SEMESTER VII

Prof. Core-13**CAD/CAM**					
Course Code	**ME710**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**56 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. To impart knowledge of Computer Aided Design and Computer Aided Manufacturing concepts
2. To introduce the basic concepts of automation in Computer Aided Manufacturing Systems and how it can be implemented in modern industry.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts of geometric modeling, Finite Element Method, Computer Graphics and Computer Integrated Manufacturing Systems
CO 2	Write programs for Line drawing, Geometric transformation and Computer Numerical Control using standard software tools
CO 3	Apply the concepts of Geometric construction, Finite Element Methods, robotics and networking for various applications
CO 4	Compare and select a suitable rapid prototyping process for a given application

UNIT-1	**14 Hrs**
Introduction to CAD/CAM and CIM, Fundamentals of CAD, CAD Software, Geometric modeling – Classification, Construction methods, Constraint based modeling, Other modeling methods, Curve and surface representation, CAD standards, CAD database, Concurrent engineering. Introduction to FEM, General steps of the finite element method, Engineering applications of FEM in various fields, Advantages of FEM, Types of elements. FEM software, Generation of matrix displacement equation for 1-D bar element using direct approach, Solution for displacements, forces, reaction, stresses. Problems on the same.	
UNIT-2	**14 Hrs**
Introduction to computer graphics, Basic working principle of Plasma, LED and LCD display devices, Bresenham's line drawing algorithm (First quadrant only), Cohen-Sutherland line clipping algorithm, Geometric transformations: Numerical on 2D transformation only, Depth buffer algorithm for hidden surface removal, Parametric representation of B-spline and Bezier curves (No numerical).	
UNIT-3	**14 Hrs**
Introduction to CAM and CIMS, Automation in production systems, Numerical	

control (NC), NC part programming, Computer controls in NC, Computer Numerical Control, Direct Numerical Control, Adaptive control machining systems. Rapid Prototyping (RP), RP procedure, Basic working principles of Stereo lithography, SLS, FDM & LOM processes, The STL file, Applications of RP, Introduction to Reverse Engineering	
UNIT -4	**14 Hrs**
Automated material handling and storage systems, Robot technology, Robot applications and types, Group Technology (GT), Lean production and agile manufacturing, Flexible Manufacturing Systems (FMS), Computer-Aided Process Planning (CAPP), Web based manufacturing, Introduction to Industry 4.0 and Industrial Internet of Things, hardware elements & interfaces of networking in CIM. Product Life Cycle Management – Introduction, Phases and Components.	

TEXTBOOKS	
1	P. N. Rao; CAD/CAM: Principals and Applications; Tata McGraw-Hill Publishing Company Ltd.; 2e; 2004
2	M. P. Groover, E. W. Zimmers, Jr.; CAD/CAM: Computer-Aided Design and Manufacturing; Prentice-Hall of India Pvt. Ltd.; 2000
3	D. F. Rogers; Procedural Elements for Computer Graphics; Tata McGraw- Hill Publishing Company Ltd.; 2e; 2001
4	D. F. Rogers, J Alan Adams; Mathematical Elements for Computer Graphics; McGraw-Hill Publishing Company Ltd, 2e
5	IbhrahimZeid , R. Sivasubramanium, CAD/CAM, Theory & Practice, Tata McGraw-Hill Publishing Company Ltd.; 2e; 2009
REFERENCES	
1	T. R. Chandrupatla, A. D. Belegundu; Introduction to Finite Elements in Engineering; Prentice-Hall of India Pvt. Ltd.; 1996
2	N. Krishnamurthy- Introduction to computer graphics --- (TMH)
3	T.K. Kundra, P. N. Rao, N.K. Tewari – Numerical control & computer aided manufacturing --- (TMH)
4	Radhakrishnan P. Subramanyan S, CAD/CAM/CIM, New Age International publishers, 1994
5	Tien Chien Chang, Rolland Wyst, HSU Pin Wang, Computer aided manufacturing, Pearson Education
6	Alasdair Gilchrist, IOT Industry 4.0: The Industrial Internet of Things, Apress, 2016

<table>
<tr><td colspan="6">Prof Elect. 5 (a) REFRIGERATION AND AIRCONDITIONING</td></tr>
<tr><td>Course Code</td><td colspan="2">ME721</td><td>Credits</td><td colspan="2">3</td></tr>
<tr><td rowspan="2">Scheme of Instructions (Hours / week)</td><td>L</td><td>T</td><td>P</td><td colspan="2">TOTAL</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td colspan="2">48 hrs/sem</td></tr>
<tr><td rowspan="2">Scheme of Examination TOTAL = 125 marks</td><td>IA</td><td>TW</td><td>TM</td><td>P</td><td>O</td></tr>
<tr><td>25</td><td>0</td><td>100</td><td>0</td><td>0</td></tr>
</table>

Course Objectives:

1. To Study the basic principles and methods of refrigeration and air conditioning.
2. Comparative study of different refrigerants with respect to properties, applications and environmental issues.
3. Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
4. To study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand and Illustrate the fundamental principles of refrigeration and air conditioning system.
CO 2	Analyse the various refrigeration systems by applying Thermodynamic principles.
CO 3	Apply refrigeration load calculations for selection of components and refrigerants.
CO 4	Evaluate Coefficient of performance, psychometric properties, heating/cooling load of different HVAC systems.

UNIT-1	**10 Hrs**
AIR REFRIGERATION SYSTEMS: Bell Coleman cycle, applications. Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, Reduced ambient, Regenerative air cooling system, Comparison of these systems based on DART rating. **NONCONVENTIONAL REFRIGERATION SYSTEMS:** Thermoelectric Refrigeration, Thermo-acoustic Refrigeration, Vortex Tube Refrigeration, steam jet refrigeration.	
UNIT-2	**11 Hrs**
REFRIGERANTS- Classification of refrigerants, Desirable properties of refrigerants, environmental issues, ODP, GWP & LCCP, selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant. **VAPOR COMPRESSION REFRIGERATION SYSTEM:** Simple vapour compression cycle, Effect of liquid sub-cooling & superheating, factors affecting the performance of VCRS, methods of improving, use of P-h charts, Limitations of simple VCR cycle, Two stage VCR cycle with Water intercooler, flash intercooler & liquid sub-cooler.	

