MASTER OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

PROGRAMME SCHEME AND SYLLABUS

(w.e.f. 2018-19)

DEPARTMENT OF MECHANICAL ENGINEERING

GURU JAMBHESWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY, HISAR

DEPARTMENT OF MECHANICAL ENGINEERING

GURU JAMBHESHWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY, HISAR

M.Tech. (Mechanical Engineering)

(w.e.f. 2018-2019)

FIRST SEMESTER

Course No.	Title	L	P	Cr.
ME-751	Advanced Mechanics of Solids	3	0	3.0
ME-753	Advanced Engineering Materials	4	0	4.0
ME-755	Automation in Manufacturing	4	0	4.0
ME-757	CNC Technology and Programming	3	0	3.0
ME-759	Advanced Heat and Mass Transfer	4	0	4.0
ME-761	Advanced Mechanics of Solids Lab	0	4	2.0
ME-763	CNC Technology and Programming Lab	0	4	2.0
	Audit Course-I (any one from attached list of audit-I courses)	2	0	0.0
	Total	**20**	**08**	**22.0**

SECOND SEMESTER

Course No.	Title	L	P	Cr.
	Programme Elective -I(any one from attached list of Programme elective-I courses)	4	0	4.0
ME-752	Advanced Machine Design	4	0	4.0
ME-754	Computer Aided Design and Manufacturing	3	0	3.0
ME-756	Finite Element Methods	3	0	3.0
ME-758	Tool Engineering	4	0	4.0
ME-760	Computer Aided Design and Manufacturing Lab	0	4	2.0
ME-762	Finite Element Methods Lab	0	4	2.0
	Audit Course-II(any one from attached list of audit-II courses)	2	0	0.0
	Total	**20**	**08**	**22.0**

THIRD SEMESTER

Course No.	Title	L	P	Cr.
	Programme Elective –II(any one from attached list of Programme elective-II courses)	4	0	4.0
	Open Elective(any one from attached list of Open elective courses offered by other departments)	3	0	3.0
ME-765	Tribology	3	0	3.0
ME-767	Tribology Lab	0	4	2.0
ME-769	Seminar	0	4	2.0
ME-771	Thesis (starts)	0	6	3.0
	Total	**10**	**14**	**17.0**

FOURTH SEMESTER

Course No.	Title	L	P	Cr.
ME-772	Thesis	--	18	**9.0**

Total Credits: 70.0

Audit Courses-I

Course No.	Title	L	P	Credit
AC01	English for research paper writing	2	0	0.0
AC02	Disaster Management	2	0	0.0
AC04	Value Education	2	0	0.0
AC07	Stress Management by Yoga	2	0	0.0

Audit Courses-II

Course No.	Title	L	P	Credit
AC03	Sanskrit for Technical Knowledge	2	0	0.0
AC05	Constitution of India	2	0	0.0
AC06	Pedagogy Studies	2	0	0.0
AC08	Personality Development through Life Enlightenment Skills	2	0	0.0

LIST OF PROGRAMME ELECTIVES –I

Course No.	Title	L	P	Cr.
ME-732	Robotics	4	0	4.0
ME-734	Instrumentation and Measuring Systems	4	0	4.0
ME-736	Flexible Manufacturing Systems	4	0	4.0
ME-738	Mechatronics	4	0	4.0

LIST OF PROGRAMME ELECTIVES –II

Course No.	Title	L	P	Cr.
ME-731	Optimal design of thermal systems	4	0	4.0
ME-733	Computational fluid dynamics	4	0	4.0
ME-735	Advanced Thermodynamics	4	0	4.0
ME-737	Heat exchanger analysis and design	4	0	4.0

LIST OF OPEN ELECTIVES

Course No.	Title	L	P	Credit
3OE01	Business Analytics	3	0	3.0
3OE02	Industrial Safety	3	0	3.0
3OE03	Operations Research	3	0	3.0
3OE04	Cost Management of Engineering Projects	3	0	3.0
3OE05	Composite Materials	3	0	3.0
3OE06	Waste of Energy	3	0	3.0
3OE07	Advancements in Communication System	3	0	3.0
3OE08	Introduction to Soft Computing Techniques	3	0	3.0
3OE09	Advanced Printing Technology	3	0	3.0
3OE10	Computer Aided Design & Manufacturing	3	0	3.0
3OE11	Food safety and quality assurance	3	0	3.0

ME-751 ADVANCED MECHANICS OF SOLIDS

L	T	P	Internal Marks	External Marks	Credit
3	**0**	**0**	**30**	**70**	**3.0**

- *To understand the concepts of stress and strain, strength and stiffness, deformation and displacement and energy theorems.*
- *To predict the behaviour of the solid bodies subjected to various types of loading.*
- *To design machine elements using theories of deformable bodies.*

Unit I

3-D dimensional stress and strain: Analysis of Stresses and Strains in rectangular and polar coordinates: Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Differential equations of equilibrium, Plane stress and plane strain, compatibility conditions.

Energy Theorems: Strain energy due to axial load, bending, shear and torsion, Maxwell's reciprocal theorem, Castigliano's theorem, analysis of helical springs by energy method.

Unit II

Unsymmetrical bending: Shear centers for sections with one axis of symmetry, shear center for any unsymmetrical Section, stress and deflection of beams subjected to unsymmetrical bending. Axi-Symmetric Problems: Rotating Discs – Flat discs, Discs of uniform thickness, Discs of Uniform Strength, Rotating Cylinders.

Unit III

Buckling of columns: Beam columns single concentrated load, number of concentrated loads, contionous lateral Load, end couple, couples at both ends triangular loads.

Bending of plates: Basic definition, stress curvature and moment relations, differential equation of plate deflection. boundry conditions, simply supported rectangular plates, axis symmetric loaded Circular plates.

Unit IV

Beam on Elastic Foundations: General theory, infinite, semi infinite, finite beams classification of beams. Beam supported by equally spaced elastic elements.

Stress concentration: Stress concentration in tension or compression members. Stresses in a plate with a circular hole, elliptical hole, small semi circular grooves.

Course Outcomes

Students would be able to

- *understand the concepts of stress and strain, strength and stiffness, deformation and displacement and energy theorems*
- *predict the behaviour of the solid bodies subjected to various types of loading.*
- *design machine elements using theories of deformable bodies.*

Books recommended

- Srinath L.S, "Advanced Mechanics of Solids", Tata McGraw-Hill Education, 2010.
- Ryder G.H, "Strength of Material", Macmillan, India, 1961.
- Sadhu Singh, "Strength of Materials", Khanna Publishers, India, 2012.
- Muubeen A, "Mechanics of Solid", Pearson Publications, India, 2011.
- Popov E.P, "Engineering Mechanics of Solids", Prentice Hall of India, 2006
- Timoshenko S, "Strength of Materials Part-11", East-West Press Pvt. Ltd., New Delhi, 2012.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-753 ADVANCED ENGINEERING MATERIALS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To understand significance of material science and its role in manufacturing.*
- *To analyze the importance of various engineering materials (metals, polymers, ceramics, composites, Semi-conductor).*
- *To recite ceramics and composites, their manufacturing techniques, properties and applications.*
- *To propose appropriate plastics and polymers for different applications.*

Unit I

Non-Ferrous Materials: Copper and its Alloys, Aluminium and its Alloys, Nickel and its Alloys, Zinc and its Alloys, Titanium and its Alloys, Magnesium and its Alloys, Cobalt and its Alloys, Lead and its Alloys

Unit II

Ferrous Materials: Production of Iron and Steel, Cast Irons, Low Alloy and High Alloy Steels, Tool Steels, Stainless Steels, Iron Carbon System, Time Temperature Transformation Relations, Heat Treatment of Plain Carbon Steels, Selective and Surface-Hardening

