SGT University, Chandu-Budhera, Gurugram
Faculty of Engineering & Technology
Department of Mechanical Engineering

M. Tech. Mechanical Engineering
Scheme & Syllabus (2017-18)

Vision of SGT University

"Driven by Research & Innovation, we aspire to be amongst the top ten Universities in the Country by 2022"

Vision of the Department

Department endeavors to be recognized globally through outstanding education & research that produces qualified engineers who are ready to cater the everchanging industrial and social demands.

Mission of the department

- To create environment conducive for the quality teaching-learning interdisciplinary research and innovation.
- To establish academic system facilitating real learning in Mechanical Engineering.
- To prepare the graduates be leader in the profession.
- To inculcate universal human values, professional ethics and life-long learning attitude.
- To empower the learners to device their own unique path of education for acquiring multi specializations and skills.

Program Specific Outcomes

- **PSO1** To broaden and deepen the knowledge base with philosophical temperament and attitude by providing research environment for mechanical and allied engineering. To equip the students with integrity and ethical values so that, they become responsible technocrats around the globe.
- **PSO2** To brace the students with latest development and trends of technology in the area of interest by making the M. Tech. teaching scheme elective to facilitate the students to decide on the broad area of specialisation.
- **PSO3** To develop and enhance the research approach with a fair degree of novelty by practical skills to design experimentation, data acquisition and presentation, data reduction and interpretation by a full semester dissertation work based on a research problem.

Program Educational Objectives (PEOs)

- **PEO1** Acquire in depth knowledge in optimisation techniques for various manufacturing process.
- **PEO2** Achieve expertise in industrial automation design and development.
- **PEO3** Foster frontier technological research in thermal science and engineering area.
- **PEO4** Undertake design of machines/components/process to meet desired specifications of need and constraints.
- **PEO5** Undertake challenges in design and development related to industrial engineering put forth by the academia and industry.

Program Outcomes (POs)

- **PO1** An ability to independently carry out research /investigation and development work to solve practical problems of Mechanical Engineering.
- **PO2** An ability to write and present a substantial technical report/document
- **PO3** Students should be able to demonstrate a degree of mastery in the area of Mechanical Engineering. The mastery should be at a level higher than the requirements in the bachelor program of Mechanical Engineering

- **PO4** An ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data for the solution of complex problems of manufacturing industries/institutions

- **PO5** An ability to develop and apply computer-based software and hardware tools for the analysis of problems related to mechanical design, manufacturing and automation fields.

- **PO6** An ability to apply the acquired knowledge to assess societal, safety, ethical issues and subsequently design / develop mechanical equipment's and systems

Curriculum for M.Tech. (Mechanical Engineering) Program

Semester Wise Course Structure

First Semester

S.NO.	Subject Code	Course Title	L	T	P	C	Examination marks		Subject Total
							Int.	Ext.	
1	13140101	Computer Aided Engineering	3	-	-	3	50	100	150
2	13140102	Numerical & Optimization Methods	3	-	-	3	50	100	150
3	13140103	Production & Operations Management	3	-	-	3	50	100	150
4	13140104	Advanced Design Of Mechanical Systems	3	-	-	3	50	100	150
5	13140105	Advanced Fluid Mechanics	3	-	-	3	50	100	150
6	13140106	Computer Aided Engineering Lab	-	-	2	1	50	50	100
7	13140107	Numerical & Optimization Methods Lab	-	-	2	1	50	50	100
		Total	**15**		**4**	**17**	**350**	**600**	**950**

Second Semester

S.NO.	Subject Code	Course Title	L	T	P	C	Examination marks		Subject Total
							Int.	Ext.	
1.	13140201	Modeling And Simulation Of Manufacturing System	4	-	-	4	50	100	150
2.	13140203	Vibration And Condition Monitoring	3	-	-	3	50	100	150
3.	13140204	Advanced Heat Transfer	3	-	-	3	50	100	150
4.		Elective I	3	-	-	3	50	100	150
5.		Elective II	3	-	-	3	50	100	150
6.	13140205	Manufacturing Simulation Lab	-	-	2	1	50	50	100
7.	13140207	Vibration And Condition Monitoring Lab	-	-	2	1	50	50	100
		Total	**15**	**-**	**4**	**18**	**350**	**600**	**950**

S. No.	Elective-I		S. No.	Elective-II	
1.	13140208	Advanced Mechanics Of Solids	1.	13140211	Robotics Engineering
2.	13140209	Analysis Of Manufacturing Processes	2.	13140212	Reliability Based Design
3.	13140210	Statistics For Decision Making	3.	13140213	Computational Fluid Dynamics

Curriculum for M.Tech. (Mechanical Engineering) Program

Semester Wise Course Structure

Third Semester

S.NO.	Subject Code	Course Title	L	T	P	C	Examination marks		Subject Total
							Int.	Ext.	
1.	13140301	Computer Integrated Manufacturing System	3	-	-	3	50	100	150
2.	13140302	Mechatronics	3	-	-	3	50	100	150
3.		Elective III	3	-	-	3	50	100	150
4.	13140303	Mechatronics & CIM Lab	-	-	2	1	50	50	100
5.	13140304	Dissertation (Phase I)	-	-	6	3	100	-	100
6.	13140305	Seminar	-	-	4	2	50	-	50
		Total	**9**	**-**	**12**	**15**	**350**	**350**	**700**

S.NO.	Elective-III	
	13140306	Mechanism And Manipulator Design
	13140307	Tribology
	13140308	Advance Operation Research
	13140309	Technology & Manufacturing Strategies
	13140310	Hydraulic & Pneumatic Systems
	13140311	I.C. Engines Process Modeling

Fourth Semester

S.NO.	Subject Code	Course Title	L	T	P	C	Examination marks		Subject Total
							Int.	Ext.	
1.	13140401	**Dissertation**	**-**	**-**	**20**	**20**	**100**	**100**	**200**
	Overall Total Credits = I to IV= 70								

	Computer Aided Engineering	Learning Schedule			
		L	T	P	C
	Pre-requisites: Basics of CAD	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

CAD is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. Students learn the importance of CAD/CAM principles in the Product development, programs related to manufacturing using codes and analyze the importance of networking in manufacturing environment.

COURSE OBJECTIVES

1. To understand the basics of CAD/CAM and concepts of computer graphics.
2. To learn about the geometric issues concerned to the manufacturing and its related areas.
3. To understand the latest advances in the manufacturing perspectives and their applications.

COURSE OUTCOMES

1. To understand the importance of CAD/CAM principles in the Product development.
2. To develop programs related to manufacturing using codes.
3. To analyze the importance of networking in manufacturing environment.

COURSE CONTENTS

Unit-I: Overview of CAD/CAM Systems

CAD/ CAM contents and tools, CAD/ CAM market trends, definition of CAD/ CAM tools, Industrial look at CAD/ CAM, CAD/ CAM Hardware, CAD/ CAM Software, Microcomputer Based CAD/CAM.

Unit-II: Geometric Modeling & Graphics Concepts

Types and Mathematical Representations of Curves, Parametric representation, Mathematical Representations of surfaces and Solids, Two and Three Dimensional Graphics Concepts: Geometrical Transformations, Visual Realism, CAD/ CAM Data Exchange.

Unit-III: Design Applications

Introduction of Finite Element Modeling and Analysis, General procedure of FEM, Development of integral equations, Discretization, Elements equations and Assembly, Imposing boundary conditions and applied loads, Solution of Global Equations, Convergence of FE solutions, Isoparametric element matrices, shape functions, FE modeling, design and engineering applications.

Unit-IV: CAD and CAM Integration

Review of NC and CNC Technology, Part Programming and Manufacturing, Integration requirements, Process Planning: Manual, Variant, Generative and hybrid approach, Geometric modeling for Process Planning, Part Programming: fundamentals of NC, Basics of NC programming, NC programming languages, Tool Path generation and verification

Books Recommended:

1. CAD/ CAM Computer-Aided Design and Manufacturing by M. Groover and E. Zimmer, Pearson.
2. CAD/ CAM Theory and Practice by Zeid, McGraw Hill
3. Mathematical Elements for computer Graphics by David F. Rogers and J. Alan Adams, McGraw Hill, New York

4. CAD/ CAM (Principles, Practice & Manufacturing Management) by Chirs McMohan & Jimmie Browne, Published by Addison- Wesley.
5. CAD/CAM Principles and Applications by P N Rao, TMG

	Numerical & Optimization Method	Learning Schedule			
		L	T	P	C
	Pre-requisites: Numerical Methods and Computational Techniques	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Numerical methods are extremely powerful problem solving tools .These tools are capable of handling large system of equations, nonlinearities and complicated geometries that are not uncommon in engineering practice and that are often impossible to solve analytically. Numerical methods are an efficient vehicle for learning to use computer. The course starts with the introduction of various types of errors and their sources that are encountered in implementation of these techniques. Students learn various methods in solving non linear equations and very large system of linear equations in the situation when analytical methods fail. They also learn to apply various interpolating methods along with the trade off in using them. Various available techniques for differentiation and integrations are discussed. Numerical solution of differential equations (Ordinary as well as Partial), that are often encountered when a dynamic system is modeled, is explained with special emphasis on standard equations such as heat equation, wave equation and Laplace equation. The practice session in computer Lab gives students an opportunity to learn the development of the code in C/C++ for implementation of these methods on a variety of problems.

COURSE OBJECTIVES

To enhance problem solving skills of engineering students using a powerful problem solving tool namely numerical methods. The tool is capable of handling large systems of equations, nonlinearities and complicated geometries that are common in engineering practice but often impossible to solve analytically.

COURSE OUTCOMES

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

1. Apply various numerical methods and appreciate a trade off in using them.
2. Understand the source of various types of errors and their effect in using these methods.
3. Distinguish between Numerical and Analytical methods along with their Merits and demerits.
4. Understand the use of digital computers in implementation of these methods.
5. Develop a code in C/C++ for the solution of problems that may not be solved by analytical methods.

COURSE CONTENTS

Unit-I: Errors in Numerical Calculations

Introduction, Numbers and their accuracy, Absolute, relative and percentage errors and their analysis, General error formula.

Interpolation and Curve Fitting

Taylor series and calculation of functions, Introduction to interpolation, Lagrange approximation, Newton Polynomials, Chebyshev Polynomials, Least squares line, curve fitting, Interpolation by spline functions.

Unit-II: Numerical Differentiation and Integration

Approximating the derivative, Numerical differentiation formulas, Introduction to Numerical quadrature, Newton-Cotes formula, Gaussion-Quadrature

Solution of Linear Systems and Nonlinear Equations
Direct Methods, Gaussian elimination and pivoting, Matrix inversion, UV factorization, iterative methods for linear systems, Bracketing methods for locating a root, Initial approximations and convergence criteria, Newton-Raphson and Secant methods

Unit-III: Solution of Differential Equations
Introduction to differential equations, Initial value problems, Euler s methods, Runge-Kutta methods, Taylor series method, Predictor- Corrector methods, Finite-difference method

Partial Differential Equations, Eigen Values and Eigen Vectors
Solution of hyperbolic, parabolic and elliptic equations, eigen value problem, Power and inverse power methods, Jacobi s method for eigen value problems.

Unit-IV: Optimization Methods
Optimal problem formulation, Engineering optimization problems; optimization algorithms: Single-variable optimization algorithms, optimality criteria, Bracketing
methods, Region-elimination methods, Point estimation method,

Multi-Variable Optimization Algorithms
Optimality criteria, Uni-directional search, Direct search methods: Evolutionary methods, Simplex search method, Gradient based methods: Cauchy s method, Newtons method, Application to Mechanical Engg. Problems, Non- traditional optimization algorithms, Genetic algorithms (GA), GA for constrained optimization, other GA operators, Multi objective Optimization, Concept of Pareto Optimality, Global optimization.

