IV- Year R20 Curriculum & Syllabus

IV-YEAR-I-SEMESTER

Course Code	Title of the course	Category	Periods						Sessionals Marks	Semester end Exam marks	Total Marks	Credits
			L	T	P	E	O	Total				
MEC 411	***Open Elective-III/Emerging subject	OE	3	0	0	0	2	5	40	60	100	3
MEC 412	Professional Elective-III	PE	3	0	0	1	2	6	40	60	100	3
MEC 413	Professional Elective-IV	PE	3	0	0	1	3	7	40	60	100	3
MEC 414	Professional Elective-V	PE	3	0	0	1	3	7	40	60	100	3
MEC 415	Heat Transfer	PC	2	1	0	2	4	9	40	60	100	3
MEC 416	Metrology & Mechatronics-Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 417	Heat Transfer-Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 418	****Industrial Training-II	PR	0	0	0	0	0	0	--	100	100	2
MEC 419	Project Phase-I	PR	0	0	4	0	4	8	--	100	100	2
MEC4110	Automotive Engineering	SC	2	0	0	2	4	10	40	60	100	2
Total			16	1	10	7	24	60	340	660	1000	24

IV-YEAR-II-SEMESTER

Course Code	Title of the course	Category	Periods						Sessionals Marks	Semester end Exam marks	Total Marks	Credits
			L	T	P	E	O	Total				
MEC 421	***Open Elective-IV/Emerging subject	OE	3	0	0	0	2	5	40	60	100	3
MEC 422	Project Phase-II/Industrial Internship	PR	0	0	16	0	16	32	100	100	200	8
Total			3	0	16	0	18	37	140	160	300	11

Professional Elective-I	Production Planning & Control	Gas Turbines & Jet Proplusions	Automation in manufacturing	Non-Destructive Testing
Professional Elective-II	Refrigeration & Air- conditioning	Power plant Engineering	Nano Technology	Quality & Reliability engineering
Professional Elective-III	Mechanical Measurements	Computatinal Fluid dynamics	Condition monitoring	Industrial tribology
Professional Elective-IV	Non-Conventional Energy Sources	Managerial Economics & Financial Accountancy	Unconventional machine process	Artificial intelligence
Professional Elective-V	Operations Research	Alternate fuels	Advanced mechanics of materials	Product Design& Manufacturing
Humanities Electives	Industrial Engineering	Stastical Quality Control	Enterprenuership development	Suppy chain management

Note: Open electives-I & II are offered by other departments. The CSE/IT departments are requested to offer PYTHON-programming & Data structures as open electives.

Note:In Open electives-III & IV/Emerging subjects -only emerging subjects will be offered by the parent department. The subjects could be Mechatronics, Robotics, Additive manufacturing,Condition monitoring etc. (will be decided by the department)

ADDITIVE MANUFACTURING(AM)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 411A	Emerging Subject	3	0	0	40	60	100	3

Prerequisite: Material Science, Manufacturing process

Course Objectives: To acquaint students with the basics of additive manufacturing technology and various techniques of it. They can define their advantages, limitations and applications in various fields of engineering.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	**Explain** additive manufacturing, its working principle, process parameters and can **identify** AM processes for specific application
CO-2	**Identify** a specific technique for a given application by applying Vat photo polymerization process.
CO-3	**Classify** various extrusion based and sheet lamination based additive manufacturing processes and **categorize** these processes for a specific application.
CO-4	**Select** a Powder Bed Fusion Processes for an engineering application.
CO-5	**Apply** direct energy deposition processes and **identify** suitable post-processing for the AM product.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3		2						1	1		1
CO-2	3		2						1	1		1
CO-3	3		2		3				1	1		1
CO-4	3		2						1	1		1
CO-5	3		2						1	1		1

Course Outcomes	PSO1	PSO2
CO-1	3	
CO-2	3	
CO-3	3	3
CO-4	3	
CO-5	3	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 9L**
INTRODUCTION TO ADDITIVE MANUFACTURING & APPLICATIONS	
Development of Additive Manufacturing Technology: Computer-Aided Design Technology, Associated Technologies, Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. **Applications for Additive Manufacture:** Introduction, The use of AM to Support Medical Applications, Aerospace and Automotive Applications.	
UNIT - II	**Periods: 9L**
VAT PHOTO POLYMERIZATION PROCESSES & JETTING PROCESSES	
VAT Photo polymerization Processes: Stereolithography (SL), Materials, SL resin curing process, SL scan patterns, Micro-stereolithography, Mask Projection Processes, Two-Photon vat photopolymerization, Process Benefits and Drawbacks, Applications of Vat Photopolymerization. **Material and Binder Jetting**: Evolution, Materials, Material Processing Fundamentals, Material Jetting Machines, Process Benefits and drawbacks, binding materials and systems.	
UNIT - III	**Periods: 12L**
EXTRUSION-BASED AND SHEET LAMINATION PROCESSES	
Extrusion Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Benefits and Drawbacks, Applications of Extrusion-Based Processes. **Sheet Lamination AM Processes:** Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications. **Case study (for internal evaluation):** Preparation of hexagonal nut on extrusion based 3d Printer	
UNIT - IV	**Periods: 9L**
POWDER BED FUSION PROCESSES	
Powder Bed Fusion Processes : Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process, Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.	

UNIT - V	**Periods: 9L**
METAL ADDITIVE AND POST PROCESSING TECHNIQUES	
Metal Additive Manufacturing processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. **Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement and Accuracy Improvement.	

TEXT BOOKS:	
1.	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, 2ndEdition (2015), Springer.
2.	Additive Manufacturing, Amit Bandyopadhayay, Susmita Bose, 1st edition (2015), CRC Press.
3.	Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, 2010, Kluwer academic publishers.
REFERENCE BOOKS:	
1.	3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai. 4th Edition (2015), World Scientific publications.
2.	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, 1st edition (2001),Springer publication.
3.	Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, 2006, John Wiley & Sons.
WEB RESOURCES:	
1.	https://blogs.sw.siemens.com/additive/free-am-101-introductory-online-3d-printing-class/
2.	https://additivemanufacturing.com/basics/

ROBOTICS								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 411(B)	Emerging Subject	2	1	0	40	60	100	3

Prerequisite: Basic Engineering Mathematics, Kinematics of Machinery, Basic Electrical and electronics engineering, Computer Programming.

Course Objectives: The objective of this course is to impart knowledge about robots for their control and design in various industrial and general applications .

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the anatomy of robots, workspaces, robot types, end effector functions, and principles of actuation and drive systems.
CO-2	Apply kinematics, DH parameters, obstacle-aware trajectory planning, and control systems for accurate, adaptable, and safe robot motion.
CO-3	Describe various sensors, feedback systems and image processing techniques in robot.
CO-4	Apply programming languages to develop robotic systems and control their behavior.
CO-5	Comprehend the application of AI and ML concepts for operation of robots

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1			2				2	2		2
CO-2	3	3	2		2				2	2		2
CO-3	2				2				2	2		2
CO-4	3	2	2		2				2	2		2
CO-5	2	2			2				2	2		2

Course Outcomes	PSO1	PSO2
CO-1	2	
CO-2	3	
CO-3	2	
CO-4	2	3
CO-5	2	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=8**
BASICS OF ROBOTICS	
Definition and scope of robotics, Historical overview of robotics, Laws of robotics, overview of robotic systems and components, Robot workspaces and configurations, Types of robots and their applications, End effectors and grippers for different tasks and selection criteria. Actuation and drive systems in robot. (For Internal Evaluation) Task: Introduction to Robot Analyzer Software	
UNIT - II	**Periods: 8L+4T=13**
KINEMATICS AND CONTROL OF ROBOT	
Kinematics: Scaling, Rotation and homogenous transformation matrix, Forward kinematics and inverse kinematics, Denavit Hartenberg (DH) parameters, **Trajectory planning**: Trajectory planning and path generation for robot motion- steps in trajectory planning, Joint Space Techniques, Cartesian Space Techniques. **Robot Control:** P,I,D, PD, PI, PID control, adaptive control. (For Internal Evaluation) Task: Perform the Forward kinematics of a 2-DOF planar robot, 3-DOF anthropomorphic arm & a 3-DOF wrist and KUKA KR5 Arc Robot.	
UNIT - III	**Periods: 6L+3T=9**
SENSORS AND COMPUTER VISION IN ROBOT	
Feedback System: Open and closed loop feedback systems. **Robot sensors:** Sensor types and characteristics (Range, proximity, vision, force and torque), Sensor fusion and filtering techniques. **Computer Vision in Robotics:** Image processing and feature extraction, Object detection, tracking, and recognition, Visual servoing and robot vision applications. (For Internal Evaluation) Task: Creating Robot Joint Trajectories	
UNIT - IV	**Periods: 6L+3T=9**
ROBOTIC PROGRAMMING, SIMULATION AND APPLICATIONS	
Programming languages for robotics (C++, Python, ROS), Behavior-based programming and robot architectures, Robot simulation and visualization tools. **Applications:** Robotics at Agriculture, Automotive, Supply Chain, Healthcare, Warehouses - material Transfer, Material handling, loading and unloading; Processing - spot and continuous arc welding & spray painting - Assembly and Inspection. (For Internal Evaluation) Task: Programming of Mobile Robot	

UNIT - V	Periods: 6L+3T=9
AI POWERED ROBOTICS	
AI and Machine Learning for Robotics: Reinforcement learning for robot control, Deep learning in perception and decision-making, **Advanced Topics in Robotics**: Human-robot interaction and collaboration, Mobile robots and navigation, Swarm robotics and multi-robot systems. (For Internal Evaluation) Task: Case study on AI robot.	