Unit III

Polymers, Composites and Ceramics: Polymer Materials (Introduction), Polymer Structure, Thermoplastics, Thermosets, Elastomers, Types and Applications of Ceramics, Properties of Ceramics Materials, Glass, Cements, Refractories and Advanced Ceramics, Structure of Composites, Metal Matrix Composites, Ceramic Matrix Composites, Polymer Matrix Composites, Fiberglass, Carbon Fiber Reinforced Polymer Composites, Properties of Composites

Unit IV

Miscellaneous Materials: Smart Materials, Shape Memory Phenomenon and Alloys, Hydrogen Storage Alloys, Functionally gradient material, Adhesives, Metals for Nuclear energy, Sound Insulating Materials

Project

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students would be able to

- *understand significance of material science and its role in manufacturing.*
- *analyze the importance of various engineering materials (metals, polymers, ceramics, composites, Semi-conductor).*
- *recite ceramics and composites, their manufacturing techniques, properties and applications.*
- *propose appropriate plastics and polymers for different applications.*

Books recommended

- William F. Smith, Havad Hashemi and Ravi Prakash, "Material Science and Engineeing", Tata McGraw Hill Education (P) Ltd, 2013.
- William D. Callister, Jr. and Balasubramaniam, R., "Callister's Material Science and Engineering", Wiley India (P) Ltd, 2009.
- Gandhi and Thompson, "Smart Materials and Structures", Chapman and Hall, 1992.
- Gladius Lewis, "Selection of Engineering Materials" Prentice-Hall, 1989.
- Rama Rao, "Advances in Materials and their applications", Wiley Eastern Ltd, 1993.

Note

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ME- 755: AUTOMATION IN MANUFACTURING

L	T	P	Internal Marks	External Marks	Credit
4	**0**	**0**	**30**	**70**	**4.0**

- *To inculcate the ability to design of hydraulic, pneumatic and electro-pneumatic logic circuits for automating processes in manufacturing, demonstrate problem-solving skills in automation and safely use the machines in the industries. Also, to explore the use of different sensors, control valves, controllers and actuators for electro-pneumatic & hydraulic circuits.*

Unit I

Introduction to Factory Automation and Integration: Basic Concepts, Types of automation, Automation. Modern developments in automation in manufacturing and its effect on global competitiveness, Need and implications of automation in Manufacturing.

Unit II

Introduction to Hydraulics/Pneumatics Electro-pneumatic controls and devices, Basic elements hydraulics/pneumatics, Electro-pneumatic systems, Fluid power control elements and standard graphical symbols for them, Construction and performance of fluid power generators, Hydraulic & pneumatic cylinders - construction, design and mounting, Hydraulic & pneumatic valves for pressure, Flow & direction control, Servo valves and simple servo systems with mechanical feedback, Solenoid, Different sensors for electro-pneumatic system, hydraulic, pneumatic & electro-pneumatic circuits.

Unit III

Introduction to rapid prototyping (RP), Basic Principles of RP, Steps in RP, Advantages of RP, Classifications of Different RP Techniques.

Materials for RP: Plastics, Ceramics, Resins, Metals, Selection criterions for materials for different processes, the advantages and limitations of different types of materials.

Unit IV

Automatic transfer machines: Classifications, Analysis of automated transfer lines, without and with buffer storage, Group technology and flexible manufacturing system.

Assembly automation: Types of assembly systems, Assembly line balancing, Performance and economics of assembly system.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *understand the concepts of automation theory and its applications in various fields of manufacturing.*
- *understand principles, methods, and hardware/software tools used in modern computerized design and manufacturing of discrete parts.*
- *understand the main principals and components involved in optimizing production system design and operations.*

Books recommended

- Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 2nd Ed., Prentice Hall, 2005.
- Boothroyd, G., "Assembly Automation and Product Design", 2nd Ed., Marcel Dekker, 1992.
- Boothroyd, G., Dewhurst, P. and Knight, W., "Product Design for Manufacture and Assembly", 2nd Ed., Taylor & Francis, 2002.
- Boothroyd, G., Poli, C. and Murch, L. E., "Automatic Assembly", Marcel Dekker, 1982.
- Tergan, V., Andreev, I. and Lieberman, B., "Fundamentals of Industrial Automation", Mir Publishers, 1986.

Note
In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-757 CNC TECHNOLOGY AND PROGRAMMING

L	T	P	Internal Marks	External Marks	Credit
3	**0**	**0**	**30**	**70**	**3.0**

Course Objectives

- *To understand fundamentals of the CNC technology.*
- *To understand the programming methods in CNC machines*.

Unit I

Computer numerical control machining: Axis standards, Coordinate systems, CNC machine motions. CNC hardware basics: Structure, Drives, Actuation systems, Sensors and Feedback devices.

Unit II

Programming fundamentals: Coding standards, Preparatory functions, Miscellaneous functions. Programming features: Tool length and radius compensation, Tool nose radius compensation, Canned cycles, Branching logics, Thread cutting, Cut planning etc. Fundamentals and programming of CNC turning center and CNC machining center, Problems.

Unit III

CNC Advanced Part Programming: Automatically Programmed Tools (APT) language: Language structure, Geometry commands, Motion Commands, Post Processor Commands, Compilation control commands, Repetitive Programming Complete part program, Problems.
CAD/CAM aided CNC part programming: Use of WinNC, ELCAM and ELPULS for product design and manufacturing.

Unit IV

CNC Tooling: Cutting tool material and characteristics, Turning tool geometry, Tooling system for turning, milling and wire cut EDM, Tool presetting, Automatic tool changers, Work holding.

Course Outcomes

Students will be able to :

- *understand the basics of CNC machines.*
- *write CNC programs proficiently.*

Books recommended

- Jon S. Stenerson, Kelly Curran , "Computer Numerical Control: Operation and Programming", Prentice Hall, 3rd edition 2007.
- Mattson Mike, "CNC Programming: Principles & Applications", Cengage learning, 1st edition 2013.
- Fitzpatrick, "Machining and CNC Technology", McGraw-Hill Higher Education, 3rd edition 2013.
- Michael J. Peterson, "CNC Programming: Basics & Tutorial Textbook", Create Space Independent Publishing Platform, 1st edition 2008.
- Peter Smid, "CNC Tips and Techniques: A Reader for Programmers", Industrial Press Inc., 1st edition 2013.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-759 ADVANCED HEAT AND MASS TRANSFER

L	T	P	Internal Marks	External Marks	Credit
4	**0**	**0**	**30**	**70**	**4.0**

Course Objectives

- *To understand the basic concepts of heat transfer and conduction.*
- *To understand the extended surfaces and the principles of convection.*
- *To understand the concept of phase change heat transfer, principles of radiation and mass transfer.*

Unit I

Brief introduction to different modes of heat transfer: Conduction: General heat Conduction equations-initial and boundary conditions, variable thermal conductivity, Internal distributed heat sources, Extended surfaces

Transient heat conduction: Lumped system analysis-Heisler charts-semi infinite solid-use of shape factors in conduction-2D transient heat conduction-product solutions.

Unit II

Finite difference methods for conduction: ID & 2D steady state and simple transient heat conduction problems-implicit and explicit methods.

Free and Forced Convection: Approximate analysis on laminar free convective heat transfer-boussinesque approximation-different geometries-combined, equations of fluid flow-concepts of continuity, momentum equations-derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method-integral analysis.

Unit III

Internal and External flows: Fully developed flow: integral analysis for laminar heat transfer coefficient-types of flow-constant wall temperature and constant heat flux boundary conditions-hydrodynamic &thermal entry lengths; use of empirical correlations, flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.

Boiling and condensation: Boiling curve-correlations-Nusselts theory of film condensation on a vertical plate-assumptions & correlations of film condensation for different geometries.

Unit IV

Radiation heat transfer: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames.