Books Recommended:

1. Numerical Methods for Mathematics, Science and Engineering by John H.Mathews, PHI New Delhi.
2. Applied Numerical Methods Carnahan, B.H., Luthar, H.A. and Wilkes, J.O., Pub.- J. Wiley, New York
3. Numerical Solution of Differential Equations, by M.K. Jain, Published by Wiley Eastern, New York.
4. Introductory Methods of Numerical Analysis by S.D. Sastry, Published by Prentice Hall of India.
5. Numerical Methods Hornbeck, R.W., Pub.- Prentice Hall, Englewood Cliffs, N.J.
6. Optimization for Engineering Design : Algorithms and Examples by Kalyanmoy Deb, PHI new Delhi
7. Numerical Optimization Techniques for Engineering Design: With Applications by GarretN.
8. Vanderplaats,Mcgraw Hill Series in Mechanical Engineering
9. Genetic Algorithms and Engineering Optimization by Mitsuo Gen, Runwei Cheng, John Wiley & Sons
10. Global Optimization in Engineering Design, by Ignacio E. Grossmann, Kluwer Academic Publisher
11. Optimization Concepts and Applications in Engineering, by Ashok D. Belegundu , Tirupathi R.Chandrupatla, Cambridge University Press, USA

		L	T	P	C
	Pre-requisites: Production Technology	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Any or every organization is a system of operations, whether or not called 'operations'. Ultimate goal or purpose of such a system being production of goods and/or services and to carry them tills the point of time and place of consumption. Therefore operations management involves everything an organization does and hence every manager is an operations manager. Production and Operations Management (POM) focuses on carefully managing the processes to produce and distribute products and services." Conventionally speaking Major, overall activities under POM, include product creation, development, production and distribution. Major functions of POM include Managing purchases, Inventory control, Quality control, Storage, Logistics and Evaluations. Focus will be efficiency and effectiveness of the processes. Keeping in view profile of the participants in this batch, this course will chart upon a different approach, specially customized for this particular batch of students. Production and Operation Management is a subject relevant to all levels of the hierarchy in an organization, but in this course, in addition to covering usual topics like routine functions of POM which are relevant mainly for the operator level staff/officials; a major amount of effort and time will be spent on high level functions and sub-functions of POM relevant to creating or gearing up the Organizational set-up to the Global standards.

COURSE OBJECTIVES

One of the most critical areas for success in any business enterprise is how Production and Operations are managed. In the 'Productions and Operations Management' course an attempt will be made to integrate the courses studied by the students like statistics, economics, finance, organizational behavior and strategy into a consolidated production and operation related decisions

COURSE OUTCOMES

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

1. Understand the Production Base.
2. Understand the Financial (Cost) Performance.
3. Understand the Technical and Operational capabilities.
4. Understand the Human Capabilities.

COURSE CONTENT

Unit-I: Introduction

Definition of Production and Service systems, Operations management and its domain, Operations strategy and competitiveness, Measures of manufacturing performance, Productivity and its measurement; Types, characteristics and performance matrices of manufacturing systems; Brief review of performance requirement and chronology of developments in manufacturing systems.

Facility Planning and Design

Objectives, parameters and methodology for plant location decision, Methodologies for Process and Product based layout design, Computerized layout Planning and SLP, Assembly line balancing, Group Technology and methodologies for GT based layout planning; Production flow analysis, Design of machining & assembly work cells, Economic analysis of facility alternatives, Numerical Problems.

Unit-II: Product Design and Development

Strategies for new product introduction, Product development process, Modular product design and its advantages, product & process design, Concurrent engineering, Life cycle costs, Quality function development (QFD), Product-Process matrix and decision variables in selection of resources alternatives, Design for manufacture & assembly, Case study on QFD.

Demand Management

Characteristics of Product demand and appropriate manufacturing control policies, Types of forecasting, Components of demand, quantitative technique in forecasting, time series analysis, Regression models, and focus forecasting, Forecasting and Strategic Capacity Planning.

Unit-III: Operations Planning

Different Operations Planning Activities, Aggregate planning: Objectives, strategies and models, Classification of Inventory systems, various Inventory costs, Master Production schedule (MPS) and methodologies for MPS, Different operations scheduling techniques, Materials Requirement Planning (MRP) and MRP II and ERP, Theory of constraint & OPT, Case example on simple MRP.

Just In Time

JIT manufacturing philosophy, Simplification, Waste elimination, variation reduction, Pull systems, KANBANS production, Withdrawn, Single card, Recorder point system, JIT system design, Pull Vs Push, CONWIP method, Implementation issues of JIT, Concept of lean, agile and leagile manufacturing.

Unit-IV: Supply Chain Management

SC and its objectives, decisions domains and phases in SC, Process view of SC, Competitiveness and Supply Chain Strategies, Strategic Fit and Strategic Scope in SC, Obstacles to Achieving Strategic Fit, Drivers of Supply Chain Performance, SC Facilities: Inventory, Transportation, Information, Sourcing, Pricing, Role of Forecasting in Supply Chains, Managing Supply, Demand and product availability in SC.

SC Initiatives

Cycle and Safety Inventory and their role in SC, Issues in SC Logistics, The Role of Sourcing in Supply Chain performance, Third- and Fourth-Party Logistics Providers, Coordination in Supply Chain and Bullwhip Effect, Continuous Replenishment and Vendor-Managed Inventories, Collaborative Planning, Forecasting, and Replenishment (CPFR), Role of IT in SC Coordination, core competence, customization, outsourcing and postponement as SC initiatives, other SC paradigms.

Books Recommended:

1. Production & Operations Management R.B. Chase, N.J. Aquilano & F.R. Jacobs, TMH, New Delhi
2. Supply Chain Management S. Chopra & P. Meindl, Pub. Pearson Education Asia, New Delhi
3. Production and Operations Management B. Mahadevan, Pearson Education Asia, New Delhi
4. Manufacturing Planning and Control Systems T.E. Vollmann, W.L. Berry and D.C. Whybark; Irwin, Illionois, USA

	Advance Design of Mechanical Systems	**Learning Schedule**			
		L	**T**	**P**	**C**
	Pre-requisites: Mechanical Machine Design	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Design of Machine Elements is a required course for mechanical engineering students. This course is an introduction to the basic principles of modern engineering. It provides the students with fundamental skills of engineering and the ability to apply the theories of science to practice and understand the factors; such as stresses, deformations, and failure criteria, influencing the machine elements like shafts, springs, belts, bearings, gears etc. The main objective of design of machine element is that the machine should function properly to satisfy the needs of the customer and it should be safe against the predicted modes of failure.

COURSE OBJECTIVES

1. To understand the design methodology for machine elements.
2. To analyze the forces acting on a machine element and apply the suitable design methodology.
3. To understand the various standards and methods of standardization.
4. To apply the concept of parametric design and validation by strength analysis.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Analyze and select machine elements/components.
2. To know the applications of the various elements, materials used to make them, and methods used
3. Integrate various machine elements and components into the design of a machine or mechanical system through a design project.

COURSE CONTENTS

Unit-I: Appreciative Review of Mechanics of Solids

State of stress at a point and stress tensor; Transformation of stresses using elementary tetrahedran, principal stresses and 3D Mohr s circle; stress equations of equilibrium. Srain-displacement relations, srain tensor, transformation equations for strains; strain Rossetes; Compatibility concept, need and physical significance, equations of compatibility; plane stress and plane strain.

Unit-II: Appreciative Review of Strength of Materials

Generalized Hook s law, elastic constants and their interrelationship; constitutive equations. Genesis of Factor of Safety and static failure theories with simple applications. Critical review of pure torsion, simple bending, buckling and deflection formulae with simple applications.

Unit-III: Design against Fluctuating Load

Fluctuating Stresses: S-N diagram and endurance limit; Modified endurance limit estimation-notch sensitivity, surface finish, size, reliability factors etc. Design for finite and infinite life for reversed stresses as well as Fluctuating Stresses: Soderberg and modified Goodman diagrams; equivalent completely reversed stress for a given fluctuating load; cumulative fatigue damage and minor s equation.

Unit-IV: Engineering Design Philosophy

Definition of engineering design; design Vs discovery; phases of engineering design problem identification and need analysis, feasibility analysis, preliminary and detailed design with simple illustrations depicting each phase; constraints, specifications and standardization in design, creativity and invention in design; brain storming, system design approach, concurrent engineering design.

Material Considerations in Design

Material consideration: Performance characteristics of engineering materials, material selection process and evaluation techniques.

Books Recommended:

1. Mechanics of solids by Crandle and Dahl Mcgraw Hill
2. Solid Mechanics by Kazimi, TMH
3. Advance Mechanics of Solids by Srinath, TMH
4. Mechanics of Solids by Popov
5. Design of Machine Elements V.B. Bhandari
6. Mechanical Engineering Design Shigley, MH (SI Edition)
7. Machine Design by R L Norton, Pearson Engineering Design by George Dieter, McHill (A material & processing approach)
8. Engineering Design by George Dieter, McHill (A material & processing approach)
9. Machine Design by R L Norton, Pearson Engineering Design by George Dieter, McHill (A material & processing approach)
10. Specific Considerations: Design for strength, design for staffness, design for stability,
11. design for aesthetics and design for ergomics.
12. Mechanical Engineering Design by Shigley SI edition Mcgraw Hill.
13. Interaction of materials, processing, and design: Economics of manufacturing; Design forcastings, design for forgings, design for machining, Design for assembly.

	Advance Fluid Mechanics	**Learning Schedule**

		L	T	P	C
	Pre-requisites: Fluid Mechanics	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Fluid mechanics is a branch of continuum mechanics that deals with the behavior of fluids (gases or liquids) either in motion or at rest and the subsequent effects of fluids upon boundaries, which may be either solid surfaces or interfaces with other fluids. This course deals fluids and their properties, and the kinematics and dynamics of fluid flow. After that students learn the fundamentals of flow through pipes, turbulent flow, dimensional analysis and boundary layers and their applications in engineering.

COURSE OBJECTIVES

1. Understand fluid behavior for engineering design and control of fluid systems.
2. Develop competence with mass, energy and momentum balances.
3. Study the development of boundary layers.

COURSE OUTCOMES

At the end of this course, the learner will be:

1. Find frictional losses in a pipe for a flow between two places.
2. Analyse the model and prototype.
3. Find the dependent and independent parameters for a fluid flow.
4. Explain various methods available for boundary layer separation.

COURSE CONTENTS

Unit-I: Review Of Basic Concept

Concept of continuum, Types of fluids

Basics Laws in Integral Form

Reynolds s transport theorem, Integral form of continuity, momentum and Energy equations:

Potential Flow

Uniform flow, Source & Sink, Free Vortex flow, Source & Uniform flow (flow past a half body), Source - Sink pair, Doublet, Flow past a Cylinder (Doublet & Uniform flow), Flow past a Rankine oval body (source, sink & a uniform flow), flow past a cylinder with circulation (Doublet , Vortex and uniform flow)

Unit-II: Turbulent Flow

Introduction, growth of instability and transition from laminar to turbulent flow, effects of turbulence, classification of turbulence, Intensity and scale of turbulence, turbulent Intensity, scale of turbulence , Isotropic and Homogenous turbulence, Reynolds Equations of turbulence. Turbulence modeling; Boussinesq Eddy Viscosity concept, Prandtl mixing length concept, von – Karman similarity concept, Empirical correlations for coefficient of Friction, Average velocity distribution for smooth and rough pipes. Friction factor for smooth and rough pipes.