TEXT BOOKS:

1.	Robert J. Schilling*, Fundamentals of Robotics Analysis and Control*, PHI Learning,
2.	Francis X. Govers*, Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques,* Pearson Edu.
3.	Groover M P *,Industrial Robotics*, Pearson Edu.
4.	Mittal R K & Nagrath I J , *Robotics and Control*, TMH.
5.	Asada and Slow time, *Robot Analysis and Intelligence*, Wiley Inter-Science.
6.	Peter Norvig & Stuart Russell, *Artificial Intelligence: A Modern Approach*, Third Edition, By Pearson Education India
7.	Kevin Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 201

REFERENCE BOOKS:

1.	Fu K S, *Robotics,* McGraw Hill.
2.	Rich and Knight, *Artificial Intelligence*, 3rd Edition, Tata McGraw Hill, 2014.
3.	Groover, *Industrial Robotics, Technology, Programming and Applications,* Tata Mc

WEB RESOURCES:

1.	http://ecoursesonline.iasri.res.in/course/view.php?id=82
2.	https://www.robotplatform.com/knowledge/sensors/types_of_robot_sensors.html
3.	https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_robotics.htm
4.	https://www.iiitdmj.ac.in/ict.iiitdmj.ac.in/summer-courses-2020/R-AI/
5.	https://ocw.snu.ac.kr/sites/default/files/NOTE/Chap12_Robot%20programming%20lang
6.	https://www.plyrotech.com/blog/artificial-intelligence-machine-learning-and-

MECHANICAL MEASUREMENTS (Professional Elective-III)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 412 (A)	PE	3	0	0	40	60	100	3

Prerequisite: Engineering Mathematics, Thermodynamics, Basic of Electrical and Electronics

Course Objectives: The course focuses on imparting the principles of measurement which includes the working mechanism of various transducers and devices that are in use to measure the important physical variables

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the basic principles & performance characteristics of measurement and also select a suitable displacement measuring instrument for a given application/experimentation.
CO-2	Explain the basic principles, working, advantages, disadvantages and applications of temperature and pressure measuring devices and select a suitable pressure & temperature measuring instrument for a given application/experimentation.
CO-3	Elucidate the basic principles, working, advantages, disadvantages and applications of level & flow measuring instruments and also select a suitable instrument for a given application/experimentation.
CO-4	Describe the basic principles, working, advantages, disadvantages and applications of speed, acceleration and vibration, force, torque and power measuring instruments and also select a suitable instrument for a given application/experimentation.
CO-5	Explain the basic principles, working, advantages, disadvantages and applications of stress strain & humidity measuring instruments and also select a suitable instrument for a given application/experimentation.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1		1								
CO-2	2	1		1								
CO-3	2	1		1								
CO-4	2	1		1								
CO-5	2	1		1								

Course Outcomes	PSO1	PSO2
CO-1	1	1
CO-2	1	1
CO-3	1	1
CO-4	1	1
CO-5	1	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT – I	**Periods: 10L**
MEASUREMENT OF DISPLACEMENT	
Definition – Basic principles of measurement – Measurement systems, generalized configuration and functional description of measuring instruments – examples. Static and Dynamic performance characteristics – sources of errors, Classification and elimination of errors. **Measurement of Displacement**: Theory and construction of various transducers to measure displacement – Piezo electric, Inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures	
UNIT – II	**Periods: 10L**
MEASUREMENT OF TEMPERATURE & PRESSURE	
Measurement of Temperature: Various Principles of measurement-Classification: Expansion Type: Bimetallic Strip- Liquid in glass Thermometer; Electrical Resistance Type: Thermistor, Thermocouple, RTD; Radiation Pyrometry: Optical Pyrometer; Changes in Chemical Phase: Fusible Indicators and Liquid crystals. **Measurement of Pressure:** Different principles used- Classification: Manometers, Dead weight pressure gauge. Tester (Piston gauge), Bourdon pressure gauges, Bulk modulus pressure gauges Bellows – Diaphragm gauges. Low pressure measurement – Thermal conductivity gauges, ionization pressure gauges, Mcleod pressure gauge.	
UNIT – III	**Periods: 8L**
MEASUREMENTS OF LEVEL & FLOW	
Measurement of Level: Direct methods – Indirect methods – Capacitive, Radioactive, Ultrasonic, Magnetic, Cryogenic Fuel level indicators – Bubbler level indicators. **Flow measurement**: Rotameter, magnetic, Ultrasonic, Turbine flow meter, Hot – wire anemometer, Laser Doppler Anemometer (LDA)	
UNIT – IV	**Periods: 10L**
MEASUREMENTS OF SPEED, ACCELERATION & VIBRATION, FORCE, TORQUE AND POWER	
Measurement of Speed: Mechanical Tachometers, Electrical tachometers, Non- contact type-Stroboscope **Measurement of Acceleration and Vibration**: Different simple instruments – Principles of Seismic instruments – Vibrometer and accelerometer using this principle- Piezo electric accelerometer. **Measurement of Force**, **Torque and Power**- Elastic force meters, load cells, Torsion meters, Dynamometers.	

UNIT – V	Periods: 10L
MEASUREMENT OF STRESS-STRAIN & HUMIDITY	
Stress-Strain measurements: Various types of stress and strain measurements –Selection and installation of metallic strain gauges- electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains – Temperature compensation techniques, Use of strain gauges for measuring torque, Strain gauge Rosettes. **Measurement of Humidity**: Moisture content of gases, Sling Psychrometer, Absorption Psychrometer, Dew point meter.	

TEXT BOOKS:	
1.	Principles of Industrial Instrumentation and Control Systems /Alavala / Cengage
2.	Mechanical Measurements and Instrumentation & Control/A.K. Sawhney & Puneet Sawhney/Dhanpat Rai & Co
3.	Instrumentation, Measurement and Analysis/ B.C.Nakra and K.K.Choudhary/ Mc Graw Hill.
REFERENCE BOOKS:	
1.	Mechanical Measurements / Sirohi and Radhakrishna / New Age International
2.	Measurement Systems: Applications & design / D.S Kumar/McGraw Hill Publishers
3.	Experimental Methods for Engineers / Holman
4.	Mechanical and Industrial Measurements / R. K. Jain/ Khanna Publishers.
5	Instrumentation and Mechanical Measurements / A.K. Tayal / Galgotia Publications.
WEB RESOURCES:	
1.	http://ecoursesonline.iasri.res.in/course/view.php?id=82

COMPUTATIONAL FLUID DYNAMICS (Professional Elective-III)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 412	PE	2	1	0	40	60	100	3

Prerequisite: Mathematics, Fluid Mechanics

Course Objectives: The course is designed to impart the knowledge of numerical techniques and its application to the solution of fluid dynamics and heat transfer problems.

Course Outcomes: At the end of the course, the student will be able to:	
CO-1	Formulate Governing Equations of fluid dynamics and analyze their mathematical behavior.
CO-2	Apply the Finite Difference and Finite volume methods for solving simple one, two and three dimensional diffusion problems.
CO-3	Apply Finite volume method for solving steady one dimensional convection diffusion problems.
CO-4	Apply Finite volume method for flow field analysis.
CO-5	Solve engineering problems using CFD.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	2									
CO-2	3	3	2									
CO-3	3	3	2			2						
CO-4	3	3	2									
CO-5	3	3	2									

Course Outcomes	PSO1	PSO2
CO-1	2	
CO-2	2	
CO-3	2	
CO-4	2	
CO-5	2	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=9**
GOVERNING EQUATIONS AND BOUNDARY CONDITIONS:	
Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behavior of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.	
UNIT - II	**Periods: 6L+3T=9**
FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION:	
Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three - dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.	
UNIT - III	**Periods: 6L+3T=9**
FINITE VOLUME METHOD FOR CONVECTION AND DIFFUSION:	
Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.	
UNIT - IV	**Periods: 6L+3T=9**
FLOW FIELD ANALYSIS:	
Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.	
UNIT - V	**Periods: 8L+4T=12**
Turbulence Modeling:	
Introduction to Turbulence Modeling, Important features of turbulent flow, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, k-ε model, k-ω model Necessity of turbulence modeling.	

TEXT BOOKS:	
1.	Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.
2.	Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition – 2007.
3	Chung, T.J., "Computational Fluid Dynamics", Cambridge University, Press, 2002.

REFERENCE BOOKS:	
1.	Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.
2.	Prodip Niyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
3.	Anil W. Date, "Introduction to Computational Fluid Dynamics", Cambridge University Press, 2005.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112105045

CONDITION MONITORING (Professional Elective-III)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 412 (C)	PE	3	-	-	40	60	100	3

Prerequisite: Engineering Mechanics, Dynamics of Machinery

Course Objectives: To familiarize the students with different types and causes of failure of mechanical components and different condition monitoring techniques available for reactive, preventive and predictive maintenance types.

