COURSE STRUCTURE (R19)
AND
DETAILED SYLLABUS
(IV YEAR)

MECHANICAL ENGINEERING

For
B.Tech, Four Year Degree Course
(Applicable for the batches admitted from 2019-20)

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUK, Kakinada
Accredited by NAAC with "A" Grade and NBA (CSE, ECE, EEE & ME)
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IV YEAR – I SEMESTER							
S. No.	**Course code**	**Course Title**	**Category**	**L**	**T**	**P**	**Credits**
1	R19MEC-PC4101	Robotics	PC	3	0	0	3
2	R19MEC-PC4102	Engineering Metrology	PC	3	0	0	3
3	R19MEC-PC4103	Operations Research	PC	3	0	0	3
4		**PROFESSIONAL ELECTIVE –III**	PE	3	0	0	3
	R19MEC-PE4101.1	1. Automobile Engineering					
	R19MEC-PE4101.2	2.Power Transmission in Hybrid and Electric Vehicles					
	R19MEC-PE4101.3	3.Automation in Manufacturing					
	R19MEC-PE4101.4	4.Cryogenic Engineering					
5		**OPEN ELECTIVE -III**	OE	3	0	0	3
	R19ECE-OE4101.1	1.Mechatronics					
	R19BSH-OE4101.2	2. Total Quality Management & Six Sigma					
	R19CSE-OE4101.3	3. Internet of Things (IoT)					
	R19MEC-OE4101.4	4.MOOCS*[Multi-Disciplinary]					
6	R19MEC-PC4104	Engineering Metrology Lab	PC	0	0	2	1
7	R19MEC-PC4105	Computational fluid Dynamics Lab	PC	0	0	2	1
8	R19MEC-PJ4101	Mini Project	PJ	0	0	8	4
9	R19MEC-SD4101	Skill Development Course -2 Hyper Meshing and Analysis	SD	0	0	3	0
			Total	**15**	**0**	**15**	**21**
***Honors Course -4/Minor Course-4**							
Summer Internship-2(Evaluation in IV-I)							

** Select subject from any other Engineering discipline other than mechanical discipline as per the guidelines from the BOS Chairman.*

**The Eligible students who opted the courses for B.Tech with Honors/Minor only*

Note: L-Lecture, T-Tutorial, P-Practical, C-Credits

IV YEAR – II SEMESTER							
S.No.	**Course code**	**Course Title**	**Category**	**L**	**T**	**P**	**Credits**
1		**Professional Elective –IV**	PE	3	0	0	3
	R19MEC-PE4201.1	1.Gas Dynamics and Jet Propulsion					
	R19MEC-PE4201.2	2.Nano Materials					
	R19MEC-PE4201.3	3.Tribology					
	R19MEC-PE4201.4	4.Production Planning and control					
	R19MEC-PE4201.5	5. MOOCS*					
2		**Professional Elective –V**	PE	3	0	0	3
	R19MEC-PE4202.1	1. Alternative fuels and Emission Control in Automotives.					
	R19MEC-PE4202.2	2. Non Destructive Evaluation					
	R19MEC-PE4202.3	3. Industrial Safety and Hazard Management					
	R19MEC-PE4202.4	4. CNC and Adaptive Control					
	R19MEC-PE4202.5	5. MOOCS*					
3	R19MEC-PJ4201	Project	PI	0	0	16	8
			Total	**6**	**0**	**16**	**14**

** Select subject from mechanical discipline as per the guidelines from the BOS Chairman.*

IV Year –I Semester

Subject Code	Subject Name	L	T	P	C
R19MEC-PC4101	Robotics	3	0	0	3

Course Objectives: The goal of the course is to familiarize the students with the concepts and techniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.

1. Make the students acquainted with the theoretical aspects of Robotics
2. Enable the students to acquire practical experience in the field of Robotics
3. Understand forward and inverse kinematics of robot manipulator
4. Program a Robot for material handling.

Course Outcomes

Upon completion of this course, students will be able to

1. ***understand*** the basic components of robots .(L2)
2. ***differentiate*** types of robot grippers. (L2)
3. ***explain*** the manipulator kinematics. (L2)
4. ***illustrate*** robot actuators and feedback components. (L2)
5. ***elucide*** the robot applications in manipulator. (L2)

UNIT-I

Robotics-Introduction-classification with respect to geometrical configuration (Anatomy), Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability-Dynamic characteristics- speed of motion, load carrying capacity & speed of response-Sensors-Internal sensors: Position sensors,& Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors.

Learning outcomes:

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

1. ***classify*** robots with respect to geometric configuration.(L2)
2. ***illustrate*** the components of robots.(L2)

UNIT-II

Grippers - Mechanical Gripper-Grasping force-Engelberger-g-factors-mechanisms for actuation, Magnetic gripper , vaccume cup gripper-considerations in gripper selection & design . Industrial robots specifications. Selection based on the Application .

Learning outcomes:

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

1. ***understand*** the mechanisms for grippers. (L2)
2. ***explain*** the factors for gripper selection. (L2)

UNIT-III

Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation.

Manipulator Kinematics-H notation –H method of Assignment of frames –H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics, Industrial Robotic Manipulation.

Learning outcomes:

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

1. ***understand*** the basic Rotation matrices. (L2)
2. ***explain*** the forward and inverse kinematics. (L2)

UNIT-IV

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors – End Effectors and Tools

Learning outcomes:

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

1. ***compare*** the robot actuators. (L2)
2. ***explain*** the sensors used in Robotics. (L2)

UNIT-V

Robot Application in Manufacturing: Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

Learning outcomes:

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

1. ***explain*** the role of robotics in material handling in industries. (L2)
2. ***understand*** the Robotic Programming methods.(L2)

TEXT BOOK(S):

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

REFERENCE(S):

1. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson
2. Robot Dynamics and controls / Spony and Vidyasagar / John Wiley

Subject Code	Subject Name	L	T	P	C
R19MEC-PC4102	Engineering Metrology	3	0	0	3

Course objectives:
The objectives of the course are to
- Inspection of engineering parts with various precision instruments
- Design of Components tolerances and fits
- Principles of measuring instruments and gauges and their uses
- Evaluation and inspection of surface roughness
- Inspection of spur gear and thread elements

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

1. ***understand*** the systems of limits and fits. (L2)
2. ***illustrate*** the measurement of linear and angular measurements. (L2)
3. ***elucidate*** the working principles of optical measuring instruments and flatness measuring instruments (L2)
4. ***understand*** the procedure for Gear measurement and Screw thread measurement.(L2)
5. ***understand*** the procedure to conduct alignment tests on machine tools.(L2)

UNIT-I

SYSTEMS OF LIMITS AND FITS: Introduction, nominal size, tolerance, limits, deviations, fits - Unilateral and bilateral tolerance system, hole and shaft basis systems- interchangeability, and selective assembly. International standard system of tolerances, selection of limits and tolerances for correct functioning.

Learning outcomes:
Students will be able to
1. ***compare*** the applications of unilateral and Bilateral tolerance system (L2)
2. ***find*** the type of fit as per the specification of the Components (L2)

UNIT-II

LINEAR MEASUREMENT: Length standards, end standards, slip gauges- calibration of the slip gauges, dial indicators, micrometers.
MEASUREMENT OF ANGLES AND TAPERS: Different methods – bevel protractor, angle slip gauges- angle dekkor- spirit levels- sine bar- sine table, rollers and spheres used to measure angles and tapers.
LIMIT GAUGES: Taylor's principles – design of go and no go gauges; plug, ring, snap, gap, taper,

Learning outcomes:
Students will be able to
1. ***understand*** the standards of length, angles, (L2)
2. ***understand*** the Measurement Of Angles And Tapers (L2)

UNIT-III

OPTICAL MEASURING INSTRUMENTS: Tools maker's microscope and uses - autocollimators, optical projector, optical flats and their uses.

INTERFEROMETRY: Interference of light, Michelson's interferometer, NPL flatness interferometer, and NPL gauge interferometer.

FLATNESS MEASUREMENT: Measurement of flatness of surfaces- instruments used-straight edges- surface plates.

Learning outcomes:

Students will be able to

1. ***understand*** the Measurement of flatness of surfaces (L2)
2. ***understand*** the Different Types of Interferometry And Their Applications (L2)

UNIT-IV

GEAR MEASUREMENT: Nomenclature of gear tooth, tooth thickness measurement with gear tooth vernier & flange micro meter, pitch measurement, total composite error and tooth to tooth composite errors, rolling gear tester, involute profile checking.

SCREW THREAD MEASUREMENT: Elements of measurement – errors in screw threads- concept of virtual effective diameter, measurement of effective diameter, angle of thread and thread pitch, and profile thread gauges

Learning outcomes:

Students will be able to

1. ***choose*** appropriate method and instruments for inspection of various gear elements and thread elements. (L2)
2. ***explain*** errors in screw threads- concept of virtual effective diameter,measurement of effective diameter(L2)

UNIT – V

SURFACE ROUGHNESS MEASUREMENT: Differences between surface roughness and surface waviness – Numerical assessment of surface finish-CLA, Rt., R.M.S. Rz, R10 values, Method of measurement of surface finish – Profilograph, Talysurf, ISI symbols for indicationof surface finish.

COMPARATORS: Types - mechanical, optical, electrical and electronic, pneumatic comparators and their uses.

MACHINE TOOL ALIGNMENT TESTS: Principles of machine tool alignment testing onlathe, drilling and milling machines.

Learning outcomes:

Students will be able to

1. ***compare*** the surface roughness measurements(L2)
2. ***understand*** the different types of comparators and their uses(L2)
3. ***understand*** the alignment test on different types of machine tools. (L2)

Text Books:

1. Dimensional Metrology/Connie Dotson/Cengage Learning
2. Engineering Metrology / R.K.Jain / Khanna Publishers

References:

1. Engineering Metrology / Mahajan / Dhanpat Rai Publishers
2. Engineering Metrology / I.C.Gupta / Dhanpat Rai Publishers
3. Precision Engineering in Manufacturing / R.L.Murthy / New Age
4. Engineering Metrology and Measurements / NV Raghavendra, L Krishna murthy/ Oxfordpublishers.
5. Engineering Metrology / KL Narayana/Scitech publishers

Subject Code	Subject Name	L	T	P	C
R19MEC-PC4103	Operations Research	3	0	0	3

Course Objectives:

The objectives of the course are to

- impart the concepts of mathematical modeling for optimization of the resources.
- apply the algorithms to solve the Linear Programming, transportation and assignment problems.
- optimize the channels in waiting lines of manufacturing and service systems.
- determine the best strategy under competitive business environment
- understand Project scheduling and optimizing the duration of the project
- simulate real life probabilistic situations with Montecarlo simulation technique.

