G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY
(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: 07104-234501 Fax: +91-07104-234501
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

RAISONI GROUP
a vision beyond

Department of Mechanical Engineering

Sr. No	Category	Course	Subject Code	Name of the Course	Teaching Scheme				Credits	Evaluation Scheme						
										Theory				Practical		Total
					L	T	P	Total Hours		TAE	CAE	ESE	Duration of ESE (Hrs)	Int.	Ext	Marks
SEMESTER-VII																
1	EL	EL2	UMEL401-UMEL406	Elective-II	3	-	-	3	3	10	15	50	2	--	--	75
2	EL	EL3	UMEL407-UMEL412	Elective-III	3	-	-	3	3	10	15	50	2	--	--	75
3	EL	EL4	UMEL413-UMEL418	Elective-IV	3	-	-	3	3	10	15	50	2	--	--	75
4	EL	EL5	UMEL419-UMEL424	Elective-V	3	-	-	3	3	10	15	50	2	--	--	75
5	EL	EL6	UMEL425-UMEL430/	Elective-VI	3	-	-	3	3	10	15	50	2	--	--	75
6	EL	EL6	UMEP425-UMEP430	Elective-VI	-	-	2	2	1	--	--	--	--	25	--	25
7	P	P3	UMEP431	Project	-	-	8	8	4	--	--	--	--	50	50	100
TOTAL					**15**	**-**	**10**	**25**	**20**							**500**

G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY
(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: 07104-234501 Fax: +91-07104-234501
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

RAISONI GROUP
a vision beyond

Department of Mechanical Engineering

Sr. No	Category	Course	Subject Code	Name of the Course	Teaching Scheme				Credits	Evaluation Scheme						
										Theory				Practical		Total
					L	T	P	Total Hours		TAE	CAE	ESE	Duration of ESE (Hrs.)	Int.	Ext	Marks
SEMESTER-VIII																
1	OE	OE3		MOOCS based open elective	3	-	-	3	3	10	15	50	2	--	--	75
2	P	P1	UMEP432	Project Internship	-	-	24	24	12	--	--	--	--	200	200	400
TOTAL					**3**	**-**	**24**	**27**	**15**							**475**

G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY
(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: 07104-234501 Fax: +91-07104-234501
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

RAISONI GROUP
a vision beyond

Department of Mechanical Engineering

Elective List 2020-21 Scheme

IV SEM Open Elective-I

Sr. No.	Subject code	Name of Elective
01	UAIL211	Data Analysis for Business Intelligence
02	UCSL209	Introduction to Block-chain Technology
03	UEEL210	Non-Conventional Energy Sources
04	UECL211	Sensors and Transducers
05	UMEL213	Total Quality Management
06	UCEL212	Basics of Civil Engineering

V SEM Elective I

Sr. No.	Subject code	Name of Elective
01	UMEL307	Non-conventional Energy Sources
02	UMEL308	Power Plant Engg.
03	UMEL309	Mechanical Vibration
04	UMEL310	Welding Technology
05	UMEL311	Simulation of Manufacturing system
06	UMEL312	Industrial Engineering

VII SEM Elective II

Sr. No.	Subject code	Name of Elective
01	UMEL401	Compressor and Pumps
02	UMEL402	Solar Energy
03	UMEL403	Industry 4.0
04	UMEL404	Supply Chain Management
05	UMEL405	Advance Manufacturing Process & Technology
06	UMEL406	Material Handling Systems

G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY
(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: 07104-234501 Fax: +91-07104-234501
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

RAISONI GROUP
a vision beyond

Department of Mechanical Engineering

VII SEM Elective III

Sr. No.	Subject code	Name of Elective
01	UMEL407	Advanced IC Engine
02	UMEL408	Advanced Cryogenics
03	UMEL409	Product Design and Development
04	UMEL410	Advanced Tool Design
05	UMEL411	Engineering Ergonomics
06	UMEL412	Tribology

VII SEM Elective IV

Sr. No.	Subject code	Name of Elective
01	UMEL413	Gas Turbine and Jet Propulsion
02	UMEL414	Automobile Engineering
03	UMEL415	Stress Analysis
04	UMEL416	Microelectro Mechanical System (MEMS)
05	UMEL417	Advanced Casting Methods
06	UMEL418	Mechanics of Composite Materials

VII SEM Elective V

Sr. No.	Subject code	Name of Elective
01	UMEL419	Energy Storage System
02	UMEL420	Energy Management
03	UMEL421	Machine Condition Monitoring
04	UMEL422	Vehicle Dynamics
05	UMEL423	Corrosion Engineering
06	UMEL424	Modeling and Simulation

G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY
(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: 07104-234501 Fax: +91-07104-234501
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

RAISONI GROUP
a vision beyond

Department of Mechanical Engineering

VII SEM Elective VI (Practical based)

Sr. No.	Subject code	Name of Elective
01	UMEL425, UMEP425	Refrigeration and Air-conditioning
02	UMEL426, UMEP426	Fuel and Combustion
03	UMEL427, UMEP427	Computer Aided Design
04	UMEL428, UMEP428	Advanced Finite Element Method
05	UMEL429, UMEP429	Robotics and Machine Vision
06	UMEL430, UMEP430	Computational Fluid Dynamics

Pool of Track wise Electives

Track		Track-I		Track-II		Track-III		Track-IV		Track -V		Track-VI
Elective-I (Credits : 3) (Semester-V)	UMEL307	Non-conventional Energy Sources	UMEL308	Power Plant Engg.	UMEL309	Mechanical Vibration	UMEL310	Welding Technology	UMEL311	Simulation of Manufacturing system	UMEL312	Industrial Engineering
Elective-II (Credits : 3) (Semester-VII)	UMEL401	Compressor and Pumps	UMEL402	Solar Energy	UMEL403	Industry 4.0	UMEL404	Supply Chain Management	UMEL405	Advance Manufacturing Techniques	UMEL406	Material Handling Systems
Elective-III (Credits : 3) (Semester-VII)	UMEL407	Advanced IC Engine	UMEL408	Advanced Cryogenics	UMEL409	Product Design and Development	UMEL410	Advanced Tool Design	UMEL411	Engineering Ergonomics	UMEL412	Tribology
Elective-IV (Credits : 3) (Semester-VII)	UMEL413	Gas Turbine and Jet Propulsion	UMEL414	Automobile Engineering	UMEL415	Stress Analysis	UMEL416	Microelectro Mechanical System (MEMS)	UMEL417	Advanced Casting Methods	UMEL418	Mechanics of Composite Materials
Elective-V (Credits : 3) (Semester-VII)	UMEL419	Energy Storage System	UMEL420	Energy Management	UMEL421	Machine Condition Monitoring	UMEL422	Vehicle Dynamics	UMEL423	Corrosion Engineering	UMEL424	Modeling and Simulation
Electives with Laboratory												
Elective-VI (Credits : 4) (Semester-VII)	UMEL425, UMEP425	Refrigeration and Air-conditioning	UMEL426 UMEP426	Fuel and Combustion	UMEL427, UMEP427	Computer Aided Design	UMEL428, UMEP428	Advanced Finite Element MethodS	UMEL429, UMEP429	Robotics and Machine Vision	UMEL430, UMEP430	Computational Fluid Dynamics

Skill Category Courses

Semester	Details	Name	Credits
I	A1	Foreign Language	1
	A2-A3	Introduction to Machine Learning	2
II	A4	Biomedical Engineering	1
	A5	Introduction to Drones	1
IV	A6-A7	Hydraulic and Pneumatic Circuits	2
	A8	Product Design and Packaging	1
V	A9	Aptitude	1
VI	A10	Employability Skill	1
	A11	Campus Recruitment Training	1
	A12-A13	IoT Based System Design	2

G H RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY

(Approved by AICTE, New Delhi and Recognized by DTE, Maharashtra)
An Autonomous Institute Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Accredited by NAAC with A+ Grade
Shraddha Park, B-37-39/1, MIDC, Hingna-Wadi Link Road, Nagpur-440016 (INDIA)
Phone Nos.: +91-07104-236102 Fax: +91-07104-236100
Email: - ghrietn@raisoni.net Web: - www.ghrietn.raisoni.net

Department of

Mechanical Engineering

Final Year B. Tech.

Semester-VII & VIII

Course Book (2020 Pattern)

(With effect from June 2023)

Department of Mechanical Engineering

Detailed Syllabus

Final Year B. Tech (Mech.)

Semester-VII

UMEL401: Compressor and Pumps (Elective-II)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Hydraulic Machines , Thermal engineering,

COURSE OBJECTIVE:

1. To present a problem oriented in depth knowledge of Compressors
2. To address the underlying concepts, methods and application of different compressors and pumps

COURSE OUTCOME: Upon successful completion of the course students will be able to-

1. To identify different areas of Fluid Power Engineering.
2. To find the applications of all the areas in day to day life.
3. To understand different types of Compressors, fans and blowers.
4. To design the pumps.

COURSE CONTENTS	Hrs.
UNIT I: Fundamentals of Turbo Machinery	**8**
Introduction to Turbo Machinery: Introduction to pumps, blowers and compressors, Basic equations of energy transfer between fluid and rotor, Performance characteristics, Dimensionless parameters, Specific speed, stage velocity triangles, work and efficiency	
UNIT II: Compressors	**8**
Centrifugal air compressors: Principle, operation, parts, velocity diagram, static & total head quantities, work done by impeller, isentropic efficiency of compressor, slip factor, pressure coefficient, power input factor. **Axial flow compressors:** Principle, operation, parts, velocity diagram, work done, degree of reaction, stage efficiency, compressor characteristics, surging & chocking. Polytrophic efficiency.	
UNIT III: Fans and Blowers	**8**
Classification of blowers, Basics of stationary and moving air, Euler's characteristics, velocity triangles and operating pressure conditions, Equations for blowers, Losses and hydraulic efficiency, flow through impeller casing, inlet nozzle, Volute, diffusers, leakage, mechanical losses, surge and stall, Applications of blowers and fans.	
UNIT IV: Pumps & Applications	**8**
Types of pump, Principle & working of Centrifugal, Reciprocating, Rotary Positive Displacement pump, Application	

UNIT V: Design of Pumps	8
Design procedure and design optimization of Pumps, selection of pumps, Thermal design- Selection of materials for high temperature and corrosive fluids. Hydraulic design- Selection of impeller and casing dimension using industrial manuals. Advance Topic: Turbo molecular Pump: Introduction & working principle	

Text Books:

1. Turbines, Compressors & Fans by S.M. Yahya, Tata-McGraw Hill
2. Thermal Engineering by B. K. Sarkar, Tata McGraw publication, 1998
3. Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Prakashan

Reference Books:

1. Thermal Turbo machines, Dr. Onkar Singh, Wiley India

UMEL402: Solar Energy (Elective-II)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Thermodynamics, Fluid Mechanics

COURSE OBJECTIVE:

1. To understand fundamentals of solar energies.
2. To understand constructions, working principle and design procedure of solar power plants.
3. To apply basic engineering principle to design a simple solar power system.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Design of solar food drier for domestic purpose referring existing system
2. Design of parabolic dish solar cooker for domestic purpose referring existing system
3. Design of solar photovoltaic system for domestic purpose referring existing system

COURSE CONTENTS	Hrs.
UNIT I: Unit 1: Solar Energy Principles	**8**
Present solar energy scenario, world energy futures, governing bodies (self-study), solar radiations and its measurements, solar constant, solar radiation geometry, solar radiation data, estimation of average solar radiation, solar radiation on tilted surface.	
UNIT II: Solar Thermal Systems and Applications	**8**
Types of Solar thermal collector, flat plate collector analysis, Evacuated Tube Collectors (ETC) analysis, its design and application, solar air heaters and its types, solar distillation. Solar Concentrating collectors: types- line and point concentrator, theory of Concentrating collectors, parabolic trough collector, parabolic dish collector, solar tower, Concentrated Fresnel Linear Receiver (CFLR).	

UNIT III: Solar Photovoltaic Cell and Applications	**8**
Forming the PN junction solar cells & its applications, Introduction to flexible solar panel, Structure of a solar cell, types of modules, PV array, Connection of PV Module in Series and Parallel, Estimation and Measurement of PV Module Power, Selection of PV Module, solar cell equation, Fill factor and maximum power, Grid aspects of solar power	
UNIT IV: Solar PV Project Equipment	**8**
Batteries, charge controller, Maximum Power Point Tracker, Electrical wiring, Power Conditioning Equipment-inverters, Regulators, Other Devices; System Analysis-Design Procedure, Design Constraints, Other Considerations, Maintenance of solar PV system & cost analysis.	
UNIT V: Case Study on Solar Energy Applications (Any three out of four)	**8**
Case study 1: Design of solar food drier for domestic purpose referring existing system. **Case study 2**: Design of Solar Pump at agricultural field referring existing system. **Case study 3**: Design of solar photovoltaic system for domestic purpose referring existing system. **Case study 4**: Case study on Installation, Commissioning, Trouble shooting of 1KWp off Grid Solar Power Plant.	