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

CO-1	**Interpret** various failures and different maintenance types
CO-2	**Predict** the causes of vibration by using vibration monitoring technique
CO-3	**Apply** thermography as a tool for condition monitoring and further explain intricacies of it
CO-4	**Describe** and **analyze** wear debris monitoring methods
CO-5	**Comprehend** structural health monitoring principle and its applications

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3	3		2						3
CO-2	3	3	3	3		2						3
CO-3	3	3	3	3		2						3
CO-4	3	3	3	3		2						3
CO-5	3	3	3	3		2						3

Course Outcomes	PSO1	PSO2
CO-1	3	2
CO-2	3	2
CO-3	3	2
CO-4	3	2
CO-5	3	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 12L**
INTRODUCTION ABOUT CONDITION MONITORING	
Introduction about Condition monitoring - Definition, phases, purpose and applications of Condition monitoring, Failure definition, classification of failures, Failure investigation principles, Failure case studies, Bath tub curve, Failure Mode Effects and Criticality Analysis (FMECA), Design, manufacturing and assembly causes of failure, Maintenance types.	
UNIT - II	**Periods: 9L**
VIBRATION MONITORING	
Different Condition monitoring techniques, Principles of vibration monitoring, Causes of vibration - Unbalance, Misalignment, Bent shaft, Oil whirl, Bearing defects, Mechanical looseness, Gear problems, Faults in fluid machines, Vibration analysis, Vibration analyzer, ISO standards, Case study: Vibration Analysis in Industries.	
UNIT - III	**Periods: 9L**
THERMOGRAPHY	
Introduction, Thermal imaging devices- Optical pyrometer, Infrared cameras, Use of IR camera, Industrial applications of thermography - Leakage detection, Electrical and Electronic Component heat generation, Machineries, Applications of thermography in condition monitoring, Case study : Applying Thermography in Industries.	
UNIT - IV	**Periods: 9L**
WEAR DEBRIS MONITORING	
Introduction, Mechanisms of wear, Benefits of wear debris analysis, Detection of wear particles – Spectroscopy, Spectrometric Oil Analysis Procedure (SOAP), Ferrography, Particle count, Common wear materials, Oil sampling technique, Oil analysis, Limits of oil analysis, Case study: Oil Analysis in Industries.	
UNIT - V	**Periods: 9L**
STRUCTURAL HEALTH MONITORING (SHM)	
Definition of Damage, Definition, Principle, Benefits and Applications of SHM, Four stages in SHM - Operational evaluation, Data acquisition, normalization and cleansing, Feature extraction and data compression, Statistical model development, Sensor technology, Piezoelectric sensors, Case studies on different structures.	

TEXT BOOKS:	
1.	Amiya R.Mohanty 'Machinery condition monitoring: Principles and Practices' , CRC Press , Taylor and Francis Group publisher (2019)
2.	R.A. Collacott 'Mechanical Fault Diagnosis and Condition Monitoring', Chapman and Hall London (2020)
3	Daniel Balageas, Claus-Peter Fritzen, Alfredo Guemes 'Structural health monitoring' ,John Wiley Publisher (2019)

REFERENCE BOOKS:	
1.	Cornelius scheffer, Paresh Girdhar Practical Machinery vibration analysis and Predictive Maintenance , Newnes(Elsevier) (2020)
2.	Alan Davies, Hand book of condition monitoring techniques and Methodology , Chapman and Hall Publisher(2021)
3.	J.S.Rao, Vibratory condition monitoring of Machines, Narosa Publishing House(2019)
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/112105048/33
2.	http://nptel.ac.in/courses/112103112/40

INDUSTRIAL TRIBOLOGY (PROFESSIONAL ELECTIVE-III)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 412(D)	PE	2	1	0	40	60	100	3

Prerequisite: Fluid Mechanics & Hydraulic Machinery, Design of machine Elements I & II

Course Objectives:

- To provide the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
- To select proper grade lubricant for specific application and understand the behavior of tribological components.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Calculate the viscosity of fluids and analyze the properties of surfaces
CO-2	Determine the friction and wear of metals and non-metals
CO-3	Analyze the behavior of hydrostatic step bearings.
CO-4	Analyze the hydrodynamic behavior of journal bearings
CO-5	Select proper materials for bearings and Analyze the behavior of coatings on surfaces

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	-	-	-	-	-	2	2	-	1
CO-2	3	2	-	-	-	-	-	-	2	2	-	1
CO-3	3	2	-	-	-	-	-	-	2	2	-	1
CO-4	3	2	-	-	-	-	-	-	2	2	-	1
CO-5	3	2	-	-	-	-	-	-	2	2	-	1

Course Outcomes	PSO1	PSO2
CO-1	3	-
CO-2	3	-
CO-3	3	-
CO-4	3	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT – I	**Periods: 6L+3T=9**
INTRODUCTION TO TRIBOLOGY	
Tribology in design, tribology in industry Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Tribological considerations Nature of surfaces and their contact; Physic mechanical properties of surface layer, Geometrical properties of surfaces, methods of studying surfaces; Study of contact of smoothly and rough surfaces	
UNIT – II	**Periods: 6L+3T=9**
FRICTION AND WEAR	
Role of friction and laws of static friction, causes of friction, theories of friction, Laws of rolling friction; Friction of metals and non-metals; Friction measurements. Definition of wear, mechanism of wear, types and measurement of wear, friction affecting wear, Theories of wear; Wear of metals and non-metals. Types of lubricants and their industrial uses; SAE classification, recycling, disposal of oils, properties of liquid and grease lubricants; lubricant additives, general properties and selection	
UNIT – III	**Periods: 6L+3T=9**
HYDROSTATIC LUBRICATION	
Principle of hydrostatic lubrication, General requirements of bearing materials, types of bearing materials., Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, Hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing, optimum design of hydrostatic step bearing	
UNIT – IV	**Periods: 6L+3T=9**
HYDRODYNAMIC THEORY OF LUBRICATION	
Principle of hydrodynamic lubrication, Various theories of lubrication, Petroff's equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl, anti –friction bearing, hydrodynamic thrust bearing	

UNIT – V	Periods: 8L+4T=12
SURFACE ENGINEERING AND MATERIALS FOR BEARINGS	
Surface modification, Transformation hardening, surface fusion, Thermo chemical processes, surface coatings, Plating and anodizing, Materials for rolling elements bearings, Materials for fluid film bearings, Materials for marginally lubricated and dry bearings.	

TEXT BOOKS:	
1.	S K Basu, S N SenGupta and B B Ahuja, Fundamentals of Tribology, Publishers
2.	Sushil Kumar Srivatsava, Tribology in Industry, Publishers S. Chand & Co Ltd ,2004
3.	H.G.Phakatkar and R.R.Ghorpade, Engineering Tribology, Nirali Publications, 2015
4.	B.C. Majumdar, Introduction to Tribology of bearings , Publishers Tata McGraw Hill
REFERENCE BOOKS:	
1.	J Halling, Introduction to Tribology, , Publishers Wykeham Publications Ltd, 1976
2.	Michael J Neale, The Tribology Hand Book, Elsevier Publications 2nd Edition , 1995
3.	FT Barwell, Bearing Systems, Principles and Practice, Publishers oxford university
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112102015
2.	https://onlinecourses.nptel.ac.in/noc22_me03/preview

NON-CONVENTIONAL ENERGY SOURCES (PROFESSIONAL ELECTIVE-IV)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 413(A)	PE	3	0	0	40	60	100	3

Prerequisite: Engineering Mechanics, Basic Thermodynamics.

Course Objectives: In the backdrop of depleting fossil fuels, the course is intended to give a overall perspective of the potential of non-conventional energy sources like solar, wind, ocean, geothermal etc. The course also attempts to stress the importance of direct energy conversion systems.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	**Distinguish** various renewable energy sources & principles of solar radiation.
CO-2	**Classify** solar collectors, solar storage systems & **demonstrate** the various solar photovoltaic systems
CO-3	**Evaluate** the performance characteristics of wind machines and **classify** the Bio-gas plants.
CO-4	**Elucidate** the working principles of OTEC, tidal power generation & geothermal power plants.
CO-5	**Illustrate** the principle and importance of MHD & Fuel cells.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1	-	-	-	1	1	-	-	-	-	-
CO-2	2	1	-	-	-	1	1	-	-	-	-	-
CO-3	2	1	-	-	-	1	1	-	-	-	-	-
CO-4	2	1	-	-	-	1	1	-	-	-	-	-
CO-5	2	1	-	-	-	1	1	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	1	
CO-2	1	
CO-3	1	
CO-4	1	
CO-5	1	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3:

SYLLABUS	
UNIT - I	**Periods: 9L**
NON-CONVENTIONAL ENERGY RESOURCES & PRINCIPLES OF SOLAR RADIATION	
Non-Conventional Sources of Energy: An overview, Energy Consumption, Details of Energy usage in each sector in India, Consequences of Energy Consumption. **Principles of solar radiation:** Solar constant, extraterrestrial and terrestrial solar radiation, Direct & diffuse radiation, solar radiation on tilted surface.	
UNIT - II	**Periods: 9L**
SOLAR THERMAL SYSTEMS & SOLAR ENERGY STORAGE SYSTEMS	
Solar Thermal Systems: Types of solar collectors-non-concentric & concentric type, flat plate collectors, Absorber coatings. **Solar energy storage systems** - Types & Applications - Solar Photovoltaic Systems	
UNIT - III	**Periods: 10L**
WIND ENERGY & BIO-MASS	
Wind energy: Sources and potentials of WEC systems, horizontal and vertical axis wind mills, performance characteristics, Betz criteria. **Bio-mass**: Principles of Bio-conversion, Anaerobic/aerobic digestion, types of bio gas digesters, Case study - utilization for cooking and economic aspects.	
UNIT - IV	**Periods: 10L**
GEOTHERMAL ENERGY & OCEAN ENERGY	
Geothermal energy: Geothermal sources- classification- vapour, liquid dominating systems, applications, potential in India. **Ocean energy:** Ocean Thermal Energy Conversion (OTEC)-principles and thermodynamic cycles. Energy of tides: Introduction, principles, components, operation methods, limitations of tidal power generation. Wave energy conversion techniques.	
UNIT – V	**Periods: 10L**
DIRECT ENERGY CONVERSION & FUEL CELLS:	
Direct energy conversion: Principles of DEC, Thermo-electric generators, seebeck, peltier and joule Thomson effects, Selection of materials, applications. **Magneto Hydro dynamic generators (MHD):** principles, dissociation and ionization, Thermal efficiency, MHD Engine, power generation systems. **Fuel cells:** Design & principle of operation, classification, types of fuel cells, efficiency and applications of Fuel cells.	