UNIT-3	10 Hrs
LOW TEMPERATURE REFRIGERATION: Limitations of VCRS for production of low temperature, Cascade refrigeration system, Solid carbon dioxide or Dry ice, Liquefaction of gases, Liquefaction of air, Liquefaction of Hydrogen, Liquefaction of Helium, Application of low temperature. **VAPOR ABSORPTION REFRIGERATION:** Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Electrolux refrigeration system. Solar VAR system.	
UNIT -4	**11 Hrs**
PSYCHROMETRY: Need for air conditioning, Principle of psychromerty, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone. **DESIGN OF AIR CONDITIONING SYSTEMS:** Different Heat sources,- Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation , Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners.	

TEXTBOOKS	
1	Refrigeration and air-conditioning – C P Arora, TMH
2	Principles of refrigeration – R J Dossat, Willey Eastern Publication
3	Refrigeration and air-conditioning – W F Stoker and J W Jones, TMH
REFERENCES	
1	Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH
2	Refrigeration and air-conditioning- Manohar Prasad, New Age Int (P) Ltd
3	Refrigeration and air-conditioning – R. K. Rajput, S. K. Kataria& Sons
4	Modern Air-conditioning practice – C P Arora, TMH

<table>
<tr><th colspan="6">FINITE ELEMENT METHOD</th></tr>
<tr><td>Course Code</td><td colspan="2">ME723</td><td>Credits</td><td colspan="2">3</td></tr>
<tr><td rowspan="2">Scheme of Instructions (Hours / week)</td><td>L</td><td>T</td><td>P</td><td colspan="2">TOTAL</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td colspan="2">42 hrs/sem</td></tr>
<tr><td rowspan="2">Scheme of Examination TOTAL = 125 marks</td><td>IA</td><td>TW</td><td>TM</td><td>P</td><td>O</td></tr>
<tr><td>25</td><td>0</td><td>100</td><td>0</td><td>0</td></tr>
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Course Objectives:

1) Understand the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in Engineering.
2) Understand the mathematical and physical principles underlying the FEA
3) Demonstrate the ability to invoke appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the steps in FEM, the principles of theory of elasticity, variation of calculus, matrix algebra & calculus, numerical methods and the various approaches to model FEM problems including weighted residual techniques & Rayleigh Ritz method and review of basic equations in fluid mechanics and heat transfer.
CO 2	Apply the FEM techniques to solve problems in statics, dynamics, structural engineering, heat transfer and fluid flow problems using FEM formulations / FEM techniques
CO 3	Analyze the structural, heat transfer and fluid mechanics problems using FEM formulation.
CO 4	Compute the stresses and displacements in structural problems, heat flow and temperature in heat transfer problems and pressure and flow rate in fluid flow problems.

<table>
<tr><th>UNIT-1</th><th>11 Hrs</th></tr>
<tr><td>Introduction to Finite Element Method- general description of the method, Types of Elements, Steps involved, advantages, range of applications.

Basic Equations from Linear theory of Elasticity – Analysis of Stress and Strain, Equilibrium Equations, Compatibility strain-displacement Equations .Generalized Hooke’s Law: Constitution Laws for plane stress & plane strain problems. Strain Energy at a point under given state of stress, Analysis of Elastic Stability of columns using Rayleigh Ritz method.

Discrete systems- Generation of matrix displacement equations for 1-D bar element using direct and potential energy approach. Application to 1-D Fluid mechanics, 1-D heat transfer problem & 1-D Torsion.</td><td></td></tr>
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UNIT-2	11 Hrs
Co-ordinate System – Global, local and natural co-ordinates. Convergence requirement on displacement field. Shape functions-Properties of shape functions, Development of shape functions for linear and higher order 1-D elements using generalized coordinates, Lagrange's interpolation function for higher order elements, shape functions in terms of natural co-ordinates and Cartesian co-ordinates for 2-D CST, shape functions for LST and 4-noded rectangular element. Brief introduction to Isoparametric element & its formulation - Jacobian matrix. Variational Calculus-functional, Euler-Lagrange's Equation. Approximate analytical method: Rayleigh-Ritz method; applications to bars, trusses and beams. Rayleigh-Ritz- piecewise approach. Solution of simultaneous equations using Gauss elimination, Cholesky's decomposition &Crout's factorization method.	
UNIT-3	**10 Hrs**
Finite element Formulation of 2-D solid mechanics and 2-D heat transfer Problem - Generation of element level matrices and force vectors. Weighted Residual methods –Strong formulation--- Sub domain, least square, collocation method, Galerkin method-applications to bars and beam. weak formulation – Galerkin's piece wise formulation. Numericalintegration – Gauss Legendre Quadrature technique	
UNIT -4	**10 Hrs**
Stiffness matrix for a beam element. Hermite shape functions. Applications to determinate and indeterminate beams Structural Dynamics - Hamilton's principle, Free vibration analysis of bar, beam and shaft – consistent mass matrix –element equations, finding natural frequency and mode shapes.	

TEXTBOOKS	
1	T.R. Chandrapatla and A.D. Belegundu; Introduction to Finite Element Method in Engineering; Prentice Hall of India; 2002
2	Abel and Desai; Introduction to the Finite Element Method; CBS Publishers & Distributors; 2005
REFERENCES	
1	S. Rao; Finite Element method in Engineering; Butterworth-Heinemann, 4th e 2005
2	K.J. Bathe; Finite Element Procedure Prentice-Hall of India Pvt. New-Delhi; 1996
3	C.S. Krishnamoorthy; Finite Element Analysis, Theory and Programming; Tata McGraw-Hill Publishing Company Ltd. New Delhi; 2nd e 2004.
4	S. Moaveni; Finite Element Analysis Theory and Application with ANSYS; Pearson Education Ltd.; 3e 2008.
5	J. N. Reddy; An Introduction to the Finite Element Method; McGraw-Hill Company; 3rd e 2005.

