn machine
2. Study and prepare the Manual Part program for CNC Mill machine
3. Study of various post processors used in NC Machines.
4. Machining of simple components on NC lathe by transferring NC Code / from a CAM package through RS 232.
5. Machining of simple components on NC Mill by transferring NC Code / from a CAM package through RS 232.
6. Automated CNC Tool path, G-Code & M-Code generation using CAM.
7. Study and prepare the Computer Aided Part-program for CNC Milling machine with APT (Automatically programmed Tools) language
8. Study and prepare the Computer Aided Part-program for CNC Turning machine with APT (Automatically programmed Tools) language
9. Study on 3-D printing equipment and prepare 3D Model to print using Idea maker software on 3-D printing equipment.
10. Prepare and create a simple box using 3-D printing equipment.

Course Outcomes:

Upon successful completion of this course student should be able to:

1. Interpret the concepts of simple machine parts and assemblies from the part drawings using standard CAM packages. (BL-2)
2. Illustrate the concepts of CNC Turning codes for different operations using standard CAM packages. (BL-2)
3. Solve CNC Milling codes for different operations using standard CAM packages. (BL-3)
4. Analyze the concepts of CNC programming for various operations of milling (BL-4)
5. Interpret the study of tools that are used in Industries by solving some real time problems using 3- D printing equipment. (BL-5)