Unit-III: Compressible Flow

Introduction, Wave propagation and sound velocity, Mach number and
compressible flow regimes. Mach Core, Mach angle and mach Line. Basic equations for one dimensional compressible flow: continuity equation, momentum equation, Energy equation, Isentropic flow relations. Compressibility correction factor, Flow from a reservoir. Variation of velocity with Area ratio. Discharge through a convergent nozzle. Nozzles of the design pressure ratio

Normal Shock Waves

Continuity equation momentum equations & Energy equations. Flow with obligue shock wave: Nature of flow through oblige shock wave, Prandtls s equation, Rankine- Hugoniot equation.

Unit-IV: Viscous Flow in Ducts

Stress deformation relations, Navier- Stokes equations**,** Reynolds number Regimes, Internal Vs. External Viscous flow, Flow in circular pipes, Alternate forms of Moody Charts, Flow in Non Circular ducts, Minor losses in pipe system, Fluid meters venturi, nozzles and orifices meters.

Books Recommended:

1. Fundamentals of compressible flow- S.M. Yahya, New Age International Publishers
2. Fluid Mechanics John F Douglas, Janusz M. Gasiorek, John A, Swaffield, Peason Education
3. Advanced Engineering Fluid Mechanics K Muralidhar & G. Biswas
4. Fluid Mechanics Frank M. White, McGraw Hill
5. Viscous Fluid Flow - Frank M. White, Tata McGraw Hill

	Computer Aided Engineering Lab	**Learning Schedule**			
		L	**T**	**P**	**C**

	Pre-requisites: Basics of CAD	**0**	**0**	**2**	**1**

COURSE OBJECTIVES

To provide the necessary foundation for students, in advance understanding of design and manufacturing problems in a systematic manner.

COURSE OUTCOMES

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

1. Gain practical experience in handling 2D drafting and 3D modelling software systems.
2. Understand and handle design problems in a systematic manner.
3. Understand the concepts of G and M codes and manual part programming.
4. To know the application of various CNC machines.

LIST OF EXPERIMENTS

1. Introduction to Finite Element Analysis.
2. Structural analysis of Trusses.
3. Structural analysis of Beams.
4. Structural analysis of Bar.
5. Plane stress/Plane strain analysis.
6. Introduction to CNC programming.
7. CNC part programming for Turning, External Thread Cutting and Drilling.
8. CNC part programming for Facing, contour Tool and Groove Tool.
9. CNC part programming for milling machine of Linear Interpolation, Circular Interpolation.
10. CNC code generation using MASTER CAM lathe.
11. CNC code generation using MASTER CAM mill.

		Learning Schedule			
	Numerical & Optimization Method Lab	**L**	**T**	**P**	**C**

	Pre-requisites: Numerical & Optimization Method	**0**	**0**	**2**	**1**

OBJECTIVES:

The objective of teaching Applied Numerical Methods lab is to develop the computational skills of the students to solve various mathematical problems by numerical techniques using C programming.

COURSE OUTCOME:

Students will be able to solve problems of mathematics using computers and apply their knowledge in solving real life problems appearing in various engineering applications that are often impossible to solve using analytical techniques.

List of exercises:

1. Write a programme that finds the solution of an equation in single variable using the method of successive bisection.
2. Write a programme that finds the solution of Non-Linear equation in single variable using the Newton Raphson/ Secant.
3. Write a programme that finds the solution of a system of simultaneous algebraic equations using the Gaussian elimination procedure.
4. Write a programme that finds the solution of a system of simultaneous algebraic equations using the Gauss Seidel iterative method.
5. Write a programme that finds the numerical solution of an ordinary differential equation using the Euler s method.
6. Write a programme that finds the numerical solution of an ordinary differential equation using the Runge Kutta 4th order method.
7. Write a programme that finds the numerical Solution of an ordinary differential equation using the Predictor corrector method.
8. Write a programme that finds the numerical solutions of Elliptic, Parabolic and Hyperbolic partial differential equations using the method of Finite Differences.
9. Write a programme that finds the minimum point of a single variable function in a specified interval using golden section search algorithm.
10. Write a programme that finds the minimum point of a multi variable function using Cauchy steepest descent algorithm.
11. Write a programme that finds the minimum point of a constrained optimization problem using penalty function method.
12. Write a programme that finds the optimum point of a constrained optimization problem using genetic algorithm.

The students will be required to carry out the exercises from the above list and any other two experiments either from the above list or designed by the department based on the theory course, Numerical & Optimization Methods.

	Modelling & Simulation of Manufacturing Systems	**Learning Schedule**			
		L	**T**	**P**	**C**

	Pre-requisites: Manufacturing Technology	**4**	**0**	**0**	**4**

COURSE DESCRIPTION

The objective of this course is to give a sound knowledge of the fundamental aspects of system simulation, which is used in the analysis of complex system and finds applications in a wide range of real life situations. Modeling and Simulation of Manufacturing Systems course is concerned with the concepts of system, system modeling and simulation, has been expanded to include the details of types of models and simulation software. This course covers the mathematical and statistical models. This course provides the knowledge of random number generation and inverse transform techniques. This course also discusses the analysis of simulation data and application of simulation system in manufacturing and material handling systems

COURSE OBJECTIVES

1. To introduce modeling, simulation and optimization as it applies to the study and systems for decision support.
2. To expose with a wide range of applications for simulation methods and models and to integrate them with their introduction to operations management

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Develop the practical skills necessary to design, implement and analyze discrete-event simulation systems.
2. Cover the basic theory underlying discrete-event simulation methodologies in order to enable a critical understanding of simulation output in managerial environments.
3. Build the foundations necessary to quickly adapt for future advances in simulation technology.

COURSE CONTENTS

Unit-I: Introduction

Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic processes, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, Steps in a simulation study, Verification, validation and credibility of simulation models, Advantages, disadvantages and pitfalls of simulation,

Statistics in Simulation

Review of basic probability and statistics, random variables and their properties, Statistical analysis for terminating simulation and steady state parameters

Unit-II: Modelling Elements in Manufacturing Systems

Definition, Classifications and characteristics of production systems; measures of manufacturing systems performance, modeling elements in manufacturing systems: processes, resources, single and multi server queues, arrival processes, service times, downtime, manufacturing costs, resources selection rules, different manufacturing flexibilities

Simulation of Manufacturing Systems

Simulation of Job shop, batch and Flexible manufacturing systems, Case studies for above systems.

Unit-III: Modelling of Manufacturing Supply Chains (SC)

Introduction of SC, Modelling elements in SC, Measures of SC performance, brief review of bear game, SC initiatives and effect on SC performance Modelling of Supply Chain Processes at different Supply chain nodes like: Retailer, assembler, distributor, and manufacturer; Modelling of different SC processes, inventory control policies like (s, S), (s, Q) systems, production control issues like Manufacturing-to-order, Manufacturing-to-stock, Assembleto-order, Assemble-to-stock; Modelling of material transport system in SC, Development of Simple SC models

Unit-IV: Design of Simulation Experiments

Consideration for selecting length of simulation run, no of replication and warm-up period, elimination of initial bias, Finance Considerations of a simulation study, Variance reduction techniques, 2k factorial design, fractional factorial design, factor screening, response surface, Meta-models and sensitivity, optimization procedures

Simulation Languages

Discussion of Continuous and discrete simulation languages, Salient features of important simulation packages like SIMSCRIPT, GPSS SIMULA, ARENA, PROMODEL etc., importance and limitations of special purpose languages.

Books Recommended:

1. Simulation Modeling and Analysis, 3e, Law A.M. and Kelton W.D., TMH, New Delhi
2. Simulation with Arena - Kelton and Sadowski, 2003, (McGraw-Hill)
3. Analysis and Control of Production Systems, Printice Hall Publn, E.A. Elsayed and T.O. Boucher, 1994.
4. Modelling and Analysis of Dynamic Systems, C.M. Close and Dean K.F., Houghton Mifflin
5. Simulation of Manufacturing, Allan Carrie, John Wiley & Sons
6. System Simulation, Geoffrey Gordon, Prentice Hall, 1998
7. Modern Production /Operations Management, 8e, Buffa E.S. and Sarin R.K., John Wiley
8. Designing and Managing the Supply Chain, 3/e, Simchi-Levi D., Kaminsky P., Simchi-Levi E., Shankar R., TMH, New Delhi

		L	T	P	C
	Pre-requisites: Mechanical Vibrations	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

A structure or a body is said to vibrate if it has a to and fro motion. A greater proportion of human activities involve vibration in one form or the other. We hear because our eardrums vibrate. The cause and effects of vibration must be clearly understood. The structures designed to support the high speed machines are subjected to inherent unbalance which causes problems. The unbalance may be due to faulty design or poor manufacture. Because of cyclic vibration, the material of the structure or the machine component may undergo fatigue failure. Vibration causes fasteners such as nuts of the machine to become loose. In metal machining processes, vibration may cause chatter, which results in poor surface finish. If the natural frequency of vibration of a machine or structure equals the forced frequency caused by external excitation, resonance occurs which causes dangerously large oscillations and the structure fails. A bridge can collapse due to wind-induced vibration. Critical instruments mounted on machines may loose their accuracy due to excessive vibrations. Vibrations can be used for useful works such as vibration testing equipments, vibratory conveyors, hoppers, sieves, compactors, washing machines.

COURSE OBJECTIVES

1. To learn the basics of vibrations including causes and effects of vibrations.
2. To study the undamped and damped free vibration.
3. To study the forced vibrations.
4. To study multi degrees of freedom system.
5. To study vibration measuring instruments.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Write differential equation of the given vibration model.
2. Calculate the frequencies of free or natural, damped and forced vibrations.
3. Find the response of a vibrating system.
4. Calculate the natural frequencies and mode shapes of multi degrees of freedom systems.
5. Use vibration measuring instruments.

COURSE CONTENTS

Unit-I: Basic Concepts and One Degree Freedom System

Concept of free and forced vibration using spring mass model, governing equation and response to an initial disturbance for an undamped spring mass system; Concept of linear and non-linear vibratory system. Natural frequency and its determination using the concept of equivalent system and energy methods - Average energy principle, principle of conservation of energy; principle of virtual work - Hamilton s principle and Lagrange s equation.

Unit-II: Damped Single Degree Freedom System-Free and Forced Vibrations

Damping models with stress on viscous damping; Governing equation and response for over damped, critically damped and under damped systems; Logarithmic decrement and its practical significance; negative damping self exited vibration.

Governing equation under harmonic excitation and response using technique of calculus and phasor diagram; Active and passive vibration isolation, transmissibility; bending critical speeds of simple staffs; Support motion; seismometer, accelerometer;

Unit-III: Multi Degree Freedom System and Numerical Techniques

Concept of mode shape through 2- DOF system governing equations and response under general initial conditions; vibration absorber; Eigen value problems close coupled system and far coupled system; orthogonality of mode shapes. Dunkerieys lower bound approximation, Rayleigh s upper bound approximation; Myklestad- Prohl method for far coupled system; finite element method for far coupled system as well as closed coupled system.

Unit –IV: Vibration Measurement and Condition Monitoring

Basic vibration measuring set up amplitude and phase measurement; vibration pick- ups general construction and working principle of piezoelectric accelerometer and eddy current based displacement probe; filters- unfiltered and filtered signals; Display devices- vibration analyzer and oscilloscope; general construction and working principle of electro-dynamic vibration shaker.