Course Pre-Requisites:

Basic concepts of statistics: random variables, discrete probability distributions, Poisson and normal Probability distributions.

Course Outcomes

After completing the course, the student will be able to

1. ***construct*** mathematical model for allocation problems. (L3)
2. ***test*** for optimality to arrive optimal solution for transportation and assignment problems(L 4)
3. ***solve*** the problems of waiting lines and scheduling to arrive the optimal decisions. (L3)
4. ***apply*** the concepts of PERT and CPM for project management. (L3)
5. ***develop*** simulation model of discrete systems under uncertainties. (L4)

UNIT I

Introduction to Operations Research (OR): OR definition - Classification of Models, modeling – Methods of solving OR Models, limitations and applications of OR models.

Linear Programming(LP): Problem Formulation, Graphical Method, Special Cases of LP- Degeneracy, Infeasibility and Multiple Optimal Solutions; Simplex Method, Big- M simplex Method, Dual simplex method, application of L.P.P. in manufacturing firms.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** the development of models in Operations Research (L2)
- ***explain*** **the** application areas of operations research in manufacturing and service firms. (L2)
- ***construct*** the mathematical model for allocation problems (L3)
- ***solve*** linear programming problems(L3)

UNIT II

Transportation and Assignment Problems: Transportation Problem – Formulation; Different Methods of Obtaining Initial Basic Feasible Solution –North West Corner Rule, Least Cost Method, Vogel's Approximation Method; Optimality Method – Modified Distribution (MODI) Method; Special Cases – Unbalanced Transportation Problem, Degenerate Problem. Assignment Problem – Formulation, Hungarian Method for Solving Assignment Problems, Traveling Salesman problem. application of Transportation and Assignment Problems in manufacturing firms.

Learning Outcomes:

At the end of the this unit, the student will be able to

- ***develop*** mathematical model for transportation and assignment Problems(L4)
- ***apply*** algorithms to obtain initial basic feasible solution for transportation Problem(L3)
- ***determine*** the optimal solution for Transportation problems. (L3)
- ***test for*** optimality to arrive optimal solution for transportation problem(L4)
- ***apply*** hungarian algorithm to assignment and traveling Salesman problems. (L3)

UNIT III

Game theory: Optimal solution of two person zero sum games, the max min and min max principle. Games without saddle points, mixed strategies. algebraic method, Reduction by principles of dominance, graphical method for [2x n] and [mx2] game problems.

Sequencing: Sequencing the jobs in flow shop scheduling, Solution of Sequencing Problem, Processing of n Jobs through two machines, Processing of n Jobs through three machines, priority rules.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***identify*** the optimal strategies in competitive situations (L3)
- ***solve*** pay off matrix games using dominance rules and algebraic method. (L3)
- ***choose*** optimal sequence of jobs for scheduling (L3)

UNIT IV

Network Analysis: Network Representation, rules for drawing network, Fulkerson's Rule, Determination of Earlier Starting Time and Earliest Finishing Time in the Forward Pass – Latest Starting Time and Latest Finishing Time in Backward Pass, determination of critical path, total float calculation, Time estimates in PERT, Probability of completing the project, project cost, project crashing, Optimum project duration, Project management.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***construct*** the network diagram (L3)
- ***compute*** the starting time, finishing times in the forward Pass and backward Pass methods(L2)
- ***identify*** the Critical Path in the project(L3)
- ***find*** the probability of completing the project with PERT (L3)
- ***understand*** the concept of Project management (L2)
- ***determine*** the optimum project duration(L3)

UNIT V

Queuing Theory: Introduction – Basic queuing process, basic structure of queuing models terminology: arrival Pattern, service channel, population, departure pattern, queue discipline, Kendall's notation. Single Channel model with poisson arrivals, exponential service times with infinite queue length

Simulation: Basic concept of simulation, applications of simulation, merits and demerits of simulation, Monte Carlo simulation, simulation of Inventory system, simulation of Queuing system.

Learning Outcomes:
At the end of this unit, the student will be able to

- ***understand*** the basic structure of queuing models and characteristics (L2)
- ***explain*** the goals of designing waiting line model (L2)
- ***compute*** parameters of the single channel waiting line (L3)
- ***design*** the discrete event simulation model for waiting line (L4)

Text books:

1. Sharma S.D., Operations Research: Theory, Methods and Applications, 15th Edition, Kedar Nath Ram Nath.
2. Prem kumar Gupta and Hira, Operations Research, 3rd Edition, S Chand Company Ltd., New Delhi.

Reference books:

1. Hiller F.S., and Liberman G.J., Introduction to Operations Research, 7th Edition, Tata McGraw Hill.
2. Sharma J.K., Operations Research: Theory and Applications, 4th Edition, Laxmi Publications.
3. Taha H.A., Operations Research, 9th Edition, Prentice Hall of India, New Delhi.
4. Pannerselvam R., Operations Research, 2nd Edition, Pentice Hall of India, New Delhi.
5. Sundaresan.V, and Ganapathy Subramanian.K.S, Resource Management Techniques: Operations Research, A.R Publications.

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4101.1	Automobile Engineering (**Professional Elective –III)**	3	0	0	3

Course Objectives

The objectives of the course are

- understand the parts of the automobile systems.
- understand the power transmission systems
- understand steering geometry and classification of steering gear mechanisms.
- create awareness on suspension system, braking system and electrical system.
- follow the safety standards and emissions controlling methods.

Course Outcomes

After completing the course, the student will be able to

- ***Illustrate*** the construction features of automobile engines and parts.[L2]
- ***Analyze*** parts/modules in transmission system. [L4]
- ***Explain*** types of steering mechanisms.[L2]
- ***Outline*** the working /features of suspension, braking and electrical systems. [L2]
- ***Analyze*** the methods for emission control of engine. [L4]

UNIT- I

Introduction To Automobile and Engine Construction : Layout 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 details, turbo charging and super charging- valve mechanisms-types– engine lubrication, splash and pressure lubrication systems, oil filters– crank case ventilation –cooling system –types

Applications: Automobile vehicles

Learning Outcomes:

At the end of this unit the student will be able to

- ***identify*** different types of automobiles.(L3)
- ***explain*** various parts of the engine.(L2)
- ***explain*** the lubrication and cooling system in IC Engines.(L2)

UNIT- II

Transmission system: Clutches - Function - Types - Single plate, Multiple plate, Cone clutch and Diaphragm Clutch – Fluid coupling - Gearbox - Sliding - Constant - Synchromesh - Overdrive – Torque converter - Continuously variable transmission - Universal joint - Propeller shaft - Drive types - Differential - rear axles– types – wheels and tyres.

Applications: Automobile vehicles, Marine Engines, Aerospace vehicles

Learning Outcomes:

At the end of this unit the student will be able to

- ***explain*** clutch functionality and transmission systems. (L2)
- ***identify*** the functionality of differential. (L2)
- ***explain*** the rear axle assembly. (L2)

UNIT- III

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

Application: Automobile vehicles, Marine Engines, Aerospace vehicles

Learning Outcomes:

At the end of this unit the student will be able to

- ***explain*** types of steering mechanisms.[Level 2]
- ***illustrate*** the steering geometry.(L2)

UNIT-IV

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

BRAKING SYSTEM: Mechanical brake system, hydraulic brake system, master cylinder, wheel cylinder tandem master cylinder, pneumatic and vacuum brakes.

ELECTRICAL SYSTEM: Wiring diagram of 4-wheeler and 2-wheeler, battery construction-ignition types– current regulator - voltage regulator - current - voltage regulator – bendix drive , solenoid switch, Charging circuit, horn circuit, wiper circuit.

Applications: Automobile vehicles

Learning Outcomes:

At the end of this unit the student will be able to

- ***identify*** the various electrical components in automobile.(L3)
- ***illustrate*** the components of braking systems.(L3)

UNIT- V

Automobile safety and Emission control: Safety and security - Seat belts - Air bags - Electronic Control Unit (ECU) - Anti lock brake system (ABS) - Active Suspension System (ASS) - Electronic Brake Distribution (EBD) – Electronic Stability Program(ESP)-Traction Control System (TCS) - Global Positioning System (GPS) - Types of pollutants, mechanism of formation, exhaust gas treatment-thermaland catalytic converters-use of alternative fuels for emission control – National and International pollution standards

Applications: Automobile vehicles

Learning Outcomes:

At the end of this unit the student will be able to

- ***explain*** the safety systems in automobile. (L2)
- ***undestand*** the emission controlling methods.(L3)

Text Books:

1. Kirpal Singh, Automobile Engineering, Vol.1&2, Standard Publications.
2. Automobile engineering by R B Gupta , Satya Prakashan publications (P) Ltd.
3. Richard Stone, Jeffrey K. Ball, Automotive Engineering Fundamentals" SAEInternational.
4. Automobile engineering by R K Rajput-Laxmi publications (P) Ltd.

Reference Books:

1. William.H.Crouse, Automotive Mechanics, 10/e Edition, McGraw-Hill.
2. David A. Corolla, Automotive Engineering: Power train, Chassis System and VehicleBody,Butterworth-Heinemann Publishing Ltd.
3. Bosch, Automotive Hand Book, 6/e SAE Publications year.
4. K. Newton and W. Steeds, The motor vehicle, 13/e Butterworth-HeinemannPublishing Ltd.

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4101.2	Power Transmission in Hybrid and Electric Vehicles (**Professional Elective –III)**	3	0	0	3

Course Objectives:
The objectives of the course are to

- provide good foundation on hybrid and electrical vehicles.
- address the underlying concepts and methods behind power transmission in hybrid andelectrical vehicles.
- familiarize energy storage systems for electrical and hybrid transportation.
- Understand specifications of electrical devices
- Understand the design consideration for electrical system body

Course outcomes:

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

1. ***explain*** the working of hybrid and electric vehicles. (L2)
2. ***select*** a suitable drive scheme for developing a hybrid and electric vehicles depending onresources. (L4)
3. ***develop*** the electric propulsion unit and its control for application of electric vehicles.(L4)
4. ***choose*** proper energy storage systems for vehicle applications. (L3)
5. ***design*** and develop basic schemes of electric vehicles and hybrid electric vehicles.(L3)

UNIT I

Introduction to Hybrid and Electric Vehicles: History of hybrid and electric vehicles, Need for hybrid and electric vehicles and their limitations. Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Specifications of hybrid and electric vehicles.