TEXT BOOKS:

1.	G.D. Rai, "*Non-Conventional Energy Sources*", Khanna publishers, 2004
2.	Tiwari and Ghosal, "*Renewable energy resources*", Narosa publications, 2004

REFERENCE BOOKS:

1.	Twidell & Weir, Taylor & Francis "*Renewable Energy Sources*", 2006
2.	Sukhatme "*Solar Energy*", Tata McGraw-Hill Education, 1996
3.	John Twideu and Tony Weir "*Renewal Energy Resources*", BSP Publications, 2006
4.	Ashok V Desai "*Non-Conventional Energy*", Wiley Eastern publications,

WEB RESOURCES:

1.	http://nptel.ac.in/courses/112101098
2.	http://nptel.ac.in/courses/121106014

MANAGERIAL ECONOMICS AND FINANCIAL ACCOUNTANCY (Professional Elective-IV)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 413 (B)	PE	3	0	0	40	60	100	3

Prerequisite: NIL

Course Objectives: To make the students to learn and Apply the fundamentals of managerial economics the concepts of costs and break – even analysis. To acquaint the students with the different market situations and forms of business organization. To impart the knowledge of financial accounting.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Differentiate micro vs macro-economics and apply the concepts of demand analysis & demand forecasting.
CO-2	Apply costing concepts and evaluate the Break even problems.
CO-3	Identify classes of market structure, Pricing Policies and business organizations.
CO-4	Differentiate fixed and working capital ,explore sources of finance, depreciation techniques for various industries.
CO-5	Prepare balance sheet of a business organization.

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	1	2									3	
CO-2	1	2									3	
CO-3											3	
CO-4		2							2	2	3	2
CO-5	1	2							2	2	3	2

Course Outcomes	PSO1	PSO2
CO-1		1
CO-2		1
CO-3		
CO-4		1
CO-5		1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 9L**
INTRODUCTION TO MANAGERIAL ECONOMICS	
Introduction to Managerial Economics: Definition; micro and macroeconomics; demand analysis - demand determinants, law of demand and its exceptions, elasticity of demand; Demand Forecasting, Factors governing demand Forecasting, Methods of demand forecasting - survey methods and statistical methods.	
UNIT - II	**Periods: 9L**
COST ANALYSIS	
Cost Analysis: Cost concepts - opportunity cost, fixed vs. variable costs, explicit vs. implicit costs, out of pocket vs. imputed costs; Break Even Analysis -determination of break-even point.	
UNIT - III	**Periods: 12L**
MARKET STRUCTURES & BUSINESS ORGANIZATION	
Market Structures: Types of competition and Markets; features of perfect competition; imperfect competition monopoly, monopolistic competition. Objectives and Policies of Pricing- Methods of Pricing. **Business Organization:** Features of different forms of Business Organization- Sole trader; partnership; joint stock company; pubic enterprises.	
UNIT - IV	**Periods: 9L**
INTRODUCTION TO CAPITAL & DEPRECIATION	
Introduction to Capital: Capital and its significance, Types of Capital, Estimation of Fixed and Working capital requirements, Methods and sources of raising finance. **Depreciation**: Causes of depreciation, Factors influencing depreciation, common methods of Depreciation.	
UNIT - V	**Periods: 9L**
INTRODUCTION TO FINANCIAL ACCOUNTING	
Introduction to Financial Accounting: Final accounts of a sole trader-preparation of trading account, profit and loss account, balance sheet. **Case Study:** Preparing a balance sheet of a sole trader with student teams.	

TEXT BOOKS:
1. Managerial Economics and Financial Analysis by A. R. Aryasri; McGraw-Hill Education (India) Private Limited, New Delhi (2015).
2. Engineering Economics, Volume I by Tara Chand; Published By Nem Chand & Bros, Roorke (2019).
3. IM Pandey, “Financial Management” Vikas Publications 11th Edition,2017.
REFERENCE BOOKS:
1. Managerial Economics by Varshney & Maheswari; Published by Sultan Chand, 2014.
2. Financial Accounting by Shim &Siegel; Published by Schaum’s Outlines, TMH 2007.
3. Fundamentals of Financial Management (13th edition) By James C. VanHorne,John M. Wachowicz FT Prentice Hall Harlow 2015.
WEB RESOURCES:
https://nptel.ac.in/courses/110101005

UNCONVENTIONAL MACHINING PROCESS (Professional Elective-IV)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 413 (C)	PE	2	1	0	40	60	100	3

Prerequisite: Metal cutting, Machine Tools & Metrology

Course Objectives:
To make students acquainted with a functional understanding of equipment, process, process parameters and various energy involved in an un-conventional machining.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the need of Un-Conventional Machining Processes and able to classify various processes
CO-2	Elucidate the role of mechanical energy in Un-Conventional Machining Processes.
CO-3	Apply the knowledge on machining electrically conductive material through electrical energy in Un-Conventional Machining Processes.
CO-4	Describe the concept of machining the hard material using chemical energy and electro chemical energy.
CO-5	Explain various thermal energy based Un-Conventional Machining Processes.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1										
CO-2	3	1										
CO-3	3	1										
CO-4	3	1										
CO-5	3	1										

Course Outcomes	PSO1	PSO2
CO-1	1	
CO-2	1	
CO-3	1	
CO-4	1	
CO-5	1	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=9**
UNCONVENTIONAL MACHINING PROCESS	
Introduction - Need - Classification - Energies employed in the processes - Brief overview of Abrasive jet machining (AJM), Water jet machining (WJM), Ultrasonic machining (USM), Electric discharge machining (EBM), Electro-chemical machining (ECM), Electron beam machining (EBM), Laser beam machining (LBM), Plasma arc machining (PAM).	
UNIT - II	**Periods: 6L+3T=9**
MECHANICAL ENERGY BASED PROCESSES	
Abrasive Jet Machining, Water Jet Machining and Ultrasonic Machining - Working Principles, Equipment, Process parameters, Material removal rate, Applications.	
UNIT - III	**Periods: 6L+3T=9**
ELECTRICAL ENERGY BASED PROCESSES	
Electric Discharge Machining - Working Principles, Equipment, Process Parameters, Material removal rate, Electrode / Tool, Tool Wear, Dielectric, Flushing, Wire cut EDM - Applications.	
UNIT - IV	**Periods: 6L+3T=9**
CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES	
Chemical machining - Etchants, Maskants - techniques. Electro-chemical machining — Working principle, Equipment, Process Parameters, Material removal rate, Electrical circuit. Electro-chemical grinding - Electro-chemical honing - Applications.	
UNIT - V	**Periods: 6L+3T=9**
THERMAL ENERGY BASED UN-CONVENTIONAL MACHINING PROCESSES	
Laser Beam machining, Plasma Arc Machining - Principles, Equipment. Electron Beam Machining -Principles, Equipment, Types, Beam control techniques, Material removal rate - Applications.	

TEXT BOOKS:	
1.	P. K. Mishra, Non-Conventional Machining, Narosa Publishing House, New Delhi, 2007.
2.	P. C. Pandey and H.S. Shan, Modern Machining Processes, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2008.
3.	Joao Paulo Davim, Nontraditional Machining Processes: Research Advances, Springer, New York, 2013.

REFERENCE BOOKS:	
1.	Vijaya Kumar Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd., New Delhi, 2005.
2.	Hassan El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill Professional, New Delhi, 2005
WEB RESOURCES:	
1.	https://onlinecourses.nptel.ac.in/noc21_me56/preview
2.	https://nptel.ac.in/courses/112/105/112105212.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (Professional Elective-IV)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 413(D)	PE	2	1	0	40	60	100	3

Prerequisite: Probability and Linear Algebra

Course Objectives: To discuss about the Basic principles, techniques, and applications of artificial intelligence and further analyze and apply the insights into knowledge representation, problem-solving, and learning methods in Science and Engineering domains.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Illustrate foundations of Artificial Intelligence (AI) and its applications, Problem Types, Characteristics and Search Space Representations.
CO-2	Apply Search Techniques (Brute-Force, Heuristic and Game Playing) of Artificial Intelligence and solving AI problems by applying suitable searching methods.
CO-3	Apply Knowledge representation and semantic in knowledge representation. Discuss about Uncertainty and its importance and classify the various approaches of the Expert systems using case studies.
CO-4	Classify the variety of learning algorithms and popular machine learning approaches.
CO-5	Identify Mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	1	2	-	2	2	2	1	1	-	2
CO-2	3	3	2	3	2	2	2	2	2	2	1	2
CO-3	2	2	1	2	1	1	2	2	2	2	-	2
CO-4	3	3	2	3	1	2	2	2	3	2	2	2
CO-5	2	2	2	2	1	2	2	2	2	1	1	2

Course Outcomes	PSO1	PSO2
CO-1	1	2
CO-2	2	2
CO-3	1	2
CO-4	2	2
CO-5	1	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=9**
FOUNDATIONS OF ARTIFICIAL INTELLIGENCE:	
AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation, AI Techniques, Problem Types and Characteristics, State Space Search, Production Systems and its characteristics, Applicationsof Artificial Intelligence.	
UNIT - II	**Periods: 8L+4T=12**
HEURISTIC SEARCHING TECHNIQUES AND GAME PLAYING:	
Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search, Bi-Directional Search and Uniform-Cost Search. Informed Search Algorithms (Heuristic search): Introduction, Heuristic evaluation function, Generate-and-Test, Best-First Search, A* Algorithm, Problem Reduction Algorithm, AO* Algorithms, Hill climbing, Simulated Annealing, Constraint Satisfaction Algorithm (CSP). Game Playing - Adversarial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.	
UNIT - III	**Periods: 6L+3T=9**
LOGIC AND KNOWLEDGE REPRESENTATION	
Knowledge Representation and Structured Knowledge: Associative networks, frame structures, conceptual dependencies and scripts, ontologies. Logic: Prepositional logic: syntax and semantics, First Order Predicate Logic (FOPL): Syntax and semantics, conversion to clausal form, inference rules, unification, and the resolution principles. Knowledge Acquisition and Expert System: Type of learning, Knowledge Acquisition, Early work in machine learning, learning by induction. Introduction to expert system, Phases of expert system, characteristics of expert system and a case study;	
UNIT - IV	**Periods: 6L+3T=9**
MACHINE LEARNING	
Introduction to machine learning, Types of Learning, Supervised Learning – Regression - Classification, Unsupervised learning/Clustering: Similarity and Distance Measures, Clustering Techniques: K-Means Algorithm, Hierarchical Clustering, Clustering of Categorical Attributes; Reinforcement Learning, Applications of Learning.	
UNIT - V	**Periods: 6L+3T=9**
ARTIFICIAL NEURAL NETWORKS:	
Introduction to Neural Networks, Model, Activation functions, Perceptron, The Multilayer Perceptron (MLP), Error Propagation, Delta Rule, Back Propagation Algorithm, Supervised, Unsupervised and Semi-Supervised Learning, introduction to Reinforcement learning, Deep Learning: layers, activation functions, optimizers, Convolutional Neural Networks (CNN), Applications, A case study on Object Recognition using CNN.	