Fourier series &Fourier Transforms, Fast Fourier Transform (FFT), concept of time domain and frequency domain. Condition Monitoring Philosophy its need and types; concept of 1X, 2X, 3X, ---vibration signals in a rotating machines; Time domain analysis- time waveform, orbit analysis, phase analysis; Frequency domain analysis: frequency spectrum, bode plot, cascade plot; Recent techniques of condition monitoring.

Books Recommended:

1. Theory and Practice of Mechanical Vibrations by Rao J S and Gupta K; New Age Publication.
2. Theory of Vibration with applications by William T Thomson
3. Mechanical Vibrations by S S Rao (2008)
4. Fundamental of Vibration by L Meirowitch (2008)

		L	T	P	C
	Pre-requisites: Heat and Mass Transfer	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

An introductory course in heat and mass transfer covering conduction, convection and radiation heat transfer, principals of heat exchanger and mass transfer. Heat transfer and mass transfer are kinetic processes that may occur and be studied separately or jointly. Studying them apart is simpler, but both processes are modelled by similar mathematical equations in the case of diffusion and convection (there is no mass-transfer similarity to heat radiation), and it is thus more efficient to consider them jointly. Besides, heat and mass transfer must be jointly considered in some cases like evaporative cooling and ablation.

COURSE OBJECTIVES

1. To comprehend and evaluate various modes of heat and mass transfer
2. To design fin enhanced systems, evaporators, condensers and heat exchangers.
3. To understand boundary layer theory, condensation and boiling.
4. To determine effectiveness of heat exchangers using LMTD and NTU.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Apply basic principles of fluid mechanics, thermodynamics, heat transfer for designing heat and mass transfer systems.
2. Model heat, mass and momentum transport systems and develop predictive correlation.
3. Assess and evaluate various designs for heat and mass transfer and optimize the solution

COURSE CONTENTS

Unit-I: Introduction

Reviews of basic laws of Conduction, Convection and Radiation

Steady State Heat Conduction

Thermal insulation problem, Extended surfaces- Fins with uniform cross-sectional area, Fins variable cross-sectional area- circumferential, triangular and parabolic shape, Fin effectiveness and efficiency, thermal contact resistance. Methods for the solution of the Multi-Dimensional heat conduction problem: Analytical Method, Graphical Method, Electrical Analogy, Numerical Methods, Numerical.

Unit-II: External Flow and Forced Convection

Introduction, Exact and approximate integral solutions for the flow over flat plate, hydrodynamic & thermal boundary layer, boundary layer thickness, drag coefficient, mean drag coefficient, The local & average heat transfer coefficient, mass flow through the boundary, Turbulent flow over flat plate, Reynolds analogy, Reynolds-Colburn analogy, Drag & heat transfer in mixed boundary layer, Flow over curved surfaces, Cylinder, Sphere, Cross flow over banks of tubes, Numericals.

Unit-III: Internal Flow and Forced Convection

Introduction, Entrance region, Fully developed region, Mean velocity, Mean temperature, Governing differential equation and velocity profile for fully developed laminar tube flow, Hagen-Poiseuille equation, Fanning friction coefficient, Heat transfer for fully developed laminar tube flow: Governing differential equation, heat transfer coefficient for constant wall temperature and constant wall heat flux boundary conditions, Velocity distribution in turbulent flow through pipe, Fluid friction, Convection Correlations for turbulent flow in tubes: Reynolds Analogy, Reynolds-Colburn analogy, Dittus- Boelter equation, Sieder and Tate equation, Petukhov expression, Numericals.

Two Phase Heat Transfer

Heat Transfer with Change of Phase: Laminar film condensation on a vertical plate, Drop-wise condensation, Boiling regimes, Nucleate and film boiling, Heat pipe.

Unit –IV: Heat Exchangers

Classification and selection of heat exchangers, Some important definitions, Heat Exchanger Analysis: Use of LMTD, Multipass heat exchangers, Effectiveness NTU Method, Plate heat exchanger, evaporative tubular heat exchanger, Evaporative Effectiveness, Dryout heat flux, Design of Shell and Tube Heat Exchanger, Simulation of heat exchangers, Pressure drop and Pumping power, Optimisation of heat exchanger size, Numericals.

Thermal Radiation

Review of basic laws for radiation-, Black body concept, gray body radiation, Solar radiations, Radiation between surfaces- Shape factor and correlations, Radiation exchange between surfaces in black enclosure, Network representation, Radiation exchange in gray enclosure, apparent emissivity of a cavity, Radiation shields, Radiations in emitting and absorbing media.

Books Recommended:

1. Fundamentals of Heat and Mass Transfer Sarit K. Dass, Narosa Publishing House, New Delhi.
2. Fundamentals of Heat and Mass Transfer Frank P. Incropera, Published by John Wiley & Sons, New York.
3. Heat & Mass Transfer P.K. Nag, Published by Tata-McGrawhill, New Delhi.
4. Heat Transfer J.P. Holman, Tata McGraw Hill, New Delhi.
5. Fundamentals of Engineering Heat and Mass Transfer R C Sachdev, Published by New Age
6. International (P) Limited, New Delhi.

	Manufacturing Simulation Lab	**Learning Schedule**

		L	T	P	C
	Pre-requisites: Manufacturing and Simulation	**0**	**0**	**2**	**1**

COURSE DESCRIPTION

The objective of this course is to give a sound knowledge of the fundamental aspects of system simulation, which is used in the analysis of complex system and finds applications in a wide range of real life situations. Modeling and Simulation of Manufacturing Systems course is concerned with the concepts of system, system modeling and simulation, has been expanded to include the details of types of models and simulation software. This course covers the mathematical and statistical models. This course provides the knowledge of random number generation and inverse transform techniques. This course also discusses the analysis of simulation data and application of simulation system in manufacturing and material handling systems

COURSE OBJECTIVES

1. To introduce modeling, simulation and optimization as it applies to the study and analysis of manufacturing systems for decision support.
2. To expose with a wide range of applications for simulation methods and models and to integrate them with their introduction to operations management

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Develop the practical skills necessary to design, implement and analyze discrete-event simulation systems.
2. Cover the basic theory underlying discrete-event simulation methodologies in order to enable a critical understanding of simulation output in managerial environments.
3. Build the foundations necessary to quickly adapt for future advances in simulation technology.

LIST OF EXPERIMENTS

1. Simulation of a single server system
2. Simulation of 2 machine n-job system for Johnson job sequencing rules
3. Simulation of a multi server system with different dispatching rules
4. Simulation of an FMS
5. Simulation of Manufacturing system for different scheduling rules
6. Simulation of a simple supply chain
7. To generate Random variates using C
8. To apply Linear programming model for an industrial scenario
9. To evaluate material flow in Facilities layouts
10. Simulation of manufacturing systems with different Inventory control policies

		L	T	P	C
	Pre-requisites: Mechanical Vibrations	**0**	**0**	**2**	**1**

COURSE DESCRIPTION

A structure or a body is said to vibrate if it has a to and fro motion. A greater proportion of human activities involve vibration in one form or the other. We hear because our eardrums vibrate. The cause and effects of vibration must be clearly understood. The structures designed to support the high speed machines are subjected to inherent unbalance which causes problems. The unbalance may be due to faulty design or poor manufacture. Because of cyclic vibration, the material of the structure or the machine component may undergo fatigue failure. Vibration causes fasteners such as nuts of the machine to become loose. In metal machining processes, vibration may cause chatter, which results in poor surface finish. If the natural frequency of vibration of a machine or structure equals the forced frequency caused by external excitation, resonance occurs which causes dangerously large oscillations and the structure fails. A bridge can collapse due to wind-induced vibration. Critical instruments mounted on machines may loose their accuracy due to excessive vibrations. Vibrations can be used for useful works such as vibration testing equipments, vibratory conveyors, hoppers, sieves, compactors, washing machines.

COURSE OBJECTIVES

1. To learn the basics of vibrations including causes and effects of vibrations.
2. To study the undamped and damped free vibration.
3. To study the forced vibrations.
4. To study multi degrees of freedom system.
5. To study vibration measuring instruments.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Write differential equation of the given vibration model.
2. Calculate the frequencies of free or natural, damped and forced vibrations.
3. Find the response of a vibrating system.
4. Calculate the natural frequencies and mode shapes of multi degrees of freedom systems.
5. Use vibration measuring instruments.

LIST OF EXPERIMENTS:

1. To determine transient and forced response of a vibratory system.
2. To determine structural damping of rotor system.
3. To determine critical speed of an actual rotor system using bode a plot.
4. To study the rotor behaviour during its start up period.
5. To determine the rotor behaviour during its shut-down period.
6. To diagnose the bearing fault using bearing fault kit.
7. To diagnose rotor behaviour after introducing commonly noticed faults.
8. To determine bearing stiffness in x and y directions.
9. To carry out two-plane rotor balancing calculations using vibratory response.

	Advanced Mechanics of Solids	**Learning Schedule**			
		L	**T**	**P**	**C**

	Pre-requisites: Engineering Mechanics	3	0	0	3

COURSE DESCRIPTION

Advanced Mechanics of Solids (also known as Mechanics of Materials) is the study of the internal effect of external forces applied to structural member. Stress, strain, deformation deflection, torsion, flexure, shear diagram, and moment diagram are some of the topics covered by this subject. The knowledge of this subject is a must in Civil Engineering, Mechanical Engineering,

The main part in this subject is

1. Focuses on the strength of materials and structural components subjected to different types of force and thermal loadings.
2. Investigates materials subjected to different types of force and thermal loadings
3. Emphasizes actual operating conditions.

COURSE OBJECTIVES

1. To learn fundamental concepts of Stress, Strain and deformation of solids with applications to bars, beams and thin cylinders.
2. To know the mechanism of load transfer in beams, the induced stress resultants and deformations.
3. To understand the effect of torsion on shafts and springs.
4. To analyze a complex two dimensional state of stress and plane trusses.

COURSE OUTCOMES

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

1. Thorough understanding of the fundamental concepts of stress and strain in mechanics of solids and structures.
2. The ability to analyze determinate beams and trusses to determine shear forces, bending moments and axial forces.
3. A sufficient knowledge in designing shafts to transmit required power and also springs for its maximum energy storage capacities.

Unit –I: Three Dimensional Stress & Strains

State of stress at a point, Determination of stresses on plane of general position, Principle axes and principle stresses, Various types of state of stress, state of strain, Generalized Hook s law geometric representation, the three dimensional Mohr s circle, stress strain relationship.

Stress Concentration

Stress concentration in tension and compression members, Stresses in a plate with a circular hole, Stress concentration in torsion and bending, Circular shafts of variable diameter, investigation of stress concentration, Geometric stress raisers and the mitigation of stress concentration.

Unit –II: Torsion

Pure shear and its characteristics, Torsion of rods of non-circular and hollow cross-sections, Membrane analogy, Thin walled tubes and rectangular sections, Thin walled open sections, Warping of sections.

Theory of Fatigue

General considerations, Basic characteristics of a cyclic loading and the fatigue limit, Effects of stress concentration on fatigue strength, Effect of surface finish and dimensions of a part on fatigue strength, Factor of safety in cyclic loading, Goodman diagrams.

Unit –III: Plates and Shells

Determination of stress in symmetrical shells by the membrane theory, bending of symmetrically loaded circular and rectangular plates, Bending of cylindrical shells under symmetrical loading.

Thin Walled Bars:
Typical features of thin walled bars, shear stresses in thin walled bars under transverse bending, Shear center, General loading case of thin walled bars.

Unit –IV: Plastic Theory of Bending
Assumptions in plastic theory, Collapse load and load factor, Plastic moment of resistance, Plastic modulus and shape factor, Derivation of formulae and their application for simply supported beams, Cantilevers and fixed beams.