Applications: e- mobility vehicles

Learning outcomes:

At the end of this unit, the students will be able to

1. ***summarize*** the concepts and recent trends in electrical and hybrid vehicles. (L2)
2. ***demonstrate*** the need for hybrid and electric vehicles and their limitations. (L2)
3. ***compare*** modern drive-trains with conventional drive-trains. (L2)

UNIT II

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

Applications: Motor driven wheels etc.

Learning outcomes:

At the end of this unit, the students will be able to

1. ***choose*** a suitable drive scheme for developing an hybrid and electric vehiclesdepending on resources.(L1)
2. ***explain*** power flow control in hybrid drive-train topologies. (L2)
3. ***compare*** hybrid electric drive-trains and electric drive-trains. (L2)

UNIT III

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Applications: space vehicles, satellites, etc.

Learning outcomes:

At the end of this unit, the students will be able to

1. ***choose*** a suitable drive scheme for developing an hybrid and electric vehiclesdepending on resources.(L3)
2. ***explain*** power flow control in hybrid drive-train topologies.(L2)
3. ***compare*** hybrid electric drive-trains and electric drive-trains.(L2)

UNIT IV

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, Fuel Cell based energy storage, Super Capacitor based energy storage, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

Applications: Automobile energy storage systems

Learning outcomes:

At the end of this unit, the students will be able to

1. ***explain*** fundamental electrochemistry of battery operation and performancerequirements for HEV, PHEV, EREV and full electric vehicles. (L2)
2. ***summarize*** different approaches to estimating state of charge, state of health,power and energy. (L2)
3. ***illustrate*** matching the electric machine and the internal combustion engine. (L2)

UNIT V

Design Considerations For Electric Vehicles: Various Resistance- Transmission efficiency- Vehicle mass- Electric vehicle chassis and Body design considerations- Heating and cooling systems- Power steering- Tire choice- Wing Mirror, Aerials and Luggage racks.

Applications: Design of electric vehicles

Learning outcomes:

At the end of this unit, the students will be able to

1. ***design*** and develop basic schemes of electric and hybrid electric vehicles. (L3)
2. ***select*** the suitable transmission systems.(L5)

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2/e, CRC Press.
2. Amir Khajepour, M. SaberFallah, AvestaGoodarzi, Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach, illustrated edition, John Wiley & Sons.
3. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley.
2. John G. Hayes, G. Abas Goodarzi, Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, 1/e, Wiley-Blackwell.

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4101.3	Automation in Manufacturing (**Professional Elective –III)**	3	0	0	3

Course Objectives

The objectives of the course are to

- understand the concept of automation and process control systems.
- Classify the automated flow lines and analyze automated flow lines
- Able to balance the operations on assembly line.
- design automated material handling systems.
- Understand the level of automation in continuous and discrete manufacturing systems.

Course Outcomes

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

1. ***understand*** the characteristics of Automated Systems. (L2)
2. ***illustrate*** operational aspects of flow lines. (L2)
3. ***apply*** heuristic methods to balance the assembly line. (L3)
4. ***compare*** conventional and automated material transport, storage system. (L3)
5. ***explain*** the control systems, level of automation in continuous and discrete manufacturingindustries. (L2)

UNIT I

INTRODUCTION TO AUTOMATION: Types, strategies and levels of automation, Basic elements of an automated system, Types of production, pneumatic and hydraulic components, circuits, automation in machine tools, mechanical feeding and tool changing and machine tool control.

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** the essential elements of an automated system related to differentmanufacturing industries.(L2)
- ***explain*** different types of automation strategies and levels of automation.(L2)

UNIT II

AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

Learning outcomes:

After completion of this unit, students will be able to

- ***illustrate*** part transfer methods and mechanisms in automated flow lines. (L2)
- ***explain*** flow lines with/without buffer storage. (L2).

UNIT III

ASSEMBLY LINE BALANCING: Assembly process and systems, assembly line, linebalancing methods, ways of improving line balance, flexible assembly lines.
FMS: Types of FMS, components of FMS, Types of flexibility, types of FMS layouts

Learning outcomes:
After completion of this unit, students will be able to

- ***explain*** line balancing methods(L2)
- ***apply*** line balancing methods for assembly line balancing for improving lineefficiency.(L3)
- ***explain*** the features of flexible assembly line.(L2)

UNIT IV

MATERIAL HANDLING SYSTEMS: Introduction to Material Handling, Material Transport equipment, analysis of material transport systems, **storage systems**–storage system performance and location strategies, Conventional storage methods and equipment, Automated storage systems, Engineering analysis of storage systems.

AUTOMATIC IDENTIFICATION METHODS: Overview of Identification Methods,Barcode technology, Radio frequency identification, other AIDC technologies

Learning outcomes:
After completion of this unit, students will be able to

- ***explain*** material transport equipment required in automated systems (L2)
- ***compare*** conventional and automated storage systems(L2)
- ***summarize*** various storage methods and equipment(L2)

UNIT V

INDUSTRIAL CONTROL SYSTEMS: Process industries Vs Discrete manufacturing industries, levels of automation in the two industries, variables and parameters in the two industries. Continuous Vs Discrete control –continuous control system, discrete control system
AUTOMATED INSPECTION: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** industrial control systems (L2)
- ***compare*** automation in Continuous and discrete control systems (L2)
- ***understand*** different types of automated inspection techniques and their applications. (L2)

TEXTBOOKS:

1. M.P. Groover, Automation, Production systems and Computer IntegratedManufacturing,3/e,PHI Learning.
2. Geoffrey Boothroyd, Assembly Automation and Product design, Taylor and Francis Publishers.
3. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel, Nicholas, G. Odrey, IndustrialRobotics, McGraw Hill.

REFERENCEBOOKS:

1. Krishna Kant, Computer based industrial control, Prentice Hall of India.
2. Tiess Chiu chang and A. W. Richard, An introduction to automated process planning systems, Tata Mc Graw Hill.
3. Shivananda HK, Beral MM, Koti V, Flexible Manufacturing Systems, New age publications

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4101.4	Cryogenic Engineering (**Professional Elective -III**)	3	0	0	3

Course Objectives:

The objectives of the course are

- To provide the knowledge of evolution of low temperature science
- To provide knowledge on the properties of materials at low temperature
- To familiarize with various gas liquefaction systems
- To provide design aspects of cryogenic storage and transfer lines
- To illustrate the applications of cryogenics in the real life situations

Course outcomes:

After successful completion of this course, student will be able to

1. ***understand*** properties of material at cryogenic temperatures. (L2)
2. ***summarize*** various liquefaction systems available (L2)
3. ***analyze*** on different gas liquefaction systems and cryogenic refrigeration systems(L4)
4. ***outline*** various design aspects of cryogenic storage and transfer lines (L2)
5. ***apply*** different cryogenic condition in real life situations (L3)

UNIT-I

Introduction to Cryogenic Systems, Historical development, Low Temperature properties of Engineering Materials, Mechanical properties- Thermal properties- Electric and magnetic properties –Cryogenic fluids and their properties. Applications of Cryogenics.

Learning outcomes:

After completion of this unit, the student will be able to

- ***understand*** material properties at low temperatures (L2)
- ***outline*** **the** properties of cryogenic fluids and their applications (L2)
- ***explain*** the development of cryogenic systems (L2)

UNIT-II

Liquefaction systems for ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude & Cascaded System, Magnetic Cooling, Stirling Cycle
,Cryo Coolers

Learning outcomes:

After completion of this unit, the student will be able to

- ***understand*** liquefaction systems available in practice (L2)
- ***apply*** Linde Hampson cycle for cryogenic fluid generation(L3)

- ***outline*** the performance of cryo coolers (L3)

UNIT-III

Gas liquefaction systems: Introduction-Production of low temperatures-General Liquefaction systems- Liquefaction systems for Neon. Hydrogen and Helium –Critical components of Liquefaction systems

Cryogenic Refrigeration systems: Ideal Refrigeration systems- Refrigeration using liquids and gases as refrigerant- Refrigerators using solids as working media

Learning outcomes:

After completion of this unit, the student will be able to
- ***summarize*** the effect of Critical components of Liquefaction systems (L2)
- ***understand*** Production of low temperature for Neon. Hydrogen and Helium (L2)
- ***illustrate*** Liquefaction systems for Neon. Hydrogen and Helium (L2)
- ***understand*** about Cryogenic Refrigeration systems. (L2)

UNIT-IV

Cryogenic fluid storage and transfer systems: Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems.

Learning outcomes:

After completion of this unit, the student will be able to
- ***understand*** the importance of cryogenic fluid storage.(L2)
- ***explain*** various types of storage vessels and transportation methods of cryogenic fluid(L2)
- ***summarize*** the importance of proper thermal insulation in cryogenic storage (L2)

UNIT-V

APPLICATIONS: Space technology, super conductivity, In-Flight air separation andcollection of LOX, Gas industry, Biomedical, Electronics, Cutting Tool technology.

Learning outcomes:

After completion of this unit, the student will be able to
- ***understand*** various applications of cryogenics (L2)
- ***illustrate*** the importance of cryogenics in biomedical application (L2)
- ***apply*** different cryogenic conditions for real life situations (L3)

TEXT BOOK:

1. Cryogenic Systems/ R.F.Barren/ Oxford University Press
2. H. Boll Jr, Cryogenic Engineering
3. R. B. Scott, Cryogenic Engineering, Van Nostrand Co.

REFERENCES:

1. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. NewJersey
2. Cryogenic Heat Transfer/ R.F.Baron
3. Cryogenic Engineering Edit / B.A. Hands/ Academic Press.
4. Cryogenic Engineering/ R.B.Scottm Vin Nostrand/ Inc. New Jersey.
5. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press.
6. Cryogenic Process Engineering/ K.D. Timmerhaus & TM Flynn/ Plenum Press.
7. Hand Book of Cryogenic Engineering – J.G.Weisend –II, Taylor and Francis.