Prof. Elec-5 (d) SIX SIGMA MANAGEMENT					
Course Code	**ME723**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. Exposing students to the fundamentals of Six Sigma methodology.
2. Exposing students to tools and techniques used in Six Sigma.
3. Building capability among students in mapping the organizational activities and problems in terms of six sigma framework.
4. Demonstrate ability to implement a structured approach for process, product or service improvement.

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the concepts, tools, techniques and methodologies in Six Sigma Management
CO2	Apply Six Sigma concepts tools and techniques and methodologies to practical problems in service and manufacturing sectors.
CO3	Analyze real-life situations for design and continual improvement of product and processes
CO4	Evaluate cases using Six Sigma Methodologies

UNIT 1	
Overview of Six Sigma Management : Introduction, Successful applications of Six Sigma Management, Timeline for Six Sigma Management, Benefits of Six Sigma Management, Voice of the Process, Voice of the Customer, Non-technical and Technical Definition of Six Sigma, Terminologies in Six Sigma Management, Overview of PDCA. **Six Sigma Roles and Responsibilities:** Champion, Master Black Belt, Black Belt, Green Belt, Yellow Belt, Process Owner. **Data Analysis:** Measures of Central Tendency, Measures of Variation, Skewness, Kurtosis, and Measurement system analysis using gauge R&R	**10 Hours**
UNIT 2	
Tools and Techniques used in Six Sigma: SIPOC diagram, Root Cause Analysis, Frequency distribution and Histogram, Run charts, Stem-and-leaf plots, Pareto diagrams, Cause and Effect Diagrams, Box Plots, Normal probability plots. Quality Function Deployment, Failure Mode	**10 Hours**

Effect Analysis - At least two case studies.	
UNIT 3	
Design of Experiments (DOE): Factorial designs: Introduction, Two-Factor factorial (2^2) design, Three-Factor Factorial (2^3) Design, ANOVA. Numericals on 2^2 and 2^3factorial designs. **Taguchi Method:** Taguchi philosophy, Loss function, Signal-to-Noise ratio, experimental design in Taguchi Method, Parameter design.	**12 Hours**
UNIT 4	
DMAIC process: Define, Measure, Analyze, Improve, Control phases. **Case study on DMAIC** - At least one each from manufacturing industry and service industry highlighting the use of tools and techniques used in each phase. **Design for Six Sigma (DFSS**): Define, Measure, Analyze, Design, Verify phases. **Case study on DFSS** - At least one each from manufacturing industry and service industry highlighting the use of tools and techniques used in each phase	**10 Hours**

TEXTBOOKS	
1	H. S. Gitlow, D. M. Levine ; Six Sigma for Green Belts and Champions; Prentice Hall; First Edition; 2004
2	. Mitra; Fundamentals of Quality Control and Improvement; Wiley; Third edition; 2013
3	D. C. Montgomery; Design and Analysis of Experiments; Wiley; Eighth Edition; 2013
REFERENCES	
1	P. J. Ross; Taguchi techniques for Quality Engineering; McGraw Hill; Second Edition; 2005
2	T. McCarty, L. Daniels, M. Bremer, P. Gupta; The Six Sigma Black Belt Handbook; McGraw Hill; 2010
3	T. Allen; Introduction to Engineering Statistics and Six Sigma; Springer ; 2008
4	J. ReVelle, J. Moran, C. Cox; The QFD Handbook; John Wiley and Sons; 1998.
5	T. Pyzdek; The Six Sigma Handbook; McGraw Hill; Eighth Edition; 2017
6	G. R. Henderson; Six Sigma Quality Improvement with Minitab; Wiley; Second Edition; 2011.
7	A. M. Roderick, J. M. Matthew, B. N. Mohamed, R. Govindarajan, J. Z. Daniel; The Certified Six Sigma Green Belt Handbook; ASQ Quality Press; 2015

Prof. Elec-5 (e)**ADVANCED OPTIMIZATION**					
Course Code	**ME724**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. To understand the advanced topics in linear programming like duality theory, parametric and goal programming
2. To analyze the computational complexity of simplex method and Karmarkar interior point algorithm
3. To analyze real life non linear situations and develop the art of converting these situations into mathematical models
4. To understand the working principles of techniques to solve single variable and multi variable non-linear problems
5. To understand the working and application of evolutionary algorithms

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the applied concept of real life linear and non-linear models, problem formulations, algorithmic complexity and tools to solve these models
CO2	Apply the appropriate technique to solve specific linear and non-linear programming model
CO3	Analyze the complexity of solution procedures used to solve specific linear and non-linear programming model
CO4	Evaluate the performance of various traditional and recent solution techniques used to solve the models

UNIT 1	
Duality theory: Dual linear programs, comparison of primal and dual solutions, economic interpretation of dual problem, Dual simplex method **Sensitivity Analysis:** Introduction, Modified simplex method, Sensitivity analysis on the cost vector, right hand side vector and the constraint matrix, Introduction of additional variable and constraint. **Parametric programming**: Parametric cost problem and parametric right hand side problem	**12 Hours**
UNIT 2	
Goal programming: Formulation with competing objectives and solution algorithms	**10 Hours**