TEXT BOOKS:	
1.	“Artificial Intelligence”, by Elaine Rich, Kevin Knight, Shivashankar B. Nair, McGraw Hill.
2.	Artificial Intelligence Modern Approach, Russell Stuart, Norvig Peter, Pearson Education series in AI, 3rd Edition, 2019.
3.	“Artificial Intelligence, Structures, Strategies for Complex Problem Solving”,by George F Luger, Addison Wesley.
4.	Machine Learning, V.K. Jain, Khanna Book Publishing Co. (P) Ltd., 2019
5.	Applied Machine Learning, M. Gopal, McGraw-Hill Education, 2018
REFERENCE BOOKS:	
1.	Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.
2.	Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
3.	“Artificial Intelligence: Foundations of Computational Agent”, by David L Poole, Alan
4.	“Artificial Intelligence: A Modern Approach, Prentice Hall series ofArtificial Intelligence.
5.	Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
6.	Introduction to Machine Learning Edition 2, by Ethem Alpaydin
7.	The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/106105077
2.	https://onlinecourses.nptel.ac.in/noc23_cs18/preview
3.	https://www.ibm.com/topics/artificial-intelligence
4.	https://hastie.su.domains/Papers/ESLII.pdf
5.	https://www.geeksforgeeks.org/machine-learning-versus-artificial-intelligence/

OPERATIONS RESEARCH (Professional Elective-V)								
Code	Category	Periods			Sessional Marks	End Exam	Total Mark	Credits
		L	T	P				
MEC 414(A)	PE	2	1	0	40	60	100	3

Prerequisite: Mathematics

Course Objectives: The course is intended to identify and develop operational research models, understand the mathematical tools to solve optimization problems, and develop a report that describes the model, the solving techniques and analyses the results.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	**Develop** a linear programming and **choose** an appropriate method for obtaining an optimal solution.
CO-2	**Estimate** optimal solution for transportation and assignment problems.
CO-3	**Compute** the scheduled time of completion of a project by applying the concepts of PERT/CPM for decision making and further **Select** an inventory model and apply them in inventory management
CO-4	**Compute** optimum replacement period and optimum Job sequencing by applying various replacement models and sequencing models
CO-5	**Develop** optimal schedule by applying the concept of game theory and further use Queuing models to **estimate** the average waiting time

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

Course Outcomes	PSO1	PSO2
CO-1	2	1
CO-2	2	1
CO-3	2	1
CO-4	2	1
CO-5	2	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 8L+4T = 12**
LINEAR PROGRAMMING MODEL	
Introduction to Operations Research – Linear Programming - Mathematical Formulation – Graphical method – Simplex method – Two – Phase Simplex 000method, Big-M method-Duality Simplex method. Introduction to Advanced optimization techniques	
UNIT - II	**Periods: 6L+3T=9**
TRANSPORTATION AND ASSIGNMENT MODELS:	
Transportation model – Initial solution by North West corner method – least cost method – VAM. Optimality test – MODI method and stepping stone method. **Assignment model** – formulation – balanced and unbalanced assignment problems.	
UNIT - III	**Periods: 6L+3T=9**
PROJECT MANAGEMENT AND INVENTORY MANAGEMENT:	
PROJECT MANAGEMENT: Basic terminologies – Constructing a project network – Scheduling computations – PERT – CPM. **INVENTORY MANAGEMENT:** Introduction, types of inventories, costs associated with inventories, concept of EOQ, deterministic inventory problems with no shortages, with shortages.	
UNIT - IV	**Periods: 6L+3T=9**
REPLACEMENT AND SEQUENCING MODELS:	
Replacement policies - Replacement of items that deteriorate with time (value of money not changing with time) – Replacement of items that deteriorate with time (Value of money changing with time) – Replacement of items that fail suddenly (individual and group replacement policies). **Sequencing models-** n job on 2 machines – n jobs on 3 machines – n jobs on m machines, Traveling salesman problem.	
UNIT - V	**Periods: 6L+3T=9**
INVENTORY MANAGEMENT AND QUEUING THEORY	
Queuing theory: Queuing systems and their characteristics. M/M/1 : FCFS/ μ / μ **Game theory**: Optimal solution of two-person zero-sum games, the max-min and min-max principle. Games without saddle points, mixed strategies. dominance , graphical method.	

TEXT BOOKS:	
1.	S.D.Shrama, Operation Research, Kedar Nath Ram Nath Publishers, 2015.
2.	Handy A. Taha, Operations Research An introduction, 10th edition, 2017.
3.	V. K Kapoor Operations Research,S.Chand Publications , 7 th edition, 2001.

REFERENCE BOOKS:	
1.	Hira D S and Gupta P K, Operations Research, S.Chand & Sons, 2007.
2.	Panneerselvan. R., Operation Research, Prentice Hall of India Pvt Ltd. 2006.
3.	Kanti Swarup, Gupta P.K., and Manmohan, Operations Research, S.Chand & sons, 2004.

WEB RESOURCES:	
1.	https://orc.mit.edu/
2.	www.orsi.in/
3.	https://nptel.ac.in/courses/110106062
4.	https://www.journals.elsevier.com/european-journal-of-operational-research/

ALTERNATE FUELS (Professional Elective-V)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 414(B)	PE	3	0	0	40	60	100	3

Prerequisite: Basic Thermodynamics, Applied Thermal Engineering -II

Course Objectives: To create awareness on various alternate fuels as a primary source of energy, understand their relative importance and limitations with reference to various distinct applications and to acquaint the student with their production.

Course Outcomes: At the end of the course, the student will be able to:	
CO-1	Explain the need for alternate fuels, categorize and outline their relative merits and demerits.
CO-2	Describe the harmful effects of emissions and further explain emission norms.
CO-3	Evaluate the properties of different gaseous fuels and further study the working of engines using these fuels.
CO-4	Demonstrate the production of bio-diesel fuel, illustrate and compare their characteristics and further investigate the performance of engines using bio-diesel.
CO-5	Outline the layout of fuel cell driven and solar powered vehicles.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2					2	2					
CO-2	2	2				2	2					
CO-3	2	2				2	2					
CO-4	2	2				2	2					
CO-5	2					2	2					

Course Outcomes	PSO1	PSO2
CO-1	2	
CO-2	2	
CO-3	2	
CO-4	2	
CO-5	2	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 8L**
INTRODUCTION TO ALTERNATE FUELS:	
Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels.	
UNIT - II	**Periods: 8L**
NEED FOR ALTERNATE FUELS:	
Effects of constituents of Exhaust gas emission on environmental condition of earth (N_2 , CO_2, CO, NO_x, SO_2, O_2) Pollution created by Exhaust gas emission in atmosphere. Greenhouse effect, Factors affecting greenhouse effect. Study of Global Carbon Budget, Carbon foot print and Carbon credit calculations. Emission norms as per Bharat Standard up to BS – IV.	
UNIT - III	**Periods: 8L**
GASES AS ALTERNATE FUELS:	
Availability of CNG, properties, modification required to use in engines, performance and emission characteristics of CNG in SI & CI engines, performance and emission using LPG. Hydrogen- storage and handling, performance and safety aspects.	
UNIT - IV	**Periods: 8L**
DIESEL/BIO-DIESEL FUELS-OIL FEED STOCKS:	
Transesterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing, Bio diesel-Oxidation stability-Performance in Engines, Properties of bio-fuels and their importance in the context of IC Engines. Vegetable Oils: Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics of bio diesel and its characteristics.	
UNIT - V	**Periods: 8L**
FUEL CELL AND SOLAR DRIVEN VEHICLES	
Fuel cell driven vehicles: Concept of Fuel cells based on usage of hydrogen and methanol, Layout of fuel cell driven vehicles, advantages and limitations, specifications, system components. Power rating and performance, Heat dissipation. **Solar driven vehicles:** Layout of solar driven vehicles, advantages and limitations, specifications, system components.	

TEXT BOOKS:	
1.	Alternate Fuels – Dr. S. S. Thipse – Jaico Publications
2.	Richard. L. Bechfold, Alternative Fuels Guide BooK, SAE International

REFERENCE BOOKS:	
1.	Alcohols as motor fuels progress in technology, Series No. 19 – SAE Publication USE
2.	Alternative Fuels Guidebook – Bechtold R
3.	Nagpal, Power Plant Engineering, Khanna Publishers, 1991.

