Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 56)
Master of Technology [Full Time] (Design Engineering)
Evaluation Scheme (w.e.f. 2021-22)

Semester I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**MAS4104**	Advanced Mathematics	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4101**	Design of Experiments	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4102**	Experimental Stress Analysis	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4107**	CAD & CAM	**3**	**1**	**0**	**40**	**60**	**100**	**4**
GE		Generic Elective - I	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4198**	Seminar	**0**	**0**	**2**	**100**	**0**	**100**	**1**
C	**MME4102P**	Experimental Stress Analysis Lab	**0**	**0**	**2**	**100**	**0**	**100**	**1**
C	**MME4107P**	CAD/CAM Lab	**0**	**0**	**2**	**100**	**0**	**100**	**1**
Total			**15**	**5**	**6**	**500**	**300**	**800**	**23**

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
GE	Generic Elective

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Semester II									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**MME4201**	Theory of elasticity	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4202**	Modeling and Simulation Analysis	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4203**	Finite Element Method	**3**	**1**	**0**	**40**	**60**	**100**	**4**
GE		Generic Elective - II	**3**	**1**	**0**	**40**	**60**	**100**	**4**
GE		Generic Elective - III	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**MME4298**	Seminar	**0**	**0**	**2**	**100**	**0**	**100**	**1**
C	**MME4299**	Industrial Training	**0**	**0**	**2**	**100**	**0**	**100**	**1**
C	**MME4202P**	Modeling and Simulation Analysis Lab	**0**	**0**	**2**	**100**	**0**	**100**	**1**
Total			**15**	**5**	**6**	**500**	**300**	**800**	**23**

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
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Semester III									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**MME4351**	State -of-the-art Seminar #	-	-	-	**200**	-	**200**	**4**
C	**MME4352**	Thesis I*	-	-	-	**400**	-	**400**	**16**
Total			-	-	-	**600**	-	**600**	**20**

Student need to perform a literature survey and will give a State-of the- art presentation and will submit a synopsis clearly mentioning the problem statement. The Presentation and synopsis will be evaluated internally within 2 months of the start of the semester and the result will be intimated to the students so as to proceed for Thesis.

*Student will develop the workable model for the problem they have supposed in synopsis.

Semester IV									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**MME4451**	Thesis II**	-	-	-	**200**	**800**	**1000**	**28**
Total			-	-	-	**200**	**800**	**1000**	**28**

** (a) Thesis in continuation with Thesis-I

(b) The require Experimental/Mathematical Verification of the proposed model will be done in this Semester.

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
GE	Generic Elective

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Credit Summary Chart

Course Category	Semester				Total Credits	%age
	I	II	III	IV		
F						
C	19	15	20	28	82	87.23%
GE	4	8			12	12.77%
OE						
GP						
Total	23	23	20	28	94	100.00%

Discipline wise Credit Summary Chart

Course Category	Semester				Total Credits	%age
	I	II	III	IV		
Basic Sciences						
Humanities & Social Sciences						
Engineering Sciences						
Professional Subject – Core	18	14			32	34%
Professional Subject – Generic Elective	4	8			12	13%
Professional Subject – Open Elective						
Thesis Work, Seminar and/or Internship in Industry or elsewhere	1	1	20	28	50	53%
Total	23	23	20	28	94	100%

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List of Generic Electives

Course Code	Generic Elective-I
GE45611	Micro Electro- Mechanical Systems
GE45612	Flexible Manufacturing Systems
GE45613	Computer Aided Process Planning
GE45614	Quality Engineering
GE45615	Advance Welding Technology
GE45616	Engineering Design
GE45617	Optimization for Engineering Design
GE45618	Theory of Vibration
Course Code	**Generic Elective-II**
GE45621	Advanced Manufacturing Processes
GE45522	Research and AI in Mfg. Systems
GE45623	Computer Graphics & Product Modeling
GE45625	Numerical methods for manufacturing Processes
GE45626	Product Development
GE45629	Automation & Control
Course Code	**Generic Elective-III**
GE45631	Mechatronics
GE45632	Tribology
GE45633	Design of pressure Vessels
GE45634	Nonlinear Vibration
GE45635	Advanced Composite Material
GE45636	Theory of Plate & Vessels
GE45637	Theory of Elasticity
GE45638	Theory of Mechanism

DESIGN OF EXPERIMENTS (MME4101)

Course Objective:

1. To learn the need of designed approach in sampling and modeling.
2. To learn the factor-based design and analysis approach.
3. To learn importance of variance in design and its implication.
4. To learn nested design and quality loss function for designed quality.