Beams on Elastic Foundations:
The infinite beam, Bending moments and deflections with
concentrated forces and couples, Non- uniformly distributed loads, Semi-infinite beams, Finite beams, Applications to rail-road tracks.

Books Recommended:

1. Advanced Strength of Materials, Vol. II by S. Timoshenko, Published by Van Nostrand and Co.
2. Advanced Mechanics of solids by L.S. Srinath, Published by T.M.H., New Delhi.

	Analysis of Manufacturing Processes	Learning Schedule			
		L	T	P	C
	Pre-requisites: Manufacturing Technology	3	0	0	3

COURSE DESCRIPTION

The Course includes the different types of materials, machinability and economics of machining. Stress strain relationship and deformation processes. It includes casting and welding metallurgy.

COURSE OBJECTIVE

The course aims to aware the students about the tool materials, Merchant and Lee Shaffer theories. Deformation process and yield criteria. The casting process and the problems. It also aims welding metallurgy.

COURSE OUTCOMES

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

1. Understand the advences in cutting tool material.
2. Understand the modern theories of cutting.
3. Understand the economics of metal machining.
4. Understand the casting technology and the problems.
5. Understand the different welding technologies.

COURSE CONTENTS:

Unit-I: Cutting Too Material

Characteristics of tool material, advances in cutting tool material, role of coating.

Machinability and Economics of Machining

Need for rational approach to the problem .of cutting metals-Observation in metal cutting, Energy considerations in machining, Modern theories in mechanics of cutting, Review of Merchant and Lee Shaffer theories, critical comparison, Measurement of cutting forces-Classification of cutting force dynamometers, Machinability, evaluation of Machinability, mechanism of tool failure, tool wear mechanism, tool life and tool life equation, factors affecting Machinability surface finish and surface integrity. Economics of machining, cost of turning operation, optimum cutting speed for minimum cost and maximum rate of production.

Unit-II: Bulk Deformation Process

Stress-Strain relations in Elastic and plastic deformations, Yield criteria for ductile metals, work hardening and anisotropy in yielding Flow curves. Slip Line Field Theory,Effects of temperature and strain rate in metal working, friction and Lubrication in Hot and Cold working. Technology and analysis of important metal forming processes - Forging, Rolling, Extrusion, Wire drawing, Sheet metal forming processes

Unit –III: Casting

Introduction, Features of Casting problems, Survey and Scope of Foundry Industry,
Solidification of pure metals, Nucleation and growth in alloys, Solidification of actual casting, Progressive and directional solidification, Centreline feeding resistance, Rate of solidification, Chvorinov s rule.

Gating and Risering Systems:

Gating systems and their characteristics, Effects of gates on aspiration, Turbulence and dross trap, recent trends, Riser design, Risering curves, NRL method of riser design, Feeding distance, Risering of complex casting, Risering of alloys other than steel, Riser design by geometrical programming.

Unit-IV: Welding Metallurgy

Welding as compared with other fabrication processes, Classification of welding processes; Heat affected zone and its characteristics; Effects of alloying elements on weldability, Weldability of steels, cast iron and aluminum and alloys, Weld testing standards, heat transfer and solidification, Analysis of stresses in welded structures, Pre and post welding heat treatments, Metallurgical aspects of joining, Conditions of soldering, Brazing and welding of materials. Weld Design & Quality Control: Principles of sound weld design, Welding joint design, Welding defects; Testing of weldament,

Books Recommended:

1. Metal Cutting Principles M.C. Shaw Oxford Clarendon Press
2. Metal Cutting Theory and Practice Bhattacharya New Central Book Agency29
3. Fundamentals of Metal Cutting andMachine Tools B.L. Juneja and G.S. Sekhon New Age
4. International
5. Metal Forming Analysis Avitzur McGraw Hill
6. Mathematical Simulation and Computer analysis of Thin
7. Strip Rolling Mill Polukhin MIR Publications
8. Principles of Manufacturing Materials & Processes Campbell J. S., Publisher Mc Graw Hill.
9. Principle of Metal casting - Rosenthal, Tata McGraw Hill, New Delhi
10. Meta Casting: Principles and Practice TV Rammana Rao New Age International
11. Welding and Welding Technology, Richard L. Little Tata McGraw Hill Ltd.
12. Manufacturing Processes and Systems: Ostwald Phillip F., Munoz Jairo, John Wiley & Sons
13. Plasticity for Mechanical Engineers Johnson & Mellore Van Nostrand

	Statistics for Decision Making	Learning Schedule			
		L	T	P	C
	Pre-requisites: Production Technology	3	0	0	3

COURSE DESCRIPTION

An introduction to statistics as applied to managerial problems. Conceptual understanding , limitations and misuses of statistics and interpretation of statistical results are emphasized. Hands-on experience is provided using software. Descriptive statistics including central tendency, dispersion, skewness, covariance, binomial and normal probability distributions, confidence intervals for means, and simple linear regression. Examples from finance, operations, and marketing.

COURSE OBJECTIVE

The main objective of the course is to develop a working proficiency of the tools used in managerial decision-making. As such, the focus will be more practical than theoretical. Because statistical analysis informs the judgment of the ultimate decision-maker—rather than replaces it—the course will cover some key conceptual underpinnings of statistical analysis to insure students understand its proper usage. Students will gain knowledge in how to perform basic data analysis, statistical tests, regression and forecasting analysis, and simulation. More importantly, students will become proficient in interpreting results, identifying problems with analyses, and making decisions using results.

COURSE OUTCOMES

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

1. Identify the analysis that would be useful for supporting the business decision at hand
2. Use spreadsheets to describe business data and identify relationships
3. Understand business typical situations where common probability distributions are appropriate and use them to make inferences
4. Construct point and interval estimates for mean and proportion
5. Interpret statistical analysis outputs correctly

COURSE CONTENTS

Unit-I: Data Collection and Analysis

Collection of data, Presentation of data, Measures of central tendency, Measures of variation and skewness

Probability and Probability Distributions

Basic concepts of Probability, Discrete Probability Distributions, Continuous Probability Distributions , Decision Theory

Unit-II: Sampling

Sampling Fundamentals, Testing of Hypothesis (Parametric and Nonparametric tests) Chi square Test

Unit –III: Forecasting Methods

Business forecasting, Correlation, Regression, Time series Analysis

Unit –IV: Variance and Co-Variance

Analysis of Variance and Co variance, Multivariate Analysis Techniques

Books Recommended:

1. Research Methodology - C.R. Kothari - Wiley Eastern Limited

2. Statistics for Management - Richard L Levin and David S. Rubin PHI
3. Quantitative Methods for Management Levin et al (McGraw Hill)
4. Quantitative Analysis for Management Render, PHI
5. Quantitative Techniques for decision Making Gupta & Khanna (PHI)

	Robotics Engineering	Learning Schedule			
		L	T	P	C
	Pre-requisites: Basics of Robots	3	0	0	3

COURSE DESCRIPTION

This subject deals with fundamentals of robotics, its components and various types of sensing. Further, robot programming and its industrial applications has been covered in detail. Robots are very useful and efficient in repeated kind of tasks such as pick and place, welding, assembly etc. Over a period of time intelligent robots are also developed which serves specific objectives.

COURSE OBJECTIVES

1. To get acquainted with constructional features and other basic information on robotics.
2. To know about the sensors used in robotics.
3. To learn robot programming of a typical robot and also the concepts of path planning and applications.

COURSE OUTCOMES

On completion of this course, the students will be able to,

1. Know the basics of robotics.
2. Do robot programming.
3. Appreciate the applications of robotics and apply economic measures to justify advantages of robots in industry.

COURSE CONTENTS

Unit-I: Fundamentals

Introduction, what is a Robot, Classification of Robots, What is Robotics, History of Robotics, Advantages and disadvantages of Robots, Robot components, Robot degree of freedom, Robot Joints, Robot coordinates, Robot reference frames, Programming modes, Robot characteristics, Robot workspaces, Robot languages, Robot applications, Other robots and applications, Social issues.

Unit-II: Robot Kinematics

Introduction, Robots as mechanism, Matrix representation, Homogeneous transformation matrices, Representation of transformation, Inverse of transformation matrices, Forward and inverse kinematics of robots, Denavit Hartenberg representation of forward kinematic, equation of robots, The inverse kinematic solution of robots, Inverse kinematic programming of robots, Degeneracy and dexterity.

Differential Motions and Velocities:

Introduction, Differential relationship, Jacobian, Differential motions of a frame, Interpretation of the differential change, Differential changes between frames, Differential motions of a robot and its hand frame, Calculation of the Jacobian, Relating Jacobian and the differential operator, Inverse Jacobean.

Unit-III: Dynamic Analysis and Forces

Introduction, Lagrangian mechanics, Effective moments of inertial, Dynamic equations for multiple-degree of freedom robots, Static force analysis of robots, Transformation of forces and moments between co-ordinate frames.

Trajectory Planning

Introduction, Path vs. trajectory, Joint-space vs. Cartesian-space description, Basics of trajectory planning, Joint trajectory planning, Cartesian space trajectories, Continuous trajectory recording.

Unit-IV: Actuators

Introduction, Characteristics of actuating systems, Comparison of actuating systems, Hydraulic devices, Pneumatic devices, Electric motors, Microprocessor control of electric motor, Magenetostrictive actuators, Shape-memory type metals, Speed reduction.

Sensors

Introduction, Sensor characteristics, Position sensors, Velocity sensors, Acceleration sensors, Force and pressure sensors, Torque sensors, Micro-switches, Light and infrared sensors, Touch and tactile sensors, proximity sensors, Range-finders, Sniff sensors, Vision systems, Voice recognition devices, Voice synthesizers, Remote centre compliance device.

Books Recommended:

1. Introduction to Robotics John J. Craig, Pub. Addison Wesley.
2. Industrial Robotics Gordon M. Mair, Pub. PHI.
3. Industrial Robotics Groover, Pub. MGH.

	Reliability Based design	Learning Schedule			
		L	T	P	C

	Pre-requisites: Basics of Reliability	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Teach the essentiality of SQC, sampling and reliability engineering. Study on various types of control charts, six sigma and process capability to help the students understand various quality control techniques. Reliability engineering focuses on the dependability, failure mode analysis, reliability prediction and management of a system.

COURSE OBJECTIVES

1. Principles of optimization and its need.
2. Various conventional optimization techniques.
3. Solving multivariable problems.
4. Solving problems using Unconventional optimization techniques.

COURSE OUTCOMES

On completion of the course the students should be able to:

1. Understand the methods and philosophy of statistical process control.
2. Understand the acceptance sampling problems.
3. Understand the principles of reliability engineering.
4. Understand the failure data analysis.

COURSE CONTENTS:

Unit-I: Reliability Concepts and Statistical Models

Failure data analysis, Reliability function, Hazard rate, Failure rate, Relation among reliability, Hazard rate and Failure rate, Mean time to failure, Mean time between failures, Normal, Long-normal, Weibull, Gamma, Exponential, uniform, Rayleigh, Chauchy, Beta and Poisson distribution.

Design of Mechanical Components and Systems

Deterministic design procedure, Probabilistic design procedure, Reliability based design of gear tains, Reliability analysis of cam-follower and four-bar mechanism.

Unit-II: Modeling of Geometry, Material, Strength and Loads

Modeling of geometry, Tolerance on finished metal products, Assembly of components, Modeling of material, strength, Statistics of elastic properties, Statistical model of material strength, Model for brittle, Plastic materials and fiber bundles, Constant and variable amplitudes, Fatigue strength, Modeling of dead, lie, wind and earthquake loads.