Subject Code	Subject Name	L	T	P	C
R19ECE-OE4101.1	Mechatronics **'(Open Elective-III)**	3	0	0	3

Course Objectives

The Objectives of this course are

- To introduce the integrative nature of Mechatronics.
- To describe the different components and devices of mechatronics systems
- To describe various applications and future trends of mechatronics systems

Course Outcomes

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

1. Describe Mechatronics design process and mechatronics system devices (L2)
2. Illustrate Solid state electronic devices and its applications in various mechatronics systems (L2)
3. Identify the different types of electro mechanical systems and its applications (L4)
4. Analyze different types of Digital electronics and systems and its applications(L4)
5. Design of mechatronics systems for future trends. (L3)

Unit I

Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

Learning Outcomes:

- Different examples for mechatronics systems (L1)
- Advantages of mechatronics systems(L2)
- Application of different types of Sensors and transducers (L1)

Unit II

Solid state electronic devices - PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering.

Learning Outcomes:

- Different examples for Solid state electronic devices (L1)
- Different types of amplifiers and its applications (L1)

Unit III

Hydraulic and pneumatic actuating systems - Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

Learning Outcomes:

- Know about electro-pneumatic, hydro-pneumatic systems (L2)
- Applications of Mechanical actuating systems and electrical actuating systems (L4)

Unit IV

Digital electronics and systems, digital logic control, micro processors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control. Dynamic models and analogies, System response. Process Controllers – Digital Controllers, Programmable Logic Controllers

Learning Outcomes:

- Know about Digital electronics and systems (L2)
- Know about comparison of PLCs and computers (L2)
- Distinguish between Process Controllers and Programmable Logic Controllers (L4)

Unit V

System and interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

Learning Outcomes:

- How to interface the systems for the purpose of data acquisition (L2)
- Different types of ADC and DAC converters (L4)
- Design of mechatronics systems for furure trends (L3)

Text Books:

1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan & MS Balasundaram/WILEY India Edition

References:

1.Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford University Press

2. Mechatronics Source Book / Newton C Braga/Thomson Publications, Chennai.

3. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.

4. Mechatronics System Design / Devdas shetty/Richard/Thomson.

5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.

6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson, 2012

7.Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indian print

Subject Code	Subject Name	L	T	P	C
R19BSH-OE4101.2	Total Quality Management & Six Sigma (**Open Elective-III**)	3	0	0	3

Course Objectives:

The Objectives of this course are to

- Introduce the basic concepts of Total Quality Management.
- Expose with various quality issues in production systems.
- Gain Knowledge on imparting quality as per customer perspective
- Understand the concept of process control
- Get awareness on six sigma problem solving approach
- Understand the importance of Quality systems

Course outcomes:

After successful completion of this course, student will be able to

1. ***comprehend*** the importance of quality & role of statistical quality control.(L2)
2. ***analyze*** the assignable causes of variations in the process.(L4)
3. ***apply*** tools and techniques of Total Quality Management(L3)
4. ***develop*** the frame-work of Six Sigma programme (L3)
5. ***explain*** the Quality Systems in practice(L2)

UNIT –I

INTRODUCTION

Introduction to quality – Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs, Definition of Total quality management – history – stages of evolution– objectives – internal and external customers - Quality Management versus TQM. Customer Supplier Focus in TQM, Quality Loss Function , Quality function deployment(QFD).

Learning Outcomes:
At the end of this unit, the student will be able to

- ***explain*** the concepts of Total Quality Management. (L2)
- ***understand*** the cost of quality control(L2)
- ***elucidate*** the concept of QFD.(L2)

UNIT- II

STATISTICAL PROCESS CONTROL

Process capability: Natural Tolerance limits, Process capability index.
Control charts: Statistical basis of the Control Charts-principles, Control limits for mean and

range -Charts, analysis of pattern on control charts, Type I and Type II errors, p chart, c chart construction. Simple Numerical Problems.

Learning Outcomes:

At the end of this unit, the student will be able to

- **understand** statistical concepts related to control charts.(L2)
- **analyze** the assignable causes for process deviations. (L4)
- **construct** control charts for variables and attributes(L3)

UNIT -III

TOOLS AND TECHNIQUES OF TQM:

Check Sheets, Histograms, Scatter Diagrams, Cause and Effect Diagrams, Pareto Chart, TPM, Kaizen, JIT, Quality Circles, Five S principle, The PDCA Cycle, Failure Mode Effect Analysis(FMEA), Benchmarking.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***illustrate*** Quality control tools (L2)
- ***construct*** the Cause and Effect Diagrams for the manufacturing process (L3)
- ***apply*** five S principle for quality enhancement (L3)

UNIT- IV

SIX SIGMA

The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma Programme, Six Sigma Organization: Roles and Responsibilities, Six Sigma Problem Solving Approach, The DMAIC Model, Six Sigma Metrics: Cost of Poor Quality, Defects Per Million Opportunities andFirst Pass Yield, Benefits and Costs of Six Sigma.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** the Six Sigma Problem Solving Approach (L2)
- ***illustrate*** the DMAIC Model (L2)
- ***explain*** the benefits and costs of Six Sigma. (L2)

UNIT- V

QUALITY SYSTEMS

Need for ISO 9000 and Other Quality Systems, ISO 9000: 2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** the importance of ISO Standards. (L2)
- ***explain*** the significance of ISO9000 and Other Quality systems. (L2)
- ***compare*** ISO 9000 and ISO 14000. (L2)

TEXTBOOKS:

1. Subburaj Ramaswamy, Total Quality Management, Tata Mcgraw Hill Publishing CompanyLtd.,
2. *Statistical Quality Control,* M.*Mahajan, Dhanpat Rai* Publishing Co Pvt Ltd
3. Evans, J R and W M Lindsay, An Introduction to Six Sigma and Process Improvement, Cengage Learning.

REFERENCE BOOKS:

1. Introduction to statistical quality control: By D.C. Montgomery 4th Edition, John Wiley&Sons.Inc.
2. Forrest W. Breyfogle , Implementing Six Sigma, John Wiley & Sons, Inc.
3. Statistical Quality Control – R.C. Gupta– Khanna Publishers, Delhi
4. Grant,E,L. and Laven Worth, R.S.: Statistical Quality Control, McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R19ECE-OE4101.3	Internet of Things (IOT) (**Open Elective-III)**	3	0	0	3

Course Objectives:
Faculty are going to
1. Introduce the basic terminology and functions of Internet of things.
2. List the connectivity and networking of devices in IoT.
3. Show the development of a Arduino and raspberry Pi based systems.
4. Provide the data processing in a IoT system.
5. List the domains and case studies in extended IoT systems.

Course Outcomes:
At the end of the Course, the Student will be able to:
1. Summarize the IoT characteristics, principles and design methodology. (L2)
2. Examine the typical connectivity and networking protocols typically used in a IoT design. (L4)
3. Demonstrate design and development of embedded applications using Arduino and Raspberry Pi platforms. (L3)
4. Recognize the importance of data processing and cloud services for IoT. (L2)
5. Illustrate the different domains and applications of IoT eco-system. (L4)

UNIT-I
Introduction to Internet of Things: Definition & Characteristics of IoT, Physical design of IoT, Logical Design of IoT, IoT Enabling Technologies, IoT Levels & Deployment Templates, M2M, Difference between IoT and M2M, SDN and NFV for IoT.
IoT platforms design methodology: purpose & requirement specification, process specification, domain model specification, information model specification, service specifications, IoT level specification, functional view specification, operational view specification, device & component integration, application development.

Learning Outcomes:
At the end of the unit, the student will be able to
1. Explain the Characteristics of IoT. (L2)
2. Explain the physical design and logical design of IoT. (L2)
3. Understand IoT and Machine to machine communication differences and working. (L2)
4. Show the typical IoT design methodology. (L2)

UNIT-II
Networking and Connectivity Technologies: Connectivity terminology, gateway prefix allotment, impact of mobility on addressing, multihoming, deviations from regular web, IoT identification and data protocols- IPv4, IPv6, MQTT, CoAP, XMPP, AMQP. Connectivity technologies- IEEE 802.15.4, Zigbee, 6LoWPAN, RFID, NFC, Bluetooth, Z-wave.

Learning Outcomes:
At the end of the unit, the student will be able to
1. list the challenges and requirements in networking of IoT systems. (L2)
2. analyze the connectivity technologies for device communication. (L4)
3. examine the different networking protocols for IoT requirements. (L4)

UNIT-III

Basics of Arduino and Raspberry Pi:

Sensor classification, working principle of sensors, criteria to choose a sensor, generation of sensors.

Arduino: Introduction to Arduino, Arduino Uno, Arduino Mega, Arduino Nano, Arduino IDE, Steps to Install Arduino IDE, Basic Commands for Arduino, LCD Commands, Serial Communication Commands Programming with Arduino, working with analog Input.

Raspberry Pi: Basics of Raspberry Pi, Introduction to Raspberry Pi, Raspberry Pi Components, Installation of Raspbian, Terminal Commands, Installation of Libraries on Raspberry Pi, Getting the Static IP Address of Raspberry Pi, Raspberry Pi Programming- Reading the Digital Input, I2C and SPI programming, Interfacing Raspberry pi-LED, Relay, DC Motor, LCD, DHT11.

Learning Outcomes:

At the end of the unit, the student will be able to

1. List the sensors and their classification for IoT. (L2)
2. Practice the basic programming of Arduino platform. (L3)
3. Employ Raspberry pi and python programming to develop simple embedded applications. (L3)

UNIT-IV

Data Processing: Data acquiring and storage, Organizing the data, Transactions, business processes, Integration and Enterprise systems, cloud computing paradigm for data collection, storage and computing, everything as service and cloud service models, IoT cloud-based services.

Learning Outcomes:

At the end of the unit, the student will be able to

1. Summarize the Data collection and storage at node and cloud systems. (L2)
2. Understand the processing of data at different levels of IoT. (L2)

UNIT-V

IoT Case Studies: Domains-Home automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Lifestyle**.** Case Studies- Home Intrusion detection, smart parking, weather monitoring system, Smart Irrigation.