Text Books:
1. G. D. Rai, 'Non-Conventional Energy Sources', Khanna Publisher
2. S. P. Sukhatme, 'Solar Energy: Principles of thermal collections and storage', McGraw Hill
3. Tiwari G N. 'Solar Energy: Fundamentals, design, modeling and Applications', Narosa, 2002
4. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 2006.
Reference Books
1. Mukund R. Patel, 'Wind And Solar Power Systems: Design, Analysis and Operation, Second Edition', CRC Press
2. Kreith And Kreider, Solar Energy Handbook, McGraw Hill
3. Ray Hunter, 'Wind Energy Conversion: From Theory to Practice', John Wiley and Son Ltd
4. Gary L Johnson, 'Wind Energy Systems', Prentice-Hall Inc., New Jersey
5. Martin O L Hansen, 'Aerodynamics of Wind Turbines', James & James/Earthscan
6. Goswami D Y, Kreith F, Kreider J F, 'Principles of Solar Engineering', Taylor & Francis
7. Robert Gasch, 'Wind Power Plant Fundamentals, Design, Construction And Operations', Springer
8. C S Solanki, 'Solar Photovoltaic: Fundamentals, Technology And Applications', PHI Learning
9. K. Jager, O. Isabella, A. H. M. Smets, R.A.C.M.M. Van Swaaij, and M. Zeman, Solar Energy – fundamentals, technology and systems, Delft University of Technology, 2014
10. T. C. Kandpal and H.P. Garg, Financial Evaluation of Renewable Energy Technologies, McMillan India Ltd., 2013

UMEL403: lndustry 4.0 (Elective-II)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

Prerequisite (if any):

Mechatronics, Industrial control system

Course Objective:

1. Understand IOT architecture and its building block
2. Applications in the business world
3. Introduction to different IOT platform
4. Understanding technology and skill required in building IOT product
5. Understand IOT application across various segment

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

1: Understand the drivers and enablers of Industry 4.0.

2: Identify the smartness in smart factories, smart cities, smart products and smart services in industry.

3: Apply the basic knowledge of Android, IOT and IIOT, Cloud Computing in an Industry.

4: Compare and analyze different decision support systems and decision making models for Industry.

COURSE CONTENTS	Hrs
Unit I : Introduction to Industry 4.0	**8**
Industry 4.0: Definition, revolution and future view, benefits and applications. Key principles and strategies. Comparison of Industry 4.0 factory & today's factory, Security issues within Industry 4.0 networks, Challenges and risk.	
Unit II: Industrial Automation	**8**
Introduction to Industrial Automation, Elements of automation, Types, Architecture of Industrial Automation Systems, Building blocks of Automation systems: LAN, Analog & Digital I/O Modules, SCADA System & RTU. Introduction to Sequence Control, the Hardware environment PLCs and Relay Ladder Logic and HMI	
Unit III: Android, IOT and IIOT Application	**8**
Fundamentals and working principles, Learning the Language, Android OS Building Mobile Applications with Android Database Connectivity Applicability to Industrial Projects. Adriano applications. Introduction to IOT. Requirement of IOT. Applications and advantages. Introduction of Industrial IOT (IIOT) and its application.	
Unit IV: Cyberphysical system	**8**
Introduction to Cyberphysical system, Use of sensors to capture data and further analysis to take decisions, Concept of Digital Twin.	
Unit V: Data Management and Decision Support System	**8**
Management planning and control, decision making models, data bases, networks, decision theory, flow charting, smart logistics, smart factory management, man-machine-computer interfacing. Introduction, types and applications of Artificial Intelligence (AI) and Machine Learning (ML). Case Studies on Industry 4.0	

Text Books:
1. Ustundag A., and Cevikcan E. Industry 4.0: managing the digital transformation. Springer; 2017.
2. Gilchrist A., Industry 4.0: the industrial internet of things. A press; 2016.
3. Raj P, and Raman A.C. The Internet of Things: Enabling technologies, platforms, and use cases. Auerbach Publications; 2017.
4. Schröder C., The challenges of industry 4.0 for small and medium-sized enterprises. Friedrich-Ebert-Stiftung: Bonn, Germany. 2016.
5. Mukhopadhyay S., Sen S., and Deb A. K. Industrial Instrumentation, Control and Automation. Jaico Publishing House; 2013
6. Bartodziej C.J., The concept industry 4.0. Springer Gabler, Wiesbaden.2017
Reference Books:
1. Ogata K., Modern control engineering. Upper Saddle River, N J: Prentice hall; 2010..
2. Burd B. Android application development all-in-one for dummies. John Wiley & Sons; 2015.
3. Kuppusamy P, and Vyas U. AWS Development Essentials. Packt Publishing Ltd; 2014.
4. Kurniawan A., Learning AWS IoT: Effectively manage connected devices on the AWS cloud using services such as AWS Greengrass, AWS button, predictive analytics and machine learning. Packt Publishing Ltd; 2018.
5. Coronel C, Morris S, Rob P, Loney K, and Gennick J. Database Systems: Design, Implementation, and Management, 2012.
6. Silberschatz A, Korth H.F., Sudarshan S. Database system concepts. New York: McGraw-Hill; 2002.
7. Phillips B., Stewart C., Hardy B., and Marsicano K. Android Programming: The Big Nerd Ranch Guide Paperback.2020.

UMEL404: Supply Chain Management (Elective-II)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):
No prerequisite
COURSE OBJECTIVE:
1. To introduce the concept and techniques of supply chain management.
2. To acquaint with supply chain networks and inventory control techniques.
3. To acquaint with likely future development of logistics and supply chain management.
COURSE OUTCOME: Upon successful completion of the course students will be able to
1. Identify the key elements and processes in a supply chain and their interaction.
2. Interpret the designing, planning and operational decisions of SCM.
3. Identify the techniques used in management of critical components of supply chain.
4. Analyze, design and optimize supply chain networks for manufacturing organizations.

5. Design and optimize inventories across the supply chain	
6. Explain the likely future development of logistics and supply chain management.	
COURSE CONTENTS	**Hrs.**
UNIT I: Network Design in Supply Chain	**8**
Basics of Supply Chain Management: Concept, Objective. Decision Phases in Supply Chain. Process View of Supply Chain – Cycle View, Push/pull view, Supply Chain Performance – Achieving Strategic Fit. Types of Supply Chain – Responsive, Efficient, Supply Chain Drivers – Facilities, Inventory, Transportation, Information	
UNIT II: Transportation Modeling & Optimization	**8**
Transportation Modeling & Optimization: Transportation Model: Vogel's Approximation Method, UV Method, Stepping Stone Method, Transshipment problems, Shortest Path Problem, Traveling Salesman Problem, Vehicle Routing Problem.	
UNIT III: Managing Supply and Demand	**8**
Managing Supply and Demand: Managing Capacity – time flexibility of workforce, seasonal workforce, subcontracting, use of dual facilities, and design product flexibility into production processes. Managing Inventory – use common components across multiple products; build inventory of high demand of predictable demand products Managing Demand: Variable pricing, Forward buying. Collaborative Planning Forecasting & Replenishment	
UNIT IV: Inventory Management, Pricing & Revenue Management in Supply Chain	**8**
Inventory Management in Supply Chain - Managing Economies of Scale: Cycle Inventory- Role in SC- Lot sizing for single product, Seasonal Inventory, Transportation & Inventory Cost Trade-off: Choice of Transportation Mode, Inventory Aggregation. Transportation cost and customer-responsiveness trade-off; **Pricing & Revenue Management in Supply Chain**: Role, Revenue Management for Multiple Customer Segments, Seasonal Demand, Bulk & Spot Customers **Network Design in Supply Chain** - Factors Influencing Distribution Network Design – Response time, Product variety, Product availability, Customer experience, Order visibility, Return ability.	
UNIT V: Internet Technologies and Electronic Commerce in SCM	**8**
Relation to ERP, E-procurement, E-Logistics, Internet Auctions, E-markets, Electronic business process optimization, Business objects in SCM **Case studies:** Case Study on Textile Industry, Health care, Power Plant etc.	
Text Books:	
1. Sunil Chopra & Peter Meindl; Supply Chain Management - Strategy, Planning & Operation, Pearson Education.	
Reference Books:	
1. Bowersox , Logistical Management - The Integrated Supply Chain Process	
2. Christopher, Logistics & Supply Chain Management, Pearson Education	
3. Raghuram ; Logistics & Supply Chain Management	
4. Ronald Ballou; Business Logistics / Supply Chain Management; Pearson Education.	

UMEL405: Advance Manufacturing Process & Technology (Elective-II)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lectures: 03 Hrs./Week	**03**	**TAE: 10** Marks **CAE: 15** Marks **ESE: 50** Marks

Prerequisite (if any):

1. Basic Engineering Science - Physics, Chemistry, Material Science, Engineering
2. Metallurgy, Manufacturing processes.

Course Objective:

1. To understand various material characterization techniques.
2. To analyze and identify applications of advanced joining processes.
3. To understand and analyze the basic mechanisms of hybrid non-conventional machining techniques.
4. To analyze and identify applications of special forming processes.
5. To understand various applications and methods of micro and nano fabrication techniques.
6. To understand advanced Additive Manufacturing (AM) technology for innovations in product development.

Course Outcome: On completion of the course, students will be able to -

1. Understand the basic concept of various advanced forming and joining processes.
2. Identify applicability of advanced joining processes.
3. Apply the knowledge of Advance manufacturing technique such as micro, nano fabrication and hybrid non-conventional machining techniques for engineering applications
4. Apply various additive manufacturing technologies for product development.
5. Analyze the effects of chemical composition, composition variation, crystal structure, etc.by using material characterization technique.

COURSE CONTENTS	Hrs.
Unit I: Unconventional Forming Processes	**8**
Principle, machines, process variables, characteristics, advantages, limitations and application of High Energy Rate Forming process (HERF), High Velocity Forming (HVF), Explosive forming, Magnetic pulse forming, Electro hydraulic forming, Flow forming, Stretch forming, Incremental sheet metal forming, Petro-forge forming, Micro forming.	

Unit II: Advanced Joining Processes	**8**
Friction stir welding, Electron Beam welding, Laser beam welding, Ultrasonic welding, Under water welding, Cryogenic welding, Thermal spray coatings, Welding of plastics and composites, Explosive joining, Adhesive bonding.	
Unit III: Hybrid Non-conventional Machining Techniques	**8**
Introduction to hybrid processes, Abrasive flow finishing, Magnetic abrasive finishing, Abrasive water-jet machining, Wire electric discharge machining, Electrochemical grinding (ECG), Electrochemical Deburring (ECD), Shaped tube electrolytic machining (STEM), Electro-jet Machining (EJM), Electrolytic In-process dressing (ELPD), Ultrasonic assisted EDM, Rotary EDM, Electrochemical discharge Machining (ECDM), Laser surface treatments.	
Unit IV: Micro Machining and Nano Fabrication Techniques	**8**
Introduction, need of micro and nano machining, Machine/setup, Process parameters, Mechanism of material removal, Applications, Advances of the Diamond Turn machining, Ultrasonic micro- machining, Focused Ion Beam Machining, Lithography, photochemical machining, Challenges in micro and nano-fabrication techniques.	
Unit V: Additive Manufacturing Processes	**8**
Introduction and principle of the additive manufacturing process; Generalized additive manufacturing process chain; Classification of additive manufacturing processes and its principle, process steps and materials; Post-processing of parts manufactured by Additive Manufacturing (AM) processes, Software issues in AM, Design For Additive Manufacturing (DFAM), Applications of Additive Manufacturing in Medical and Aerospace technologies, Metal 3D Printing.	

Text Books:
1. Jain V K. Advanced machining processes. Allied publishers; 2009.
2. Groover M. P., Fundamentals of modern manufacturing: materials, processes, and systems. John Wiley & Sons; 2020.
3. Mallik A.K., Ghosh A. and Dittrich G., Kinematic analysis and synthesis of mechanisms. Crc Press; 2021.
4. Ghosh A, Mallik A. K. Manufacturing science. Ellis Horwood, 1986.
Reference Books/Journals:
1. Welding E.B., and Handbook A.S., Welding, brazing, and soldering. ASM Int. 1993.
2. Muldoon K, Marquard E, Lampman H, Karcher C, Musgrove B, Dragolich K, and Schaefer M. ASM Handbook. 2005.
3. Balasubramaniam R, Sarepaka R.V., and Subbiah S., Diamond turn machining: Theory and practice. CRC press; 2017.
4. Kumar L. J., Pandey P.M., and Wimpenny D. I., 3D printing and additive manufacturing technologies. Berlin, Germany: Springer; 2019.
5. Murphy D.B., Fundamentals of light microscopy and electronic imaging. John Wiley & Sons; 2002.

UMEL406: MATERIAL HANDLING SYSTEMS (Elective-II)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

Prerequisite (if any):

Course Objective:

1. To prepare students with fundamental aspect of material handling.
2. Student should select proper materials for different machine elements depending on their physical and mechanical properties
3. To develop competency in designing various components of various material.
4. To develop competency in designing a system involving the various component, as a design project in Practical.
5. To develop an ability to identify, formulate, and solve engineering problems

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

1. Understand the flow and type of movement of industrial goods.
2. Identify the appropriate material handling systems to suit the said requirement.
3. Apply general rules for the type of movement
4. Design of material handling system.