Complexity of algorithms: Introduction, space and time and computational complexity of algorithms, notations, performance measurement. **Interior point algorithm**: Karmarkar algorithm and its comparison with simplex method	
UNIT 3	
Non-linear optimisation: Optimization in design, need. Concept of adequate, optimum and robust design. Formulation of design problem. Classification of design problems, classification of Optimization methods. **Single variable optimization**: Classical technique, Bracketing and locating methods, Unrestricted search, Dichotomous search, Interval Halving method, Golden Section method, Fibonacci search. Interpolation methods: Bisection method, Secant method, Newton Raphson method, Quadratic Interpolation	**10 Hours**
UNIT 4	
Multi-variables optimization without constraints: Classical method, Powell's Conjugate direction method, Steepest Ascent Descent method, Newton's method, Simplex method. **Multi-variables optimization with constraints**: KTC conditions, Lagrange's method, Cutting Plane method. **Evolutionary algorithms:** Introduction to other evolutionary algorithms like Genetic algorithm, Simulated Annealing, Tabu search, Neural networks and Ant Colony Optimization	**10 Hours**

TEXTBOOKS	
1	A. Ravindran, D. Philips and J. J. Solberg, Operations Research: Principles and Practice, John Wiley & Sons Inc., 2e; 2012
2	H. Ellis, S. Sartaj and R. Sanguthevar, Computer Algorithms, Galgotia Publications Pvt. Ltd. 2006
3	S. S. Rao, Optimisation Theory and Applications, Wiley Eastern Limited, 1984
4	P. K. Gupta and D. S. Hira, Operations Research, S Chand., 5e; 1976
5	D. Kalyanmoy, Optimization for Engineering Design: Algorithms and examples, PHI Learning Pvt. Ltd., 2e; 2012
6	S. D. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath. 2012
REFERENCES	
1	S. N. Sivanandam and S. N. Deepa, Introduction to Genetic Algorithms, Springer, 1e, 2007
2	S. R. Yadav and A. K. Malik, Operations Research, Oxford University Press, 1e, 2014
3	F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, 8e, 2005

<table>
<tr><th colspan="6">Prof.Elec-5 (c) ADDITIVE MANUFACTURING</th></tr>
<tr><td>Course Code</td><td colspan="2">ME725</td><td>Credits</td><td colspan="2">3</td></tr>
<tr><td rowspan="2">Scheme of Instructions (Hours / week)</td><td>L</td><td>T</td><td>P</td><td colspan="2">TOTAL</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td colspan="2">42 hrs/sem</td></tr>
<tr><td rowspan="2">Scheme of Examination TOTAL = 125 marks</td><td>IA</td><td>TW</td><td>TM</td><td>P</td><td>O</td></tr>
<tr><td>25</td><td>0</td><td>100</td><td>0</td><td>25</td></tr>
</table>

Course Objectives:

1. To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies
2. To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
3. To introduce the concepts of reverse engineering.
4. To provide an overview the software‘s and design methodology of RP.

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Course Outcomes:

On completing this course students will be able to:

CO1	Understand the various processes of additive manufacturing, rapid tooling and reverse engineering
CO2	Select the appropriate additive manufacturing and rapid tooling process for a desired application
CO3	Apply the knowledge of Computer aided design and additive manufacturing for engineering and biomedical applications
CO3	Develop a simple prototype using the principle of additive manufacturing

UNIT 1	
Introduction: Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling –Applications. **Liquid based and solid based additive manufacturing systems:** Classification –Liquid based system –Stereo lithography Apparatus (SLA) -Principle, process, advantages and applications –Solid based system –Fused Deposition Modeling –Principle, process, advantages and applications	**10 Hours**
UNIT 2	

Powder based additive manufacturing systems: Selective Laser Sintering –Principles of SLS process –Process, advantages and applications, Three Dimensional Printing –Principle, process, advantages and applications-Laser Engineered Net Shaping (LENS), Electron Beam Melting. Laminated Object Manufacturing: **Principle of operation, LOM materials, process details, Applications.** **Solid Ground Curing:** Principle of operation, Machine details, Applications	**11 Hours**
UNIT 3	
Concepts Modelers: Principle, Thermal jet printer, Sander_s model market 3-D printer, object Quadra systems, Laser Engineering Net Shaping (LENS) **Rapid Tooling :**Indirect Rapid tooling -Silicon rubber tooling —Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3D keltool, Direct Rapid Tooling —Direct AIM, Quick cast process, Copper polyamide, Rapid Tool DMILS, Sand casting tooling, soft Tooling vs. hard tooling. **Rapid manufacturing process optimization:** factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation.	**10 Hours**
UNIT 4	
Software for RP: STL files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools. **Cad & reverse engineering:** Basic Concept –Digitization techniques –Model Reconstruction –Data Processing for Additive Manufacturing Technology: CAD model preparation –Part Orientation and support generation –Model Slicing –Tool path Generation. Surface digitizing, surface generation from point cloud, surface modification —data transfer to solid models. Medical and bio-additive manufacturing: Customized implants and prosthesis, Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) –Case studies	**11 Hours**

TEXTBOOKS	
1	Paul F. Jacobs: —Stereo 1ithography and other RP & M Technologies -SME NY, 1996
2	Flham D.T &Dinjoy S.S —Rapid Manufacturing-Verlog London 2001
3	Terry Wohler_s —Wohler‘s Report 2000 -Wohler_s Association 2000
REFERENCES	
1	Tooling: Technologies and Industrial Applications , CRC press, 2000
2	Kamrani A.K. and Nasr E.A., —Rapid Prototyping: Theory and practice , Springer, 2006. 3. Hilton P.D. and Jacobs P.F., —Rapid
3	Liou L.W. and Liou F.W., —Rapid Prototyping and Engineering applications : A tool box for prototype development , CRC Press, 2007
4	Gebhardt A., —Rapid prototyping , Hanser Gardener Publications, 2003
5	Chua C.K., Leong K.F., and Lim C.S., —Rapid prototyping: Principles and applications , Third Edition, World Scientific Publishers, 2010