Security and future of IoT Ecosystem:

Learning Outcomes:

At the end of the unit, the student will be able to

1. Categorize the domains of IoT development. (L4)
2. Examine the different IoT applications with detailed case study. (L4)

Text Books

1. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1e, University Press Private Limited-2016.
2. Internet of Things: Architecture, Design Principles and Applications, Rajkamal, McGraw Hill Higher Education.
3. Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, and Mahendra Swain "Internet of Things with Raspberry Pi and Arduino", CRC Press.
4. Dr Jeeva Jose, "Internet of Things", Khanna Book Publishing Co. (P)LTD, 2018

Reference Books:

1. Donald Norris, Internet of things do-it-yourself projects with Arduino, Raspberry Pi, and Beagle Bone Black,1st Edition, McGraw-Hill,2015

2. Getting Started with the Internet of Things Cuno Pfister, Oreilly.
3. Richard Blum, Arduino Programming in 24 Hours, Sams Teach Yourself, Pearson Education,2017
4. Jain, Prof. Satish, Singh, Shashi, Internet of Things and its Applications, 1st Edition, BPB, 2020.

Subject Code	Subject Name	L	T	P	C
R19MEC-PC4104	Engineering Metrology Laboratory	0	0	2	1

Course Objectives:

The Objectives of this course are to

- understand the measuring and inspection of precision linear, geometric forms, angular andsurface finish.
- understand the machine tool alignment test.
- understand the inspection of the surface roughness.
- demonstrate Thread inspection with two wire/ three wire method
- demonstrate angle and taper measurements with bevel protractor, Sine bar, rollers and balls.

Course outcomes:

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

1. ***understand*** the quality standards of engineering products in industries.(L4)
2. ***analyze*** the measurement of the surface roughness and perform alignment tests(L4)
3. ***develop*** the ability to apply the principles in instruments and measuring techniques(L4)
4. ***demonstrate*** thread inspection with two wire/ three wire method(L2)
5. ***demonstrate*** angle and taper measurements with bevel protractor, Sine bar, rollers and balls.

METROLOGY LAB

1. Measurement of lengths, heights, diameters by vernier calipers, micrometers etc.
2. Measurement of bores by internal micrometers and dial bore indicators.
3. Use of gear tooth vernier caliper for tooth thickness inspection and flange micro meter forchecking the chordal thickness of spur gear.
4. Machine tool alignment test on the lathe.
5. Machine tool alignment test on drilling machine.
6. Machine tool alignment test on milling machine.
7. Angle and taper measurements with bevel protractor, Sine bar, rollers and balls.
8. Use of spirit level in finding the straightness of a bed and flatness of a surface.
9. Thread inspection with two wire/ three wire method & tool makers microscope.
10. Surface roughness measurement with roughness measuring instrument.

Subject Code	Subject Name	L	T	P	C
R19MEC-PC4105	Computational Fluid Dynamics Laboratory	0	0	2	1

Course Pre-requisites:

- Basic concepts of Fluid Mechanics, Heat transfer and Numerical methods are required.
- Knowledge on operations of matrices, solving integration and differential equations are required.

Course Objectives:

The Objectives of this course are

- Solve Problems of fluid mechanics and heat transfer by writing programs in C-language andMATLAB.
- Use ANSYS-FLUENT to build a geometry, mesh that geometry, Perform CFD method on themesh,
- perform the calculation, and post-process the results.
- validate the numerical result with known analytical results.
- analyze the numerical results by invoking the physical principles of fluid mechanics and heattransfer.

Course Outcomes:

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

1. ***solve*** problems of fluid mechanics and heat transfer by writing programs in C-language and MATLAB. (L-3)
2. ***perform*** CFD method on the mesh, perform the calculation, and post-process the results. (L-3)
3. **e*valuate*** the numerical result by comparison with known analytical results. (L-5)
4. **a*nalyze*** the numerical result by invoking the physical principles of fluid mechanics and heat transfer.(L-4)
5. ***solve*** Elliptical, Parabolic, Partial and Hyperbolic partial differential equations. (L-3)

PART-A

Writing Programs in C and MATLAB for the following:

1. Solution of Transcendental equations
2. Solution of Simultaneous algebraic equations
3. Numerical differentiation and Integration
4. Solution of Ordinary Differential Equation
5. Solution of a Tri-diagonal matrix using Thomas Algorithm.
6. Solution of Partial differential equations related to
    i) Elliptical Partial differential equations
    ii) Parabolic Partial differential equations
    iii) Hyperbolic Partial differential equations
7. Solution of 1-D and 2-D heat conduction with (Finite Difference method)
    i) Constant temperature boundary conditions
    ii) Constant heat flux boundary conditions
    iii) Convective boundary conditions
8. Solution of Incompressible Navier-Stokes equations (Finite difference and Finite Volume methods)
9. Solution of Inviscid incompressible fluid flows.(Finite difference and Finite Volume methods)

PART-B

Using ANSYS-FLUENT solve the following problems of heat transfer analysis

1. Steady state conduction
2. Lumped heat transfer
3. Convective heat transfer – Internal flow (study both velocity and thermal boundary layers)
4. Convective heat transfer – External flow (study both velocity and thermal boundary layers)
5. Radiation heat transfer– Emissivity

Subject Code	Subject Name	L	T	P	C
R19MEC-SD4101	Hyper Meshing and Analysis (**Skill Development course-II**)	0	0	3	0

COURSE OBJECTIVES:

The Objectives of this course are to

1. understand the basics of HyperMesh skills in 1D, 2D (shell meshing), 3D (solid meshing) and connectors.
2. construct complex models of different types of curves, surfaces and solids and practising the skillstaught in this course.
3. understand the skills of group technology, transformation of points and lines in computer aidedsoftware.
4. implement the FEA meshing and cleaning geometry skills before sending it for various analysis.
5. apply computer aided Design and Analysis Process Planning skills and clear the mesh quality errors

COURSE PRE-REQUISITES:

1. Basic Knowledge of handling PC
2. Basic Knowledge of modeling on any CAD software will be advantageous.
3. Knowledge of fundamentals of like stress, strains, heat transfer, machine design will be helpful inunderstanding the analysis

COURSE OUTCOMES:

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

1. ***develop*** the concepts of HyperMesh, and its application to various Engineering Problems. (L3)
2. ***analyze*** the engineering problems using HyperMesh and factors influencing analysis process. (L4)
3. ***outline*** the need and application of HyperMesh Tools depending on the type of Analysis (Structural/Thermal/Fluid flow). (L2)
4. ***evaluate*** various results under different boundary conditions (Geometry/ Material properties/ loads).(L 5)
5. ***explain*** the domain of operation of Hypermesh for advanced applications (Dynamic analysis/Impactanalysis. (L2)

UNIT-I

INTRODUCTION TO HYPER MESH

Introduction about Hyper mesh, Introduction to CAD & CAE, Application of CAE Software, Advantages and Theory of FEM and Basic engineering and Shortcuts.

GEOMETRY

Create node, Node edit, Temp nodes, Distance, Dimensioning, Lines, Line edit, Length, Creation of surfaces and surface edit, Normal, Translate and Rotate

MID – SURFACE EXTRACTION

Auto – mid surface Extraction, De – featuring, Quick Edit

GEOMETRY CLEAN – UP

Surface edges, Visualization tool bar, Display tool bar, Clean up using quick edit

UNIT-II

2D MESHING

Introduction to meshing, Auto meshing, Size & Biasing, Density and mesh style, Mesh connectivity, Replace and remeshing, Current and surface components, Reviews of all options and doubt clarification

2D MESH QUALITY

Quality criteria, War page, Aspect ratio, Jacobian, Skew, Reducing the Tri as percentage

QUALITY INDEX

Quality index, T – connections, Duplicates, Free – edges

UNIT-III

MANUAL MESH

Ruled, Spline, Skin, Drag, Elem offset

TOOLS

Colour, Rename, Order, Number and mass calculation, Project, Position

3D HEX MESHING

Introduction to 3D meshing, Types of 3D elements, Drag, spin, line drag & Elem offset

3D SOLID MESH

Solid and solid edit, Solid map commands, Linear mesh, Solid mesh

UNIT-IV

1D MESH

Introduction to 1D element, Beam elements, bars, rods, RBE2 & RBE3 Elements, welding, Boltcreation.

3D TETRA MESHING

Introduction to tetra mesh, Tetra parameters, Tet collapse, remeshing

UNIT-V

LINEAR MESHING

Introduction to analysis, Create collectors, Material properties, Load constraints, Load steps

MODAL, LINEAR STATIC AND BUCKLING ANALYSIS

Deck preparation, Material and properties assignment, Assign of loads and constraints, Saving thefile formats

LEARNING OUTCOME:

Upon completion of this course students will be able to

1. ***learn*** how to Validate and simulate the product.
2. ***learn*** how to optimize you design according to given specifications.
3. ***learn*** how to understand, interpret and document the results of simulation.
4. ***gain*** ample knowledge to ace in placement drive.

TEXT BOOKS

HyperMesh from entry to the master / YU KAI PING DENG / Publisher: Science Press

REFERENCE

HYPERMESH/HYPERVIEW- SOFTWARE MANUAL

IV Year –II Semester

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4201.1	Gas Dynamics and Jet Propulsion (**Professional Elective –IV**)	3	0	0	3

Course Objectives:

The Objectives of this course are to

- Understand the concept of Mach number and equations of continuity andmomentum.
- Illustrate about stagnation properties and nozzle efficiencies.
- Explain frictional flow with its governing equations
- Analyze the effects of heat transfer on flow parameters
- Understand the working of jets and its components

Course outcomes:

After successful completion of this course, student will be able to

1. ***explain*** sonic velocity, mach number and continuity and momentum equations for a control volume (L2)
2. ***identify*** stagnation properties, performance of nozzle and nozzle efficiencies. (L1)
3. ***analyze*** the gas flow in different situations with and without friction. (L4)
4. ***identify*** the effects of heat transfer on flow parameters. (L1)
5. **analyze** the gas flow in air jets propulsion and rocket engines. (L4)

UNIT-I

Introduction to gas dynamics: Control volume and system approaches acoustic waves and sonic velocity - Mach number - classification of fluid flow based on Mach number - mach cone- compressibility factor - general features of one dimensional flow of a compressible fluid
- Continuity and momentum equations for a control volume.