Course Contents	Hrs
Unit I : Material Handling System and Equipment Selection	**8**
Principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, classification of material handling equipment, choice of material handling equipment, factors affecting for selection, general analysis procedures, basic analytical techniques, the unit load concept	
Unit II: Study of Bulk Material Handling Systems	**8**
Objectives of storage; bulk material handling; gravity flow of solids through slides and chutes; storage in bins and hoppers; screw conveyor, vibratory conveyor, pneumatic & hydraulic conveyor (classification, types, principles of operation)	
Unit III : Design of Mechanical Handling Equipment	**8**
Design of Hoists:- Drives for hoisting, components, and hoisting mechanisms; rail traveling components and mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms	

Unit IV : Design of Mechanical Handling Equipment	**8**
Design of Cranes:- Hand-propelled and electrically driven E.O.T. overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.	
Unit V: Design of Belt Conveyor System for Material Handling	**8**
Belt conveyors, Flat belt and troughed belt conveyors, capacity of conveyor, rubber covered and fabric ply belts, belt tensions, conveyor pulleys, belt idlers, tension take-up systems, power requirement of horizontal belt conveyors for frictional resistance of idler and pulleys. Modern Material Handling System	

Text Books:
1. N. Rudenko, 'Material Handling Equipment', Peace Publishers, 1964.
2. James M. Apple, 'Material Handling System Design', John-Wiley and Sons, 1972.
3. John R. Immer, 'Material Handling' McGraw Hill, 1953.
Reference Books:
1. Colin Hardi, 'Material Handling in Machine Shops'. Machinery Publication, 1970.
2. M .P. Alexandrov, 'Material Handling Equipment', MIR Publication,1981.
3. Spivakovsy, A.O. and Dyachkov, V.K., 'Conveying Machines', Volumes I and II, MIR Publishers, 1985.
4. Kulwiac R. A., 'Material Handling Hand Book', John Wiley Publication, 1985.

UMEL407 : ADVANCED IC ENGINE (Elective-III)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):
IC Engine
COURSE OBJECTIVE:
1. To understand the underlying principles of operation of different IC Engines and components.
2. To provide knowledge on pollutant formation, control, alternate fuel etc.
COURSE OUTCOME: Upon successful completion of the course students will be able to
1. To compare the operations of different IC Engine and components
2. To evaluate the pollutant formation, control, and alternate fuel.

COURSE CONTENTS	Hrs.
UNIT I: Spark Ignition Engines	**8**
Mixture requirements – Fuel injection systems – Monopoint, Multipoint & Direct injection - Stages of combustion – Normal and Abnormal combustion – Knock - Factors affecting knock – Combustion chambers.	
UNIT II: Compression Ignition Engines	**8**
Diesel Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Introduction to Turbocharging. Testing of Engine: SI &CI Engine	
UNIT III: Emission Control	**8**
Pollutant – Sources – Formation of Carbon Monoxide, Un-burnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters, Selective Catalytic Reduction and Particulate Traps – Methods of measurement – Emission norms and Driving cycles.	
UNIT IV: Alternative Fuels	**8**
Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits - Engine Modifications.	
UNIT V: Recent Trends	**8**
Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles – NOx Adsorbers - Onboard Diagnostics, Camless Engine, variable valve control, quad & triple turbo engine.	

Text Books:

1. Ramalingam. K.K., "Internal Combustion Engine Fundamentals", Scitech Publications, 2002.
2. Ganesan, "Internal Combustion Engines", II Edition, TMH, 2002.

Reference Books:

1. Mathur. R.B. and R.P. Sharma, "Internal Combustion Engines"., Dhanpat Rai & Sons 2007.
2. Duffy Smith, "Auto Fuel Systems", The Good Heart Willcox Company, Inc., 1987.
3. Eric Chowenitz, "Automobile Electronics", SAE Publications, 1995

UMEL408: ADVANCED CRYOGENICS (Elective-III)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**
Prerequisite(if any):		
Course Objectives		
1. To understand cryogenic system and gas liquefaction system		
2. To analyze gas cycle cryogenic refrigeration system		
3. To Comprehend gas separation and gas purification system		
4. To have detailed knowledge of vacuum technology, insulation, storage of cryogenic liquids		
5. To study applications of cryogenics and to embark on cryogenic fluid		
Course Outcome: On completion of the course, student will be able to		
1. Understand the cryogenic system.		
2. Have complete knowledge of cryogenic refrigeration system		
3. Design gas separation and gas purification system		
4. Solve the problem in , insulation, storage of cryogenic liquids		
5. Apply cryogenic in various areas and to be able take up research in cryogenics		
Course Contents		**Hrs**
Unit I : Introduction to Cryogenic Systems		**8**
Cryogenic propellants and its applications, liquid hydrogen, liquid nitrogen, and liquid Helium. The thermodynamically Ideal system Production of low temperatures – Joule Thompson Effect, Adiabatic expansion, Inversion Curve **Gas Liquefaction Systems** Liquefaction systems for Air Simple Linde –Hampson System, Claude System, Heylndt System, Dual pressure, Claude. Liquefaction cycle Kapitza System. Comparison of Liquefaction Cycles Liquefaction cycle for hydrogen, helium and Neon, Critical components of liquefaction systems, property of material at low temperature.		
Unit II : Gas Cycle Cryogenic Refrigeration Systems		**8**
Classification of Cryocoolers Stirling cycle Cryo – refrigerators, Ideal cycle – working principle. Schmidt's analysis of Stirling cycle, Various configurations of Stirling cycle refrigerators, Integral piston Stirling cryo-cooler, Free displacer split type Stirling Cryo coolers, Gifford Mcmahon Cryo-refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator, Cryogenic regenerators		
Unit III :Gas Separation and Gas Purification Systems		**8**
Thermodynamic ideal separation system, Properties of mixtures, Principles of gas separation, Linde single column air separation. Linde double column air separation, Argon and Neon separation systems.		

Ultra Low Temperature Cryo – Refrigerators Magneto Caloric Refrigerator 3He-4He Dilution refrigerator. Pomeranchuk cooling. Measurement systems for low temperatures, Temperature measurement at low temperatures, Resistance thermometers, Thermocouples, Thermistors, Gas Thermometry. Liquid level sensors.	
Unit IV :Vacuum Technology	**8**
Fundamental principles. Production of high vacuum, Mechanical vacuum pumps, Diffusion pumps, Cryo-pumping, Measurement of high vacuum level. Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation Powder & Fibers Opacified powder insulation, Gas filled powders & Fibrous materials Multilayer super-insulation, Composite insulation.	
Unit V : Cryogenic Fluid Storage And Transfer Systems	**8**
Design of cryogenic fluid storage vessels, Inner vessel, Outer Insulation, Suspension system, Fill and drain lines. Cryogenic fluid transfer, External pressurization, Self-pressurization, Transfer pump	

Text Books:

1. Cryogenic Systems – R.F. Barron, Oxford, 1967
2. Cryogenic Engineering – R.B. Scott – D.VanNostrand Company, 1959

Reference Books:

1. Cryogenic Process Engineering – K.D. Timmerhaus and T.M. Flynn, Plenum Press, New York,1989
2. High Vacuum Technology: A Practical Guide, M. H. Hablanian, Marcel Dekker Inc; 2 edition (March 31, 1997)
3. Experimental Techniques in Low Temperature Physics – G.K. White – Oxford University Press; 4 edition, 2002.

UMEL409: PRODUCT DESIGN & DEVELOPMENT (Elective-III)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Lectures: 03 Hr. /Week	**03**	**TAE : 10** Marks **CAE : 15** Marks **ESE : 50** Marks

Prerequisite:- Engineering Graphics, CAD

Course Objectives:

1. To impart knowledge on CAD based product design and Manufacturing
2. To understand the concepts of product assembly and tolerance
3. To explore product quality and functionality in applications.

Course Outcomes: On completion of the course, student will be able to:

1. Select an appropriate product design and development process for a given application
2. Select an appropriate standardization method. Update product design and analysis concepts
3. Analyze the product for QFD and DFX.
4. Study new Manufacturing concepts such as 3D Printing Methods.
5. Design & Develop new mechanical product and method to minimize the cost

Course Contents	Hrs
Unit I: Introduction to PDD	**8**
Introduction, Concept of Product Life Cycle management, Components/Elements of PLM, Customer Involvement, Product Data and Product Workflow, The Link Between Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technology.	
Unit II: Product Design & Analysis	**8**
Value engineering in product design; Advantages, Applications in product design, Problem identification and selection, Analysis of functions, Anatomy of function. Primary versus secondary versus tertiary/unnecessary functions, Functional analysis: Functional Analysis System Technique.	
Unit III: Production Design Tools	**8**
Introduction to product design tools, QFD, Computer Aided Design, Robust design, DFX, DFM, DFA, Ergonomics in product design, DFMA Principles & guidelines, and Product design for manual assembly.	
Unit IV: PDD Techniques	**8**
3D Printing and details. Design guidelines for metallic and non- metallic products to be manufactured by different processes such as casting, machining, injection moulding. Rapid prototyping, needs, advantages, working principle of SLA, LOM and SLS etc.	

Unit V: Product Development - Technical and Business Concerns	8
Mission Statement and Technical Questioning, Technology Forecasting and S Curve, Customer Needs and Satisfaction, Customer Needs - Types and Models, tools for Gathering Customer Needs, Customer Population and Market Segmentation	

Text Books:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, –Product Design and Development –, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, –Product Design|, Indian Reprint 2004, Pearson Education,2003.

Reference Books:

1. Yousef Haik, T. M. M. Shahin, –Engineering Design Process|, 2nd Edition Reprint, Cengage
2. Clive L. Dym, Patrick Little, –Engineering Design: A Project-based Introduction|, 3rd Edition, John.

UMEL410: Advanced Tool Design
(Elective-III)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Tool Design

COURSE OBJECTIVE:

1. The objective of this course is to provide students the tools required for design and analysis of advanced tool design.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Interpret the geometrical and dimensional details of a production drawing.

2. Understand principles of locating and clamping systems

3. Design jigs and fixtures for conventional and NC machining

4.Select and design progressive, compound or combination dies for press working operations

5. Design single point and multipoint cutting tools

COURSE CONTENTS	Hrs.
UNIT I: Conventional Cutting Tools	**8**
Introduction to single point tool geometry. Tool strength and rigidity. Designing various tool angles according to application. Application of chip breakers. Carbide tipped cutting and High speed cutting tools. Design of milling cutters.	

UNIT II: Work Holding Methods	8
Work holding devices. Introduction to six point location. Methods of locating components. Types of locators. Introduction of clamping methods for the job. Various types of clamps used in jigs and fixtures.	
UNIT III: Jigs & Fixture Design	**8**
Introduction to jig and fixture. The design principles applied in both jigs and fixtures. Designing of Drilling Jig & Milling fixtures.	
UNIT IV: Press Tool Design	**8**
Introduction to press tool design. Various Die cutting operations. Press and the classifications. Die set assembly with components. Basic of center of pressure with examples.	
UNIT V: Design of Dies	**8**
Design of various dies like piercing die, blanking die, progressive die.	

Text Books:
1. Tool Engineering and Design" by G R Nagpal.
2. Donaldson.C, G.H.Lecain and V.C.Goold "Tool Design", TMH, New Delhi, 2010
3. Metal Cutting Principles" by M C Shah.
4. Machine Tool Design by N. Q. Mehta
Reference Books:
1. F.W.Wilson.F.W. "Fundamentals of Tool Design", ASME, PHI, New Delhi, 2010
2. Gigs and Fixtures" by Grant.

UMEL411: Engineering Ergonomics (Elective-III)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):
Industrial Engineering
COURSE OBJECTIVE:
1. To recognize, evaluate, and control work place conditions that cause or contribute to employee safety and productivity issues.
2. To understand and define components of ergonomics; work physiology; anthropometry; musculoskeletal disorders; common risk factors such as vibration, temperature, material handling, repetition, and lifting; computer workstations;.
COURSE OUTCOME: Upon successful completion of the course students will be able to
1. Determine the basic concepts of Ergonomics and demonstrate a sound knowledge of Ergonomics in engineering applications.
2. Interpret the nuances of Human Factors in Engineering and analyze its role in their disciplines.

3. Demonstrate a sound knowledge of Man-Machine Interfaces and design of displays and controls in engineering systems.

4. Describe how to evaluate, select and implement ergonomic solutions.

5. Apply ergonomics to a work place problem.

COURSE CONTENTS	Hrs.
UNIT I: Ergonomics	**8**
Concept, Scope, Historical background, Human- machine system interfaces, Basic Ergonomics, Work Physiology, and Measurement of work.	
UNIT II: Physical Ergonomics	**8**
Physical work load and energy expenditure, Anthropometry – measures – design procedure, Work postures measurement-sitting, standing, ergonomic implications, Design of displays and controls.	
UNIT III: Human Factors Engineering (HFE)	**8**
Introduction & brief history of HFE; essentials of HFE, person-machine systems- basic human factors: sensory systems, perception, cognition, information processing approach, memory, decision making, workspace designs- general principles, designing work areas; machine displays & controls; current trends in HFE- use of artificial intelligence, cognitive engineering, sociotechnical systems, etc.	
UNIT IV: Man-Machine Interaction	**8**
Man-Machine interaction cycle, Man-machine interfaces, Displays : factors that control choice of display, visual displays- qualitative displays; moving pointer displays, moving scale displays, digital displays Indicators, auditory displays, tactile displays. Factors affecting effectiveness of displays. Quantitative displays, check- reading displays, representational displays. Types of controls and their integration with displays.	
UNIT V: Design Guidelines for Displays and Controls	**8**
Viewing distance, Illumination, angle of view, reach etc., general design checklist for displays and controls. Standards for ergonomics in engineering and design, displays and controls. **Environmental Factors** Sources & effects of Noise - Vibration, lighting, temperature, humidity & atmosphere. Measures for monitoring, control & mitigation.	

Text Books:

1. Sanders McCormick, “Human Factor Engineering and Design”
2. Martin Helander, A Guide to Ergonomics of Manufacturing, TMH, 1996.
3. R.S.Bridger -Introduction to Ergonomics, ISBN:13:9780849373060, Publisher Taylor and Francis dated 20th Aug 2008, 3rdEdition.