Mass Transfer: Concepts of mass transfer-diffusion & convective mass transfer analogies significance of non-dimensional numbers.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

- *Students will be able to understand and can analyzeheat conduction problems under steady and transient states.*
- *Student will be to understand the physical phenomena associated with free and forced convection, boiling and condensation and will be able to solve problems based on them.*
- *Each student understands the physical mechanisms involved in radiation heat and mass transfer.*

Books recommended

- Kreith F., Manglik R., & Bohn M., "Principles of heat transfer", Cengage learning, 2010.
- Incropera F., & DeWitt D, "Fundamentals of heat and mass transfer", John Wiley 5th edition 2002.
- Bergman T. L., Incropera F. P., & Lavine A. S, "Fundamentals of heat and mass transfer". John Wiley & Sons, 2011.
- Sarit K Das, "Fundamentals of Heat and Mass Transfer", Narosa Publications, 2010.

- Y.A Cengel, "Heat Transfer: A Practical Approach", TMH India, 2013.
- KV Narayanan and B Kakshmikutty, "Mass Transfer:Theory and Applications", CBS Publishers and Distributors Pvt. Ltd, 2014.

Note

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ME-761 ADVANCED MECHANICS OF SOLIDS LAB

L	T	P	Internal Marks	External Marks	Credit
0	**0**	**4**	**30**	**70**	**2.0**

Course Objectives

- *To predict the behavior of the solid bodies subjected to various types of loading.*

List of experiments

1. To perform uniaxial tension and compression tests for ductile and brittle materials, compare stress-strain curves for ductile and brittle materials, verify failure criterions for ductile and brittle materials and find out reasons of erratic failure, if any.
2. To perform torsion tests for ductile and brittle materials, verify failure criterions for ductile and brittle materials and find out reasons of erratic failure, if any.
3. To find out hardness value (Vickers/Rockwell/Brinell) of the given specimen and interpret the obtained experimental results and use them as a tool for material selection in engineering applications.
4. To understand principle of fatigue testing machine in a reverse loading manner and to find the endurance limit of the given specimen on Fatigue Testing Machine. To construct an S-N curve (stress level - number of cycles to failure) of the test samples provided and interpret the obtained experimental results and use them as a tool for material selection in engineering applications.
5. To prepare a given specimen (mild steel) for micro structural examination. To observe different micro-structures like ferrite, perlite, cementite, austenite, bainite and martensite and study their properties.

Course Outcomes

Students will be able to

- *predict the behaviour of the solid bodies subjected to various types of loading.*
- *design machine elements using theories of deformable bodies.*
- *select material in engineering applications based upon experimental data.*

Note

The internal evaluation will be done by course coordinator. At the end of the semester, viva-voce will be conducted both by internal and external examiners to be appointed by the University.

ME-763 CNC TECHNOLOGY AND PROGRAMMING LAB

L	T	P	Internal Marks	External Marks	Credit
0	**0**	**4**	**30**	**70**	**2.0**

Course Objectives

- *To understand and operate CNC machines.*
- *To create manual part programming on CNC machines.*

List of Experiments

1. To perform basic setup, startup, and safely features in CNC turning, machining and wire-cut EDM machine tools.
2. To select optimum cutters, cutting and spindle speeds, and other parameters of CNC turning, machining and wire-cut EDM machine tools according to tool and work material.
3. To set up cutting tools and part holding devices in CNC turning, machining and wire-cut EDM machine tools for optimal movement of tool and piece.
4. To create manual part programs for least machining time and simulate the tool-path on CNC turning, machining and wire-cut EDM machine tools.
5. To operate CNC turning center, machining center and wire-cut EDM. Load a program and execute actual machining.

Course Outcomes

Students will be able to

- *manually write, edit, debug, and use CNC programs to produce products.*

Note

The internal evaluation will be done by course coordinator. At the end of the semester, viva-voce will be conducted both by internal and external examiners to be appointed by the University.

ME-752 ADVANCED MACHINE DESIGN

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To understand the concept of design and its considerations for manufacturing, assembly, aesthetics, ergonomics, fatigue and creep*.

Unit I

Design Philosophy: Design process, design models,design phases, product design strategies, product design planning and specification, need analysis, concept generation, concept selection, concept testing. Statistical design considerations: Frequency distribution, Histogram and frequency polygon, Normal distribution, Units of measurement of central tendency and dispersion, standard variable -population combinations, Design and natural tolerances

Unit II

Design for Manufacture and Assembly: General considerations in design for casting, forging, machining, powder metallurgy and welding, Design considerations for assembly.

Unit III

Design for aesthetics and ergonomics: Aesthetics considerations in design-Basic types of product forms, designing for appearance –shape, features, materials and finishes, Ergonomic considerations in design display and controls, workspace design, hand tool design, human engineering considerations-Relation between man, machine and environmental factors,

Optimum Product Design: Objective of optimum design, Johnson 's method of Optimum Design (MOD), Optimum design with normal specification of simple machine elements.

Unit IV

Design for fatigue and creep: Static failure theories, Fatigue mechanisms, Design for fatigue strength and life, creep: Types of stress variation, design for fluctuating stresses, design for limited cycles, multiple stress cycles, Fatigue failure theories, cumulative fatigue damage, thermal fatigue and shock, harmful and beneficial residual stresses, yielding and transformation.

Project work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students would be able to

- *design products for manufacturing, assembly, aesthetics, ergonomics, fatigue and creep.*

Books recommended

- Richard G Budynas and Keith J Nisbett, "Shigley's Mechanical Engineering Design", McGraw-Hill Higher Education, 10th edition, 2014.
- Bhandari V., "Design of machine Elements", McGraw Hill Education (India) Private Limited, 3rd edition, 2010.
- William C. Orthwein, "Machine Component Design: v. 1 & 2", Jaico Publishing House, New Ed edition, 2006.
- Robert C. Juvinall and Kurt M. Marshek, "Fundamentals of Machine Components Design", Wiley, 5th edition, 2011.
- Hall A. S., Holowenko A. R. and Laughlin H. G, "Theory and problems of Machine Design", Schaum, 1981.
- Johnson R. C, "Mechanical Design Synthesis with optimization applications", Van Nostrand Reinhold Company, 1st edition 1971.
- Harry Peck, "Design for Manufacture", Pittman Publication, 1983.
- Robert Matousek, "Engineering Design – A systematic approach", Blackie & sons Ltd., 1963.

Blackie & Son Ltd, 1972.
- James G. Bralla, "Design for Manufacturability Handbook", McGraw Hill Co., 2 edition 1998.
- K. G Swift, "Knowledge based design for manufacture", Kogan Page Ltd., 1987.
- Penny R.K. And Marriott D. L., "Design for Creep", 2nd edition 1995.

Note

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ME-754 COMPUTER AIDED DESIGN AND MANUFACTURING					
L	**T**	**P**	**Internal Marks**	**External Marks**	**Credit**
3	**0**	**0**	**30**	**70**	**3.0**

Course Objectives

- *To understand the basic parametric fundamentals that are used to create and manipulate geometric models.*

Unit I

Introduction: Definition and scope of CAD/CAM, Introduction to design process and role of computers in the design process.
Transformations: 2D and 3D transformations.

Unit II

Curves and Surfaces: Analytical, Synthetic curves with advantages, Disadvantages, Comparison with parametric curves, Geometric modeling curves and surfaces, Representation, Wire frame models, Parametric representations, Parametric curves and surfaces.
Solid modeling: Solid models, Fundamentals of solid modeling, Different solid representation schemes, Half -spaces, Boundary representation (B-rep), Constructive solid geometry (CSG).