Learning outcomes:

After completion of this unit, the student will be able to

- ***understand*** acoustic waves and sonic velocity (L1)
- ***apply*** the Mach number on gas dynamics (L3)
- ***illustrate*** the continuity and momentum equations for control volume (L3)

UNIT-II

Isentropic flow of an ideal gas: Basic equation - stagnation enthalpy, temperature, pressure and density stagnation, acoustic speed - critical speed of sound- dimensionless velocity- governing equations for isentropic flow of a perfect gas - critical flow area - stream thrust and impulse function. Steady one dimensional isentropic flow with area change-effect of areachange on flow parameters- chocking convergent nozzle - performance of a nozzle under decreasing back pressure -De lavel nozzle - optimum area ratio effect of back pressure - nozzle discharge coefficients - nozzle efficiencies.

Applications: Nozzles.

Learning outcomes:

After completion of this unit, the student will be able to

- ***identify*** basic properties of gases (L2)
- ***apply*** governing equations on gas flow (L3)
- ***illustrate*** the performance of nozzle (L3)

UNIT- III

Simple frictional flow: Adiabatic flow with friction in a constant area duct-governing equations - fanno line limiting conditions - effect of wall friction on flow properties in an Isothermal flow with friction in constant area duct-governing equations - limiting conditions. Steady one dimensional flow with heat transfer in constant area ducts- governing equations - Rayleigh line entropy change caused by heat transfer - conditions of maximum enthalpy and entropy.

Applications: Aero dynamics

Learning outcomes:

After completion of this unit, the student will be able to

- ***study*** the effect of friction on flow properties (L2)
- ***understand*** one dimensional Steady flow with heat transfer (L1)
- ***illustrate*** conditions for maximum enthalpy and entropy (L3)
- ***explain*** about fanno line and Rayleigh line (L2)

UNIT-IV

Effect of heat transfer on flow parameters: Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas properties of flow across a normal shock - governing equations - Rankine Hugoniat equations - Prandtl's velocity relationship - converging diverging nozzle flow with shock thickness - shock strength.

Applications: Gas turbines

Learning outcomes:

After completion of this unit, the student will be able to

- ***understand*** the formation of shock waves and its properties (L1)
- ***explain*** effect of heat transfer on flow parameters (L2)
- ***formulate*** the Rankine Hugoniat equations and Prandtl's velocity relationship (L4)

UNIT- V

Propulsion: Air craft propulsion: - types of jet engines - energy flow through jet engines, thrust, thrust power and propulsive efficiency turbojet components-diffuser, compressor, combustion chamber, turbines, exhaust systems.

Performance of turbo propeller engines, ramjet and pulsejet, scramjet engines. Rocket propulsion - rocket engines, Basic theory of equations - thrust equation - effective jet velocity- specific impulse - rocket engine performance - solid and liquid propellant rockets - comparison of various propulsion systems.

Applications: Aero space applications

Learning outcomes:

After completion of this unit, the student will be able to

- ***differentiate*** the types of jet engines (L2)
- ***identify*** different components in air craft's (L2)
- ***illustrate*** the energy flow through jet engines (L3)
- ***design*** different air propulsion systems (L4)
- ***understand*** the concept of rocket propulsion (L1)

Text Books:

1. Compressible fluid flow /A. H. Shapiro / Ronald Press Co.,
2. Fundamentals of compressible flow with aircraft and rocket propulsion/S. M. Yahya /New Age international Publishers
3. Fundamental of Gas dynamics-2nd edition/ M J Zucker/ Wiley publishers

References:

1. Elements of gas dynamics / HW Liepman & A Roshko/Wiley
2. Aircraft & Missile propulsion /MJ Zucrow/Wiley
3. Gas dynamics / M.J. Zucrow & Joe D.Holfman / Krieger Publishers

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4201.2	Nano Materials (**Professional Elective –IV)**	3	0	0	3

Course objective:

The course conveys the basic concepts relevant to nano material properties, synthesis, characterization and applications

- ***define*** 'nano materials '
- ***list*** common applications for nanotechnology
- ***explain*** how nanotechnology has influenced the field of information technology

Course outcomes:

1. ***understand*** importance of Nano materials (L2)
2. ***explain*** the properties of Nano Materials(L2)
3. ***illustrate*** the different synthesis process used for getting Nano materials (L2)
4. ***describe*** the various characterization techniques used for getting Nano materials(L2)
5. ***explain*** the applications of Nano materials(L2)

UNIT-1

INTRODUCTION: History of nano science, definition of nano meter, nano materials, nano technology. Classification of nano materials.

Learning outcomes:

- ***understand*** importance of nano materials

Unit-II

PROPERTIES OF MATERIALS: Mechanical properties, electrical properties, dielectric properties, thermal properties, magnetic properties, opto electronic properties. Effect of size reduction on properties, electronic structure of nano materials.

Learning outcomes:

- ***explain*** the properties of Nano Materials

Unit-III

SYNTHESIS OF NANOMATERIAL: S Top-down (Nanolithography, CVD),Bottom-up (Sol-get processing, chemical synthesis). Wet Deposition techniques, Self-assembly (Supramolecular approach).

Learning outcomes:

- ***illustrate*** the different synthesis process used for getting Nano materials

Unit-IV

CHARACTERIZATION: TEM, SEM and SPM technique, Fluorescence Microscopy and Imaging.

Learning outcomes:

- ***describe*** the various characterization techniques used for getting Nano materials

Unit-V

APPLICATIONS OF NANO TECHNOLOGY: Applications in material science, biology and medicine, surface science, energy and environment. Applications of nano structured thin fins, applications of quantum dots.

Learning outcomes:

- ***explain*** the applications of Nano materials

Text Books

1. Textbook of nanoscience and nanotechnology, B.S. Murty et al. Universities Press
2. Nano: the essentials- T.Pradeep, Tata McGrawHill Publishers

Reference Books

1. Introduction to nanotechnology, Charles P. Poole, Wiley publishers

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4201.3	Tribology **(Professional Elective –IV)**	3	0	0	3

Course Objective:

The Objectives of this course are

- To know the contact surface effects of bearings
- To know the seals and analysis of failure

Course Outcomes:

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

- ***understand*** the contact surfaces & Effects of lubricants(L2)
- ***explain*** the selection of Rolling contact bearings(L2)
- ***illustrate*** the design procedure of Hydrostatic Bearings(L2)
- ***develop*** optimum bearing with maximum load capacity (L3)
- ***analyze*** Failure of tribological components (L4)

Unit–I

Introduction: Nature of surfaces and contact-Surface topography-friction and wear mechanisms, wear maps, effect of lubricants-methods of fluid film formation.

Lubrication: Choice of lubricants, types of oil, Grease and solid lubricants- additives- lubrication systems and their selection.

Application: Automobile &Machine components

Learning outcomes:

After completion of this unit, students will be able to

- ***explain*** contact surfaces & Effects of lubricants**(L2)**
- ***illustrate*** Analyze on Bearing still it failure**(L2)**

Unit–II

Selection of rolling element bearings: Nominal life, static and dynamic capacity-Equivalent load, probabilities of survival- cubic mean load- bearing mounting details, pre loading of bearings, conditioning monitoring using shock pulse method.

Application: Automobile & Machine components

Learning outcomes:

After completion of this unit, students will be able to

- ***develop*** Rolling contact bearings (L6)

Unit–III

Hydrostatic Bearings: Thrust bearings – pad coefficients- restriction- optimum film thickness- journal bearings – design procedure –Aerostatic bearings; Thrust bearings and Journal bearings – design procedure.

Learning outcomes:

After completion of this unit, students will be able to

- ***develop*** Hydro static Bearings(L6)

Application: Machine components

Unit–IV

Hydrodynamic bearings: Fundamentals of fluid formation – Reynold's equation; Hydro dynamic journal bearings– Sommerfield number- performance parameters–optimum bearing with maximum load capacity – Friction – Heat generated and Heat dissipated. Hydrodynamic thrust bearings; Raimondi and Boyd solution for hydrodynamic thrust bearings- fixed tilting pads, single and multiple pad bearings-optimum condition with largest minimum film thickness.

Application: Automobile& Machine components

Learning outcomes:

After completion of this unit, students will be able to

- ***develop*** Hydro dynamic Bearings (L6)

Unit–V

Seals: different type-mechanical seals, lip seals, packed glands, soft piston seals, Mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves– Selection of mechanical seals.

Failure of Tribological components: Failure analysis of plain bearings, rolling bearings, gears and seals, wear analysis using soap and Ferro graphy.

Dry rubbing Bearings: porous metal bearings and oscillatory journal bearings–qualitative approach only.

Application: Automobile & Machine components, Construction & Material optimization on Mechanical components

Learning outcomes:

After completion of this unit, students will be able to

- ***develop*** Hydro dynamic Bearings (L6)

Text Books

1. Rowe WW& O'Dionoghue, "Hydro static and Hybrid bearing design "Butter worths& Co. Publishers Ltd.
2. Collacott R.A, "Mechanical Fault diagnosis and condition monitoring", Chapman and Hall, London.
3. Bernard J.Hamrock, "Fundamentals of fluid film lubricant", McGraw- Hill Co.

References

1. Neale MJ,(Editor)"Tribology hand Book" Neumann Butterworths.
2. Connor and BoydJJO (Editors) " Standard hand book of lubrication engineers "ASLE, McGraw Hill Book &Co.
3. ShigleyJ, E Charles, "Mechanical Engineering Design", McGraw Hill Co.,

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4201.4	Production Planning and Control **(Professional Elective –IV)**	3	0	0	3

Course objectives:

The Objectives of this course are

- To understand the characteristics of production and service systems.
- To Apply principles and techniques in the development of integrated systems
- To understand the challenges faced by the production manager in manufacturing andservice organizations
- To identify different strategies employed in manufacturing and service industries to control inventory.
- To apply scheduling methodology in mass production and job order production systems
- To Understand the concepts of dispatching and methods of dispatching.