Reference Books:

1. H.B. Maynard, Hand Book of Industrial Engineering
2. Zandin K.B. - Most Work Measurement Systems
3. Martin Helander, A Guide to human factors and Ergonomics, Taylor and Francis, 2006
4. Kodak Ergonomics Group, Ergonomic Design for People at Work, Volumes I and II. Van Nostrand Reinhold Co. Ltd.

UMEL412: TRIBOLOGY (Elective-III)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Machine Design-I & II, Fluid Mechanics

COURSE OBJECTIVE:

1. To know about properties of lubricants, modes of lubrication, additives etc.
2. To Select suitable/proper grade lubricant for specific application.
3. To select suitable material combination for Tribological contact.
4. To apply the basic theories of friction, wear and lubrications about frictional behavior, commonly encountered sliding surfaces.
5. To know the Automobile and engines lubrication systems.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Understand the basic tribological concepts and lubrication system for industry.
2. Understand the properties of basic theories of wear and friction and the mechanics of rubbing bodies.
3. To design the hydrodynamic lubrication in machine parts.
4. To understand and design the hydrostatic lubrication.
5. Demonstrate and design the Elasto-hydrodynamic lubrication and Gas (air) lubrication
6. Select suitable grade of lubricants and its specification for automobiles and engine parts.

COURSE CONTENTS	Hrs.
UNIT I: Introduction to Tribology	**8**
Tribology definition, Tribology in industry (Maintenance), Lubrication-Definition, basic modes of lubrication, properties of lubricants, additives. Bearing Terminology Types of Sliding contact, rolling contact bearings. Comparison between sliding and rolling contact bearing. (Theoretical treatment only)	
UNIT II: Friction and Wear	**8**
Friction- Introduction, laws of friction, Friction classification, causes of friction. Theories of dry friction, Friction measurement, Stick-slip motion and friction instabilities, Wear classification, wear between solids, wear between solid and liquids, factors affecting wear. Theories of wear. Wear measurement. Approaches to friction control and wear prevention.	
UNIT III: Hydrodynamic Lubrication	**8**
Theory of hydrodynamic lubrication, mechanism of pressure development in oil film. Two Dimensional Reynolds‟s equation and its limitations, Petofi‟s equation. Infinitely long journal bearing, infinitely short journal bearing and finite bearing, (Numerical on Reynolds‟s equation only)	

UNIT IV: Hydrostatic Lubrication	8
Hydrostatic lubrication-Basic concept, advantages, limitations, viscous flow through rectangular slot, load carrying capacity, flow requirement of hydrostatic step bearing, energy losses, optimum design of stepped bearing, compensators and their actions. Squeeze film lubrication- Basic concept, circular and rectangular plate approaching a plane (Numerical on hydrostatic bearing, Squeeze film lubrication).	
UNIT V: Elasto-Hydrodynamic Lubrication and Gas (air) Lubrication	**8**
Elasto-hydrodynamic lubrication-Principle and applications, pressure viscosity term in Reynolds's equation, Hertz theory, Ertel-Grubin equation. Gas(air) lubricated bearings-Introduction, advantages, disadvantages, applications of tilting pad bearing, hydrostatic and hydrodynamic bearing with air lubrication, Active and passive magnetic bearings (working principle, types and advantages over conventional bearing). (Theoretical treatment only)	

Text Books:

1. Mujumdar B. C., Introduction to Tribology and Bearings, S. Chand and Company Ltd. New Delhi.
2. Bharat Bhushan, Principles and Applications of Tribology, 2nd Edition, Wiley India
3. Davis J., Surface Engineering for Corrosion and Wear Resistance, Woodhead Publishing, 2001.

Reference Books:

1. Halling J., Principles of Tribology, McMillan Press Ltd.
2. Bhushan B. and Gupta B. K., Handbook of Tribology: Material, Coatings and Surface Treatments, McGraw Hill Ltd.
3. Cameron A., Basic Lubrication Theory, Wiley Eastern Ltd.
4. Fuller D. D., Theory and Practice of Lubrication for Engineers, John Wiley and Sons.

UMEL413: Gas Turbine & Jet Propulsion (Elective-IV)

Teaching Scheme:	Credit	Examination Scheme
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE:10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Fluid Mechanics, Turbo Machinery

COURSE OBJECTIVE:

1. Understand the thermodynamics of each component of a turbine engine which include inlets, fans, compressors, burners, turbines, afterburners and nozzles
2. Know what the design variables are for each component

3. Understand the linked system performance of all components in the engine and performance trends for each component	
4. Understand the basis for off-design performance	
COURSE OUTCOME: Upon successful completion of the course students will be able to	
1. Demonstrate the gas turbine power plant	
2. Illustrate the jet propulsion system	
3. Analyze the performance of gas turbine engine	
4. Present the technical details of compressors used in gas power systems	
COURSE CONTENTS	**Hrs**
Unit I : Gas Turbine System	**8**
Gas turbine cycle analysis – layout of turbo jet engine. Turbo machinery, compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis. Flight Performance: Forces acting on vehicle, Basic relations of motion, multi stage vehicles, Different types of nozzles	
UNIT II: Principles of Jet Propulsion and Rocketry	**8**
Fundamentals of jet propulsion, Rockets and air breathing jet engines, Classification, turbo jet, turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines.	
UNIT III: Solid Rocket Propulsion System	**8**
Classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.	
UNIT IV: Liquid Rocket Propulsion System	**8**
Classification, Mono and Bi propellants, Cryogenic and storage propellants, Ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components.	
UNIT V: Ramjet and Integral Rocket Ramjet Propulsion System	**8**
Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IRR propulsion systems.	
Text Books:	
1. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 6th Edition, Pearson PrenticeHall, 2008.	
2. Ganesan, V., Gas Turbines, 3rd Edition, Tata McGraw Hill, 2010.	
3. J.D. Anderson, ―Introduction to Flight‖, 5th ed., Tata McGraw Hill, 2013	
Reference Books :	
1. Sutton, Rocket Propulsion elements‖, 7th edition Wiley, India, 2000.	
2. Flack R., Fundamentals of Jet Propulsion with Applications, Cambridge Uni. Press, 2010.	
3. Dr. M.L. Mathur and R P Sharma, Gas Turbines and Jet and Rocket Propulsion, Standard Publishers Distributors, second edition, 2014	
4. Jack D. Mattingly, ―Elements of Gas Turbine Propulsion, McGraw-Hill Science/Engineering/Math; International Ed edition (1996)	

UMEL414: Automobile Engineering (Elective-IV)

Teaching Scheme	Credit	Examination Scheme
Lectures:03 Hr/Week	**03**	**TAE : 10** Marks **CAE : 15** Marks **ESE : 50** Marks

Prerequisite (if any): I. C. Engines, Theory of Machines, Basics of Electrical and Electronics

Course Objectives

1. To make the student conversant with Fundamentals of Automotive systems.
2. To develop competencies of students in vehicle performance and safety
3. To make the student conversant with automotive electrical system and vehicle maintenance.
4. To understand the emerging trends of electric vehicles, hybrid electric vehicles and solar vehicles.

Course Outcome: After studying this course student will able to

1. Compare and select the proper automotive parts and system for the vehicle.
2. Analyze the performance and safety aspects of the vehicle.
3. Diagnose the faults of automotive vehicles.
4. Apply the knowledge of Electric vehicles, hybrid electric vehicles and solar vehicles for further development.

COURSE CONTENTS	Hrs.
Unit I : Current Scenario and Drive Train	**8**
Introduction: Current scenario in Indian auto/ancillary industries, vehicle specifications and classification. **Chassis and Frames**: Types of chassis layout with reference to power plant locations and drive, various types of frames, constructional details. **Drive Train**: Types of transmission system, necessity and selection of clutch, necessity of gear box and different types, fluid flywheel, torque convertor, continuous variable transmission, overdrive and differential.	
Unit II: Axles, Wheels and Tyres, Steering System	**8**
Axles: Purpose, requirement and types of front and rear axle, loads acting on rear axles. **Wheels and Tyre:** Wheel construction, alloy wheel, wheel balancing, type of tyre, tyre construction, tyre materials, factors affecting tyre life. **Steering system:** Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristics, steering linkages and gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering, wheel alignment.	
Unit III :Suspension and Brake System	**8**
Suspension: Types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self-leveling suspension (active suspension), shock absorbers (hydraulic and air). **Brake systems**: Drum, disc, mechanical, hydraulic, air brakes, vacuum, power assisted brakes, hand brake, Antilock braking system(ABS), Electronic Brake Distribution(EBD).	

Unit IV : Vehicle Performance and Safety	**8**
Vehicle performance: Parameters, vehicle resistances, traction and tractive effort, power requirement for propulsion, road performance curves (numerical), stability of vehicles, vehicle testing on chassis dynamometer, maintenance, different BS norms **Vehicle safety:** Types of active and passive safety, vehicle interior and ergonomics, NVH in automobiles. Study of various performance and safety Test. **Batteries:** Electrical safety accessories	
Unit V: Electric and Hybrid Electric Vehicles	**8**
Introduction: Concept and environmental importance of Electric vehicles, Hybrid electric and solar vehicles. **Electric vehicles:** Layout, construction and working, study of charging system. **Hybrid electric vehicles:** Types, layout, hybridization factor, plug in hybrid electric vehicles, fuel efficiency analysis. Challenges and future scope of Electric and Hybrid Electric Vehicles.	

Text Books:

1. Newton K., Seeds W., and Garrett T.K., "Motor Vehicle", Society of Automotive Engineers; 12th Edition (December 1996)
2. Braess H.H, Seiffen U., "Handbook of Automotive Engineering", SAE Publications, 2005.
3. Crouse W.H., "Automotive Mechanics", McGraw-Hill Higher Education; 10 edition, 1993.
4. Kohali P. S., Automobile Electrical Equipment, McGraw Hill Education; 1st edition, 2017.
5. Narang G. B. S, "Automobile Engineering", S. Chand and Company Ltd., 1989.
6. Automobile Engineering Volume 1 & Volume 2 by Kirpal Singh

Reference Books:

1. Sclar D., "Auto repair for dummies, John Wiley & Sons Publication 2nd edition ,2019.
2. Singh K., "Automobile Engineering", Volume 1, Standard Publishers distributors. 13th Edition 2012.
3. Crouse W. and Anglin D., Automobile Mechanics, ", McGraw Hill Education; 10th edition 2017.
4. Gupta B K, Gupta R. B., Automobile Engineering, Satya Prakashan, 2016.
5. Heitner J., "Automotive Mechanics", C.B.S Publishers, 2nd Edition, 2006.

UMEL415: Stress Analysis (Elective-IV)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Engineering Mechanics. Strength of Materials

COURSE OBJECTIVE:

1. The objective of this course is to provide students the tools required for design and analysis of complex problems in mechanics of materials.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Understand elasticity, stress and strain.
2. Understand isotropic, orthotropic and anisotropic terms related to materials.
3. Understand the basic concepts of plane stress, plane strain, principal stress and principal strain.
4. Apply the basic tensor notations, the stress, strain and inertia tensors.
5. Analyze the basic strain gauge measurements problems.

COURSE CONTENTS	Hrs.
UNIT I: Simple Stress and Strain	**8**
Introduction to plain stress and plain strain and their relationship. Different Elastic constants.	
UNIT II: Two Dimensional Stress Analysis	**8**
Two-dimensional stress analysis problems in Cartesian coordinate system. Differential equilibrium and compatibility equations. Application of the boundary conditions. Introduction to Airy's stress function. Two dimensional stress analysis problems in Polar coordinate systems. Introduction to general equations in Polar coordinate systems. The stress distribution about systematic axis. Pure bending of curved beams. Discontinuity effect on stress distribution in plain lamina.	
UNIT III: Thermal Stress Analysis	**8**
Introduction to the thermal stress related to circular disc, thin plate and long cylinder. Basics of Photo elasticity. Polarized light, wave plates, plane and circular poloriscope, Introduction to fringe pattern of 3 D Photo elasticity	
UNIT IV: Different Theories of Failure	**8**
Brittle coating technique, coating stress. Different failure theories. Crack patterns with crack detection. Moire fringe techniques.	
UNIT V: Fracture Mechanics	**8**
Overview of fracture mechanics, Energy concepts in fracture mechanics, Linear elastic fracture mechanics, Analytical methods for determining stress intensity factors, Fatigue crack growth, elastic plastic fracture mechanics, interfacial fracture, Mode of cracks, notches, similarity, S/N Curve.	