<table>
<tr><td colspan="6">Lab 9 CAD/CAM Laboratory</td></tr>
<tr><td>Course Code</td><td colspan="2">ME730</td><td>Credits</td><td colspan="2">1</td></tr>
<tr><td rowspan="2">Scheme of Instructions (Hours / week)</td><td>L</td><td>T</td><td>P</td><td colspan="2">TOTAL</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td colspan="2">28 hrs/sem</td></tr>
<tr><td rowspan="2">Scheme of Examination TOTAL =75 marks</td><td>IA</td><td>TW</td><td>TM</td><td>P</td><td>O</td></tr>
<tr><td>0</td><td>25</td><td>0</td><td>50</td><td>0</td></tr>
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Course Objectives:

1. To learn the basics of CAD modeling and 1D FEA analysis
2. To learn the basics of CNC programming

Course Outcomes:

The student after undergoing this course will be able to:
1. Draw simple 3D & 2D views of machine parts using a standard CAD software
2. Analyse simple 1D structural problems using a standard FEM software
3. Simulate CNC programs for simple turning and milling operations

LIST OF EXPERIMENTS	
1. CAD: Solid modeling of any six 3-D objects, machine parts/ components using standard CAD software. **2. FEA**: One exercise on 1D structural analysis using bar element using a standard FEA software. **3.** Two exercises on CNC programming using any simulation software.	

SEMESTER VIII

Prof. Core-14 **INDUSTRIAL ENGINEERING AND OPERATIONS MANAGEMENT**					
Course Code	**ME810**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:
1. To understand the concept of productivity
2. To understand methods of improving existing methods
3. To study methods of establishing work standard
4. To understand the role of operations manager
5. To study the techniques for effective management of operations

Course Outcomes:
On completing this course students will be able to:

CO 1	Understand the objectives and techniques of Industrial Engineering and Operations Management
CO 2	Apply techniques of Industrial Engineering and Operations Management for improving methods, establishing work standards, productivity improvement and effective management of Operations
CO 3	Analyze work cycles for improving methods and establishing work standards for productivity improvement and Analyze situations using qualitative and quantitative techniques in operations management.
CO 4	Evaluate situations to provide solutions to industrial problems.

UNIT-1	**10 Hrs**
Productivity: Definition, measurement, scope, Partial and total productivity, Means of increasing productivity. **Work Study**: Definition, objectives, procedure, Work content analysis, Work study as a means of improving productivity, Human factor in the application of work study. **Method Study:** Definition, objectives, procedure, Selection of a job, Recording techniques – Charts-Outline, Flow process, two-handed, multiple activity and travel chart, Diagrams- Flow and string diagram, Critical examination, Design cycle of Method Study. **Principles of Motion Economy and Ergonomics:** Use of human body, arrangement of the work place, design of tools and equipments.	
UNIT-2	**10 Hrs**

Work Measurement: Definition, objectives, Techniques of work measurement. **Time Study:** Definition, Time Study Equipment's, Job selection, Steps in time study, Breaking jobs into elements, Systems of rating, Standard rating, Performance rating, Allowances, Calculation of standard time, Predetermined Motion time study (PMTS). **Work Sampling:** Definition, procedure, determination of sample size. **Wages and Incentives:** Wages, need, Elements of ideal wage system, types of wages - Time wage system, Piece wage system, Characteristics, types of incentives plans - Financial and Non-financial, Individual and Group Incentives schemes - Taylors differential piece rate plans, Emerson Efficiency plan	
UNIT-3	**11 Hrs**
Forecasting Techniques: Forecasting as a planning tool, forecasting time horizon, short and long range forecasting, sources of data, types of forecasting, qualitative forecasting techniques, quantitative forecasting models - Linear regression, Moving average, Weighted moving average, Exponential smoothing, Exponential smoothing with trends, Measurement of errors, accuracy and control of forecast. **Plant Location:** Need and nature of location decisions, factors affecting location decisions and their relative importance for different types of facilities, Evaluating Location alternatives – Break Even Analysis, Factor Rating, Center of Gravity Method. **Plant Layout:** Layout and its objectives, principles, types of plant layouts – product layout, process layout, fixed position layout, cellular manufacturing layouts, Factors influencing layout changes. **Assembly Line Balancing:** Concept of work stations, cycle time, idle time. Assigning task to work station using single rule or combination of rules - task times, following tasks, positional weight.	
UNIT -4	**11 Hrs**
Sequencing and Scheduling: Sequencing, Priority rules, Single processor system, Two processor and Three processor systems, Johnson's rule, Scheduling operations, Gantt chart. **Inventory Management:** Dependent and independent demand. Inventory control - ABC analysis, EOQ models for purchasing and manufacturing situation without shortages. **Project Management and Network Analysis:** Introduction, Network construction -AON and AOA diagrams, CPM and PERT analysis.	

TEXTBOOKS	
1	K. George; Introduction to work study by ILO; Universal Book Corporation, Bombay, 2011
2	M. Telsang; Industrial Engineering and Production Management; S. Chand, New Delhi; 2015
3	W. J. Stevenson; Operation Management; McGraw Hill, New York; 2005
REFERENCES	
1	R. M. Barnes; Motion and Time study - Design and Measurement of Work; Wiley and Sons; New York; 1980
2	J. G. Monks; Operations Management: Theory and Problems; McGraw Hill, New York; 1987

3	A. P. Verma; Industrial Engineering & Management; S. K. Kataria& Sons; 2012.
4	M. Mahajan; Industrial Engineering and Production Management; Dhanpat Rai & Co.; 2014

Prof. Elect. – 7 (a)-**ENERGY CONSERVATION AND MANAGEMENT**					
Course Code	**ME821**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. Study principles of energy management
2. Study energy economics and auditing
3. Study electrical energy management, cogeneration and waste heat recovery Outcomes:

Course Outcomes:

On completing this course students will be able to:

CO 1	Remember basics of General Aspects of Energy Auditing and Management
CO 2	Understand working principles boilers, waste heat recovery systems, cogeneration, insulation and electrical systems.
CO 3	Apply principles of working principles boilers, waste heat recovery systems, cogeneration, insulation and electrical systems.
CO 4	Analyze energy economics and performance of thermal and electric utilities