Course outcome:

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

1. ***Summarize*** the production planning and control functions.(L2)
2. ***Apply*** quantitative techniques for demand forecasting in manufacturing firms.(L3)
3. ***Compare*** inventory management systems applicable to optimize cost to controldifferent types of inventories. (L4)
4. ***Analyze*** factors affecting in preparation of route sheets to make the product. (L4)
5. ***Evaluate*** Scheduling methodologies applicable to job order and mass productionsystem. (L4)
6. ***Illustrate*** the Dispatching procedure (L2)

UNIT–I

Introduction: Definition – characteristics of production systems, layouts used, objectives and functions of production planning and control — organization of production planning and control department–internal organization of department.

Learning outcomes

After completion of this unit, students will be able to

- ***understand*** the functions of production planning and control (L2)
- ***compare*** the characteristics of the production systems(L2)

UNIT–II

Forecasting – importance of forecasting – types of forecasting, their uses– Quantitative Forecasting technique: Least Square Method, Exponential Smoothing Method, Moving Average Method, Seasonal forecasting. Errors in forecasting methods, Qualitative Forecasting technique: opinion survey method, executive opinion method, customer and distributor survey method, marketing trails method, market research method and Delphi method.

Learning outcomes:

After completion of this unit, students will be able to

- ***explain*** qualitative and quantitative methods of forecasting (L2)
- ***develop*** regression equation for demand forecasting(L3)

UNIT–III

Inventory management – functions of inventories – relevant inventory costs – Selective control methods-ABC analysis –VED analysis –EOQ model–exercises, Inventory controlsystems–P–Systems and Q-Systems, MRP I, MRP II, ERP, JIT and KANBAN systems.

Learning outcomes:

After completion of this unit, students will be able to

- ***explain*** the functions of inventories(L2)
- ***illustrate*** the applications of P–Systems and Q-Systems. (L2)

UNIT–IV

Routing: Definition – routing procedure – route sheets – bill of material –factors affecting routing procedure, schedule – definition – difference with loading.

Scheduling: Scheduling in mass production system, Line Balancing, Scheduling in job production system, n jobs-2machines, n jobs-3 machine problems.

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** routing procedure (L2)
- ***differentiate*** loading and scheduling. (L4)
- ***explain*** various scheduling methods. (L2)

UNIT–V

Dispatching – dispatching procedure – dispatching rules- Mean flow time, mean lateness of the job orders, follow up and controlling aspects ,applications of software modules in production planning and control.

Learning outcomes:

After completion of this unit, students will be able to

- ***understand*** the activities of dispatching (L2)
- ***explain*** the dispatching rules (L2)
- ***explain*** the application of software modules in production planning and control(L2)

Text Books:

1. Elements of Production Planning and Control/Samuel Eilon / Universal Book Corp.
2. Production and *Operations Management*. R. *Panneerselvam*,. Prentice Hall India Pvt. Ltd.

References:

1. Inventory Control Theory and Practice/ Martin K. Starr and David W.Miller /Prentice-Hall
2. Production Planning and Control/ Mukhopadyay/ PHI.
3. Production Control/ Franklin G Moore & Ronald Jablonski/ Mc-Graw Hill
4. Production and Operations Management/Ajay K Garg /Mc Graw Hill

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4202.1	Alternative fuels and Emission Control in Automotives (**Professional Elective –V)**	3	0	0	3

Course Objectives:

The main objectives of this course are to make the student

- Explain alcohol and gaseous fuels and their use in SI and CI engines.
- Explain properties of vegetable oils to use in CI engines.
- Identify formation of various emissions from SI and CI engines.
- Understand about different emission control techniques
- Describe emission measuring instruments and test procedures.

Course Outcomes:

At the end of this course, the student will be able

- ***explain*** the properties of alcohol fuels and gaseous fuels. (L3)
- ***analyze*** the methods to improve engine performance with vegetable oils (L3)
- ***identify*** formation of various emissions from SI and CI engines (L3)
- ***understand*** about different emission control techniques (L3)
- ***explain*** test procedures using emission measuring instruments (L3)

UNIT I

Alcohol fuels and gaseous fuels: Properties of alcohols, alcohol – gasoline blends, fuel flexible vehicle, methanol reformed gas engine, dual fuel system, Spark assisted diesel engine, surface ignition engine, ignition accelerators, performance, combustion and emission characteristics in SI and CI engines, Properties of hydrogen, production and storage methods, safety precautions, biogas production and its properties, properties of LPG and CNG, Performance, combustion and emission characteristics of hydrogen, biogas, LPG and CNG inSI and CI engines

Applications: Cooking, Gas heaters, sports vehicles

Learning Outcomes:

At the end of this unit, the student will be able to

- ***explain*** the properties of alcohols and alcohol gasoline blends (L3)
- **explain** the principles of spark assisted diesel engine and surface ignition engine. (L3)
- ***identify*** the performance, combustion and emission characteristics in SI and CIengines. (L3)
- ***explain*** production, storage methods and emission characteristics of hydrogen. (L3)

UNIT II

Vegetable oils: Various vegetable oils for diesel engines, structure and properties, problems in using vegetable oils in diesel engines, Methods to improve the engine performance using vegetable oils – preheating, Esterification, blending with good secondary fuels, Semi- adiabatic engine, surface ignition engine, ignition accelerators dual fuelling with gaseous and liquid fuels coils, Performance, combustion and emission characteristics of biodiesel fuelled diesel engines.

Applications: Agricultural vehicles

Learning Outcomes:

At the end of this unit, the student will be able to

- ***list*** various vegetable oils and its properties used for diesel engines (L1)
- ***identify*** the problems in using vegetable oils in diesel engines. (L3)
- ***explain*** the methods to improve the engine performance using vegetable oils. (L3)
- ***explain*** the method of blending with good secondary fuels. (L3)
- ***summarize*** the performance, combustion and emission characteristics of biodieselfuelled diesel engine (L3)

UNIT III

Emissions from SI engines and CI engines: Emission formation in SI engines (CO, HC and NOx), Effect of design and operating variables on emission formation. Emission formation in CI engines (HC, CO, NOx, Aldehydes, smoke and particulates), Effect of design and operating variables on emission formation.

Applications: SI engine of auto mobiles

Learning Outcomes:

At the end of this unit, the student will be able to

- ***explain*** emission formation in SI engines. (L3)
- ***explain*** emission formation in CI engines (L3)
- ***explain*** the effect of design and operating variables on emission formation in CI engine. (L3)

UNIT IV

Emissions control techniques for SI engines and CI engines: Control techniques for SI engine emissions – Thermal reactor, exhaust gas recirculation, Three way catalytic convertor and Charcoal canister control for evaporative emission, Positive crank case ventilation for blow by gas control.

Control techniques for CI engine emissions – Exhaust gas recirculation, NOx selective catalytic reduction, Diesel oxidation catalytic convertor, Diesel particulate filter, NOx versus particulates – Trade off

Applications: CI engines of automobiles & generators

Learning Outcomes:

At the end of this unit, the student will be able to

- ***categorize*** various control techniques on SI engine emission formation. (L2)
- ***identify*** appropriate emission control techniques for a specific problem in SI engine operation (L3)
- ***explain*** on positive crank case ventilation for blow by gas control. (L3)
- ***explain*** various control techniques on CI engine emission formation. (L3)
- ***identify*** appropriate emission control techniques for a specific problem in CI engine operation (L3)

UNIT V

Emission measuring instruments and test procedures: Principle of operation of emission measuring instruments used in SI and CI engines, Measurement of CO_2 and CO by NDIR, Hydrocarbon emission by FID, Chemiluminescent analyser for NOx, Liquid and Gas chromatograph Spot sampling and continuous indication type smoke meters (Bosch, AVL and Hartridge smoke meters) emission test procedures – FTP, Euro and Bharat norms

Applications: Pollution testing vehicles

Learning Outcomes:

At the end of this unit, the student will be able to

- ***differentiate*** various emission measuring instruments for SI and CI engines (L2)
- ***apply*** the principle of operation of emission measuring instruments used in SI and CI engines (L3)
- ***explain*** the methods of measurement of different emissions (L3)
- ***apply*** the norms to prepare the test procedures (L3)

Text book

1. Ganesan V, Internal combustion engines, 4th Edition, Tata McGraw Hill Education,.
2. Thipse.S.S, Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.

Reference books

1. Michael F. Hordeski, Alternative Fuels: The Future of Hydrogen, The Fairmont Press.
2. R.K.Rajput, A textbook of Internal Combustion Engines, 2nd Edition, Laxmi Publications.
3. "Society of Automotive Engineers", Alternative Fuels: Fuel Cells and Natural Gas, Society of Automotive Engineers, Incorporated.

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4202.2	Non-Destructive Evaluation **(Professional Elective –V)**	3	0	0	3

Course Objectives:

The main objectives of this course are to

- Concepts of various NDE techniques using radiography, ultrasonic's, liquid penetrates, magnetic patches and Eddy currents are dealt with
- Learn basic principles of these methods and select a testing process.
- Understand the advantages and disadvantages of these techniques
- Knowledge on which NDE method to apply under appropriate circumstances
- Classify non-destructive testing equipment.
- Knowledge of all the different types of Non-destructive testing

Course Outcomes:

At the end of this course, the student will be able

1. ***understand*** non-destructive destructive testing methods and radiographic testing in industries. – (**L2)**
2. ***explain*** ultrasonic testing and its effectiveness and limitations. – (**L2)**
3. ***illustrate*** Liquid penetrate testing and types of penetrates used in die penetrating testing. – (**L2)**
4. ***identify*** internal flaws of the work piece using magnetic particle testing. – (**L3)**
5. ***apply*** knowledge of non-destructive testing techniques to test equipment/work pieces in various industrial/automobile sectors. – (**L3)**

UNIT-I

INTRODUCTION TO NON-DESTRUCTIVE TESTING: Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** non-destructive testing techniques. (L2)
- ***summarize*** the basic concepts of Radiographic test.(L2)
- ***outline*** the concepts of sources of X and Gamma Rays.(L2)
- ***explain*** the radiographic techniques. (L2)

UNIT-II

ULTRASONICS TEST: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection

- Effectiveness and Limitations of Ultrasonic Testing.