Text Books:

1. Theory of Elasticity" by S P Timoshenko and J N Goodier
2. Experimental Stress Analysis" by J W Dally and W F Riely
3. Strength of Materials by S. Ramamrutham

Reference Books:

1. Experimental stress Analysis, Srinath L.S tata Mc Graw Hill.
2. Photo Elastic Stress Analysis, Kuske, Albrecht & Robertson John Wiley & Sons.
3. Dove, Adams, "Experimental Stress Analysis," Prentice Hall of India, 1965

UMEL416: Micro Electro Mechanical System (Elective-IV)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Mechatronics

COURSE OBJECTIVE:

1. To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.
2. To educate on the rudiments of Micro fabrication techniques.
3. To introduce various sensors and actuators
4. To introduce different materials used for MEMS
5. To educate on the applications of MEMS to disciplines beyond Electrical and Mechanical engineering.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Ability to understand and apply basic science, circuit theory, Electro-magnetic field theory control theory and apply them to electrical engineering problem
2. Ability to understand and analyze linear and digital electronic circuits.
3. Grain a knowledge of basic approaches for micro/Nano system design
4. Gain a knowledge of state-of-the-art lithography techniques for micro/Nano systems

COURSE CONTENTS	Hrs.
UNIT I: Overview of MEMS and Microsystems	**8**
MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Micro fabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems, Miniaturization. Applications and Markets.	
UNIT II: Working Principles of Microsystems	**8**

Working Principles of Microsystems: Introduction, Micro sensors, Micro actuation, MEMS with Micro actuators, Micro accelerometers, Microfluidics **Engineering Science for Microsystems Design and Fabrication:** Introduction, Molecular Theory of Matter and Inter-molecular Forces, Plasma Physics, Electrochemistry.	
UNIT III: Engineering Mechanics for Microsystems Design	**8**
Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermo mechanics, Fracture Mechanics, Thin Film Mechanics, Overview on Finite Element Stress Analysis.	
UNIT IV: Scaling Laws in Miniaturization	**8**
Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling in Fluid Mechanics, Scaling in Heat Transfer.	
UNIT V: Overview of Micro manufacturing	**8**
Introduction, Bulk Micro manufacturing, Surface Micromachining, The LIGA Process, Summary on Micro manufacturing, Micro electronics in Automobile	

Text Books:
1. Marc J Madou – 'Fundamentals of Micro fabrication' – CRC Press – 2002 – 2nd Editio
Reference Books:
1. Marc J Madou – 'Fundamentals of Micro fabrication' – CRC Press – 2002 – 2nd Edition 2. Marc J Madou – 'Fundamentals of Micro fabrication' – CRC Press – 2002 – 2nd Edition

UMEL417: Advanced Casting Methods (Elective-IV)

Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):
Casting Process, Basic manufacturing process
COURSE OBJECTIVE: The objective of this course is
1. To make students aware of Foundry Technology including different casting processes.
2. To impart knowledge about design of gating system in casting to get quality-wise acceptable casting.
COURSE OUTCOME: Upon successful completion of the course students will be able to
1. An ability to apply knowledge of mathematics, science, and engineering in casting process.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. A recognition of the need for, and an ability to engage in lifelong learning in foundry practices.
4. An ability to identify, formulates, and solves engineering problems related to various casting processes.

COURSE CONTENTS	**Hrs.**

UNIT I: Advance Moulding Processes	**8**
Introduction to Moulding & Casting, moulding processes like CO_2 Moulding, Shell Moulding, Investment Moulding, Sweep Moulding, Ceramic and Plaster Moulding.	
UNIT II: Advance Casting Processes	**8**
Casting methods like Investment casting, Permanent Mould Casting, Gravity die casting, Pressure die Casting. Coatings for Moulds, Core and their testing, Core design, Evaporative pattern casting	
UNIT III: Melting Practices	**8**
Melting Furnaces – Introduction to Cupola furnace and fluxes. Calculations of Cupola Furnace charge. Introduction to induction furnaces, arc furnace. Introduction to Foundry refractory.	
UNIT IV: Metal Solidification Technique	**8**
Solidification theory of metals and alloys. Directional Solidification. Casting feeding shrinkage, riser and chills. Gating systems- fluid flow, metal filtration.	
UNIT V: Casting Finishing and Quality Control	**8**
Shakeout, cleaning, fettling, finishing and heat treatment of casting, salvaging of defective castings, Reasons of Casting defects, their remedies. Casting design, Quality control and assurance, Statistical quality control, Inspection and testing of castings. Different Control Charts for controlling the casting quality to achieve defect free casting.	

Text Books:

1. P.L. Jain- Principles of Foundry Technology, 4 th ed.,Tata-McGraw-Hill, New Delhi , 2003.
2. A.K. Chakabarti, Casting Technology and cast alloys, Prentice-Hall of India, 2005.
3. A Text-Book of Foundry Technology" by Khanna O P.

Reference Books:

1. Peter Beeley, Foundry Technology, 2nd ed., Butterworth-Heinemann, Oxford, 2001.
2. Principles of Metal Casting" by Heine..

UMEL418- MECHANICS OF COMPOSITE MATERIALS (Elective-IV)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	**03**	**TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Composite Materials

COURSE OBJECTIVE:

1. Explain the behavior of constituents in the composite materials
2. Enlighten the students in different types of reinforcement •
3. Develop the student's skills in understanding the different manufacturing methods available for composite material.

4. Illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Identify and understand the basic mechanical behavior of composite materials and make sound prediction on the likely behavior of new combinations of materials.
2. Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro levels.
3. Compute the stresses and strains relation in composites materials
4. Analyze the micromechanical properties of fibre reinforced composites.

COURSE CONTENTS	Hrs.
UNIT I: Introduction	**8**
Basic concepts: Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.	
UNIT II: Lamina Constitutive Equations	**8**
Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina – Transformation Matrix, Transformed Stiffness	
UNIT III: Definition of Stress and Moment Resultants	**8**
Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates	
UNIT IV: Laminate Configuration	**8**
Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates	
UNIT V: Environmental Induced Cracking	**8**
Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.	

Text Books:

1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
3. Hyer, M.W., "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw-Hill, 1998.

Reference Books:

1. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006 .
2. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006

UMEL419: Energy Storage System (Elective-V)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Electro chemistry

COURSE OBJECTIVE:

1. To enable the student to understand the need for energy storage, devices and technologies available and their applications

COURSE OUTCOME: Upon successful completion of the course students will be able

1. To analyze the characteristics of energy from various sources and need for storage.
2. To classify various types of energy storage and various devices used for the purpose
3. To identify various real time applications.

COURSE CONTENTS	Hrs.
UNIT I: Features of Energy Storage Systems	**8**
Classification of Energy Storage systems: Mechanical storage systems, Thermal energy storage system, Electrical energy storage system, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES),Electrochemical storage systems, Magnetic energy storage system, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H2),Synthetic natural gas (SNG).	
UNIT II: Needs for Electrical Energy Storage	**8**
Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses, The roles of electrical energy storage technologies. The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy	
UNIT III: Electrical Energy Storage Technologies	**8**
Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods, Need for continuous and flexible supply, Long distance between generation and consumption, Congestion in power grids, Transmission by cable.	
UNIT IV: Li-ion battery	**8**
Applications of Li-ion battery: i. Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements. ii. Automotive Applications- Drive Cycles, SLI (Starting, Lighting and Ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs.	
UNIT V: Fuel Cells	**8**
Introduction to fuel cells, components of fuel cells, Types of fuel cells: Alkaline fuel cells, proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell.	

Text Books:

1. "James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.
2. The Electrical Energy Storage by IEC Market Strategy Board.
3. Lithium-Ion Batteries Science and Technologies by Ralph J. Brodd (auth.), Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa (eds.), Springer.
4. Energy Storage for Power Systems, A.ter-Gazarian, Peter Peregrines Ltd. UK 1994
5. Thermal Energy Storage – Systems and Applications, Ibrahim Dincer, Marc Rosen, 2nd Edition, Wiley, 2011.

Reference Books:

1. Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.
2. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
3. E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.

UMEL420: Energy Management (Elective-V)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Thermodynamics, Turbo Machines

COURSE OBJECTIVE: Student should be able to -

1. To Understand the Importance of Energy Management.
2. To Carry out Energy Audit.
3. To know the methods to reduce consumption of energy and save cost.
4. To improve energy efficiency of overall system.
5. To understand the Significance of Waste heat recovery and Cogeneration.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Compare energy scenario of India and World.
2. Carry out Energy Audit of the Residence / Institute/ Organization.
3. Evaluate the project using financial techniques
4. Identify and evaluate energy conservation opportunities in Thermal Utilities.
5. Identify and evaluate energy conservation opportunities in Electrical Utilities.
6. Identify and evaluate performance of Cogeneration and identify feasibility of waste heat recovery systems.

COURSE CONTENTS	Hrs.
UNIT I: General Aspects of Energy Management	**8**

Current energy scenario - India and World, Current energy consumption pattern in global and Indian industry, Concept of energy conservation and energy efficiency, Energy and environment, Need of Renewable energy, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy reforms.	
UNIT II: Energy Audit & Economics	**8**
Energy Audit: Necessity, Types, Components, methodology, Instruments used, Analysis and recommendations of energy audit, reporting of energy audits, software for Energy audit, Current Energy Conservation Act. Case Study : Example on Fuel Substitution Costing of Utilities- Determination of cost of steam, natural gas, compressed air and electricity, Financial Analysis Techniques (Numerical) - Simple payback, Time value of money, Net Present Value(NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis.	
UNIT III: Energy Efficiency in Thermal Utilities	**8**
Energy performance assessment (Numerical) and efficiency improvement of Boilers, Furnaces, Heat exchangers, Cooling tower, DG sets, Fans and blowers, Pumps, Compressors, Compressed air system and HVAC systems. Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system.	
UNIT IV: Energy efficiency in Electrical Utilities	8
Electricity billing, Electrical load management and maximum demand control, penalties, Power factor improvement and benefits, Selection and location of capacitors. Distribution and transformer losses, Electrical motors- types, efficiency and selection, Speed control, Energy efficient motors, Introduction of Electricity Act 2003,Lamp types and their features, recommended illumination levels, Lighting system performance assessment and efficiency improvement (Numerical)	
UNIT V: Cogeneration (CG) & Waste Heat Recovery (WHR)	8
Definition, need & principle of CG, technical options of CG, CG cycles, Selection of CG systems, Performance evaluation of CG, Case study , Need of WHR, Waste sources and Quality, Benefits of WHR.Case study: Energy Audit of Department / Institute.	
Text Books:	
1. Energy Management : Conservation and Audits byAnil Kumar, CRC Press, 2020	
Reference Books:	
1. Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.	
2. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc., 5th Edition, Georgia.	
3. H andbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, Press, New Delhi, 2006	
4. Energy Performance assessment for equipment and Utility Systems.-Vol. 2,3.4 BEE Govt. of India	
5. Boiler Operator‘s Guide Fourth Edition, Anthony L Kohan, McGraw Hill	
6. Energy Hand book, Second edition, Von Nostrand Reinhold Company - Robert L. Loftness.	
7. www.enrgymanagertraining.com	
8. http://www.bee-india.nic.in	

UMEL421: Machine Condition Monitoring (Elective-V)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Manufacturing Processes, Basics of Maintenance Engineering

COURSE OBJECTIVE:

1. To equip the graduates to plan, design, and execute effective maintenance strategy and maintenance practices in various types of industries.
2. To equip graduates with the state of the art maintenance repair techniques and condition monitoring technologies and instrumentation.
3. To equip graduates with the essentials of reliability engineering techniques to enable them to develop and enhance reliability programs.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Understand effective maintenance schemes in industries.
2. Diagnose the mechanical systems by applying vibration monitoring techniques.
3. Apply oil analysis technique to diagnose the wear debris.
4. Identify nonconventional methods for machine diagnoses.

COURSE CONTENTS	**Hrs.**
UNIT I: Plant Maintenance	**8**
Plant Maintenance: concept, Maintenance Strategies: planned/unplanned maintenance, breakdown, corrective. Opportunistic, routine, preventive, predictive maintenance: condition based maintenance system, design-out maintenance, selection of maintenance system. Maintenance Planning. Maintenance Scheduling, Spare Parts Management, Replacement Analysis, Basics of condition monitoring & noise control	
UNIT II: Diagnostic Maintenance	**8**
Maintenance defect failure analysis and repair techniques: Defect recording and failure analysis. Break down analysis (FTA, FMEA), dismantling and assembling, inspection and adjustment, lubrication.	
UNIT III:Condition Monitoring & Trend Analysis	**8**
Machinery condition monitoring: Thermography, Wear debris analysis, Fundamentals of machine vibrations, Digital Signal Processing, Vibration Monitoring, Noise Monitoring, Motor current signature analysis, other techniques such as Ultrasonic testing, Radiography, Eddy current testing etc., FFT Analyser	
UNIT IV: Reliability Oriented Maintenance Systems and Evaluation	**8**

Reliability Oriented Maintenance Systems and Evaluation: Elements of Probability, Reliability definition, Failure data analysis, Analysis of Failure Data, Overview of estimation techniques, Distribution Fitting, Hazard Models, System Reliability, Reliability Improvement,	
UNIT V: Contaminant Analysis	**8**
Contaminant analysis: Contaminants in lubricating oils - monitoring techniques (wear debris) - SOAP technique, Ferrography, X-ray spectrometry, Particle classification. **Temperature Monitoring**: Techniques like - thermograph, pyrometers, indicating paint and NDT methods.	

Text Books:

1. Srivastava S K, "Industrial Maintenance Management", S. Chand, 1998
2. L.S. Srinath , "Reliability Engineering", Affilated East-West Press , 4th Edition 2005
3. Williams, "Condition Based Maintenance and Machine Diagnostics " Chapman & Hall
4. Fault Diagnosis Application, Isermann R., Springer-Verlag Berlin, 2011.
5. Vibration Condition Monitoring, Rao J. S., Narosa Publishing House, 2/e 2000.
6. Mechanical Faults Diagnosis, Collacott, R. A., Chapman and Hall, London, 1990

Reference Books:

1. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000
2. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill, 2012
3. Condition Monitoring and Maintenance Engineering-BME-025- IGNOU Course Materials
4. Plant Maintenance and Reliability Engineering- Prof. N.V.S.Raju, Sengage Learning India Publications

UMEL422: Vehicle Dynamics (Elective-V)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	**03**	**TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Kinematics of Machines, Dynamics of Machinery (Mechanical Engineering), Automobile System, Physics (Automobile Engineering)

COURSE OBJECTIVE:

1. To present a problem oriented in depth knowledge of Vehicle Dynamics.
2. To address the underlying concepts and methods behind Vehicle Dynamics

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Understand the dynamics of vehicle ride.
2. Calculate and refer the loads and forces associated to the vehicles.
3. Analyze the behavior of the vehicles under acceleration, ride and braking.