WEB RESOURCES:	
1.	https://afdc.energy.gov/fuels/
2.	https://www.fueleconomy.gov/feg/current.shtml
3.	https://www.energy.gov/sites/default/files/2014/03/f11/fcm08r0.pdf

ADVANCED MECHANICS OF MATERIALS (Professional Elective-V)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 414 (C)	PE	2	1	0	40	60	100	3

Prerequisite: Engineering Mechanics, Mechanics of Solids

Course Objectives: To make students understand the advanced topics related to indeterminate beams, plane stress and plane strain and analyze stresses in rotating discs and curved bars. Further the student will be taught the concept of shear centre and Torsion of non-circular shafts..

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Determine stress and strain transformations and derive constitutive equations in elasticity.
CO-2	Analyze stresses in curved bars and rotating discs
CO-3	Calculate fixing moments and support reactions in fixed and continuous beams
CO-4	Determine displacements of determinate and indeterminate structures by applying Castigliano's theorem and stresses due to torsion of non-circular shafts.
CO-5	Determine shear center in thin walled members

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3									
CO-2	3	3	3									
CO-3	3	3	3									
CO-4	3	3	3									
CO-5	3	3	3									

Course Outcomes	PSO1	PSO2
CO-1	3	
CO-2	3	
CO-3	3	
CO-4	3	
CO-5	3	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=9**
STRESS AND STRAIN TRANSFORMATION & THEORY OF ELASTICITY	
Stress and Strain Transformation: Plane stress transformation, plane strain transformation, principal stresses and principal strains, strain rosettes. **Theory of Elasticity**: Equilibrium and compatibility equations in Cartesian coordinates, Material property relationships - generalized Hooke's law, shear and bulk moduli.	
UNIT - II	**Periods: 6L+3T=9**
CURVED BARS & ROTATING DISCS	
Stresses in Curved Bars: Determination of radius of neutral axis in circular, rectangular and trapezoidal sections, stresses in crane hook **Stresses due to Rotation:** Stresses in wheel rim, rotating disc of uniform thickness and disc of uniform strength, permissible speed of a solid disc.	
UNIT - III	**Periods: 6L+3T=9**
FIXED AND CONTINUOUS BEAMS	
Fixed Beams: Fixing moments for a fixed beam: using moment area method and Macaulay's method, effect of sinking support and rotation of support. **Continuous Beams**: Analysis of continuous beams using Clapeyron's three-moment theorem, reactions at the supports.	
UNIT - IV	**Periods: 8L+4T=12**
ENERGY METHODS AND TORSION OF NON-CIRCULAR SHAFTS	
Energy Methods: Elastic strain energy for various types of loading, Application of Castigliano's theorems to statically determinate and indeterminate structures subjected to axial and transverse loading. **Torsion of Non-Circular Shafts:** Concept of Saint Venant's warping function and Prandtl stress function, maximum shear stress in solid sections – triangular and square. maximum shear stress in thin walled closed sections.	
UNIT - V	**Periods: 6L+3T=9**
TRANSVERSE SHEAR	
Shear in straight members, thin walled members, concept of shear center for open thin walled members.	

TEXT BOOKS:	
1.	L. S. Srinath, Advanced mechanics of solids, 3rd Edition, McGraw-Hill, 2009
2.	S S Rattan, Strength of Materials, 2nd Edition, Tata McGraw Hill Education, 2011.
REFERENCE BOOKS:	
1.	Stephen Timoshenko/Theory of Plates and Shells/TATA McGraw Hill Second
2.	Ferdinand P. Beer, E. Russell Johnston /Mechanics of Materials / TATA McGraw Hill Third Edition
3.	Jacob Pieter Den Hartog /Advanced strength of materials /Dover Publications NewYork
4.	Seely and Smith /Advanced Mechanics of materials/ / John Willey
WEB RESOURCES:	
1.	https://ocw.mit.edu/courses/materials-science-and-engineering/3-11-mechanics-of-materials-fall-1999/modules/

PRODUCT DESIGN AND MANUFACTURING (Professional Elective-V)								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 414(D)	PE	3	0	0	40	60	100	3

Prerequisite: Manufacturing Process

Course Objectives: Develop a comprehensive understanding of product design principles, manufacturing considerations, value engineering, modern approaches, and the role of computers in product design, manufacturing, and management.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the essential factors and phases involved in the design process.
CO-2	analyze product strategies, consider human factors in product design, and apply functional design principles.
CO-3	Describe the DFM process, estimate manufacturing costs, and consider human factors in product design for optimal usability.
CO-4	Apply value engineering techniques, explore modern approaches to product design, and analyze the benefits of concurrent design.
CO-5	Explain the role of computers in product design, manufacturing, and management, and explore advanced manufacturing concepts such as CIM and JIT.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1	1									
CO-2	2	2	2									
CO-3	2	2	2									
CO-4	2	2	2									
CO-5	2	2	2									

Course Outcomes	PSO1	PSO2
CO-1	1	
CO-2	2	
CO-3	2	
CO-4	2	
CO-5	2	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 9L**
INTRODUCTION TO PRODUCT DESIGN:	
Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production–Consumption Cycle, Flow and Value Addition in the Production–Consumption Cycle, The Morphology of Design (The Seven Phases), Primary Design Phases and Flowcharting, Role of Allowance, Process Capability, and Tolerance in Detailed Design and Assembly.	
UNIT - II	**Periods: 9L**
PRODUCT DESIGN PRACTICE AND HUMAN ENGINEERING CONSIDERATIONS:	
Product Strategies, Pricing Strategy for Product, Product Quality Strategy, Product Luxuriousness Strategy, Product Utility Strategy, Time to Market, Analysis of the Product, The Three S's , Standardization, Renard Series, Simplification, Role of Aesthetics in Product Design, Functional Design Practice	
UNIT - III	**Periods: 9L**
DESIGN FOR MANUFACTURING(DFM) AND HUMAN ENGINEERING CONSIDERATIONS IN PRODUCT DESIGN :	
Design for Manufacturing: Overview of the DFM Process, Estimation of manufacturing costs, Reduction of costs of components, assembly and supporting production, impact of DFM decisions on Development Time, Development Cost, Product Quality, External Factors Component reuse, Life cycle costs. **Human Engineering Considerations in Product Design:** Human Being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange, Workplace Layout from Ergonomic Considerations, Noise, Heating and Ventilating, Lighting	
UNIT - IV	**Periods: 9L**
VALUE ENGINEERING AND MODERN APPROACHES TO PRODUCT DESIGN:	
Value, Nature and Measurement of Value, Maximum Value, Normal Degree of Value, Importance of Value , The Value Analysis Job , Creativity , Steps to Problem-Solving and Value Analysis, Value Analysis Tests , Value Engineering Idea Generation Check-list, Cost Reduction Through Value Engineering Case Study on Tap Switch Control Assembly Material and Process Selection in Value Engineering. Modern Approaches to Product Design: Concurrent Design, The Design Team, Benefits from Concurrent Design Approach, Quality Function Deployment (QFD), Rapid Prototyping	

UNIT - V	Periods: 9L
ROLE OF COMPUTER IN PRODUCT DESIGN, MANUFACTURING AND MANAGEMENT:	
Product Cycle and CAD/CAM, Role of Computer in Manufacturing, Role of Computer in Design Process, Creation of a Manufacturing Database , Computer Integrated Manufacturing: Definition, Integrating Product Design, Manufacturing and Production Control, Benefits of CIM; Communication Networks, Group Technology, Production Flow Analysis (PFA), Computer Aided Process Planning (CAPP), Material Requirement Planning (MRP), Moving Towards Total Automation: Role of Artificial Intelligence, Flexible Manufacturing Systems, Just-In-Time (JIT) Manufacturing	

TEXT BOOKS:	
1.	A. K. Chitale, R. C. Gupta, Product Design And Manufacturing, Sixth edition, PHI
2.	Eppinger, S. and Ulrich, K., 2015. Product design and development. McGraw-Hill Higher Educatio
REFERENCE BOOKS:	
1.	Magrab, E.B., Gupta, S.K., McCluskey, F.P. and Sandborn, P. *Integrated product and process design and development: the product realization process*. CRC Press. ., 2009
2.	Boothroyd, G.,. *Product design for manufacture and assembly. Computer-Aided Design,* 26(7), pp505-520
WEB RESOURCES:	
1.	https://onlinecourses.nptel.ac.in/noc21_me66

HEAT TRANSFER								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 415	PC	2	1	0	40	60	100	3

Prerequisite: Mathematics-I, Basic Thermodynamics , Fluid Mechanics & Hydraulic

Course Objectives: To understand and apply the principles of heat transfer in analyzing heat exchange devices.

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

CO-1	Determine the one dimensional steady state heat conduction through slabs, concentric cylinders, concentric spheres and fins.
CO-2	Predict the temperature-time history and heat foregone in unsteady state heat conduction, and apply dimensional analysis to convection heat transfer.
CO-3	Determine rate of heat transfer in forced and natural convection.
CO-4	Apply LMTD and ϵ-NTU methods for design of heat exchangers and explain pool boiling and condensation phenomena.
CO-5	Calculate the radiative heat exchange between various geometries by making use of radiation laws.