UNIT-1	**10 Hrs**
General Aspects of Energy Management: Current energy scenario: India and World, Current energy consumption pattern in global and Indian industry, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy and environment, Need of Renewable and energy efficiency. **Energy Auditing** : Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments, equipment used in energy audit, Analysis and recommendations of energy audit - examples for different applications, Energy audit reporting.	
UNIT-2	**11 Hrs**
Energy Economics: Costing of Utilities - Determination of cost of steam, natural gas, compressed air and electricity. Financial Analysis Techniques - Simple payback, Time value of money, Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis. **Boiler Performance Calculations:** Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities, Boiler performance.	
UNIT-3	**11 Hrs**
Energy Efficiency in Thermal Utilities: Energy conservation in refrigeration and air conditioning system, compressed air system. Energy conservation in steam	

generation and supply system. **Cogeneration:** Need for cogeneration, Principle of cogeneration, Technical options for cogeneration, Classifications of cogeneration systems, Factors influencing cogeneration choice. Important Technical parameters for cogeneration, Quality of Thermal Energy Needed, Prime-movers for cogeneration, Typical cogeneration performance parameters, relative merits of cogeneration systems, Case study **Waste Heat Recovery:** Classification, Advantages and applications, commercially viable waste heat recovery devices, saving potential.	
UNIT -4	**10 Hrs**
Insulation: Materials of insulations form of insulations, desirable properties of insulations, economic thickness of insulation, Refractories. **Electrical Energy Management:** Distribution and transformer losses. Electrical motors - types, efficiency and selection. Speed control, Energy efficient motors, Electricity Act 2003.	

TEXTBOOKS	
1	Energy engineering and management, AmlanChakrabarti, PHI Learning, New Delhi 2012
2	Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
3	Energy Performance assessment for equipment and Utility Systems Vol. 1 to 4, Bureau of Energy Efficiency, Govt. of India
REFERENCES	
1	Trivedi P R, Jolka K R, Energy Management, Commonwelth Publications, New Delhi
2	Handbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, New Delhi, 2006
3	Energy management Handbook, 5th Edition, Wayne C. Turner, The Fairmont Press Inc., Georgia.
4	Boiler Operators Guide Fourth Edition, Anthony L Kohan, McGraw Hill

Prof. Elect 6 (a1)-**AUTOMOBILE ENGINEERING**					
Course Code	**ME822**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. It aims to provide students with a thorough understanding of the construction and operating principle of modern automobile.

2. It also enables students to familiarize with regulatory norms concerning performance, safety and pollution.

Course Outcomes:
On completing this course students will be able to:

CO 1	Understand the need functioning and purpose of various automotive system.
CO 2	Applying Automobile engineering solutions to performance pollution and safety norms.
CO 3	Analyze the vehicle performance in various scenarios.
CO 4	Evaluate automotive solutions to Performance, pollution and safety.

UNIT-1	**11 Hrs**
Introduction: Automobile history and development, Classification, Basic Frame Structure, Sub-frames, Integral and Chassis-less construction, Body styles, Engine and Drive-Train. **Engine Components:** Engine Block, Cylinders, Piston and Rings, Connecting Rod, Crankshaft, Bearings, Camshaft, Valve-Train and Valves, Cylinder Head, Combustion chamber, Intake and Exhaust Manifold construction, Oil pan and sump, Gasket and Sealant. **Friction Clutches:** Requirement and Operating Principle of friction clutch, Clutch components and construction, Single plate clutch, Diaphragm spring clutch, Multi-plate clutch, Semi Centrifugal, Centrifugal and Electro-Magnetic clutches. Fluid Coupling.	
UNIT-2	**10 Hrs**
Gearbox: Necessity of gear box, Sliding Mesh, Constant mesh, Synchromesh, Torque convertor, Epicyclic gear box, Transfer Case and Four wheel drive system, Overdrive. **Drive Line:** Universal joint, Constant Velocity joint, Propeller Shaft, Slip Joint,	

Differential gears and mechanism, Rear axles. **Tyres and Wheels:** Types of tyre construction, Tyre tread, Aquaplaning, Tyre specification, Types of wheels, Wheel construction, alloy wheels. **Vehicle Performance:** Power for propulsion, Traction and Tractive effort, Acceleration, Gradiability and Drawbar pull.	
UNIT-3	**11 Hrs**
Steering System: Condition for true rolling motion, steering geometry, and General arrangement of a Steering System. **Types of Steering Gear boxes:** Worm and Worm wheel, Worm and Nut, recirculating ball type and Rack and pinion. Over–Steer and Under–Steer, collapsible steering, Tilt steering, Hydraulic power Steering and Electronic power steering. **Wheel Alignment:** Principles, Caster angle, Camber angle, King Pin Inclination, Toe-in and Toe out. **Suspension System:** Suspension Components, Leaf Spring and Coil Spring, Torsion bar, Telescopic Damper, Independent **suspension types:** Double wishbone and MacPherson strut, **Independent Rear suspension**. **Brakes:** Functions and Requirements of Brakes, Types of brake systems, Stopping distance. Theory of shoe brakes, Weight transfer, Drum brake, Self-Energized brakes, Disc brake, Hydraulic Brakes, Parking brakes, Air brakes, Power brakes.	
UNIT -4	**10 Hrs**
Automotive Electrical Systems: Starting system, Battery, Starting Motor. Charging system, Ignitions system, Purpose and Requirement, Battery Ignition and Magneto Ignition. Electronic Ignition system Electric, Hybrid and Fuel Cell Vehicles: Battery Electric Vehicle and Layout, Basic unit of battery electric vehicle, Hybrid Electric Vehicles and Layout, Fuel Cell Vehicle. **Safety Features:** Antilock Braking system, Seat belts, Air bags, Traction Control and Stability Control, Crumple Zone, Hill start assistant control, Intelligence Speed Assist, Lane Assist System, parking assistant. **Automobile Air Conditioning:** Introduction, Construction and working. **Automobile sensors:** Introduction to temperature sensors, inductive sensors, Position sensors (rotary, linear). Hot wire and thin film air flow sensors, Optical sensor, Oxygen sensors, Light sensors, Rain sensors. Drive/ Steer by Wire Automobiles.	