COURSE CONTENTS	Hrs.
UNIT I: Consideration of Design Parameters	**8**

SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, transmission characteristics, power limited and traction limited acceleration, braking performance.	
UNIT II: Tyre Mechanics	**8**
Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tyre Formula	
UNIT III: Suspension System	**8**
Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions	
UNIT IV: Steering System	**8**
The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady state model), Understeer and Oversteer, Effect of Tyre Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.	
UNIT V: Stability of Vehicles:	**8**
Load distribution, calculation of tractive effort and reactions for different drives, stability of a vehicle on a slope, on a curve and a banked road, Wheel balancing and alignment Effect of Aerodynamic on vehicle, Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids	
Text Books:	
1. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012	
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.	
3. Rajesh Rajamani, Vehicle Dynamics & control, Springer.	
4. R.V. Dukkipati, Vehicle dynamics, Narsova Publications	
Reference Books:	
1. Heinz Heister, "Vehicle and Engine Technology", SAE Second Edition, 1999	
2. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE.	
3. Gillespie.T.D., “Fundamental of vehicle dynamic society of Automotive Engineers ",USA, 1992.	

UMEL423: Corrosion Engineering (Elective-V)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Material and Nano Science

COURSE OBJECTIVE:

1. To provide an understanding of the corrosion principles and engineering methods used to minimize and prevent the corrosion

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Solve problems involving various types of corrosion
2. Select corrosion resistant materials for a given application.
3. Select technique for corrosion prevention.

COURSE CONTENTS	Hrs.
UNIT I: Introduction	**8**
Basic concepts: Definition and importance, Electrochemical nature and forms of corrosion, Corrosion rate and its determination. **Electrochemical thermodynamics and kinetics**: Electrode potentials, Potential-pH (Pourbiax) diagrams, Reference electrodes and experimental measurements, Faraday's laws, Instrumentation and experimental procedure.	
UNIT II: Galvanic and Concentration Cell Corrosion	**8**
Basic concepts, Experimental measurements, and determination of rates of galvanic corrosion, Concentration cells. Corrosion measurement through polarization techniques- Tafel extrapolation plots, Polarization resistance method, Commercial corrosion probes, Other methods of determining polarization curves.	
UNIT III: Passivity, Pitting and Crevice Corrosion	**8**
Basic concepts of passivity, Properties of passive films, Experimental measurement, Applications of Potentiostatic Anodic Polarization, Anodic protection. Mechanisms of pitting and crevice corrosion, Secondary forms of crevice corrosion, Localized pitting, Metallurgical features and corrosion: Intergranular corrosion, Weldment corrosion, De-alloying and dezincification.	
UNIT IV: Environmental Induced Cracking	**8**
Stress corrosion cracking, Corrosion fatigue cracking, Hydrogen induced cracking, Methods of prevention and testing, Erosion, Fretting and Wear. **Environmental factors and corrosion-**Corrosion in water and aqueous solutions, Corrosion in sulphur bearing solutions, Microbiologically induced corrosion, Corrosion in acidic and alkaline process streams.	
UNIT V: Atmospheric and Elevated Temperature Corrosion	**8**
Atmospheric corrosion and its prevention, Oxidation at elevated temperatures, Alloying, Oxidizing environments. **Prevention and control of corrosion**: Cathodic protection, Coatings and inhibitors, Material selection and design.	

Text Books:
1. Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd ed. (seventh reprint)
2. Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall (1996).
Reference Books:
1. Pierre R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill (2008).
2. Pierre R. Roberge, Handbook of corrosion engineering, McGraw-Hill (2012). 2nded.
3. Sastri, V.S., Ghali, E. and Elboujdaini, M., Corrosion prevention and protection: Practical solutions, John Wiley and Sons (2007).

UMEL424: MODELING AND SIMULATION (Elective-V)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**
Prerequisite (if any):		
Course Objective:		
1. To introduce the students about the knowledge of basic and dynamic system models of engineering		
2. To introduce the students about the knowledge of simulation system.		
Course Outcome: Students able to		
1. Understand the system concept and apply functional modeling method to model the activities of a static system;		
2. Understand the behavior of a dynamic system and create an analogous model for a dynamic system.		
3. Simulate the operation of a dynamic system and make improvement according to the simulation results		
4. Characterize a given engineering system in terms of its essential elements, that is, purpose, parameters, constraints, performance requirements, subsystems, interconnections and environmental context.		
5. Interpret the simulation results of an engineering system model, within the context of its capabilities and limitations, to address critical issues in an engineering project		
Course Contents		**Hrs**
Unit I : System Models		**8**
Basic System models: Mathematical models, Mechanical system building blocks, Electrical system building block, fluid system building block, thermal system building block. **System Models**: Engineering systems, Rotational translational systems, Electro-mechanical systems, linearity, Hydraulic Mechanical systems.		
Unit II : Queuing Model		**8**

Characteristic of Queue system, Queue behavior & queue discipline, Transient & steady state behavior, longrun performance measure, infinite & finite population model.	
Unit III : Mechanical Event Simulation (Finite Element Modeling and Analysis)	**8**
Introduction, General procedure of finite element method, finite element analysis, iso-parametric evaluation of element matrices, finite element modeling, mesh generation, design and engineering applications. Introduction to software – Mechanical & dynamic simulation module.	
Unit IV: System Simulation	**8**
Introduction, Review of probability and statistics, Managing the event calendar in a discrete event simulation model, Modeling input data Industrial case study	
Unit V: Simulation Application	**8**
Generation of random numbers and variants, generic features and introduction to Arena Software, Real world applications of simulation, Discrete continuous simulation, verification and validation of simulation models Flexisim, MATLAB	

Text Books:

1. W. Bolton, "Mechatronics – Electronic control systems in Mechanical & Electrical Engineering", Pearson Education Ltd, 2018.
2. Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw-Hill Publishing Company Limited, 1998.
3. SankarSengupta, System Simulation and modelling, Pearson, 2010.

Reference Books:

1. Deo, Narsingh, Millican Charles E.,"System Simulation with Digital Computer", PHI, 2004.
2. Gordon, Geoffrey, System Simulation, PHI, 2009.
3. P. Radhakrishnan, S Subramanyan, V. Raju, CAD/CAM/CIM, New Age International Publishers, 2008.

UMEL425 : REFRIGERATION & AIR CONDITIONING (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Lecture: 03 Hrs./Week	**03**	**Theory:** **TAE:10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics

COURSE OBJECTIVE:

1. Learning the fundamental principles and different methods of refrigeration and air conditioning.
2. Study of various refrigeration cycles and evaluate performance using Refrigeration charts and/ or refrigerant property tables.
3. Comparative study of different refrigerants with respect to properties, applications and environmental issues.
4. Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning, and study of air distribution system for air conditioning applications.
5. Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Illustrate the fundamental principles and applications of refrigeration and air conditioning
2. Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems.
3. Present the properties, applications and environmental issues of different refrigerants.
4. Operate, analyze and calculate cooling load for refrigeration and air conditioning systems.
5. Design of Air distribution system for air conditioning applications.

COURSE CONTENTS	**Hrs**
UNIT I: Introduction to Refrigeration, Refrigerants and Vapour Refrigeration Systems	**8**
Applications: Applications in Domestic Refrigerator, Domestic Air Conditioners, Automotive Air Conditioners, Evaporative coolers, water coolers, Commercial Refrigeration- Dairy, Cold storage, Ice plant, Commercial Air Conditioning-Multiplex, Hospitals. **Refrigerants:** Classification of refrigerants, Designation of refrigerants, Desirable properties of refrigerants, environmental issues, Ozone depletion and global warming, ODP, GWP & LCCP, Montreal, Kyoto Protocol, and Kigali Amendment, selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant: recovery reclaims, recycle and recharge. **Vapour compression systems:** Working of simple vapour compression system, T-s and P-h diagram, COP, EER, SEER, IPLV, NPLV, effect of operating parameters on performance of VCC, actual VCC, methods of improving COP using flash chamber, sub- cooling, liquid vapour heat exchanger, comparison of VCC with Reverse Carnot cycle.	
UNIT II: Vapour Absorption Systems & Other Refrigeration Techniques	**8**
Vapour absorption systems: Introduction, Working of simple vapour absorption system (VAS), desirable properties of binary mixture (aqua-ammonia), performance evaluation of simple VAS (simple numerical treatment), actual	

VAS, Li-Br absorption system, three fluid system (Electrolux refrigeration), applications of VAS, comparison between VCC and VAC. **Other Refrigeration Techniques:** Air cycle refrigeration, Vortex tube, Thermoelectric refrigeration, Steam Jet refrigeration, Adiabatic Demagnetization refrigeration, Cryogenics, Introduction, Application of cryogenics Houle – Thomson coefficient, inversion curve methods of liquefaction of air.	
UNIT III: Multiple Stage Refrigeration Systems	**8**
Introduction, need of multistage system, Intermediate pressure, two stage compression with flash gas removal and liquid intercooler, single compressor with multiple evaporator: individual and multiple expansion valves, individual compressors, cascade system: application and numerical(numerical only by using p-h chart), Introduction to aircraft refrigeration system.	
UNIT IV: Psychometry, Air Conditioning System and Load Estimation	**8**
Psychometry: Basic Psychometry and processes, BPF of coil, ADP, adiabatic mixing of two air streams, SHF, RSHF, GSHF, ESHF. Factors contributing to cooling load, Numerical based on load analysis. **Human Comfort**: Thermodynamics of human body, comfort and comfort chart, factors affecting human comfort, concept of infiltration and ventilation, indoor air quality requirements. **Air Conditioning Systems:** Working of summer, winter and all year round AC systems, all air system, all water system, air water system, variable refrigerant flow and variable air volume systems, unitary and central air conditioning.	
UNIT V: Air Distribution System, Components of Refrigeration and Air Conditioning Systems:	**8**
Ducts: Classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct (friction losses, dynamic losses), air flow through simple duct system, equivalent diameter, Methods of duct system design: equal friction, velocity reduction, static regain method (numerical on duct system design) **Air handling unit**: Air handling unit, Fan coil unit, types of fans used air conditioning applications, fan laws, filters, supply and return grills, sensors (humidity, temperature, smoke). **Components of refrigeration and air conditioning systems:** Working of reciprocating, screw and scroll compressors, working of air cooled, water cooled and evaporative condensers, working of DX, Flooded, Forced feed evaporators, Defrosting Methods (types & principle only), Expansion devices –Capillary tube, TXV, EXV, operating and safety controls.	

Text Books:

1. Arora C. P., Refrigeration and Air Conditioning, McGraw Hill Education; 3 edition, 2008.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 2005.
3. A Arora Domkundwar, Av Domkundwar, , Refrigeration & Air Conditioning, Dhanpatrai & Company,2017.

Reference Books :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000.
2. Stockers W.F and Jones J.W., Refrigeration and Air conditioning, McGraw Hill International editions 1982
3. Kuehn T. H., Ramsey J. W., Threlkeld J.L, Thermal Environmental Engineering, Pearson; 3 edition, 1998.
4. Aanant Narayan P. N., Basics of refrigeration and Air Conditioning, Tata McGraw Hill Publications, 2015.

UMEP425: REFRIGERATION & AIR CONDITIONING (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Heat Transfer

COURSE OBJECTIVE:

1. Learning the fundamental principles and different methods of refrigeration and air conditioning.
2. Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
3. Comparative study of different refrigerants with respect to properties, applications and environmental issues.
4. Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
5. Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems.
6. Study of air distribution system for air conditioning application.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Illustrate the fundamental principles and applications of refrigeration and air conditioning system.
2. Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems.
3. Present the properties, applications and environmental issues of different refrigerants.
4. Calculate cooling load for air conditioning systems.
5. Operate and analyze the refrigeration and air conditioning systems.
6. Design of Air distribution system for air conditioning applications.

COURSE CONTENTS	**Hrs.**
List of Practicals: Conduct any eight practicals.	
1. Test on Domestic Refrigerator for evaluation of EER.	**2**
2. Test on vapour compression test rig and its performance	**2**
3. Test on ice plant test rig for its performance	2
4. Test on air conditioning test rig for its performance	2
5. Test/visit on Vapour absorption refrigeration test rig for its performance	2
6. Estimation of cooling load of simple air conditioning system (case study)	2
7. Thermal analysis of refrigeration cycle using suitable software.	2
8. Installation and servicing of refrigeration and air conditioning	2
9. Visit to cold storage plant for its working and applications	2
10. Visit to any air conditioning plant for its working and applications	2

UMEL426: Fuel and Combustion (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination scheme**
Lecture : 03 Hrs./Week	**03**	**Theory:** **TAE: 10 Marks** **CAE: 15 Marks** **ESE: 50 Marks**

PREREQUISITE (IF ANY):

Engineering chemistry
Thermodynamics

COURSE OBJECTIVE: To make the student understand

1. Solid, liquid and gaseous fuel properties, analysis, process and handling
2. Stoichiometry relations
3. The combustion process
4. Features of different types of burners
5. About emissions

COURSE OUTCOME: Upon successful completion of the course students will be able to

1 Differentiate between various fuels
2. Analyze exhaust and flue gases
3. Understand design considerations of burners
4. Control of emissions in combustion.