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	**3**	**3**	**2**				**1**	**1**	**1**	**1**		**1**
CO-2	**3**	**3**	**2**				**1**	**1**	**1**	**1**		**1**
CO-3	**3**	**3**	**2**				**2**	**1**	**1**	**1**		**1**
CO-4	**2**	**3**	**2**				**2**	**1**	**1**	**1**		**1**
CO-5	**3**	**3**	**2**				**1**	**1**				

Course Outcomes	PSO1	PSO2
CO-1	3	
CO-2	3	
CO-3	3	
CO-4	3	
CO-5	3	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+3T=9**
UNIT TITLE: Conduction Heat Transfer	
Basic Concepts: Modes of heat transfer – Basic laws of heat transfer – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates. **One-Dimensional Steady State Heat Conduction:** Temperature distribution and heat conduction in homogeneous slabs, coaxial cylinders and concentric spheres – Overall heat transfer coefficient - Electrical analogy - Critical radius of insulation. Systems with variable Thermal conductivity – Systems with internal heat generation, Temperature distribution and heat transfer in long fins, short fins and fins with insulated tip – fin effectiveness and fin efficiency. ***NOTE: Case study on Fins***	
UNIT - II	**Periods: 6L+3T=9**
UNIT TITLE: Transient Heat Conduction & Dimensional Analysis	
Transient heat conduction (One-Dimensional): Systems with negligible internal resistance – Significance of Biot and Fourier Numbers - Chart solutions of transient conduction systems. **Dimensional Analysis:** Buckingham's π-theorem – Dimensional analysis applied to forced convection and natural convection – Significance of various non-dimensional numbers. ***NOTE: Case study on applications of Transient Heat Conduction***	
UNIT - III	**Periods: 6L+3T=9**
UNIT TITLE: Convective Heat Transfer	
Forced Convection: External Flow – Boundary layer theory - flow over a horizontal flat plate – flow across cylinders and spheres - Empirical correlations for Nusselt number. Internal Flow - velocity and thermal boundary layers in laminar flow through pipe – hydrodynamic and thermal entry lengths - Empirical correlations for Nusselt number. Reynolds and Colburn analogies for turbulent flow. **Natural Convection:** Velocity and thermal boundary layers in heat transfer by natural convection from a vertical plate - empirical correlations for Nusselt number for natural convection from plates and cylinders. ***NOTE: Case study on applications of Convection***	

UNIT - IV	**Periods: 6L+3T=9**
UNIT TITLE: Heat Exchangers and Heat Transfer in Phase Change	
Heat Exchangers: Classification – Overall heat transfer coefficient - Fouling factor – LMTD and NTU methods for Parallel flow and Counter flow heat exchangers **Boiling and Condensation:** Regimes of saturated pool boiling of water – Drop-wise and film-wise condensation – Nusselt's analysis for laminar film-wise condensation on a vertical plate and horizontal pipes. ***NOTE: Case study on Shell and tube Heat Exchangers***	
UNIT - V	**Periods: 6L+3T=9**
UNIT TITLE: Radiation Heat Transfer Concepts	
Thermal Radiation: Emissivity characteristics and laws of Black body radiation – Irradiation– laws of Planck, Wien, Kirchoff, Stefan and Boltzmann **Radiation Heat Transfer:** Heat exchange between two black bodies – shape factor, Heat exchange between between (i) a small gray body with a large enclosure, (ii) two parallel geometries - Radiation shields.	

TEXT BOOKS:	
1.	Dr. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, 5th Edition , New Age International Publishers Limited, 2017.
2.	A.F. Mills & V. Ganeshan, Heat Transfer, 2nd Edition, Pearson Publishers, 2009.
3.	J.P. Holman and S. Bhattacharya, Heat Transfer, 10th Edition, Tata McGraw Hill, 2017.
DATA BOOKS:	
1.	C.P.Kothandaraman, S. Subramaniam, *Heat and Mass Transfer Data Book*, 10th Edition, New Age International Publishers Limited,2022.
REFERENCE BOOKS:	
1.	Er. R.K. Rajput, *Heat and Mass Transfer*, 4th Edition, S. Chand Limited, 2007.
2.	Yunus A Cengel; Afshin J. Ghajar, *Heat and Mass Transfer: Fundamentals and Applications*, 5th Edition, Tata Mc Graw Hill, 2014.
3.	F.P. Incropera, D.P. Dewitt, T.L. Bergman and A.S. Lavine, Incropera's Principles of Heat and Mass Transfer, Wiley India Edition, 2018.
WEB RESOURCES:	
1.	http://www.mie.uth.gr/labs/ltte/grk/pubs/ahtt.pdf

METROLOGY & MECHATRONICS- LAB								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 416	PC	0	0	3	50	50	100	1.5

Prerequisite: Metal cutting, Machine tools & Metrology & Kinematics of machinery

Course Objectives:

To acquaint the students with calibrating measuring instruments and also to measure different parameters like angle, distance, flatness, gear tooth parameters and roundness & concentricity of spigot. Further the objective is also to introduce PLC and familiarize them with ladder programming for applications using sensor & traffic light applications.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	**Calibrate** measuring instruments (Vernier caliper, Screw gauge , Dial gauge & Vernier height gauge).
CO-2	**Measure** the included angle between two adjacent sides of a given specimen by using a Universal Bevel protractor and also taper angle of a tapered bar by using a Sine bar.
CO-3	**Determine** the included angle of a V-block and Gear tooth parameters of a given spur gear by experimentation.
CO-4	**Check** the concentricity and roundness of the given spigot by using a dial gauge, **check** the flatness of the given surface using Autocollimator and also **determine** the central distance between two holes in a template using Vernier height gauge.
CO-5	**List and Explain** the working of components in a PLC and sensor kit & **develop** a ladder logic programme in PLC for applications using sensors & Traffic signal application.

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	2		2				1		2		1
CO-2	2	2		2				1		2		1
CO-3	2	2		2				1		2		1
CO-4	2	2		2				1		2		1
CO-5	2	2	2		3			1		2		1

Course Outcomes	PSO1	PSO2
CO-1		2
CO-2		2
CO-3		2
CO-4		2
CO-5		2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

LIST OF EXPERIMENTS		
S.NO	**NAME OF THE EXPERIMENT**	COURSE OUTCOME
1	Calibrate the given Vernier caliper and determine the thickness of the given work piece.	CO1
2	Calibrate the given micrometer and determine the thickness of the given work piece.	CO1
3	Calibrate the given Dialguage and determine the thickness of the given work piece.	CO1
4	Calibrate the given Vernier height gauge and determine the thickness of the given work piece.	CO1
5	Measure the included angle between two adjacent sides of a given specimen by using a Universal Bevel protractor.	CO2
6	Determine the taper angle of a tapered bar by using a Sine-bar.	CO2
7	Measure the included angle of a V-block.	CO3
8	Measure the Gear tooth parameters of a spur gear.	CO3
9	Check the flatness of the given surface plate by using an auto-collimator.	CO4
10	Measure the central distance between two holes of a template by using a Vernier height gauge.	CO4
11	Check the roundness and concentricity of a spigot using a Dial gauge.	CO4
12	Training on PLC based Sensor kit.	CO5
13	Training on PLC based control of Traffic lights.	CO5

HEAT TRANSFER LABORATORY								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 417	PC	0	0	3	50	50	100	1.5

Prerequisite: Heat Transfer, Fluid Mechanics & Hydraulic Machinery

Course Objectives: To demonstrate the principles of conduction, convection and radiation through experimentation.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Evaluate thermal conductivity of liquids and solids through experimentation.
CO-2	Verify lumped system analysis and performance of extended surfaces by experimental work.
CO-3	Analyze the heat transfer in free and forced convection.
CO-4	Determine Stefan-Boltzmann constant and emissivity of a gray body experimentally.
CO-5	Determine the overall heat transfer coefficient in a double pipe heat exchanger and on condensing surfaces experimentally.

PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO	3	3		2				1		2		2
CO	3	3		2				1		2		2
CO	3	3		2				1		2		2
CO	3	3		2				1		2		2
CO	3	3		2				1		2		2

Course Outcomes	PSO1	PSO2
CO-1	2	2
CO-2	2	2
CO-3	2	2
CO-4	2	2
CO-5	2	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS
LIST OF EXPERIMENTS
1. Determination of thermal conductivity of asbestos powder at different heat inputs in hollow sphere. 2. Determination of thermal conductivity of glass wool at different heat inputs in composite cylinder. 3. Determination of thermal conductivity of metal rod (Brass). 4. Determination of thermal conductivity of Liquid (Liquid Paraffin) 5. Determination of overall heat transfer coefficient of composite wall. 6. Determination of convective heat transfer coefficient of vertical cylinder in free convection. 7. Determination of convective heat transfer coefficient of horizontal pipe in forced convection. 8. Determination of Stefan-Boltzmann constant. 9. Determination of Emissivity of Grey body. 10. Determination of fin effectiveness and efficiency under forced convection. 11. Determination of time interval in different mediums under unsteady state heat transfer. 12. Determination of condensation coefficient in film and dropwise condensation. 13. Determination of overall heat transfer coefficient of a double pipe heat exchanger.

DATA BOOKS:	
1.	Heat and Mass Transfer Data Book , C.P.Kothandaraman , S. Subramaniam, 10th Edition, New Age International Publishers Limited, 2022.
WEB RESOURCES:	
1.	https://vlab.amrita.edu/index.php?sub=1&brch=194

NOTE: Heat Transfer Data Books are permitted for internal and external examinations.

INDUSTRIAL TRAINING-II								
Code	Category	Periods/Week			Sessional Marks	End Exam	Total Marks	Credits
		L	T	P				
MEC 418	PR	-	-	-	100	-	100	1

Prerequisite: Core subjects of Mechanical Engineering

Course Objectives: The Industrial training program is intended to provide an exposure to the student on the industrial ambience, safety, processes, machinery, the intricacies involved in the industrial activities and most significantly the application of theoretical concepts to solve industrial problems.

Course Outcomes: At the end of Industrial Training, the student will be able to:	
CO-1	Demonstrate the application of basic engineering principles for explaining the industrial processes.
CO-2	Explore the effects of industrial operations on the society and environment and the importance of ethics and moral values in engineering practice.
CO-3	Explain the significance of working in teams for accomplishment of a given task in industry.
CO-4	Communicate orally and in written format with dexterity on the processes observed in the industry.
CO-5	Exhibit interest in extending the knowledge gained in the industrial training.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO-1	3	2	2	2	2						2	
CO-2	1	1	1	1	1	3	3	3				
CO-3									3			
CO-4										3		
CO-5	2	1	1	1	1							3

Course Outcomes	PSO1	PSO2
CO-1	3	2
CO-2	2	2
CO-3	1	1
CO-4	1	1
CO-5	2	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

GUIDELINES

The industrial training program is for a minimum duration of a fortnight and can be extended to one month. The student can choose an industry of his/her choice for the program. It has to be carried out at the end of III year – II semester The student has to submit a comprehensive report at the end of the program.