Unit-III: Strength Based Reliability and Interference Theory

General and alternate expressions for reliability and probability of failure, Reliability when strength follows normal exponential, extreme value and type-iii extreme distributions, Reliability in terms of experimentally determine distributions of strength and load, Factor of safety corresponding to given reliability.

Reliability Based Optimum Design

Optimization problem, Reliability allocation problems, Structure and mechanical design problems, Optimum design by graphical optimization, Lagrange multiplier, Penalty function and dynamic programming methods.

Unit-IV: Maintainability and Availability

Concepts, Preventive and imperfect maintenance, Repair time distributions, Un repaired failures, Optimal replacement strategy, Spare parts requirements, Development of availability models, System with a single component.

Failure Modes, Event-Tree and Fault-Tree Analysis
System safety analysis, Failure modes and effects analysis, Event-tree and fault-tree analysis, Minimum cut-sets.

Books Recommended:

1. Reliability Based Design by S.S. Rao, Published by McGraw Ill.
2. Mechanical Reliability by L.S. Srinath, Published by EWP.

	Computational Fluid Dynamics	Learning Schedule			
		L	T	P	C
	Pre-requisites: Basics of Fluid Dynamics	3	0	0	3

COURSE DESCRIPTION

The course includes the Basic equations of fluid dynamics, FDM and FVM. The Runge-Kutta schemes Numerical solution of the incompressible Navier-Stokes equations.

COURSE OBJECTIVES

The overarching goal of the course is to learn how to solve the Navier-Stokes and Euler equations for engineering problems using computational algorithms and programming. Various numerical solution techniques will be introduced and applied to several course projects.

COURSE OUTCOMES

On completion of the course the students should be able to:

1. Understand basic properties of computational methods – accuracy, stability, consistency
2. Learn computational solution techniques for time integration of ordinary differential equations
3. Learn computational solution techniques for various types of partial differential equations
4. Learn how to computationally solve Euler and Navier-Stokes equations
5. Acquire basic programming and graphic skills to conduct the flow field calculations and data analysis.

COURSE CONTENTS:

Unit-I: Introduction To CFD

Basic thoughts and philosophy, CFD as research tool, CFD as design tool, automobile and engine applications.

Conservation equations

Mass, momentum and energy equations; Conservative forms of the equations and general description, physical boundary conditions.

Unit-II: Numerical Methods

Classification into various types of equations parabolic, elliptic, hyperbolic and mixed type; Boundary and initial conditions; Overview of numerical methods.

Discretization

Finite Difference Method - explicit, implicit, stability requirement, polynomial fitting, approximation of boundary conditions, applications to heat conduction and convection; Finite Element Method: Variational principle and weighted residual, Rayleigh-Ritz, Galerkin and Least squaren methods, 1-D and 2-D elements, applications to fluid flow and heat transfer problems; Finite Volume Method finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison.

Unit-III: Methods Of Solution

Solution of finite difference equations, iterative methods, matrix inversion methods, ADI technique, SIMPLE algorithm, operator splitting, fast Fourier transform, applications.

Numerical Grid Generation

Grid generation techniques, transformation and mapping,
structured and unstructured grid generation, Application of grid generation techniques.

Unit-IV:

Introduction and Application of Ansys Fluent

Geometric modeling-ANSYS Workbench/CFX, mesh generation, boundary and initial conditions, computational approach, analysis.

Case Study

Design of gas carburetor using ANSYS software use ANSYS Workbench for geometrical modeling and turbulence models (i.e., RNG k- model, Standard k- model) for comparative analysis.

Books Recommended:

1. Computational Fluid Dynamics Anderson JD Jr, McGraw Hill.
2. Computational Fluid Flow and Heat Transfer Muralidhar K and Sundararajan T., Narosa Publishing House, New Delhi
3. Computational Fluid Mechanics and Heat Transfer Anderson DA, Tannehill JC and Pletcher RH, Taylor & Francis.

	Computer Integrated Manufacturing System	Learning Schedule			
		L	T	P	C
	Pre-requisites: Basics of CIM	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

The course includes fundamental knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas. To create congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations. To broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation. To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

COURSE OBJECTIVES

This course aims to acquaint the students with principles, concepts and techniques that are essential in Computer Integrated Manufacturing.

COURSE OUTCOMES

On completion of the course the student will be able to:

1. Develop an understanding of CAD systems and graphical modeling.
2. Get acquainted with data bases and numerical analysis related to CIM
3. Understand Computer Aided Manufacturing (CAM) systems
4. Understand about Automated Material Handling Systems, Automated Inspection Systems, Flexible Manufacturing Systems (FMS)

COURSE CONTENTS

Unit-I: Introduction

Historical Developments in Manufacturing and Automation, Introduction to CAD, CAM & CIM, Components of CIM and CIM wheel.

Manufacturing System

Introduction of Manufacturing System and Its Objectives, Identifying Business Opportunities and Problems, Classification of Production Systems, Linking Manufacturing Strategies and System Analysis of Manufacturing Operations.

Unit-II: Group Technology and Computer Aided Process Planning

Introduction, Part Families, Parts Classification and Coding; Group Technology Machine Cells and Benefits of G.T. Process Planning Function, CAPP, Computer Generated Time Standards

Computer Aided Planning and Control

Production Planning and Control, Cost Planning and Control, Inventory Management, Material Requirement Planning (MRP).

Unit-III: Shop Floor Control System

Shop Floor Control, Factory Data Collection System, Supervisory Computer Control.

Integrated Manufacturing System

Definition, Application, Features, Types of Manufacturing Systems, Machine Tools, Materials Handling System, DNC System, Manufacturing Resource Planning, Manufacturing Cell, Flexible Manufacturing Systems and Concept, Transfer System, CAD/CAM system.

Unit-IV: Production Monitoring System

Types of Production Monitoring system, Direct Digital Control, Computers in Quality Controls, integration of CAQC with CAD/CAM Intelligence Systems In Cim: Intelligent Systems Rapid Prototyping, Artificial Intelligence and Expert Systems in CIM

Books Recommended:

1. CAD/CAM, Mikell P. Grover M. P. and Emory W.Zimmers, JR, PHI Pvt. Ltd., New Delhi.
2. CAD/CAM, Principle and Applications P.N Rao, TMH, New Delhi.
3. Computer Integrated Manufacturing - James A Rehg and Henry W Kraebble Pearson
4. Education Asia.Principles of Computer Integrated Manufacturing - S. Kant Vajpayee PHI, New Delhi.
5. Computer Integrated Manufacturing - James A Rehg and Henry W Kraebble Pearson
6. Education Asia..
7. Computer Integrated Manufacturing - From concepts to realization . Roger Hanman, Addision
8. Wesley.
9. System Approach to Computer Integrated Manufacturing- Singh, Nanua, John Wiley and Sons.
10. Automation, Production System and CIM Grover M. P., PHI, New Delhi.
11. Computer Integrated Design and Manufacturing - David Bedworth, TMH, New Delhi.

		L	T	P	C
	Pre-requisites: Basics of Electronics & Mechanical	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Mechatronics is a design process that includes a combination of mechanical engineering, electrical engineering, control engineering and computer engineering. Mechatronics is a multidisciplinary field of engineering, that is to say, it rejects splitting engineering into separate disciplines. Originally, mechatronics just included the combination of mechanics and electronics, hence the word is a combination of mechanics and electronics; however, as technical systems have become more and more complex the word has been "updated" during recent years to include more technical areas.

COURSE OBJECTIVES

1. To introduce integrated approach to the design of complex engineering systems.
2. To provide knowledge of sensors, actuators and their selection for an application.
3. To expose interfacing of devices with controllers.

COURSE OUTCOMES

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

1. Identify the elements of mechatronics system.
2. Select suitable sensors, actuators and controllers to meet specific requirements.
3. Demonstrate intelligent mechatronics system for engineering applications.

COURSE CONTENTS

Unit-I: Mechatronics

Appreciate what Mechatronics is about. Comprehend the various forms and elements of control systems. Integrated design issues in Mechatronics. Mechatronics key elements. The Mechatronics design process. Advanced Approaches in Mechatronics.

Sensors & Transducers, Signal Conditioning and Data Presentation System

Describe the performance of commonly used sensors. Evaluate sensors used in the measurements of: displacement, position and proximity; velocity & motion; force; flu id pressure; liquid flow; liquid level; temperature; light. Selection of sensors, inputting data by switches. Explain the requirements for signal conditioning. Exp lain how operational amplifiers can be used , the requirements for protection and filtering, the principle of the Wheatstone bridge and , in particular, how it is used with strain gauges, the principles and main methods of analogue-to-digital and digital-to-analogue converters, multiplexers and data acquisition using DAQ board s. Exp lain the principle of digital signal processing. Exp lain the principle of pulse-modulation. Explain the problem of loading. Describe the basic principles of u se of commonly used data presentation elements: meters, analogue chart recorders, oscilloscopes, visual display units, printers. Explain the principles of magnetic recording on flop p y and hard disk. Explain the principles of displays and in particular, the use of LED seven -segment and dot matrix displays and the u se of d river circuits. Explain how data presentation can occur with the use of DAQ board s. Design measurement systems.

Unit-II: Pneumatic & Hydraulic, Mechanical and Electrical Actuation Systems

Interpret system drawings, and design simple system s, for sequential control systems involving valves and cylinders. Explain the principle of process control valves, their characteristics and sizing. Evaluate mechanical systems involving linkages, cams, gears, ratchet and pawl, belt and chain drives, and bearing. Evaluate the operational characteristics of electrical actuation system s: relays, solid -state switches (thrusters, bipolar transistors and MOSFETs, solenoid actuated

system s, DC motors, AC motors and steppers motors).

Engineering System Models, Dynamic Response of Systems

Devise models from basic building blocks for mechanical, electrical flu id and thermal systems. Devise models for rotational-translational, electro-mechanical and hydraulic-mechanical systems. Model dynamic systems by means of differential equations. Determine the response of first and second-order system to simple inputs.

Unit-III: System Transfer Functions, Frequency Response

Define the transfer function and determine the responses of system s to simple inputs by its means, u sing Lap lace transform s. Identify the effect of p ole location on transient response. Exp lain the u se of MATLAB and SIMULIN K to model systems. Analyze the frequency response of systems subject to sinusoidal inputs. Plot and interpret Bode plots.

Closed-Loop Controllers

Predict the behavior of systems with proportional, integral, derivative, proportional plus integral, proportional plus derivative and PID control. Explain how such modes of control can be realized with operational amplifiers and digital controllers and controller settings determined. Explain what is meant by velocity feedback and adaptive control.

Unit-IV: Digital Logic, Microprocessors

Use the binary, octal, hexadecimal and binary coded decimal number system s; exp lain how numbers can be signed and the twos complement method s of hand ling negative numbers. Exp lain the ad vantages of the Gray cod e. Describe parity method s of error detection . Recognize the symbols and Boolean representation of, w rite truth tables for and use in applications, the logic gates of AN D, OR, N OT, N AN D, N OR AN D XOR. Use Boolean algebra to simplify Boolean expressions and present them in the form of sums of products or product of sums. Use Karnaugh maps to determine the Boolean expressions to represent truth tables. Exp lain how SR, JK and D flip -flop s can be used in control system s. Describe the basic structure of a microcomputer, a microprocessor and a microcontroller. Explain how program can be developed using flow charts or pseudo-code.