Unit III

CAD/CAM Data Exchange Formats: Types of file formats & their exchange, Graphics standards.
Simulation: Need of simulation , concept of a system, Model and its purpose , Types of simulation approaches-Event Scheduling Approach (ESA) , Activity Scanning Approach (ASA), Process Interaction Approach (PI A), Steps in a simulation study , advantage s disadvantages and pitfalls of simulation ,Simulation Languages.

Unit IV

Computer Aided Manufacturing : CNC machine tools, principle of operation of CNC, Steps in manufacturing , construction features including structure and drives, Direct numerical control (DNC) and its application, advantages and limitations of CNC systems.
Computer Assisted Part Programming: CNC part programming, axes of CNC machines, manual part programming using G code, use of subroutines, computer aided part programming using APT or any other language, Automatic NC program generation from CAD models, Machining of surfaces, Mould, Casting and Die design and manufacture using CAD/CAM software.

Course Outcomes

Students will be able to

- *create the different wireframe and surface primitives using parametric modeling.*
- *create the different solid primitives using the different representation schemes.*
- *manipulate the created wireframe, surface and solid models.*

Books recommended

- Zeid, I., "CAD/CAM", McGraw Hill, 2008.
- Rogers, D. F. and Adams, J. A., "Mathematical Elements for Computer Graphics", McGraw Hill 2nd edition, 1989.
- Radhakrishnan, P. and Kothandaraman, C. P., "Computer Graphics & Design", Dhanpat Rai Publication", 2nd edition, 2005.
- Krishnamoorathy, C. S. and Rajeev, J. S., "Computer Aided Design (Software and Analysis Tools)", Narosa Publication House, 2nd edition, 2005.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-756 FINITE ELEMENT METHODS					
L	T	P	**Internal Marks**	**External Marks**	**Credit**
3	**0**	**0**	**30**	**70**	**3.0**

Course Objectives

- *To develop the knowledge and skills needed to apply Finite Element Methods to problems in Mechanical Engineering*

Unit I

Introduction: Basic concepts, Historical background, general applicability of the method, general description of FEM, one dimensional problems with linear & cubic interpolation model, derivation of finite element equations using direct approach, comparison with other methods commercial finite element program packages.

Discretization of domain: introduction, basic element shapes, discretization process, node numbering scheme, automatic mesh generation

Unit II

Interpolation Models: Introduction, polynomial form of interpolation functions, simplex, complex and multiplex elements, interpolation polynomial in terms of nodal degree of freedom, selection of order of interpolation polynomial, convergence requirements, linear interpolation polynomial in terms of global coordinates, interpolation polynomial for vector quantities, linear interpolation polynomial in terms of local coordinates, integration of functions of natural coordinates, patch test

Unit III

Higher order and Isoparametric elements: Introduction, higher order one dimensional elements, higher order elements in terms of natural coordinates, Isoparametric elements

Derivation of element matrices and vectors by using direct and weighted residual approach, assembly of element matrices and vector and derivation of system equations, Numerical solution of finite element equations by using Gaussian elimination method.

Unit IV

Applications in heat transfer: Finite element solution of one-dimensional, two-dimensional and three-dimensional steady state heat conduction problems by using Galerkin approach.

Applications in fluid mechanics: Finite element solution of incompressible and compressible fluid film lubrication problems by using Galerkin approach.

Applications in solid mechanics: Finite element solution of three-dimensional elasticity problems by using Galerkin approach.

Course Outcomes

The students will be able to

- *select the different types of element, generate mesh, construct element stiffness matrices, assemble element stiffness matrices, impose boundary conditions, solve the equations and interpret the results for different problems.*
- *apply Finite Element Methods to 1D, 2D, 3D practical engineering problems.*

Books recommended

- Fish, J., and Belytschko, T., "A First Course in Finite Elements", 1st Ed.,John Wiley and Sons (2007)
- Chaskalovic J., "Finite Element Methods for Engineering Sciences: Theoretical Approach and Problem Solving Techniques", 1st Ed., Springer (2008)
- Huebner K.H., Dewhirst, D. L., Smith, D. E., and Byrom, T. G., "The Finite Element Method for Engineers", 4th Ed., Wiley(2008)
- Rao, S.S., "The Finite Element Method in Engineering", 5th Ed., Butterworth-Heinemann (2010)
- Zienkiewicz, O. C., Taylor R.L. and Zhu J.Z., "The Finite Element Method: Its Basis and Fundamentals", 7th Ed., Elsevier, (2013)

- Zohdi T.I., "A Finite Element Primer for Beginners: The Basics" Springer, (2014)

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-758 TOOL ENGINEERING					
L	**T**	**P**	**Internal Marks**	**External Marks**	**Credit**
4	**0**	**0**	**30**	**70**	**4.0**

- *To understand the mechanics of various advanced machining processes including the material removal, tool design, effect of process parameters on the output responses.*
- *To impart depth knowledge on principle involved, accuracy involved, tooling requirement and knowledge about the process capability.*
- *To develop knowledge and skills design of various jigs and fixtures to increase the production rate.*

Unit I

Cutting Tool Materials: Introduction and Desirable Properties, Carbon and Medium-Alloy Steels, High-Speed Steels, Cast-Cobalt Alloys, Carbides, Coated Tools, Alumina-Based Ceramics, Cubic Boron Nitride, Silicon-Nitride Based Ceramics, Diamond, Reinforced Tool Materials, Cutting-Tool Reconditioning

Design of Cutting Tools: Basic Requirements, Mechanics and Geometry of Chip Formation, General Considerations for Metal Cutting, Design of Single Point Cutting Tools, Design of Milling Cutters, Design of Drills and Drilling, Design of Reamers, Design of Taps

Unit II

Gages and Gage Design: Limits Fits and Tolerances, Geometrical Tolerances-Specification and Measurement, Types of Gages, Gage Design, Gage Tolerances, Material for Gages

Work Holding Devices: Basic Requirements of Work Holding Devices, Location: Principles, Methods and Devices, Clamping: Principles, Methods and Devices

Unit III

Design of Drill Jigs: Definition and Types of Drill Jigs, Chip Formation in Drilling, General Considerations in the Design of Drill Jigs, Drill Bushings, Drill Jigs, and Modern Manufacturing

Design of Fixtures: Fixtures and Economics, Types of Fixtures, Milling Fixtures, Boring Fixtures, Broaching Fixtures, Lathe Fixtures, Grinding Fixtures

Unit IV

Design of Sheet Metal Bending, Forming and Drawing Dies, Bending Dies, Forming Dies, Drawing Operations, Variables that Affect Metal Flow during Drawing, Determining Blank Size, Drawing Force, Single and Double Action Draw Dies.

Tool Design for Numerically Controlled Machine Tools: Fixture Design for Numerically Controlled Machine Tools, Cutting Tools for Numerical Control, Tool-Holding Methods for Numerical Control.

Project

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students would be able to

- *understand the mechanics of various advanced machining processes including the material removal, tool design, effect of process parameters on the output responses.*
- *impart depth knowledge on principle involved, accuracy involved, tooling requirement and knowledge about the process capability.*
- *develop knowledge and skills design of various jigs and fixtures to increase the production rate.*

Books Recommended

- Mehta, N. K., "Metal Cutting and Design of Cutting Tools, Jigs & Fixtures" , McGraw Hill Education (India) Private Limited, 2014.
- Cyril Donaldson, George H LeCain, Goold V.C., Joyjeet Ghose , "Tool Design", Tata-McGraw Hill, 2012.