The evaluation process is done in the final year Ist semester and is based on internal Viva – voce examination.

PROJECT PHASE-I								
Code	Category	Periods			Sessional Marks	End Exam	Total Marks	Credits
		L	T	P				
MEC 419	PR	-	-	4	-	100	100	2

Prerequisite: All Courses of Mechanical Engineering

Course Objectives: The project work is intended to give the student an opportunity to apply the theoretical and practical concepts of sciences, mathematics and engineering to formulate and analyze engineering problems by using experimentation / analytical methods / software tools to obtain valid solutions, which are innocuous to the environment & beneficial to the society. The project work also envisions to imbibe the importance of human ethics, working in teams, enhancing the managerial competencies and skills of communication and presentation.

Course Outcomes: At the end of Project-Phase-I, the student will be able to:

CO-1	Formulate an engineering problem from the gaps identified from the literature (or) by observing the societal/industrial requirements.
CO-2	Devise a solution methodology and chart out its implementation.
CO-3	Assess the worthiness of the project in terms of its impact on meeting the needs of the society for sustainable development.
CO-4	Develop the ability to work as a team member for the accomplishment of the project.
CO-5	Comprehend the design of experiments/model and/or usage of software tools.
CO-6	Communicate orally and in written format with dexterity on the Project.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	1	2	2	3	1	2	3	2		3
CO-2	2	2	3	2	3						2	2
CO-3				1	1	3	3	1				1
CO-4									3			1
CO-5	2	2	2	3	3			2				1

Course Outcomes	PSO1	PSO2
CO-1	3	2
CO-2	3	2
CO-3	3	1
CO-4	2	1
CO-5	3	3
CO-6	2	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

GUIDELINES

In the project first phase, the student is exposed to the requirements to be met in the project. The student is given an opportunity to decide the area of work based on his interest. Thereafter, the student has to review the literature and summarize the findings. Based on the review, the student and the guide finalize the problem and chart out the procedure for executing the project work.

- For analytical work, the governing equations and mathematical modeling has to be completed.
- For projects involving experimental analysis, the setting up of experimentation, procurement of materials & accessories should be completed.
- For projects involving simulation using software tools, modeling should be completed.
- For projects involving fabrication of prototypes, the basic design & development of the model and procurement of accessories should be completed.

The evaluation of Phase-I of the project work is based on an internal Viva-voce examination which is conducted twice. The first evaluation is done in the mid of the semester followed by the final evaluation at the end of the semester. The student has to submit a report.

AUTOMOBILE ENGINEERING								
Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 4110	SC	2	0	0	40	60	100	2

Prerequisite: Applied Thermal Engineering - II, Theory of Machines - I, Material Science, Basic Electrical and Electronic Systems

Course Objectives: To acquaint the students with the working of various automobile systems like engine, transmission, suspension, vehicle control, electrical and electronics.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Categorize automobiles and describe the constructional features of engine parts.
CO-2	Examine the operational features of various systems of engines used in an automobile.
CO-3	Explain various transmission systems of an automobile.
CO-4	Describe & distinguish various suspension systems, steering systems & brake systems of an automobile.
CO-5	Illustrate the principles related to electrical and electronic systems used in an automobile.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	2									
CO-2	3	2	2									
CO-3	3	2	2									
CO-4	3	2	2						1	1	1	1
CO-5	3	2	2									2

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	2	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 8L**
INTRODUCTION:	
Automobile - Definition, layout, classification; chassis. **Engine components**: cylinder block and crank case, cylinder, cylinder head, piston and piston rings, crank shaft, connecting rod, muffler. **Engine Classification:** based on arrangement of cylinders, Multi-Valve engines. **Exhaust Emissions and their control**: EGR and Catalytic Converters, BS-6 Phase-1 and Phase-2 - RDE, DEF, SCR	
UNIT - II	**Periods: 10L**
ENGINE AND GEAR BOX:	
Fuel Systems: Basic components in Petrol engine fuel system, Electronic Fuel Injection. Ignition Systems: Conventional and Electronic. Basic components in diesel engine fuel system, Injectors: distributor type; CRDI. **Engine Cooling**: Air cooled and Water cooled Engines. **Lubrication:** Dry sump and Wet sump. **Clutch**: Necessity, Working of single & multi plate clutch, centrifugal clutch, CVT and Fluid coupling/Torque converter. **Gearbox**: Necessity of gear box, Working Principle of Constant mesh clutch, Synchromesh and Automatic Gearbox.	
UNIT - III	**Periods: 10L**
TRANSMISSION, SUSPENSION AND VEHICLE CONTROL SYSTEM:	
Differential: Necessity, Constructional Features and Working of LSD. **Axles**: Constructional Features and Types of Rear Axle. **Tires**: Tire Construction, Radial Tires, Tire specification, Tire rotation. **Wheel alignment and balancing**: Importance of Castor, Camber, Toe-in, Toe-out and balance weight. **Suspension System**: Types of suspension systems: MacPherson strut and Wishbone, air suspension. **Vehicle Control**: Steering system: Steering gear box and its types, Power Steering. **Brake system**: Necessity, Drum, Disc, Parking and Power Brakes, Working Principle of Air and Hydraulic Brakes, ABS, EBD.	
UNIT - IV	**Periods: 10L**
HYBRID VEHICLES:	
Hybrid Vehicles - Need for hybrid and electric vehicles - Series parallel architecture of Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components. Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle. **Electrical system**: Starting system, Charging System. **Electronic System**: Electronic Engine Management system, Automotive Embedded Systems-Vehicle Security System. **Case study**: Economic feasibility of hybrid vehicles.	

UNIT - V	Periods: 10L
ELECTRIC VEHICLES	
Design requirement for electric vehicles- Layout of an electric vehicle, Range, maximum velocity, acceleration, power requirement, mass of the vehicle and transmission efficiency. Types of Motors, Characteristic of DC motors, PM motors, Switched reluctance motors, Motor Drives and speed controllers, Regenerative Braking. **Battery Parameters**- Different types of batteries – Lead Acid- Nickel based-Sodium based-Lithium based- Metal Air based. Battery charging- Quick Charging devices. Battery Management System.	

TEXT BOOKS:

1.	Kirpal Singh, Automobile Engineering Vol-I & II, 12thedition, Standard Publishers, 2011.
2.	William H. Crouse and Donald L. Anglin, Automotive Mechanics, 10^{th}edition, Tata McGraw- HillPublishing Company Limited, 2006.
3.	KK Jain & RB Asthana,Automobile Engineering, 9^{th}edition ,Tata McGraw-Hill Publishing Company Limited, 2002.
4.	James Larminie and John Lowry, “Electric Vehicle Technology Explained “ John Wiley & Sons,2003.

REFERENCE BOOKS:

1.	S. Srinivasan, Automotive Mechanics, 2^{nd} edition, Tata McGraw-Hill Publishing Company Limited, 2003
2.	Joseph Heitner, Automotive Mechanics (principles and practices,2^{nd} edition, East West press, 2006.
3.	S Srinivasan,*Automotive Engines, 4^{th}* edition, Tata McGraw-Hill Publishing Company Limited, 2001.
4.	Iqbal Husain, “ Electric and Hybrid Vehicles-Design Fundamentals”, CRC Press,2003

WEB RESOURCES:

1.	https://saeindia.org/mobility-engineering/
2.	https://www.autocarindia.com/stories
3.	https://www.autocarpro.in/segments/autotechnology
4.	https://www.motorauthority.com/news/technology
5.	https://www.princeton.edu/~ota/disk1/1995/9514/9514.PDF

PROJECT PHASE-II

Code	Category	Periods			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P				
MEC 422	PR	-	-	16	100	100	200	8

Prerequisite: All Courses of Mechanical Engineering

Course Objectives: The project work is intended to give the student an opportunity to apply the theoretical and practical concepts of sciences, mathematics and engineering to formulate and analyze engineering problems by using experimentation / analytical methods / software tools to obtain valid solutions, which are innocuous to the environment & beneficial to the society. The project work also envisions to imbibe the importance of human ethics, working in teams, enhancing the managerial competencies and skills of communication and presentation.

Course Outcomes: At the end of Project-Phase-II, the student will be able to:

CO-1	Apply the basic engineering knowledge for solving the problem identified.
CO-2	Perform experimentation/analysis/simulation by using appropriate tool to assimilate the required data.
CO-3	Assess and validate the data obtained with the existing literature/implement the data to fabricate the prototype of the intended component.
CO-4	Demonstrate ethical values and detail the financial aspects in the execution of the project
CO-5	Develop the ability to work as a team member for the accomplishment of the project.
CO-6	Articulate orally and in written format with dexterity on the project

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO-1	3	3	3	2	2	2	2				2	3
CO-2	3	3	3	3	3		1				2	3
CO-3	3	3	3	2	2						2	3
CO-4	2				3	2	1	3			3	3
CO-5									3		2	3
CO-6	2									3		3

Course Outcomes	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3
CO-6	3	3

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

GUIDELINES

In the second phase of the project work, the student should continue the work from the stage where he has left in the phase-I.

The evaluation of Phase-II of the project work is based on both internal and external examination. The internal evaluation is done in the mid and also at the end of the semester. The students have to present their findings before a review committee which is followed by Viva – voce in both the internal and external examinations