In Put/Output Systems, Programmable Logic Controllers, Communication Systems, Fault Find in G, Design And Mechatronics

Identify interface requirements and how they can be realized ; in particular buffers, hand shaking, polling and serial interfacing. Exp lain the function of peripheral interface adapters and program them for particular situations. Explain the function of asynchronous communications interface adapters. Describe the basic structure of PLCs. Program a PLC, recognizing how the logic functions, latching and sequencing can be realized. Develop programs involving timers, internal relays, counters, shift registers, m aster relays, jumps and data hand ling. Describe centralized , hierarchical and distributed control system s, network configurations and methods of transmitting data, describing protocols used in the transmission of data. Describe the op en system s Interconnection communication model. Describe commonly used communication interfaces: RS-232, Centronics, IEEE-488, personal computer buses, VXI bus, and I2C bus. Recognize the techniques used to identify faults in microprocessor-based system s, including both hard w are and software. Explain the u se of emulation and simulation. Compare and contrast possible solutions to design problem s w hen considered from the traditional and the mechatronic point of view. Analyze case studies of Mechatronics solutions. Design Mechatronics solutions to problems.

Books Recommended:

1. Mechatronics by W. Bolton, published by Pearson Education Asia
2. Mechatronics by David G. Alciatore and Michael B. Histand, Published by Tata McGraw-Hill Publishing company Limited

3. Mechatronics System Design by Devdas Shetty and Richard A. Kolk, Published by Vikas Publishing House
4. Introduction to Mechatronics by Appuu Kuttan K. K. Published by Oxford University Press.
5. Mechatronics: Integrated Technologies for Intelligent Machines by A. Smaili, F. Mrad published by Oxford University Press.

	Mechatronics and CIM Lab	Learning Schedule			
		L	T	P	C
	Pre-requisites: Mechatronics & CIM	0	0	2	1

The students will be required to carry out 8 to 10 experiments covering the theory courses Mechatronics & Computer Integrated Manufacturing Systems

	Dissertation Phase-I	Learning Schedule			
		L	T	P	C
	Pre-requisites: NIL	**0**	**0**	**6**	**3**

The primary objective of this course is to develop in student the capacity for analysis & judgment and the ability to carry out independent investigation in design / development through a dissertation work involving creativity, innovation and ingenuity. The work must start with comprehensive literature search and critical appreciation thereof so as to select research problem the student wishes to work on.

Each student will carry out independent dissertation under the supervision of some teacher(s) who will be called Supervisor(s). In no case more than two supervisors can be associated with one dissertation work.

The dissertation involving design/ fabrication/ testing/ computer simulation/ case studies etc. which commences in the III Semester will be completed in IV Semester. The evaluation of the dissertation phase I besides approval of the dissertation topic of the students will be done by a committee constituted as under:

Chairperson of Department : Chairperson

M Tech Coordinator / Sr. Faculty : Member Secretary

Respective dissertation supervisor : Member

The student will be required to submit two copies of his/ her report to the department for record (one copy each for the department and participating teacher).

	Seminar	Learning Schedule			
		L	T	P	C
	Pre-requisites: NIL	**0**	**0**	**4**	**2**

The objectives of the course remain:

- To learn how to carryout literature search
- To learn the art of technical report writing
- To learn the art of verbal communication with the help of modern presentation techniques

A student will select a topic in emerging areas of Engineering & Technology and will carry out the task under the supervision of a teacher assigned by the department.

He/ She will give a seminar talk on the same before a committee constituted by the chairperson the department. The committee should comprise of 2 or 3 faculty members from different specializations. The teacher(s) associated in the committee will each be assigned 2 hours teaching load per week.

However, supervision of seminar topic will be in addition to the regular teaching load.

	Mechanism and Manipulator Design	Learning Schedule			
		L	T	P	C
	Pre-requisites: Theory of Machines and Robotics Engineering	3	0	0	3

COURSE DESCRIPTION

This course includes basically kinematics of Machines consists of Kutzbach and Grublers criterion, links, pairs, chains. It covers Dimensional synthesis of mechanism. It consists Actuation and transmission systems and rigid body dynamics.

COURSE OBJECTIVES

The course aims to study different types of mechanism. To understand the basics of manipulator.

COURSE OUTCOMES

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

1. Understand the links, pairs and chains.
2. Understand the different mechanisms uses in machines.
3. Understand the anatomy of manipulators.
4. Understand the basic design of the manipulators.
5. Understand the dynamics of manipulators.

COURSE CONTENTS

Unit-I: Mechanism Design

Kinematics and Dynamics, Mechanisms and Machines, Plane and Space Mechanisms, Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion, Mobility and range of movement - Kutzbach and Grubler s criterion, Number Synthesis, Grashof s criterion, Plane motion of a rigid body, Instantaneous Centre (IC) of Velocity, Velocity and Acceleration Diagrams, Velocity and Acceleration analysis, Corioli s component of acceleration

Unit-II: Mechanism Synthesis

Dimensional synthesis of mechanism; motion, path and function generation, precision point approach, Chebyshev spacing, Three position synthesis, graphical approach for four link mechanisms, Advanced synthesis solutions, branch and order defects,
Analytical methods, straight line mechanisms

Unit-III: Manipulator Kinematics

Classification, Actuation and transmission systems, Homogeneous Co-ordinate transformations, DH notations, Inverse and forward kinematics

Unit-IV: Manipulators Dynamics

Rigid body dynamics, Manipulator dynamics by Newtonian and Lagrangian approach.

Books Recommended:

1. Robot Design Handbook G.B. Andeen McGraw Hill
2. Introduction to Robotics, Mechanics and Control J.J. Craig Addison Wesley
3. Robotic Manipulators: Mathematics, Programming and Control R.P. Paul MIT Press
4. Robot Dynamics and Control M. Spong and M.Vidyasagar JohnWiley, NY
5. Dextrous Robot Hands S.T. Venkataraman Springer-Verlag
6. Theory of Mechanism and Machine Amitabh Ghosh, Asok Kumar Malik Affiliated East-West Press Private Limited

	Tribology	Learning Schedule			
		L	T	P	C
	Pre-requisites: Basics of Lubrication & Bearing	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

This course includes basically different types of wear mechanism. It covers the properties and testing of lubricants and surface properties of target material. It deals with the different types of bearings.

COURSE OBJECTIVES

The aim of this course is to provide the basic understanding of different types of wear mechanism.

COURSE OUTCOMES

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

1. Understand the properties and testing of lubricants.
2. Understand the surface properties of target material.
3. Understand the mechanism of wear.
4. Understand different types of bearings.

COURSE CONTENTS

Unit-I: Introduction

Tribology, Historical background; Properties and testing of lubricants, Viscosity, Viscometry, Effect of temperature and pressure on viscosity

Surface Roughness, Friction and Wear

Surface topography, surface characterization, apparent & real area of contract, laws of friction, friction theories with criticism, frictional heating, classification of wear, mechanism of wear, laws of wear: Qualitative & quantitative, wear resistance materials.

Unit-II: Hydrodynamic Bearings

The generalized Reynold s equation, fundamentals of lubrication and lubrication regims, mechanism of pressure development, Plane slider bearing, Step bearing, Idealized journal bearing: infinitely long & short journal bearing; Petroff equation, oil film thickness: approx. relation, film shape, accurate expression; finite journal bearings, boundary conditions: Sommerfeld condition, Half Sommerfeld condition, Reynold s condition; load carrying capacity and attitude angle, oil flow, friction in journal bearings; Cavitation, oil whirl in journal bearings and methods of cure; bearing materials

Unit-III: Hydrostatic Bearings

System of hydrostatic lubrication, restrictors, circular step bearings, Rectangular thrust bearings, opposed pad bearings; multirecess journal bearings, hydrostatic lift, hybrid bearings.

Gas Lubricated Bearings

Governing equations, limiting solutions, infinitely long plane slider & journal bearings, externally pressurized gas bearings.

Unit-IV: Elasto hydrodynamic Lubrication & Rolling Element Bearings

Theoretical consideration, Grubin type solution, film-thickness equation, different regimes in EHL contacts, Geometry and kinematics of ball bearings, stress & deformations, load capacity, prediction of fatigue life of ball bearings and lubrication of ball bearings.

Books Recommended:

1. Basic Lubrication Theory by Alastair Cameron, Published by El;lis Horwood Ltd., New Work.
2. Introduction to Tribology of bearings by B.C. Majumdar, a.h. wheeler & Co. Pvt. Ltd., Delhi.
3. Applied Tribology: Bearing Design & Lubrication, M.M. Khonsari & E.R. Booser, John Wiley & Sons INC.
4. Engineering Tribology by G.W. Stachowiak & A.W. Batchlor, Butterworth-Heinenann.

	Advance Operation Research	Learning Schedule			
		L	T	P	C
	Pre-requisites: Operation Research	**3**	**0**	**0**	**3**

COURSE DESCRIPTION

Operation research is having many powerful tools to optimize the real life problems. The study of this subject will give knowledge to the students regarding transportation and inventory related problems. This also describes the method of sequencing of jobs through different number of machines. Focus is also given to most common problems of waiting of either jobs/machines/peoples. Emphasis is given to decision models and replacement problems. So the study of this subject will develop the capability among students to solve effectively many problems arising during their career.

COURSE OBJECTIVES

1. To provide students the knowledge of optimization techniques and approaches.
2. To enable the students apply mathematical, computational and communication skills needed for the practical utility of Operations Research.
3. To introduce students to research methods and current trends in Operations Research.

COURSE OUTCOMES

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

1. Apply operations research techniques in industrial optimization problems.
2. Solve transportation problems using various OR methods.
3. Illustrate the use of OR tools in a wide range of applications in industries.
4. Explain current topics and advanced techniques of Operations Research for industrial solutions.

COURSE CONTENTS

Unit-I: Advanced Topics in LP

Duality, Dual simplex method, Revised simplex method, The decomposition method, Sensitivity analysis, Parametric LP, Variants in Transportation problem, Least time Transportation problem, Post optimality analysis in Transportation, Trans-shipment problem, Dual of TP, Variants in Assignment Problem, Sensitivity Analysis in Assignment Problems, The travelling salesman Problems(Shortest Cyclic Route Models)

Unit-II: Games Theory and Goal Programming

Introduction, Theory of games, Application of Goal Programming

Replacement: Introduction, Replacement of items that deteriorate , Replacement of items that fail suddenly, Group replacement, Mortality and staffing problems, Renewal Theory, Application of Replacement Policy in Real life Problem

Unit-III: Queuing Models

Multichannel queuing systems, limited queue length

Network Analysis

Financial Planning through network, Network crashing, Allocation of resources in a Project, Applications of Network Techniques

Simulation

Monte Carlo method, Markov Chains

Unit-IV: Non Linear Programming

Introduction, Integer Programming, Non linear Programming Problem, Quadratic Programming, Separable Programming, Dynamic Programming

Books Recommended:

1. Operations Research -C.K. Mustafi- New Age International Publishers
2. Operations Research Prem Kumar Gupta and D.S. Hira- S. Chand
3. Introduction to Operations Research- Hiller/ Liberman- Tata Mcgraw Hill
4. Operations Research- Taha- PHI
5. Operations Research- Gupta and Khanna (PHI)

	Technology and Manufacturing Strategies	Learning Schedule			
		L	T	P	C
	Pre-requisites: Production Planning & Control	3	0	0	3

COURSE DESCRIPTION

This course includes the strategies adopted for competitive Planning. It includes the new manufacturing philosophy and Competitiveness through Manufacturing Advantage. Different stages of product development cycle and its problems.

COURSE OBJECTIVES

The course aims to prepare the student industry ready by giving the knowledge about the planning strategies and new manufacturing philosophy. To study the product life cycle development and the related problems.