Learning outcomes:

At the end of this unit, the student will be able to

- ***explain*** the principle of ultrasonic test.(L2)
- ***understand*** the performance of wave propagation, reflection, refraction,diffraction and sound field in ultrasonic test.(L2)
- ***outline*** the limitations of ultrasonic testing. (L2)

UNIT-III

LIQUID PENETRANT TEST:

Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness and Limitations of Liquid Penetrant Testing

EDDYCURRENTTEST: Principle of Eddy Current, Eddy Current TestSystem, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing

Learning outcomes:

At the end of this unit, the student will be able to

- ***Illustrate*** the procedure of Liquid Penetrant, eddy current tests.(L2)
- ***Outline*** the limitations of Penetrant, eddy current tests.(L2)
- ***Explain*** the effectiveness of Penetrant, eddy current tests.(L2)

UNIT-IV

MAGNETICPARTICLETEST: Magnetic Materials, Magnetization of Materials, Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test.

Learning outcomes:

At the end of this unit, the student will be able to

- ***Illustrate*** the procedure of magnetic particle tests.(L2)
- ***Outline*** the limitations of magnetic particle tests.(L2)
- ***Explain*** the effectiveness of magnetic particle tests.(L2)

UNIT-V

INDUSTRIAL APPLICATIONS OF NDE: Span of NDE Activities Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions.

Learning outcomes:

At the end of this unit, the student will be able to

1. ***illustrate*** applications of NDE.(L2)
2. ***explain*** the applications of Railways, Nuclear and chemical industries. (L2)
3. ***outline*** the limitations of NDE.(L2)
4. ***explain*** the applications of NDA of pressure vessels, casting and welding constructions(L2)

TEXTBOOKS:

1. JPrasad, GCKNair, Nondestructive test and evaluation of Materials, Tata mcgraw-Hill Education Publishers.
2. Josef Kraut krämer, Herbert Kraut krämer, Ultrasonic testing of materials, 3/e, Springer-Verlag,.
3. X. P. V. Maldague, Non destructive evaluation of materials by infrared thermography,1/e,Springer-Verlag.

REFERENCES:

1. GaryL.Workman, Patrick O.Moore, Doron Kishoni, Non-destructive, Hand Book, Ultrasonic Testing, 3/e, Amer Society for Nondestructive.
2. ASTM Standards,Vol3.01, Metals and alloys

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4202.3	Industrial Safety and Hazard Management (**Professional Elective –V)**	3	0	0	3

Course Objectives

The main objectives of this course are

1. To know about Industrial safety programs , Industrial laws and regulations
2. To understand about fire and explosion, preventive methods, relief and its sizing methods
3. To analyse industrial hazards and its risk assessment.

Course Outcomes:

By the end of the course the students will be able to

1. ***analyze*** the effect of release of toxic substances (L4)
2. ***understand*** the industrial laws, regulations and source models. (L2)
3. ***apply*** the techniques for prevention of fire and explosions. (L3)
4. ***illustrate*** the relief and its sizing methods. (L2)
5. ***explain*** the methods of hazard identification and preventive measures.(L2)

UNIT -I

Introduction: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety, Seven Significant Disasters. Toxicology: Effect of Toxicants on Biological Organisms, Toxicological Studies, Dose versus Response, Models for Dose and Response Curves, Relative Toxicity, Threshold Limit Values, National Fire Protection Association (NFPA) Diamond.

Learning Outcomes:

After completion of this unit student will be able to

- ***understand*** the safety programs in the industries(L2)
- ***analyze*** the effect of pollutants on atmosphere and human beings(L4)

UNIT -II

Industrial Hygiene: Government Laws and Regulations, OSHA: Process Safety Management, EPA: Risk Management Plan, DHS: Chemical Facility Anti-Terrorism Standards (CFATS) Industrial Hygiene: Anticipation and Identification, Evaluation, Control.

Source Models: Introduction to Source Models, Flow of Liquid through Holes, and Pipes, Flow of Gases or Vapors through Holes and Pipes, Flashing Liquids, Liquid Pool Evaporation or

Boiling, Conservative Analysis.

Learning Outcomes:

After completion of this unit student will be able to

- ***understand*** the importance of industrial hygiene(L3)
- ***explain*** the risk management plan(L3)

Unit-III

Fires and Explosions: The Fire Triangle, Distinction between Fires and Explosions, Definitions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram, Ignition Energy , Autoignition , Auto- Oxidation , Adiabatic Compression, Ignition Sources, Sprays and Mists, Explosions Concepts to Prevent Fires and Explosions: Inerting, Static Electricity and its Control, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Miscellaneous Concepts for Preventing Fires and Explosions.

Learning Outcomes:

After completion of this unit student will be able to

- ***explain*** the methods used to prevent fires or explosions in anindustry (L3)
- ***understand*** the importance of ventilation during fires at a firm(L2)

Unit-IV

Introduction to Reliefs: Relief Concepts, Definitions, Location of Reliefs, Relief Types and Characteristics, Relief Scenarios, Data for Sizing Reliefs, Relief Systems. Relief Sizing : Conventional Spring-Operated Reliefs in Liquid and in Vapor or Gas Services, Rupture Disc Reliefs in Liquid in Vapor or Gas Services, Two-Phase Flow during Runaway Reaction Relief , Pilot-Operated and Bucking-Pin Reliefs, Deflagration Venting for Dust and Vapor Explosions, Venting for Fires External to Process Vessels, Reliefs for Thermal Expansion of Process Fluids

Learning Outcomes:

After completion of this unit student will be able to

- ***explain*** different kind of relief scenarios(L4)
- ***illustrate*** the process of venting(L3)

Unit-V

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews, Other Methods, Risk Assessment: Review of Probability Theory, Event Trees, Fault Trees, QRA and LOPA

Learning Outcomes:

After completion of this unit student will be able to

- ***prepare*** the process hazards checklists (L2)
- ***understand*** the safety methods (L2)

Text Book:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals withApplications), Prentice Hall.

Reference Books:

1. R.K. Sinnott, Coulson & Richardson's, Chemical Engineering, Vol. 6, Elsevier India.
2. Fawcett H.H. and W.S.Wood, Safety and accident prevention in Chemicaloperations 2ndediton John Wiley and Sons Inc.

Subject Code	Subject Name	L	T	P	C
R19MEC-PE4202.4	CNC and Adaptive Control **(Professional Elective –V)**	3	0	0	3

Course Objectives:

The main objectives of this course are

- Understand the Role and Applications of NC / CNC.
- Introduce Part Program and its elements
- Explain the Components of CNC machine tool, Drives and controls
- Develop the adaptive control problem and Gain scheduling
- Introduce the deterministic self-tuning regulators
- Introduce the stochastic and predictive self-tuning regulators

Course Outcomes:

By the end of the course the students will be able to

- ***understand*** the Role, Applications, Benefits of NC/ CNC (L1)
- ***explain*** the Methods of part Programming and Apply APT and its variations (L2)
- ***explain*** tool offsets and work offsets. (L2)
- ***apply*** the principle of gain scheduling controllers (L3)
- ***understand*** deterministic self-tuning regulators. (L1)

UNIT-I

Numerical Control - Introduction, Role of NC / CNC in CAM, Applications of NC / CNC, Benefitsof NC / CNC, Limitations of CNC.
Basic Components of CNC system - Part programming, Machine control unit, Machine tool - Historical developments and their role in control of machine tools, Classification of NC / CNC systems - Based on type of Control (PTP\C\L), method of programming, type of architecture - Hardwired / Soft wired / Open.
Applications: Most commonly used in wide variety of production operation such as metal cutting, automatic drafting ,spot welding, press working, assembly ,inspection etc.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***explain*** the Role, Applications, Benefits of NC/ CNC. (L2)
- ***explain*** the basic components of CNC system. (L2)
- ***classify*** the NC / CNC systems, Based on type of Control (PTP\C\L). (L1)

UNIT-II

Part programming - Introduction; Part Program and its elements, Methods of Programming - Manual and Computer Assited Part programming - Custom Macro (Parametric Programming), APT and its variations, Concepts of CAM - Tool path generation and control methods.

Applications: *part program* is a sequence of instructions, which describe the work, which has to be done on a *part*, in the form required by a computer under the control of a numerical control computer *program*. It is the task of preparing a *program* sheet from a drawing sheet.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***explain*** the Methods of part Programming. (L2)
- ***apply*** APT and its variations. (L3)
- ***explain*** the Concepts of CAM-path generation and control methods.(L2)

UNIT-III

Machine Tool - Components of CNC machine tool, Drives and controls, Automatic Tool Changers, Automatic Pallet Changers, tool offsets and work offsets, high speed and precision machining concepts.

Applications: mostly used in production and manufacturing industry, and also used for milling and machining centres.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** the Components of CNC machine tool. (L1)
- ***explain*** tool offsets and work offsets. (L2)

UNIT-IV

INTRODUCTION: Development of adaptive control problem-The role of Index performance (IP) in adaptive systems- Parametric models of dynamical systems - Adaptive Schemes- The adaptive Control Problem- Applications. Gain scheduling: The principle - Design of gain scheduling controllers- Nonlinear transformations -application of gain scheduling - Auto-tuning techniques-Methods based on Relay feedback.

Applications: *Adaptive control* has been extended to new *applications* such as drying ovens, active *control* of vibrations, efficient conditioning, robotics… permitting to *control* the process or even improve the efficiency that was performed with conventional *controls*.

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** The role of Index performance (IP) in adaptive systems. (L1)
- ***apply*** the concept of adaptive Control. (L3)
- ***apply*** the principle - Design of gain scheduling controllers.(L3)

UNIT-V

DETERMINISTIC SELF-TUNING REGULATORS: Pole Placement design - Indirect Self-tuning regulators - Continuous time self tuners direct self-tuning regulators – Disturbances with known characteristics

Applications:

Learning Outcomes:

At the end of this unit, the student will be able to

- ***understand*** deterministic self-tuning regulators. (L1)
- ***explain*** Continuous time self tuners direct self tuning regulators. (L2)

Text books:

1. Computer aided manufacturing by N.K.TIWARI,P.N.RAO,T.K.KUNDRA
2. Advanced Manufacturing Technology by Rao K V (Author)
3. Introduction to Computer Numerical Control, 5th Edition, James V. Valentino, Queens boroughCommunity College, Joseph Goldenberg, Queens borough Community College.

References:

1. Computer Numerical Control Programming Basics Steve Krar Arthur Gill
2. Reinbold U, Blume C and Dilmann R, Computer Integrated Mfg. Technology & Systems,Marcel Dekker.
3. Petruzella F D, Programmable Logic Controllers, McGraw Hill.