COURSE CONTENTS	Hrs.
UNIT I: Introduction to Fuels	**8**
Classification of coal, analysis and properties of coal, oxidation of coal, hydrogenation of coal, agro fuels, solid fuel handling.	
UNIT II: Liquid and Gaseous Fuels	**8**
Classification of petroleum products, Handling and storage of petroleum products, Refining and other conversion processes, property and testing of petroleum products, other liquid fuels. Types of gaseous fuels, natural gases, methane from coal mines, manufactured gases, producer gas, water gas, blast furnace gas, refinery gas, LPG, cleaning and purification of gaseous fuels	
UNIT III: Combustion Phenomenon	**8**
Stoichiometry relations, theoretical and minimum air required for complete combustion, calculation of dry flue gases, exhaust gas analysis, flue gas analysis. Principles of combustion, rapid methods of combustion, flame propagation, various methods of flame stabilization, Combustion of biofuel & emission, Standard BS VI	
UNIT IV: Burner Design	**8**
Basic features of burner, types of solid, liquid and gaseous fuel burners, design consideration of different types of burners, recuperative and regenerative burners, Pulverized fuel furnaces–fixed, entrained, and fluidized bed systems.	
UNIT V: Combustion Types	**8**
Emissions, Emission index, corrected concentrations, control of emissions for premixed and non-premixed combustion.	

Text Books:
1. Arthur H. Lefebvre & Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition, 2010
2. Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworths, 1962.
3. Samir Sarkar, Fuels & Combustion, Orient Long man 1996.
Reference Books:
1. Arthur H. Lefebvre & Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition, 2010
2. Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworths, 1962.
3. Samir Sarkar, Fuels & Combustion, Orient Long man 1996.

UMEP426: FUEL AND COMBUSTION (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Heat Transfer

COURSE OBJECTIVE:

1. Comprehend the basic properties of fuel.
2. Acquire the knowledge of fuel treatment.
3. Understand the combustion fundamentals and performance.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Explain the fuel properties and fuel treatment process.
2. Select the alternative fuels for aerospace applications.
3. Compute the combustion performance.

COURSE CONTENTS	**Hrs.**
List of Practical :	
1. Find the smoke point of different fuels.	2
2. Find the pour point and cloud point of various lubricants.	2
3. Find the calorific value of fuels with the help of Bomb Calorimeter.	2
4. Find the calorific value of fuels with the help of Junker's Gas Calorimeter.	2
5. Test the performance of fuel pump with fuel pump test rig.	2
6. Study of various spray characteristics of fuel.	2
7. Study of flame stabilization at different equivalence ratio.	2
8. Study of laminar premixed flames.	2
9. Study of turbulent flames.	2
10. Model different H2/O2 mechanism and find equilibrium temperatures at different equivalence ratios.	2
Design based Problems (DP)/Open Ended Problem:	
1. Experimentally distinguish the laminar and turbulent flame regimes.	2

2. Design an industrial gas burner.	2
3. Analyze domestic stove.	2
Major Equipment:	
1. Bomb Calorimeter and Junker's Gas Calorimeter	2
2. Fuel pump test rig	2
3. Bunsen Burner	2
4. Temperature measurement apparatus	2
5. Fuel supply system	2
6. Ignition system	2

UMEL427: Computer Aided Design (Elective-VI)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lectures:03 Hr/Week	**03**	**TAE : 10** Marks **CAE : 15** Marks **ESE : 50** Marks
Prerequisite (if any): Engineering Graphics, Engineering Mathematics, Numerical Methods & Optimization, Computer Aided Machine Drawing, Strength of Materials, Manufacturing Processes		
Course Objectives		
1. Learning the fundamental principles for basic geometric entities.		
2. To apply homogeneous transformation matrix for geometrical transformations of 2D/3D CAD entities		
3. To model mathematically analytical and synthetic curves, surfaces		
4. Features of different types of design.		
Course Outcome: On completion of the course, student will be able to		
1. Illustrate the fundamental principles for basic geometric entities.		
2. Apply homogeneous 2D & 3D transformation for CAD entities for basic geometric models.		
3. Develop the various type of analytical & synthetic curves and Geometric modeling.		
4. Understand design optimization for optimum design.		
COURSE CONTENTS		**Hrs.**
Unit I : Introduction of CAD		**8**
Introduction of CAD, Difference between Conventional & CAD design, Rasterisation techniques frame buffer, N-bit plane buffers, Simple color frame buffer algorithm for the generation of basic geometric entities like line, circle & ellipse by using parametric & non-parametric equations.		
Unit II: 2D Transformation		**8**

Introduction to windowing & clipping (excluding algorithm), Window and Viewport, line clipping & polygon clipping 2D transformation: Translation, Scaling, Rotation, Reflection & Shear, Concept of homogeneous representation & concatenation. Inverse Transformation (enumeration of entity on graph paper)	
Unit III: 3D Transformation	**8**
3D Transformation ; Translation, Scaling, Rotation, Reflection etc.	
Unit IV : Techniques for Geometric Modeling	**8**
Graphic standards, parametric representation of geometry, Bezier curves, Cubic spline curves, B-Spline curves, constructive solid geometry, Feature Based modeling, Feature recognition, Design by feature, Wire frame modeling, Surface Modeling and solid modeling of basic entities like box, cone, and cylinder. CSG & B- representation technique using set theory. Assembly modeling: Representation, mating conditions, representation schemes, generation of assembly sequences and importance of precedence diagram.	
Unit V: Optimization in Design	**8**
Objectives of optimum design, adequate and optimum design, Johnson's Method of optimum design, primary design equation, subsidiary design equations and limit equations, optimum design with normal and redundant specifications of simple machine elements like: tension bar, transmission shaft and helical spring.	

Text Books:

1. Zeid I. and Sivasubramanian R., CAD/CAM - Theory and Practice, Tata McGraw Hill Publishing Co., 2nd Edition, 2009
2. Gokhale N. S., Bedekar S. V., Thite A. N., and Deshpande S. S., Practical Finite Element Analysis, Sted Finite To Infinite publication Pune, 1st Edition, 2008.

Reference Books:

1. Zeid I., Mastering CAD/CAM, Tata McGraw Hill Publishing Co., 1st Edition, 2000.
2. Rao P. N., Introduction to CAD/CAM, Tata McGraw-Hill Education Pvt. Ltd., 1st Edition, 2012

UMEP427: Computer Aided Design (Elective-VI)

Teaching Scheme:	Credit	Examination Scheme
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Engineering Graphics, Engineering Mathematics, Numerical Methods & Optimization, Computer Aided Machine Drawing, Strength of Materials, Manufacturing Processes

COURSE OBJECTIVE:

1. To apply homogeneous transformation matrix for geometrical transformations of 2D/3D CAD entities

2. To model mathematically analytical and synthetic curves, surfaces	
COURSE OUTCOME: Upon successful completion of the course students will be able to	
1. Apply homogeneous transformation matrix for geometrical transformations of 2D CAD entities for basic geometric transformations.	
2. Use analytical and synthetic curves and surfaces in part modeling.	
COURSE CONTENTS	**Hrs.**
List of Practicals:	
1. 2-D Geometric modeling of an Engineering object, demonstrating Boolean operations like add, subtract and PAN, ZOOM, ROTATE commands	2
2. 3-D Geometric Modeling of an Engineering object, demonstrating extrude, revolve and loft commands.	2
3. Generation of at least two simple solid models showing geometric properties using any CAD software.	2
4. Generation of any Assembly model along with animation.	2
5.Programs for generation of entities like Line, Circle, Ellipse using Bressenham's algorithms.	2
6.Programs for 2-D & 3-D transformations.	2
7.Program for Bezier Curve generation.	2
8. Case study based on modeling and analysis of structural system (Industry Based)	2

UMEL428: Advanced Finite Element Method (Elective-VI)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lectures:03 Hr/Week	**03**	**TAE : 10** Marks **CAE : 15** Marks **ESE : 50** Marks

Prerequisite (if any): Engineering Mathematics; Mechanics of Material

Course Objective:

1. To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics and thermal analysis problems
2. To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
3. It provides a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states
4. To study approximate nature of the finite element method and convergence of results are examined
5. It provides some experience with a commercial FEM code and some practical modeling exercises

Course Outcome: On completion of the course, student will be able to

1. Apply the different techniques used to solve Mechanical Engineering problems.
2. Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
3. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
4. Use commercial Finite element analysis software to solve complex problems in solid mechanics and Heat transfer.
5. Interpret the results of finite element analyses and make an assessment of the results in terms of modelling (physics assumptions) errors, discretization errors.
6. Interpret the results of finite element analyses and make an assessment of the results in terms of modelling (physics assumptions) errors, discretization errors.

COURSE CONTENTS	**Hrs**
Unit I :Fundamentals Concepts of FEA	**8**
Introduction about FEM: Equilibrium equations in elasticity subjected to body force, traction forces, stress strain relations for plane stress and plane strain, Boundary conditions, Initial conditions, Euler's Lagrange's equations of bar, beams, Principle of a minimum potential energy, principle of virtual work, Rayleigh-Ritz method Galerkins method and Matrix techniques, Brief history of FEM, Finite Element terminology, general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, essential and natural boundary conditions, symmetric boundary conditions. **Types of Analysis (Introduction):** Linear static analysis, Non-linear analysis, Dynamic analysis Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.	
Unit II: 1D Elements	**8**

Types of 1D elements, displacement function, global and local coordinate systems,	
polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar). Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth treatment of boundary conditions- elimination approach, stress and reaction forces Calculations, 1 D heat transfer problem	
Unit III : 2D Elements	**8**
Shape functions and stiffness matrix of 2D elements four-Node quadrilateral, Nine-Node quadrilateral Eight-Node quadrilateral, serendipity and LaGrange comparison with 2D Pascal's triangle. CST and LST shape functions , Jacobean matrix , stiffness matrix, force terms, stress calculation . **Numerical integration:** Gauss Quadrature in one and two dimension, Order of Gauss integration, full and reduced integration, sub-modeling, sub structuring.	
Unit IV : Iso-Parametric Elements	**8**
Isoparametric quadrilateral elements-Shape functions for rectangular elements, Isoparametric mapping for quadrilateral elements, Numerical integration for quadrilateral elements, Four node quadrilateral element for 2D BVP, Eight node serendipity element for 2D BVP, Isoparametric triangular elements-Natural (or Area) coordinates for triangles, Shape functions for triangular elements, Natural coordinate mapping for triangles,	
Unit V: Dynamic Analysis	**8**
Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element. Undamped-free vibration: Eigen value problem, evaluation of eigen values and eigen vectors (characteristic polynomial technique)	
Text Books:	
1. Daryl L., A First Course in the Finite Element Method, Logan, 4th Edition, 2007.	
2. Narasaiah G. L., Finite Element Analysis, B S Publications, 1st Edition, 2008.	
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 4th Edition, 2002.	
4. Seshu P., Textbook of Finite Element Analysis, PHI Learning Private Ltd., 1st Edition, 2004.	
Reference Books:	
1. Bathe K. J., Finite Element Procedures, Prentice Hall of India (P) Ltd., Revised Edition, 1996.	
2. Moaveni S., Finite element analysis, theory and application with Ansys, Pearson, 4th Edition, 2015.	
3. Gokhale N. S., et al., Practical Finite Element Analysis, Stat Finite to Infinite, Pune, 1st Edition, 2008.	
4. Madenci E. and Guven I., The Finite Element Method and Applications in Engineering Using Ansys, Springer, 2nd Edition, 2006.	

UMEP428: ADVANCED FINITE ELEMENT METHODS (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Heat Transfer

COURSE OBJECTIVE:

1. To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics and thermal analysis problems
2. To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
3. It provides a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states
4. To study approximate nature of the finite element method and convergence of results are examined
5. It provides some experience with a commercial FEM code and some practical modeling exercises

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Understand the different techniques used to solve mechanical engineering problems
2. Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses
3. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results
4. Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis
5. Use commercial finite element analysis software to solve complex problems in solid mechanics and heat transfer
6. Interpret the results of finite element analyses and make an assessment of the results in terms of modelling (physics assumptions) errors, discretization errors.