- Jeff Lantrip, John G. Nee, David Alkire Smith, "Fundamentals of Tool Design", Society of Manufacturing Engineers, 2003.
- Jones E.J.H., Town H.C., "Production Engineering: Jig and Tool Design", Butterworth and Co (Publishers) Ltd, 2009.
- Maurice Henry Albert Kempster , "An Introduction to Jig and Tool Design', Maurice Henry Albert Kempster, English Universities Press, 1964.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-760 COMPUTER AIDED DESIGN AND MANUFACTURING LAB

L	T	P	Internal Marks	External Marks	Credit
0	**0**	**4**	**30**	**70**	**2.0**

Course Objectives

- *To use professional CAD software(s) for modeling, analysis and computer assisted manufacturing.*
- *To learn advance machining features on CNC machines.*

List of Experiments

1. Practicing the part modeling, assembly and simulation operations on available CAD package(s).
2. Generating automatic Cutter Location (CL) data from CAD models and post processing for machining on CNC machines.
3. Producing complex cylindrical shaped pieces on CNC machining center with the help of 4^{th}axis.
4. 3-D virtual machining on offline CNC machining center.
5. Creating radial and axial surface profiles by using C-axis and driven tools on CNC turning center.
6. Manufacturing parts on CNC machining center with WinNC.
7. Machining complex parts on CNC wire-cut EDM with ELCAM and ELPULS.
8. Fabrication of 3-D physical part using additive manufacturing technology from 3-D CAD model.

Course Outcomes

Students will be able to

- *use parametric CAD software(s) for geometric modeling, analysis and computer assisted manufacturing of mechanical components.*
- *manually write, edit, debug, and use CNC programs to produce complex profiles on CNC machines.*

Note

The internal evaluation will be done by course coordinator. At the end of the semester, viva-voce will be conducted both by internal and external examiners to be appointed by the University.

ME-762 FINITE ELEMENT METHODS LAB

L	T	P	Internal Marks	External Marks	Credit
0	0	4	**30**	**70**	**2.0**

Course Objectives

- *To provide practical knowledge in finite element methods and to solve practical engineering problems by developing computer program and by using FEM software*

List of Experiments

1. Introduction to basic concepts of programming for FEM problems. To develop the computer program for the addition, multiplication and inverse of matrices.
2. Finite element formulation and analysis of one dimensional problem (direct approach) by developing computer programme.
3. Finite element formulation and analysis of one dimensional problem (Galerkin approach) by developing computer programme.
4. The modeling and analysis two dimensional problems usingfinite element software (ANSYS).
5. The modeling and analysis three dimensional problems usingfinite element software (ANSYS).

Course Outcomes

Students will be able to

- develop the computer program for the *analysis and solution of practical engineering problems.*
- *analyze and solve the practical engineering problems by using the FEM software (ANSYS).*

Note

The internal evaluation will be done by course coordinator. At the end of the semester, viva-voce will be conducted both by internal and external examiners to be appointed by the University.

PROGRAMME ELECTIVE - I

ME-732 ROBOTICS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To introduce the students to the basic terminologies, applications, design specifications, and mechanical design aspects both kinematics and dynamics of industrial robotics/ manipulator along with various types and working of sensors and actuators used in robotic applications*

Unit I

Introduction: Definition of a robot, Economic aspects in robot applications with respect to quality and productivity, Robot classifications and applications.
Robot Elements and Control: Manipulators, Drives, Sensors, End Effectors, Configuration, Force/Torque Relationship, Trajectory Planning, Position Control, Feedback System, Digital Control.

Unit II

Robot Kinematics: Homogeneous co-ordinates and co-ordinate transformations, Forward and inverse kinematics.
Robot Dynamics: Introduction to Lagrangian and Newton-Euler formulations.

Unit III

Linear and Non Linear Control of Manipulators: control law partitioning, trajectory following control, multi input multi output control systems, Cartesian based control scheme.
Force Control of manipulators: hybrid position/force control

Unit IV

Robot in Work Place: Robot Trajectory planning considering velocity and acceleration. Work cell organization in robotics environment, Work cell design and control, Robot vision, Introduction to image processing.
Robot Programming: Robot Programming for Manufacturing and Other Applications, Robot Integration with CAD and CAM.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students would be able to

- *Work individually and/or with an interdisciplinary team for the purpose of manipulator design for a specific need using mechanical kinematic structure along with the understanding of requirements from robotic work cell controller and its programming, for enabling robotic manipulator to work in an integrated automated industrial environment.*
- *Understand, create and demonstrate the technical reports for robotic automation.*

Books recommended

- Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., "Robotics: Control, Sensing, Vision, and Intelligence", McGraw Hill, 1987.
- Schilling, R.J., "Fundamentals of Robotics Analysis and Control", Prentice Hall of India, 2006.
- Craig, J.J., "Introduction to Robotics: Mechanics and Control", prentice Hall, 2004.
- Deb, S.R., "Robotics and Flexible Automation", McGraw Hill, 2004.
- Saha, S.K., "Introduction to Robotics", McGraw Hill, 2008.

- **Note**

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-734 INSTUMENTATION AND MESURING SYSTEMS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *The course is intended to give students a thorough understanding of a measuring system, different transduction principles, error analysis response etc. and various other issues related to instrumentation system.*

Unit I

Generalized Configuration of Measuring System: Functional elements of a basic measuring system; different types of measurands, description of functional elements. Input-output configuration of a measuring system interfering and modifying inputs; methods for correction for interfering and modifying inputs.

Characteristics of Instruments: Objective of studying the characteristics of the instruments. Static characteristics accuracy precision, error, sensitivity, hysterisis, threshold, drift, span, static stiffness etc. Dynamic characteristics - time domain and frequency domain characteristics terms input-output impedance's and meaning of impedance mismatching. Concept of mechanical loading.

Unit II

Response of Instruments: Description of mathematical model for the generalized configuration of a measurement system. Order of the systems, response of zero, first and second order systems of step, ramp and sinusoidal inputs. Transfer function method to study the response of the system.

Errors: Classification of various types of errors and statistical analysis of experimental data.

Unit III

Principles of Transduction and Transducers: Description of various types of transduction principles. Trandducers based on variable resistance, variable inductance, variable capacitance and piezo-electric effects. Displacement transducers - wire wound potentiometers, LVDT, strain gauges, strain gage designation system. Signal conditioners - filters, low, high, band pass and charge amplifiers.

DAS and Signal Analysis: Data acquisition system via computers. The components of Data acquisition system, DAS Hardware, selection criteria for choosing a DAS. Techniques for signal analysis.

Unit IV

Flow Measurement: Flow visualization, shadowgraph; schlieren and interferometric techniques; Pitot static tubes; hot wire anemometers; Laser Doppler velometer; flow measurements using coriolis effect.

Temperature and Heat Flux Measurement: Thermoelectric sensors; electric resistance sensors; thermistors; radiations pyrometers; Temperature measuring problems in flowing fluids, dynamic compensation.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *describe the operation of transducers for strain, acceleration, pressure, temperature, and fluid flow measurement.*
- *select and assemble the components of basic analog and digital data acquisition systems.*
- *apply theoretical analysis of time-varying signals to selection of signal conditioning components.*
- *conduct uncertainty analysis and perform basic statistical treatment of experimental data.*

Books recommended

- Doeblin E. O., "Measurements System Application and Design", 5th Ed., McGraw Hill, 2004.
- Trietly Harry L., Dekker Marcel, "Transducers in Mechanical and Electronic Design", Ist Ed., CRC Press, 1986.
- Beckwith T. G., Marangoni R. D., and Lienhard J. H., "Mechanical Measurements", 6th Ed., Prentice Hall, 2006.
- Eckert E. R. G. and Goldstein R. J., "Measurements in Heat Transfer", 2nd Ed., Springer, 1986.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-736 FLEXIBLE MANUFACTURING SYSTEMS

L	T	P	Internal Marks	External Marks	Credit
4	**0**	**0**	**30**	**70**	**4.0**

Course Objectives

- *Learn the concepts and technologies associated with Flexible Manufacturing System.*

Unit I

Manufacturing Systems: Introduction, Single station manufacturing cells, Manual Assembly lines, Automated Production and Assembly lines. Different types of manufacturing systems.
Manufacturing Automation: Types of Automation systems, Logic Controllers and its applications, Programming of controllers.