COURSE OUTCOMES

On completion of this course, the students will be able to

1. Understand the levels of strategy and customer matrix.
2. Understand the Strategic importance of various Manufacturing systems based on Volume & Variety.
3. Understand the Manufacturing Strategy Competitiveness & activities.
4. Understand the Technology strategy & Technology Management.
5. Understand the Managing technology for new product

COURSE CONTENTS

Unit-I: Competitive Strategy Planning

Levels of Strategy, Strategy process, Customer Matrix - Perceived use value, Producer matrix Core Competences, Scenarios planning- PEST analysis, PORTER Five force model, Value Chain Concept, Generic strategy concept.

New Manufacturing Philosophy

Strategic importance of various Manufacturing systems based on Volume & Variety, Three flows of manufacturing systems, Synchronous Manufacturing, Brief concept of JIT, TQM, Simultaneous Engineering & Reverse Engineering, Lean Manufacturing.

Unit-II: Manufacturing Competitiveness

Competitiveness through Manufacturing Advantage- Quality, Speed, Dependability, Flexibility and Cost advantages; Internal & External performance, Manufacturing focus & Segmentation, Manufacturing Strategy Competitiveness & activities.

Manufacturing Structure & Strategy

Manufacturing structure, Focused factory, Group technology & its impact on manufacturing Strategy; Experience curve; Objective and characteristics of Manufacturing strategy, Order winning & qualifying objectives, process of formulating & implementing manufacturing strategy.

Unit-III: Strategic Technology Management: Understanding technology, Business strategy, Technology strategy & Technology Management, Technology Management philosophy; Brief idea of technology forecasting; Technology Portfolio, Competitive position analysis, Strategic planning & management of technology.

Technology Development

Product development cycle & its problems; Managing technology for new product, Managing product development capability, Technological innoration - Context & opportunities, Project & its evaluation, Policy imperatives & strategic issues; Technology fusion- its principles, New R&D collaboration.

Unit-IV: International Technology & Operations Strategy

Global strategy, Porter s model of International Strategy, Technology Innovation and Strategy process, Technology accumulation, Global manufacturing, International procurement, Manufacturing strategy, Process development, Organization issues.

Organizational Support Systems

Organization structure, environment & technology, Organization flexibility, Role of Manager in organization design, Five parts of the organization and various configuration - Mintzberg theory; Strategic issues of Organization Culture - Creative Miller's Theory, Learning Organization- SENGE's Theory.

Books Recommended:

1. Management of Technology & Innovation - P.N. Rastogi, Sage Publiation, New Delhi
2. Manufacturing Advantage - Nigel Slack, Viva Books, New Delhi.
3. The Essence of Competitive Strategy - Faulkner & Bowman, PHI, New Delhi
4. The Essence of International Business - Taggart & McDermott, PHI, New Delhi
5. Manufacturing Strategy T.Hill Macimillan
6. Operations Management - Schroeder, McGraw Hill, ISE
7. Manufacturing - The Formidable competitive Weapon - W. Skinner, Jotin Wiley

	Hydraulic and Pneumatic Systems	Learning Schedule			
		L	T	P	C
	Pre-requisites: Fluid Mechanics & Machines	3	0	0	3

COURSE DESCRIPTION

The course describes the Fundamental principles, Hydraulic pumps and pressure regulation, air compressors, air treatment and pressure regulations, control valves, actuators, hydraulic and pneumatic accessories, process control pneumatics, basic hydraulic and pneumatic circuit design, basics of PLC control and automation.

COURSE OBJECTIVES

The course elaborates principles of hydraulic and pneumatic devices, electro pneumatic components. It gives an overview of control systems associated with hydraulic applications.

COURSE OUTCOMES

On the completion of the course the student will be able to:

1. Explain the similarities and differences of the electrical, pneumatic and hydraulic systems.
2. Decide which system is better for a specific application.
3. Explain the basic parts of the industrial hydraulic and pneumatic systems and their functions
4. Design a hydraulic or pneumatic system circuit by using related software and make simulations

COURSE CONTENTS

Unit-I: The Source of Hydraulic Power

Introduction, Pumping Theory, Pump Classification, Gear Pumps, Vane Pumps (Balanced & Unbalanced), Piston Pumps: Axial Piston Pump (Bent-Axis Design), In Line Piston Pumps (Swash Plate Design), Radial Piston Pumps, Pump Performance, Pump Noise, Pump Selection

Hydraulic Actuators and Motors

Introduction, Linear Hydraulic Actuators (Hydraulic Cylinders): Single Acting, Double acting (Single rod end, Double rod end, Tandem), Cushing Devices, Sealing Devices: O-ring, Compression packing, Piston Cup packing, Piston Rings, Wiper Rings, Mechanics of Hydraulic Cylinder Loadings: Limited Rotation Hydraulic Actuators: Rotary Actuators: Gear Motors, Vane Motors, Piston Motors, Hydraulic Motor Performance.

Unit-II: Valve & Other Control Components in Hydraulic System

Introduction: Direction Control Valve: 2/ 2 way, 3/ 2 way, 4/ 2 way, 5/ 2 way, 4/ 3 way, Pressure Control Valve: Pressure Relief Valve, Pressure Reducing Valve, Sequence Valve, Flow Control Valve: Check Valve, Pilot Controlled Check Valve, 2-Way Flow Control Valve, Hydraulic Fuses: Valve Actuation

Electric Controls

Basic Electrical Devices: Push button, Limit switch, Pressure switch, Temperature switch, Timer, Relay & solenoid

Fluid Conditioners

Air Filter, Air Pressure Regulator, Air Lubricator, Pneumatic Indicator, Pneumatic Silencer, Aftercoler, Chiller Air Dryer.

Unit-III: Hydraulic Circuit Design and Analysis

General Types of fluids, ANSI symbols of hydraulic components, The Reservoir System, Filters & Strainers, Power Pack, Control of Single & Double Acting Hydraulic Cylinder, Regenerative Circuit, Double Pump Hydraulic System, Pressure Intensifier Circuit, Hydraulic Cylinder Sequencing Circuits, Automatic Cylinder Reciprocating System, Locked Cylinder Using Pilot Check Valves, Cylinder Synchronizing Circuits, Meter-in flow Control, Meter-out flow Control, Time- Motion Diagram, Circuit Design for a particular Application like Lifting Platforms, Clamping Fixtures, Tool slides working under varying load, Uniform & jerk less feed motion, To lift unevenly loaded plate, To hold the cylinder at a particular position, Accumulator Circuit, Practice to design a circuit on a Software.

Unit-IV: Pneumatic Circuit Design and Analysis

Introduction, Air Control Valves, Pneumatic Actuators, Pneumatic Circuit Design Considerations, Basic Pneumatic Circuit: Operation of Single & Double Acting Cylinder, Air Pilot Control of Double Acting Cylinder,, Cylinder Cycle Timing System, Two-Step Speed control System, Two Handed Safety Control System, Control of Air Motor, Deceleration Air Cushion of Cylinder, Practice to design a circuit on a Software.

Electrical Circuit Design and Analysis for Fluid Power Circuits

Introduction, Circuit Diagram, Electro-hydraulic Servo System, Programmable Logic Controller, Electrical Components, Control of a Cylinder Using a Single Limit Switch, Reciprocation of a Cylinder Using Pressure or Limit Switches, Dual-Cylinder Sequence Circuits, Electro-Pneumatic System for Sorting Different-Sized Boxes, An Electro-Hydraulic System for Counting, Timing and Reciprocation of Hydraulic Cylinder, Practice to design a circuit on a Software.

Books Recommended:

1. Anthony Esposito, Fluid power with Applications , Prentice Hall,/ Pearson .
2. James A. Sullivan, Fluid Powe-Theory and Applicationr , Prentice Hall,.
3. Andrew Parr, Hydraulics and Pneumatics , (HB), Jaico Publishing House, 1999.
4. Bolton, W. Pneumatic and Hydraulic systems , Butterworth Heinneman, 1997
5. A text Book from FESTO DIDACTIC, Hydraulics Course for Vocational Training

	I.C. Engines Process Modeling	Learning Schedule			
		L	T	P	C
	Pre-requisites: I.C. Engines	3	0	0	3

COURSE DESCRIPTION

The course aims to develop the students with the knowledge about the advanced theory and working of I.C engines and the phenomena of combustion and modelling.

COURSE OBJECTIVES

To impart knowledge in simulating IC engine processes. The detailed concept of air standard, fuel air cycle, progressive and actual cycle simulation of SI engine will be taught to the students.

COURSE OUTCOMES

At the end of the course the students will have command over simulation of IC engine process. The student will be familiar with the basics of simulation, combustion process, SI Engine modeling and simulation process.

COURSE CONTENT

Unit-I: Introduction
Overview and historical perspective on development of internal combustion engines.

IC engine cycles
Properties of working fluid, air-standard cycle, fuel-air cycle, real cycle, availability analysis of engine processes.

Unit-II: Engine Processes Modeling
Inlet and exhaust processes in four stroke cycle, volumetric efficiency, flow through valves, essential features of combustion process in S.I. and C.I. engines; Autoignition, Knock models, Modeling Spray, Flame Propagation, Heat Release, Laminar burning speed, free gas jet theory., packet models.

Modeling Pollutant Formation
Modeling pollutant formation in SI and CI engines Models for NOx, CO and soot formation, unburned hydrocarbon combustion.

Unit-III: Engine Cycle Simulation
Simulation of ideal and actual Otto cycles at full throttle, part throttle and super charged conditions and their comparative evaluation Introduction to Computer Routines: Estimation of the composition and properties of unburned and burned mixtures.

Simulation of Combustion Processes
Progressive and spray combustion processes with reference to homogeneous and heterogeneous charge engines.

Unit-IV: Engine Simulation Tools
Introduction to FIRE and BOOST software

Introduction to Ansys Fluent For Engine Processes Simulation
Geometric modeling-ANSYS Workbench/ CFX, mesh generation, boundary and initial conditions, computational approach, analysis.

Books Recommended:

1. Internal Combustion Engine Fundamentals Heywood, JB, McGraw Hill.
2. Modeling Engine Spray and Combustion Processes Stiesch G, Springer-Verlag.
3. Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments,
4. Pollutant Formation Warnatz J, Mass U, and Dirbble RW, 4th Ed., Springer-Verlag
5. Modeling Diesel Combustion Lakshminarayanan PA and Aghav YV, Springer-Verlag
6. Fluid Dynamics and Transport of Droplets and Sprays Sirignano WA, Cambridge University Press.

	Dissertation	Learning Schedule			
		L	T	P	C
	Pre-requisites: Dissertation Phase-I	**0**	**0**	**20**	**20**

The dissertation started in III Semester will be completed in IV Semester and will be evaluated in the following manner.

Internal Assessment
Internal Assessment (class work evaluation) will be effected as per ordinance through interim report, presentation and discussion thereon by the following committee of three persons:

Chairperson of Department : Chairperson
M Tech Coordinator/ Sr. Faculty : Member Secretary
Respective dissertation supervisor : Member

External Assessment
Final dissertation will be assessed by a panel of examiners consisting of the following:

Chairperson of Department : Chairperson
Respective Supervisor(s) : Member(s)
External expert : To be appointed by the University

Note:
The External Expert must be from the respective area of specialization. The chairperson & MTech Coordinator with mutual consultation will divide the submitted dissertations into groups
depending upon the area of specialization and will recommend the list of experts for each group
separately to the V C for selecting the examiners with the note that an external expert should be
assigned a maximum of FIVE dissertations for evaluation.

The student will be required to submit THREE copies of his/ her report to the M Tech Coordinator for record and processing.