COURSE CONTENTS	**Hrs.**
List of Practicals: Conduct any eight practicals.	
1. Stress analysis of 1D bar using linear and quadratic Elements	4
2. Stress analysis of beam carrying simply supported, cantilever beam with UDL and UVL	2
3. Stress analysis of a rectangular plate with circular hole	2
4. Thermal analysis -2D problem with conduction and convection Boundary conditions	4
5. Fluid Flow analysis-Potential Distribution in the bodies	2
6. Dynamic analysis to determine the natural frequency of fixed – fixed beam	2
7. Dynamic analysis to determine the natural frequency of fixed – fixed beam subjected to	2
8. Stress and deflection analysis of any machine component consisting of 3-D elements using	4
9. Elasto-plastic stress analysis of plate using FEA software	2
10. Coupled Thermal-Structural Analysis using FEA software	2

UMEL429: ROBOTICS & MACHINE VISION (Elective-VI)

Teaching Scheme:	Credit	Examination scheme
Lecture: 03 Hrs./Week	03	Theory: TAE: 10 Marks CAE: 15 Marks ESE: 50 Marks

PREREQUISITE (IF ANY):

Sensors & Actuators, Design of Machsine Elements

COURSE OBJECTIVE:

1. To get acquainted with basic components of robotic systems.
2. To study various gripper mechanisms and sensors and understand role of suitable control system.
3. To understand statistics & kinematics of robots
4. To develop competency in obtaining desired motion of the robot.
5. To study various programming methods in robotics.
6. To understand need of modern techniques in robotics.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Identify different type of robot configuration with relevant terminology.
2. Select suitable sensors, actuators and drives for robotic systems.
3. Understand kinematics in robotic systems.
4. Design robot with desired motion with suitable trajectory planning.
5. Basis of machine vision and apply the concept of image processing

COURSE CONTENTS	Hrs.
UNIT I: Fundamentals of Robotics	**8**
Introduction: Basic terminologies, Asimov‘s laws of Robotics, anatomy of Robot, Classification of robots, robots structure, Robot Degrees of Freedom, Work volume and work envelope, point to point and continuous path robotic systems. Robot performance- resolution, accuracy, repeatability, dexterity, compliance, RCC device, various applications of robots. **End Effectors:** Gripper types, Design of gripper, Force analysis for different basic gripper systems including, Hydraulic, Pneumatic and Mechanical systems.vaccum grippers	
UNIT II: Robotic Sensors, Drivers & Control System	**8**
Robotic Sensors: Characteristics of sensing devices, Classification, Selection and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot. GPS, IMU, Vision, PVDF Tactile (construction, working and selection) **Drives and Control Systems :** Types and selection of Drives, Actuators and transmission systems, Types of Controllers, closed loop control, second order linear systems and their control, control law of partitioning, trajectory-following control, modeling and control of a single joint, force control.	
UNIT III: Mathematical Modeling of Robot	**8**
Kinematics : Transformation matrices and their arithmetic, link and joint description, Denavit–Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics of two joints, solvability, algebraic and geometrical methods. **Velocities and Static Forces in Manipulators**: Motion of the manipulator links, Jacobians, singularities, static forces, Jacobian in force domain.	

UNIT IV: Robot Dynamics	**8**
Introduction to Dynamics, Trajectory generations, Motion planning and control: Joint and Cartesian space trajectory planning and generation, potential field method for motion planning Manipulator Mechanism Design, Force control and hybrid position/force control	
UNIT V: Machine Vision System	**8**
Machine Vision System: Vision System Devices, Image acquisition, Masking, Sampling and quantization, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation. Thresholding-edge detection- binary morphology – grey morphology	

Text Books:

1. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
2. M.P.Groover, M.Weiss ,R.N. Nagal, N.G.Odrey, "Industrial Robotics – Technology, programming and Applications" Tata , McGraw-Hill Education Pvt Limited 2ndEdition, 2012
3. K.S.Fu, R.C.Gonzalez, C.S.G.Lee, "Robotics: Sensing, Vision and Intelligence", Tata McGraw-Hill Publication, First Edition, 1987.
4. Carsten Steger, Markus Ulrich, Christian Wiedemann, Machine Vision Algorithms and Applications, WILEY-VCH, Weinheim,2008.
5. Damian m Lyons,Cluster Computing for Robotics and Computer Vision, World Scientific, Singapore, 2011.

Reference Books:

3. Groover M.P.-Automation, production systems and computer integrated manufacturing' - Prentice Hall of India
4. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
5. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
6. Mathia, Robotics for Electronics Manufacturing, Cambridge Uni. Press, India
7. A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2013.
8. R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015.
9. K Astrom & T Hagglund, PID Controllers: Theory, Design and Tuning, 2nd Edition, The Instrumentation, Systems, and Automation Society, 1995.
10. Asfahl, Robots and Manufacturing Automation, Wiley, India, 2012
11. S. K. Saha, Introduction to Robotics, TMH International
12. Ganesh Hegde, Industrial Robotics, Laxmi publication
13. Shimon Ullman, High-Level Vision: Object recognition and Visual Cognition, A Bradford Book, USA, 2000.

UMEP429: ROBOTICS & MACHINE VISION (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Heat Transfer

COURSE OBJECTIVE:

1. To get acquainted with basic components of robotic systems.
2. To study various gripper mechanisms and sensors and understand role of suitable control system.
3. To understand statistics & kinematics of robots
4. To develop competency in obtaining desired motion of the robot.
5. To study various programming methods in robotics.
6. To understand need of modern techniques in robotics.

COURSE OUTCOME: Upon successful completion of the course students will be able to

1. Identify different type of robot configuration with relevant terminology.
2. Select suitable sensors, actuators and drives for robotic systems.
3. Understand kinematics in robotic systems.
4. Design robot with desired motion with suitable trajectory planning.
5. Basis of machine vision and apply the concept of image processing

	COURSE CONTENTS	**Hrs.**
List of Practicals:		
1.	Design, modeling and analysis of two different types of grippers.	2
2.	Simulation of Cartesian / Cylindrical/Spherical robot.	2
3.	Simulation of Articulated / SCARA robot.	2
4.	Study of components of a real robot & its DH Parameters	2
5.	Identify and selection of Actuators and related hardware such as DC motor, Servo motor, Stepper Motor, Motor drivers based on applications	2
6.	Study of Forward Kinematics & validate using a software(Robo analyser)	2
7.	Image Processing using open cv	2
8.	Inverse kinematics of a real robot & validation using suitable software	2
9.	Report on industrial application of robot /Industrial visit	2

UMEL430: Computational Fluid Dynamics (Elective-VI)		
Teaching Scheme	**Credit**	**Examination Scheme**
Lectures:03 Hr/Week	**03**	**TAE : 10** Marks **CAE : 15** Marks **ESE : 50** Marks

Prerequisite (if any):

Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objective: Students should be able to

1. Model fluid / heat transfer problems and apply fundamental conservation principles.
2. Discretize the governing equations by Finite Difference Method and Finite volume Method.
3. Develop programming skills by in-house code development for conduction, convection and fluid dynamics problems.
4. Solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.

Course Outcome: Students able to

1. Understand governing equations of conservation of mass, momentum and energy
2. Generate high quality grids and interpret the correctness of numerical results with physics.
3. Analyze and model fluid flow and heat transfer problems
4. Evaluate fluid flow and heat transfer problems by using CFD tools

COURSE CONTENTS	Hrs
Unit I : Governing Equations	**8**
Introduction to Computational Fluid Dynamics, Derivation and physical interpretation of governing equations (conservation of mass, momentum and energy) in differential form, Concept of substantial derivative, divergence and curl of velocity, Mathematical behavior of Governing Equations and boundary conditions.	
Unit II: Conduction Equation	**8**
Introduction to FEA, FDM and FVM, Solution of two dimensional steady and unsteady heat conduction equation using finite volume method (Implicit and Explicit) with Dirichlet, Neumann, Robbin boundary conditions, Stability Criteria.	
Unit III : Advection Equation	**8**
Solution of two dimensional steady and unsteady heat advection equation using finite volume method (Implicit and Explicit) with Dirichlet BC, Stability Criteria, Introduction to first order up wind, CD, Second order upwind and QUICK convection schemes.	
Unit IV : Convection-Diffusion Equation	**8**
Solution of two dimensional steady and unsteady heat convection-diffusion equation for slug flow using finite volume method (Implicit and Explicit), Stability Criteria, 1-D transient convection- diffusion system, Peclet Number	

Unit V: Navier-Stokes Equation	**8**
Solution of Navier-Stoke‘s equation for incompressible flow using SIMPLE algorithms for lid driven cavity flow problem, Introduction to external flow simulation.	

Text Books:

1. Anderson J. D., Computational Fluid Dynamics- The Basics with Applications, McGraw- Hill, 1995.
2. Sharma A., Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Wiley, 2016.
3. Patankar S.V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980.
4. Date A. W., Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2012.
5. Versteeg H., and Malalasekara W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Prentice Hall, 2nd edition, 2007.

Reference Books:

1. Tennekes H. and Lumley J. L., A First Course in Turbulence, MIT Press, 1972.
2. Wilcox D.C., Turbulence Modeling for CFD, D C W Industries; 3rd edition, 2006.
3. Chung T. J., Computational Fluid Dynamics, Cambridge University Press, 2002.
4. Tu J., Yeoh G.H. and Liu C., Computational Fluid Dynamics: A practical approach, Elsevier, 3 rd Edition 2018.
5. Schlichting H. and Gersten K., Boundary-Layer Theory, Springer, 2017.

UMEP430: COMPUTATIONAL FLUID DYNAMICS (Elective-VI)		
Teaching Scheme:	**Credit**	**Examination Scheme**
Practical : 02 Hrs./Week	**01**	**Internal Assessment : 25 marks**

PREREQUISITE (IF ANY):

Basic Thermodynamics, Heat Transfer

COURSE OBJECTIVE:

1. Students should be able to model fluid / heat transfer problems and apply fundamental conservation principles.
2. Students should be able to do discretize the governing equations by Finite Difference Method and Finite volume Method.
3. Students should be able to develop programming skills by in-house code development for conduction, convection and fluid dynamics problems.
4. Students should be able to solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
5. To prepare the students for career in CAE industry using software tools.

Course Outcome: Students able to

1. Analyze and model fluid flow and heat transfer problems.
2. Generate high quality grids and interpret the correctness of numerical results with physics.
3. Conceptualize the programming skills.
4. Use a CFD tool effectively for practical problems and research.

	COURSE CONTENTS	**Hrs.**
	List of Practicals: Conduct any eight practicals.	
1.	2-D Modelling and meshing of fluid flow/ heat transfer problem	2
2.	3-D Modelling and meshing of fluid flow/ heat transfer problem	2
3.	Simulation of conductive steady state heat transfer 2-Dimensional	2
4.	Simulation of conductive steady state heat transfer 3-Dimensional	2
5.	Simulation of convective heat transfer 2-Dimensional	2
6.	Simulation of convective heat transfer 3-Dimensional	2
7.	Internal flow simulation	2
8	External flow simulation	2
9	Write codes for 1-D steady state conduction with and without source and do the post processing to verify with analytical results	2
10	Write codes for 2-D steady state conduction with and without source and do the post processing to verify with analytical results	2

UMEP431:Project		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical: 08 Hrs/Week	**04**	**Internal Assessment : 50** Marks **External Assessment : 50** Marks

Introduction:

The student shall take up a suitable project, the scope of the project shall be such as to complete it within the time schedule, and the term work shall consist of:

- Fabrication of models, machines, prototypes based on new ideas, robots and machine based on Hi-tech systems and automation, experimental set-up, fabrication of testing equipment, Renovation of machines, etc.

Above work shall be taken up individually or in groups. The group shall not be more than 4 students,

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

- A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

1. Manufacturing/Fabrication of a prototype machine including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation.
2. Improvement of existing machine / equipment / process.
3. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for machine tools.
4. Computer aided design, analysis *of* components such as stress analysis.
5. Problems related to Productivity improvements/Value Engineering/Material Handling Systems
6. Energy Audit of an organization, Industrial evaluation of machine devices.
7. Design of a test rig for performance evaluation of machine devices.
8. Product design and development.
9. Analysis, evaluation and experimental verification of any engineering problem
10. Quality systems and management. Total Quality Management.
11. Quality improvements, In-process Inspection, Online gauging.
12. Low cost automation, Computer Aided Automation in Manufacturing.
13. Time and Motion study, Job evaluation and Merit rating
14. Ergonomics and safety aspects under industrial environment
15. Management Information System.
16. Market Analysis in conjunction with Production Planning and Control.

OR

Computer based design/analysis or modeling/simulation of product(s), mechanism(s) or System and its validation or comparison with available benchmarks/results. When a group of students is doing a project, names of all the students shall be included on every certified report copy.

Department of Mechanical Engineering

Detailed Syllabus

Final Year B. Tech (Mech.)

Semester-VIII

UMEP432: Project Internship		
Teaching Scheme	**Credit**	**Examination Scheme**
Lectures: Nil **Tutorials:** Nil **Practical: 24 Hrs/Week**	**12**	**Practical:** **Internal Assessment : 200** Marks **Internal Assessment : 200** Marks

Introduction:

The student shall take up a suitable project, the scope of the project shall be such as to complete it within the time schedule, and the term work shall consist of:

1. Fabrication of models, machines, prototypes based on new ideas, robots and machine based on
2. hi-tech systems and automation, experimental set-up, fabrication of testing equipment,
3. Renovation of machines, etc. Above work shall be taken up individually or in groups.
4. The group shall not be more than 4 students,

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

5. A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

   i. Manufacturing/Fabrication of a prototype machine 'including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation.
   ii. Improvement of existing machine / equipment / process.
   iii. Design and fabrication of Jigs and Fixtures, dies, tools, special purpose equipment, inspection gauges, measuring instruments for machine tools.
   iv. Computer aided design, analysis *of* components such as stress analysis.
   v. Problems related to Productivity improvements/Value Engineering/Material Handling Systems
   vi. Energy Audit of an organization, Industrial evaluation of machine devices.
   vii. Design of a test rig for performance evaluation of machine devices.
   viii. Product design and development.
   ix. Analysis, evaluation and experimental verification of any engineering problem
   x. Quality systems and management. Total Quality Management.
   xi. Quality improvements, In-process Inspection, Online gauging.
   xii. Low cost automation, Computer Aided Automation in Manufacturing.
   xiii. Time and Motion study, Job evaluation and Merit rating
   xiv. Ergonomics and safety aspects under industrial environment
   xv. Management Information System.
   xvi. Market Analysis in conjunction with Production Planning and Control.

OR

Computer based design/analysis or modeling/simulation of product(s), mechanism(s) or System and its validation or comparison with available benchmarks/results. When a group of students is doing a project, names of all the students shall be included on every certified report copy.