Unit II

Flexible Manufacturing System: FMS components, Different types of flexibility in manufacturing, , FMS compared to other manufacturing approaches, Optimization of FMS, FMS applications, FMS planning and implementation.

Unit III

Numerical Control: Fundamentals of NC technology, Computer Numerical Control, Distributed Numerical Control, Applications of NC.
Industrial Robotics: Robot Anatomy, Robot Control System, Sensors, Robot Accuracy and Repeatability.

Unit IV

Cellular Manufacturing: Part classification and coding, production flow analysis, Machine Cell design, Group Technology.
Material Handling and Identification: Material Transport Systems, Storage systems, Automatic Identification.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *design the basic Flexible Manufacturing Systems.*

Books recommended

- Mikell P. Groover**, "**Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Third edition,PHI, 2009.
- Alavala Chennakesava R., "Cad/Cam: Concepts and Applications", PHI, 2008.
- Mikell P. Groover, "Automation, Production Systems, and Computer - Integrated Manufacturing", PHI, 2008
- S. Joshi , Jeffrey Smith, "Computer control of flexible manufacturing systems: Research and development", Springer; 1994.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME- 738 MECHATRONICS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *The course deals with basic principles of Mechatronics involving sensors, actuators, control systems, and microprocessor systems. The aim of this course to make a bridge between Mechanical, Electronics, Instrumentation, Computer and Controls field.*

Unit I

Introduction: Definition of mechatronics, measurement system, control systems, microprocessor based controllers, mechatronics approach.

Sensors and Transducers: Sensors and transducers, performance terminology, photoelectric transducers, flow transducers, optical sensors and transducers, semiconductor lasers, selection of sensors, mechanical / electrical switches, inputting data by switches.

Unit II

Actuators: Actuation systems, pneumatic and hydraulic systems, process control valves, rotary actuators, mechanical actuation systems, electrical actuation systems.

Signal Conditioning: Signal conditioning, filtering digital signal, multiplexers, data acquisition, digital signal processing, pulse modulation, data presentation systems.

Unit III

Microprocessors and Microcontrollers: Microcomputer structure, microcontrollers, applications, programmable logic controllers.

Modeling and System Response: Mathematical models, bond graph models, mechanical, electrical, hydraulic and thermal systems, dynamic response of systems, transfer function and frequency response, closed loop controllers.

Unit IV

Design and Mechatronics: Input/output systems, computer based modular design, system validation, remote monitoring and control, designing, possible design solutions, detailed case studies of mechatronic systems used in photocopier, automobile, robots.

DAS and Signal Analysis: Data acquisition system via computers. The components of Data acquisition system, DAS Hardware, selection criteria for choosing a DAS. Techniques for signal analysis.

Project Work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students would be able to

- *understand the basic elements of any Mechatronic device.*
- *develop the mathematical model of any physical model from any engineering domain.*
- *understand the key inputs and outputs of any physical device, different sensors and transducers to measure the outputs, interfacing of the sensors and actuators to the computers.*
- *study and design different controllers to obtain the desired performance from the system.*

Books recommended

- Bolton, W., "Mechatronics", Longman, 1999.
- Alciatore, D. G. and Histrand, M. B., "Introduction to Mechatronics", Tata McGraw Hill, 2003.
- Shetty, D. and Richard, A.K., "Mechatronics System Design", PWS Pub. Boston, 1997.
- Mahalik, N., "Principles, Concept and Applications: Mechatronics", Tata McGraw, 2003.
- Bishop, R.H. "Mechatronics Handbook", CRC Press, 2002.
- Anslander, D. M. and Kampf, C. J., "Mechatronics: Mechanical System Interfacing", Prantice Hall, 1995.
- Alciatore, D. G. and Histand, M. B., "Introduction to Mechatronics and Measurement System", McGraw Hill, 1999.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-765 TRIBOLOGY

L	T	P	Internal Marks	External Marks	Credit
3	0	0	30	70	3.0

Course Objectives

- *The course has been designed to give an understanding of tribological phenomena, industrial lubricants and additives.*

Unit I

Introduction: History of Tribology, Introduction to Friction, Wear and Lubrication, economic aspects of Tribology.

Friction: Laws of static friction, causes of friction, Adhesion, Adhesion theory, laws of rolling friction

Wear: Wear definitions, types of wear mechanisms: Adhesive wear, Abrasive wear, Fatigue wear, impact wear, Corrosive war, Fretting wear.

Unit II

Physical Properties of Lubricants: Introduction, Oil viscosity, Viscosity temperature relationship, Viscosity index, Viscosity pressure relationship, Viscosity-shear rate relationship, Viscosity measurements, Viscosity of mixtures, Oil viscosity classification, Lubricant density and specific gravity, Thermal properties of lubricants, Temperature characteristics of lubricants, Other lubricants characteristics, Optical properties of lubricants, Additive compatibility and solubility, Lubricant impurities and contaminants, Solubility of gases in oils.

Lubricants and Their Composition: Introduction, Mineral oils, Synthetic oils, Emulsions and aqueous lubricants, Greases, Lubricant additives.

Unit III

Fluid Film Lubrication: Regimes of fluid film lubrication, Hydrodynamic Lubrication; Introduction, Generalized Reynolds equation, Converging-diverging wedges, Journal bearings, Thermal effects in bearings, Limits of hydrodynamic lubrication, Hydrodynamic lubrication with non-Newtonian fluids, Reynolds equation for squeeze films, Porous bearings. Hydrostatic Lubrication; Basic concepts, Aerostatic bearings, Hybrid bearings, Stability of journal bearings.

Unit IV

Bearing Materials: Selection of bearing materials, Metal bearings, Nonmetal bearing materials

Future Directions in Tribology: Biotribology-basic concepts; Nanotribology-basic concepts; Environmental implications of Tribology.

Course Outcomes

The students will be able to

- *to understand the interdisciplinary subject 'Tribology' and its technological significance*
- *to understand the genesis of friction and wear*
- *to learn about the principles of lubrication, lubrication regimes, hydrodynamic lubrication and hydrostatic lubrication*
- *to learn about emerging areas such as bio Tribology and micro/nano Tribology*

Books recommended

- Conner, J.J. and Boyd, J., "Standard Handbook of Lubrication Engineering", McGraw Hill (1968)
- Khonsari, M. M. and Booser, E. R., "Applied Tribology: Bearing Design and Lubrication", 2nd Ed, Wiley (2008)
- Kudish, I. I. and Covitch, M. J., "Modeling and Analytical Methods in Tribology", Chapman and Hall/CRC (2010)
- Bhushan, B., "Principles and Applications of Tribology", 2nd Ed., Wiley (2013)
- Stachowiak, G.W. and Batchelor, A. W., "Engineering Tribology", 4th Ed, Butterworth-Heinemann (2013)
- Wyong B., "Tribology: Engineering Applications", NY Research Press (2015)

Note
In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-767 TRIBOLOGY LAB

L	T	P	Internal Marks	External Marks	Credit
0	0	4	30	70	2.0

Course Objectives

- *To learn about tribotesting and experimental techniques in Tribology and analysis of real time results.*

List of Experiments

1. To perform experiment on the journal bearing test rig for the measurement of Pressure and Temperature distribution in the fluid film of hydrodynamic journal bearings at different loads and speeds. To analyze the real time results obtained through data acquisition system for predicting the performance characteristics of bearing.
2. To perform experiment on the journal bearing test rig for investigating the fluid film thickness of hydrodynamic journal bearings at different loads and speeds. To analyze the real time results obtained through data acquisition system for predicting the performance characteristics of bearing.
3. To measure the frictional torque in hydrodynamic journal bearings at different loads and speeds on journal bearing test rig. To analyze the real time results obtained through data acquisition system for predicting the performance of bearing.
4. To determine wear preventive (WP) and extreme pressure(EP) behavior of lubricants on four ball tester and to measure viscosity of lubricants with the help of viscometer . To analyze the real time results obtained through data acquisition system for predicting behavior of lubricants.
5. To determine the friction and wear characteristics in sliding contacts under various normal loads and speeds on wear and friction monitor. To analyze the real time results obtained through data acquisition system for predicting tribological characteristics.
6. The modeling and analysis hydrodynamic/hydrostatic bearings using software (ARMD).