TEXTBOOKS	
1	K. Singh, Automobile Engineering, Vol I & II, Standard Publishers Distributors; 13e; 2012

2	K. K. Jain, R. B. Asthana; Automobile Engineering; Tata McGraw Hill; 2002.
3	A. S. Rangwala; Trends in Automobile Engineering, New Age International Publishers; 2017
4	N. K. Giri; Automotive Mechanics; Khanna Publishers, New Delhi; 2005.

REFERENCES

1	W. H. Crouse, Donald L Anglin Author; Automotive Mechanics; Tata McGraw Hill; 2007.
2	M. J. Nunney; Light and Heavy Vehicle Technolog; Elsevier Ltd, 2009.
3	R. K. Rajput; Automobile Engineering; Laxmi Publications Ltd.; 2017.

Prof. Elect-6 (c)**INDUSTRIAL AUTOMATION AND ROBOTICS**					
Course Code	**ME823**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

1. To introduce students to the structure, performance characteristics, forward & inverse kinematics of an industrial robot.
2. To impart knowledge of machine vision, mobile robots and industrial automation tools.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts in industrial robot, machine vision and mobile robots
CO 2	Understand the working principles of robot grippers, sensors, control systems and drives used in industrial robot
CO 3	Apply the knowledge of PLC programming for an automatic control system
CO 4	Apply spatial transformation to obtain forward kinematics equation and to solve inverse kinematics for robot manipulators

UNIT-1	**11 Hrs**
Introduction to Automation: Automation in Production systems, Types of Automation: Fixed, Programmable and Flexible, Basic Elements of an Automated System, Levels of Automations. Introduction to basics of SCADA and DCS (Basic concepts only). **PLC Applications for control**: Pneumatic pistons, Servo motors, Level control in a tank, Detection and Sorting. **Basic Concepts in Robotics**: Robot anatomy, Basic structure of robots, DOF and degree of motion, Joints and symbols, Work volume and envelope, Robot Body-arm and wrist motions, Resolution, Accuracy, Repeatability and Compliance, Robot Applications	
UNIT-2	**10 Hrs**
Classification of Robotic Systems: Point to point and Continuous path systems. Grippers, Factors for Gripper selection. **Drives and Control Systems**: Hydraulic and Pneumatic systems, Control loop of robotic systems. **Sensors in Automation and Robotics:** Touch sensors, Force and torque sensors, Acoustic sensors, Slip sensors, Proximity & Range sensors, Smart sensors and transmitters, smart actuators.	
UNIT-3	**11 Hrs**

Robot Arm Kinematics: General Mathematical Preliminaries on Vectors & Matrices, Direct kinematics problem, Denavit-Hartenberg convention and its applications, Inverse kinematics solution for 2 axis planar mechanisms and 3-axis spherical. **Trajectory planning**: Introduction, Steps in Trajectory planning, Necessity of interpolators, Generation of motion commands, Joint space and Cartesian space Techniques.	
UNIT -4	**10 Hrs**
Machine Vision: Introduction, Sensing & digitizing function, Imaging devices, Lighting techniques, Image storage, Image processing and analysis, Image data reduction, Segmentation, Feature extraction, Object recognition **Mobile Robotics:** Introduction, Key issues for locomotion, Legged mobile robots: Types, leg configuration and stability, Wheeled mobile robots: Wheel configuration & wheel design.	

TEXTBOOKS	
1	Singh, M. Deswal; PLC and SCADA; Laxmi Publications Private Limited; First edition; 2016.
2	C. Johnson; Process Control Instrumentation Technology; Pearson; 8e; 2006
3	J. Prasad, M. N. Jayaswal, V. Priye; Instrumentation and Process Control; I K International Pvt Ltd; 1st Reprint;2011
4	K. S. Fu, R. C. Gonzalex, C. S. G. Lee; Robotics Control Sensing, Vision and Intelligence; McGraw Hill Book Co.; Tata McGraw Hill Education; 1e; 1987
5	S. Soloman, Sensors and Control systems in Manufacturing; Mcgraw Hill Professionalpublishing, 2e, 2009
6	Roland Siegwart and Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, The MIT Press (2004).
REFERENCES	
1	S. K. Singh; Industrial Instrumentation and Control; McGraw Hill Publications; 2010
2	D. Popovic, V. Bhatkar; Distributed Computer Control Systems in Industrial Automation; CRC Press; 1990.Y. Koran; Robotics for engineers; McGraw Hill Co.; 1985
3	M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics Technology, Programming and Applications; Tata McGraw Hill Education; Special Indian; 2e; 2012.
4	R. K. Mittal, I J Nagrath; Robotics and Control; Mcgraw Hill Education; 1e; 2003
5	M. Chidambaram, Computer control of processes; Narosa Publishing house; 2006

Prof. Elec-6 (d)**MAINTENANCE ENGINEERING AND MANAGEMENT**					
Course Code	**ME824**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:
1. To introduce students various aspects of Maintenance and its related statistical analysis.
2. To develop awareness of Reliability, Availability and Maintainability strategies in the improvement of product and process quality.
3. To instill liking among student community, for techniques which are used in reduction of failures and downtime.
4. To enhance analytical abilities through the use of statistical approaches in Reliability, Availability and Maintainability.

Course Outcomes:
On completing this course students will be able to:

CO 1	Understand Reliability, Availability and Maintainability concepts.
CO 2	Apply Reliability, Availability and Maintainability to product or system.
CO 3	Analyze measures of Reliability, Availability and Maintainability.
CO 4	Evaluate performance of product or system based on Reliability, Availability and Maintainability.

UNIT-1	**10 Hrs**
Introduction: Maintenance Concept, Challenges, Objectives, Responsibilities of Maintenance Department, Types of Maintenance, Benefits and Effects of Maintenance, Maintenance Evaluation, Computers in Maintenance Economic Aspects of Maintenance, Organizational Structure for Maintenance, Lubricants and Maintenance, Maintenance Material Planning and Control, Manpower Planning for Maintenance, Environmental Impact of Maintenance, Categories of Maintenance Selective control. **Advanced Maintenance Systems:** Introduction, Methodology and Benefits of Total Productive Maintenance, Reliability Centered Maintenance and Condition Based Maintenance.	
UNIT-2	**11 Hrs**
Reliability Concepts: Review of Reliability Measures and failure distributions. Nonparametric methods for Ungrouped and Grouped Complete data. Probability Plotting: Exponential, Weibull, Normal and Lognormal distribution. **System Reliability:** Series Configuration, Parallel Configuration, Complex Configuration, Star-Delta Configuration, Time dependent, Rare-event approximation, Standby Redundant systems: Perfect switching and Imperfect switching.	
UNIT-3	**11 Hrs**

Reliability Testing: Product Testing, Reliability Life Testing, Test time calculations, Burn-in Testing, Accelerated Life Testing: Number of units on test, Accelerated Cycling, Constant-Stress Models. **State-Dependent Systems:** Markov Analysis, Load-Sharing System, Standby Systems, Degraded Systems, Three-State Devices. Failure Analysis, FMEA, System Safety and Fault Tree Analysis.	
UNIT -4	**10 Hrs**
Maintainability: Analysis of downtime, The Repair-time distribution; Exponential, Lognormal, Reliability under Preventive Maintenance, State-Dependent Systems with repair. **Design for Maintainability:** Maintenance Requirements, Design methods, Human Factors and Ergonomics, Maintenance and Spares Provisioning, Maintenance Prediction and Demonstration. **Availability:** Concepts and Definitions, Exponential Availability model, System Availability: Introduction, Standby system availability, Stead-state system availability, Design trade-off analysis, Maintainability allocation	

TEXTBOOKS	
1	R. C. Mishra, K. Pathak; Maintenance Engineering and Management; Prentice Hall of India Pvt. Ltd.; 2e; 2012
2	C. E. Ebeling; An Introduction to Reliability and Maintainability Engineering; Tata McGraw Hill; 2009
3	S. S. Rao; Reliability Engineering, Pearson Education; 2016
REFERENCES	
1	K. C. Kapur, L. R. Lamberson; Reliability in Engineering Design; Wiley India; 2011

<table>
<tr><td colspan="7">Prof. Elec-6 (a2)COMPUTATIONAL FLUID DYNAMICS</td></tr>
<tr><td>Course Code</td><td colspan="2">ME825</td><td>Credits</td><td colspan="2">3</td></tr>
<tr><td rowspan="2">Scheme of Instructions (Hours / week)</td><td>L</td><td>T</td><td>P</td><td colspan="2">TOTAL</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td colspan="2">48 hrs/sem</td></tr>
<tr><td rowspan="2">Scheme of Examination TOTAL = 125 marks</td><td>IA</td><td>TW</td><td>TM</td><td>P</td><td>O</td></tr>
<tr><td>25</td><td>0</td><td>100</td><td>0</td><td>0</td></tr>
</table>

Course Objectives:

1. To model fluid/heat transfer problems and apply fundamental conservation principles.
2. To discretize the governing differential equations and domain by Finite Difference Method.
3. To solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
4. To prepare the students for career in industry in CAE through use of software tools.
5. To prepare the students for research leading to higher studies.

Course Outcomes:
On completing this course students will be able to:

CO 1	Remember basics of thermodynamics, Fluid Mechanics and Heat Transfer
CO 2	Understand working principles of Basic governing equations in integral and differential forms
CO 3	Apply principles of Two Dimensional Steady and unsteady heat conduction, Convection and Incompressible Fluid Flow
CO 4	Analyze CFD as Practical Approach

UNIT-1	**11 Hrs**
Introduction to CFD: CFD – a research and design tool, CFD as third dimension of engineering supplementing theory and experiment, Steps in CFD solution procedure, strengths and weakness of CFD, Flow modeling using control volume - finite and infinitesimal control volumes, Concept of substantial derivative, divergence of velocity, Basic governing equations in integral and differential forms – conservation of mass, momentum and energy (No derivations), Physical interpretation of governing equations, Navier-Stoke‘s model and Euler‘s model of	

equations.	
UNIT-2	**10 Hrs**
Basic Discretization Techniques: Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), Need to discretize the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation) and second order (based on 3 node, 4 node and 5 node points),explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation using FTCS and Crank Nicholson's Method,	
UNIT-3	**11 Hrs**
Two Dimensional Steady and unsteady heat conduction: Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method). **Convection:** first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation Convection –Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, upwind difference approach, 1 D transient convection-diffusion system.	
UNIT -4	**10 Hrs**
Incompressible Fluid Flow: Solution of Navier-Stoke's equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method. **CFD as Practical Approach:** Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initializing and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle.	

TEXTBOOKS	
1	John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill
2	J. Tu, G.-H. Yeoh and C. Liu: Computational Fluid Dynamics: A practical approach, Elsevier.

3	A. W. Date: Introduction to Computational Fluid Dynamics, Cambridge University Press, India
REFERENCES	
1	P. S. Ghoshdastidar: Computer Simulation of Fluid flow and heat transfer, Tata McGraw Hill.
2	C. Hirsch: Numerical Simulation of internal and external flows Vol. 1, John Wiley
3	Tannehill, Anderson, and Pletcher: Computational Fluid Mechanics and Heat transfer, CRC Press.
4	Zikanov, Essential Computational Fluid Dynamics, Wiley India