Course Outcomes

Students will be able to

- *predict the performance characteristics of hydrodynamic journal bearings experimentally.*
- *determine the behaviour of lubricants under different operating conditions.*
- *predict the friction and wear characteristics under different loads.*
- *analyze and predict the performance characteristics of hydrodynamic/hydrostatic journal bearings using software (ARMD).*

Note

The internal evaluation will be done by course coordinator. At the end of the semester, viva-voce will be conducted both by internal and external examiners to be appointed by the University.

ME-769 SEMINAR				
L	**T**	**P**	**Internal Marks**	**Credit**
0	**0**	**4**	**100**	**2.0**

Course Objectives

- *To prepare students for the method of literature survey, realization of journal papers outcomes, expose them to the world of research and compilation/review of a research area of current era and prepare them for presentation of literature summary.*
- *Presentation on advanced topics in the field of Mechanical Engineering.*

Course Work

The topic of the seminar will be related to the current research & development in the field of Mechanical Engineering. Each student is required to submit a report on the topic of seminar as per the guidelines decided by the department from time to time.

Course Outcomes

Students will be able to

- *expose themselves to the world of research*
- *review of a research area of current era*

Note

The internal evaluation will be done by course coordinator. During the semester, each student is required to give a presentation before the class and course coordinator.

ME-771 THESIS (STARTS)				
L	**T**	**P**	**Internal Marks**	**Credit**
0	**0**	**6**	**100**	**3.0**

Course Objectives

- *To identify research issue/problem on advance engineering topics related to Mechanical Engineering.*
- *To gain knowledge on the research problems identified through extensive literature survey.*
- *To understand the tools required to carry out research work.*

Course Work

The Thesis work should be of research nature only. During the third semester, following must be carried out by the student:

- Literature Survey
- Problem Formulation

Thesis work will be started during the third semester and must be continued in fourth semester. Around 35% of the Thesis work should be completed in this semester. The remaining 65% work will be carried out in the fourth semester.

Course Outcomes

Students will be able to:

- *gain knowledge on the research problems identified through extensive literature survey.*
- *understand professional & ethical research issues.*
- *present effectively the research topic through synopsis presentation.*

Note

The internal evaluation will be through synopsis presentation and viva-voice before the faculty members of the department. Each student is required to submit a detailed synopsis report about the work done on topic of Thesis.

PROGRAMME ELECTIVE - II

ME-731 OPTIMAL DESIGN OF THERMAL SYSTEMS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To know and understand the different thermal systems and to get familiar with their design, thermal modeling, objectives, simulation, and economic analysis.*
- *To understand the optimization, its role, and methods in the analysis and design of various types of thermal systems and equipment's.*

Unit I

Engineering design: Introduction, engineering design, design as part of engineering undertaking, workable and optimum systems, Basic considerations in design: formulation of the design problem, conceptual design, steps in the design process, computer aided design.
Economic analysis: Calculation of interest, worth of money as a function of time, series of payments, depreciation.

Unit II

Modeling of thermal systems: Types of models, modeling of heat exchangers, evaporators and condensers, mathematical modeling.
Equation fitting: Method of least squares and the art of equation fitting, physical modeling and dimensional analysis.

Unit III

Numerical modeling and simulation: Numerical modeling, system simulation, methods for numerical simulation.
Acceptable design of thermal systems: Initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems.

Unit IV

Optimization: Optimization in design, levels of optimization, basic concepts, practical aspects in optimal design, mathematical representation and statement of the optimization problem, practical aspects in optimal design.
Optimization methods: Lagrange multipliers, search methods, and geometric programming.

Project work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *understand about the thermal interactions and its role in many like processes and to develop the means to tackle the various thermal problems.*
- *design and selection of the materials/equipments for a particular application based upon its thermal response and to analyze and optimize the thermal problems.*

Books recommended

- W. F. Stoecker, "Design of Thermal Systems", McGraw-Hill, 3rd ed. 2014.
- Y. Jaluria, "Design and Optimization of Thermal Systems", CRC Press, 2nd ed. 2008.
- A. Bejan, G. Tsatsaronis and M. J. Moran, "Thermal Design and Optimization", John Wiley and Sons, 2012.
- N. Suryanarayana and O. Arici, "Design and Simulation of Thermal System", McGraw-Hill, 2002.
- Robert F. Boehm, "Development in the Design of Thermal Systems", Cambridge University Press, 2009.
- C. Balaji, "Essentials of thermal system design and optimization", CRC Press, 2011.
- William S. Janna, "Design of fluid thermal systems", Cengage learning, 3rd ed., 2011.

Note
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ME-733 COMPUTATIONAL FLUID DYNAMICS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To impart the knowledge of governing equations for fluid flow.*
- *To learn about the Numerical methods used to solve the partial differential equation.*
- *To solve the fluid flow problem using CFD analysis.*

Unit I

Introduction: History of CFD, Motivation and role of computational fluid dynamics, Concept of modeling and simulation, Experimental and Computational Methods. Recent Advances in Computational Techniques.
Governing Equations of Fluid Dynamics: Introduction, Models of flow, The substantial derivatives, Divergence of velocity, Continuity equation, Momentum equation, Energy equation, Physical boundary conditions.

Unit II

Nature of Equations: Classification of PDE, General behavior of parabolic, Elliptic and hyperbolic equations, Boundary and initial conditions.
Discretization Techniques: FDM,FVM and FEM, Introduction to Finite Difference, Discretization, Difference equations, Explicit and Implicit approaches, errors and an analysis of stability.
Grids with appropriate transformations: Introduction, General transformation of equations, Metrics and jacobians, Stretched grid, Elliptic Grid, adaptive grid, Modern developments in grid generation and Finite volume mesh.

Unit III

Basics of fluid dynamics, CFD Techniques: Introduction, Lax Wendroff Techniques, Mac Cormack's Technique, Relaxation technique, ADI Technique
Pressure correction Technique and its application to Incompressible Viscous flow, SIMPLE Algorithm

Unit IV

Numerical Solution to Heat Conduction Problems:
Steady-state and Unsteady-state Problems: (i) One-dimensional Heat Conduction Transfer through a Pin-fin (ii) Two-dimensional Conduction through a plate, One dimensional Transient Heat Conduction.
Numerical solution to internal and external flow problems eg. Incompressible Couette Flow using (a) Crank Nicholson solution (b) Pressure correction Technique etc.
Commercial and freely available tools for CFD analysis, Steps to solve a problem using any software, grid independence test

Project work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *acquire adequate knowledge of various types of fluid flow governing equations.*
- *analyze the internal fluid flow phenomena of any Engineering system.*
- *acquire enough knowledge to design of the Engineering systems using computational fluid dynamics.*

Books Recommended

- Anderson, J. D. ,"Computational Fluid Dynamics: The Basics with Applications.", McGraw-Hill. Inc., New York, 1995.
- Pletcher, R. H., Tannehill, J. C., & Anderson, D. ,"Computational fluid mechanics and heat transfer", CRC Press, 2012.
- Patankar, S.," Numerical heat transfer and fluid flow", CRC Press, 1980.
- Chung, T. J. ,"Computational fluid dynamics", Cambridge university press, 2010.
- Ghoshdastidar, P. S., "Computer Simulation of flow and heat transfer". Tata McGraw-Hill Publishing Company Limited, 1998.
- Jaluria, Y. , " Computational heat transfer", CRC Press, 2002.

- Wendt, J. (Ed.).,"Computational fluid dynamics: an introduction", Springer Science & Business Media, 2008.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-735 ADVANCED THERMODYNAMICS

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To impart knowledge on the fundamentals of theory of energy, its quality and significance for the applications of thermal systems. To impart knowledge on the analysis of simple compressible and multicomponent systems.*
- *To impart knowledge on the different thermodynamic property relations, applications, power, refrigeration cycles and use of thermodynamics in daily life.*

Unit I

Basic concepts, work, heat, and first law of thermodynamics: Macroscopic and microscopic views, state, property, interaction by contact, work, the first law, heat, energy, and characteristics of an object.
The second law of thermodynamics: Reversible process, Caratheodory's formulation, entropy, entropy change in an irreversible process, corollaries of second law, and applications.

Unit II

Analysis of simple compressible systems and other simple systems: Basic governing equations, thermodynamic relations, equation of state, cubic equations, generalized compressibility chart, and applications.
Analysis of open systems, exergy and irreversibility: Conservation of mass and energy, steady and transient states, maximum work potential of open and closed systems, exergy analysis of simple processes, and heat engines producing maximum power.

Unit III

Multicomponent systems: Fundamental property relationships, partial molar properties, equation of state for mixtures, chemical potential, and fugacity.
Phase equilibrium in multicomponent and reactive mixtures: Conditions for equilibrium, analysis phase equilibrium, stability, mass balance, first law analysis, second law analysis, work potential of a chemical reaction, chemical exergy.

Unit IV

Power and refrigeration cycles: Periodic heat engines, vapor power cycles, and gas power cycles, modified vapor compression cycles, actual vapor compression cycles, gas refrigeration and absorption refrigeration cycles.
Non equilibrium thermodynamics and thermodynamics in daily life: Basic postulates, thermoelectric phenomenon, thermal diffusion, the first and second law in daily life.

Project work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *understand theoretical principles of energy and exergy analysis, behavior of real and ideal gases, thermodynamic property relations and reactive systems.*
- *analyze thermodynamic processes in daily routine life and in various industries.*

Books recommended

- Dhar, P.L, "Engineering Thermodynamics- a generalized approach", Elsevier Ltd., 1st ed. 2008.
- A. Bejan, "Advanced Engineering thermodynamics", John Wiley and Sons, 3rd ed. 2006.
- G. Rogers and Y. Mayhow, "Engineering thermodynamics", Prentice Hall, 4th ed. 1996.
- R. Balmer, "Modern Engineering thermodynamics", Academic Press, 1st ed. 2010.
- Y.A. Cengel & M. A. Boles, "Thermodynamics: An engineering approach", TMH Publishing Company Ltd., 2006.
- O.J. Bevan & B.J. Juliana, "Chemical thermodynamics: principles and applications", Elsevier Ltd., 1st ed. 2005.
- M. S. Moran & H. N. Shapiro, "Fundamentals of Engineering thermodynamics", John Wiley & Sons,

1988.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME- 737 HEAT EXCHANGER ANALYSIS AND DESIGN

L	T	P	Internal Marks	External Marks	Credit
4	0	0	30	70	4.0

Course Objectives

- *To study and understand the role of different types of heat exchangers, their design, functioning and related concepts.*

Unit I

Classification of heat exchangers, temperature distribution for parallel flow, counter flow, cross flow heat exchangers, evaporators and condensers, concept of LMTD and overall heat transfer coefficient.
Fouling of heat exchangers, NTU method for gauging exchanger performance, LMTD for parallel, counter and cross flow heat exchangers, effectiveness for parallel and counter flow exchangers.

Unit II

Important design considerations: material selection and optimization of heat exchangers, analysis of regenerative heat exchangers. Vibrations induced by flow, International Standards for heat exchangers.
Compact heat exchangers, thermal and mechanical design of: Shell & tube heat exchangers, Double pipe, Extended surface, Condensers & evaporators.

Unit III

Heat Exchanger Pressure Drop Analysis, Importance of Pressure Drop, Fluid Pumping Devices, Major Contributions to the Heat Exchanger Pressure Drop, Assumptions for Pressure Drop Analysis. Extended Surface Heat Exchanger Pressure Drop. Regenerator Pressure Drop.
Heat transfer augmentation in heat exchangers using active and passive techniques.

Unit IV

Selection of Heat Exchangers and their Components on the basis of operating conditions, General Selection guidelines for major exchanger types (shell and tube type, Plate heat exchanger, Extended surface exchanger etc.), Modeling of heat exchanger based on first law of thermodynamics
Energy, Exergy, and Cost Balances in the Analysis and Optimization of Heat Exchangers, Performance Evaluation Criteria Based on the Second Law of Thermodynamics
Applications of heat exchangers in various industries (automobile, electronic, process, chemical etc.)

Project work

Students are required to carry out a project related to the course contents. The topic of the project will be selected in consultation with course coordinator. The project report will be submitted at the end of semester. The evaluation will be done internally by the course coordinator.

Course Outcomes

Students will be able to

- *aquire adequate knowledge about working and design concepts of heat exchanger.*
- *analyze the heat transfer & pressure drop analysis.*
- *aquire adequate knowledge about heat transfer augmentation Techniques used in heat exchangers*

Books recommended

- Shah, R. K., & Sekulic, D. P. "Fundamentals of heat exchanger design" John Wiley & Sons, 2003.
- Kakaç, S., Shah, R. K., & Aung, W. (Eds.)., "Handbook of single-phase convective heat transfer (pp. 7-1)", New York et al.,Wiley. 1987.
- Fraas, A. P., "Heat exchanger design", John Wiley & Sons, 1989.
- Bejan, A., "Second law analysis in heat transfer", Energy, 5(8), 720-732, 1980.
- Webb, R. L., & Kim, N. H., "Principles of enhanced heat transfer", Taylor Francis: New York, NY, USA 1994.
- Kakac, S., Liu, H., & Pramuanjaroenkij, A., "Heat exchangers: selection, rating, and thermal design", CRC press, 2012.
- Kreith, F., Manglik, R., & Bohn, M., "Principles of heat transfer", Cengage learning, 2010.
- Hewitt, G. F., Shires, G. L., & Bott, T. R., "Process heat transfer (Vol. 113)". Boca Raton, FL: CRC press, 1994.
- Bejan, A., "Convection heat transfer", John wiley & sons, 2013.

Note

In the semester examination, nine questions are to be set by the examiner. Question No. 1 will be compulsory and based on the entire syllabus (all four units). It will contain seven short answer type questions, each of two marks. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt other four questions by selecting one from each of the four units.

ME-772 THESIS				
L	**T**	**P**	**External Marks**	**Credit**
0	**0**	**18**	**100**	**9.0**

Course Objectives

- *Ability to bring ideas into practice through simulation of analysis of research topic.*
- *Ability to identify specific industrial problems in the form of research objectives.*
- *Ability to propose a novel idea/modified technique/new interpretation after analyzing the existing research work.*

Course Work

Around 35% of the Thesis work is required to be completed in third semester. The remaining 65% work will be carried out in this semester. Each student is required to submit a detailed Thesis report about the work done (III Sem + IV Sem) on the topic of Thesis.

One paper in national/international conference/journal of repute is required before submission of thesis. Research work should be carried out at GJUS&THisar. However, candidate may visit research labs/institutions with the due permission of Chairperson on recommendation of supervisor concerned.

Course Outcomes

Students will be able to

- *contribute in the Research and Development*
- *upgrade knowledge of scientific community and society in general through their research.*

Note

Thesis evaluation and viva-voice will be carried out by the internal and external examiners appointed by the University.