Learning Outcome:

1. To understand the fundamentals of optimized design.
2. To understand the effect of error and variance on quality and delivery.
3. To understand different methods of response surface design.
4. To understand and interpret the graphical results.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Fundamentals of experimental design, Selection of an appropriate design, Criteria for evaluation, Factors and levels, Reviews of statistical inference, Importance of optimized design, Functional design, Parametric design, Guidelines for Designing Experiments.	30	1
II	Single Factor Experiments, Analysis of variance (ANOVA), Effect of total sum of Squares, Randomized block design, F-ratio P-value and percentage contribution, Concepts of random variable, probability, density function cumulative distribution function.	30	1
III	Factorial Experiments, one-way analysis of variance, Fixed Random and Mixed models, Expected mean square rules, Nested and nested factorial designs, Effect of confounding, Fractional factorial design, Response Surface Methodology – Central composite designs, Box –Behnken Techniques.	30	1
IV	Taguchi's definition of quality Loss functions, Orthogonal arrays vs. classical statistical experiments, Graphic evaluations of main effects, Selecting factors for Taguchi Experiments. Concepts of S/N Ratios-its significance in robust design and Some standard designs such as CRD, RBD.	30	1

Reference Books:

1. Douglus C. Montgomery (2003). Statistical Quality Control, John Wiley and sons.
2. Charles R. Hicks (1999). Fundamental Concepts in design of experiments. OUP USA.
3. Tapan P. Bagchi (1993). Methods Explained: Practical steps to Robust Design, Prentice Hall.
4. Cochran, W.G. and Cox. G.M. (2003). Experimental Designs Asia Publishing House.
5. Phadke M.S. (1996). Quality Engineering Using Robust Design, Prentice-Hill.

EXPERIMENTAL STRESS ANALYSIS (MME4102)

Course Objective:

1. To develop the relationship between the loads applied to a non-rigid body and the internal stresses and deformations induced in the body.
2. To study the general state of stresses and strains in a given loaded member and the magnitude and direction of the principal stresses.
3. To study stress, crack and failure pattern and strain rate sensitivity.
4. To learn the impact and implication of principal direction, plane and stresses.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the different techniques and method to calculate and assess the stresses experienced by a component.
2. To understand the failure initiation, occurrence and avoidance.
3. To learn different theories and models of stress strain modeling.
4. To appreciate and design complex real structures.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Stress and Stress Equations of Equilibrium Laws of Stress Transformations and principal Stresses, Two-Dimensional State of Stress, Stresses Relative to Principal Coordinate System, Strain: Introduction, Displacement and Strain, Strain transformation equation and principal strains, compatibility, Stress-Strain Relations for Two-Dimensional State of Stress, Equilibrium equations. Stress Strain Measurements	**30**	**1**
II	Brittle Coating Method: Coating Stresses, Failure Theories, Brittle Coating Crack Patterns, Resin and Ceramic Based Brittle Coating, Test Procedure, and Analysis of Brittle Coating Data, Gage Sensitivity and Gage Factor, Strain Gage Circuit: Potentiometer and its Application, Wheat-Stone Bridge, Bridge Sensitivity, Null Balance Bridges. Analysis of Strain Gage Data. Moire Method of Strain Analysis, Grid Method of Strain Analysis	**30**	**1**
III	Stress Optic Law, Relative Retardation, Stressed Model in Plane Polariscope, Effect of Principal Directions,	**30**	**1**

	Effect of Principal Stress Difference, and Stressed Model in Circular Polari-scope, Light and Dark Field arrangements, Tardy's method of Compensation, Fringe Sharpening and Multiplication by Partial Mirrors. Photo-elastic Behavior of Light, Polarized Light, Plane Polarizers		
IV	Two-Dimensional Photo-elasticity: Isochromatic Fringe Patterns, Isoclinic Fringe Patterns, Compensation Techniques, Calibration Methods, Separation Methods, Oblique Incidence Method, Calibration of Photo-elastic material: Need and advantages of circular disk. Crack Detection, Load-Time relation and its influence.	**30**	**1**

Reference Books:

1. James W. Dally and William F. Riley (1999). Experiment Stress Analysis. McGraw-Hill Book Company.
2. Dr. Sadhu Singh (1998). Experiment Stress Analysis. Khanna Publishers.
3. Jindal U.C. (2012). Experimental stress analysis. Pearson Publishers.

CAD & CAM (MME4107)

Course Objective:

1. To learn advance concepts of CAD and computer graphics.
2. To learn about the geometric issues concerned with solid modeling, also in-depth concepts of curves, surfaces and solid modeling.
3. To acquire knowledge about various methods of advance manufacturing welding, cold and hot working and forming
4. To understand forging, molding and powder metallurgy processes in detail and application of these in manufacture of a product.

Learning Outcome:

1. Have a conceptual understanding of CAD systems
2. Get knowledge of various approaches of geometric modeling, Understand mathematical representation of 2D and 3D entities, also students learn about importance of geometric, solid and surface modelling
3. To use the principles of foundry and casting.
4. To choose materials in a manufacturing process based on their properties.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Definition of CAD Tools, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations Coordinate Systems, Curves: Fundamental of Curve Design, Rational Polynomials, Rational curves, NURBS, Geometric Modeling, Polygons, Curves, and Paths, Types of Polygons, Curves & Equations, Plane Curve and Space Curve, Analytical and Synthetic Curves, Hermite cubic curve. Implicit Equations & Curves, Explicit Equations & Curves, Parametric Representation of Curve, Parametric Representation of Circle, Helix, Sphere, Ellipse and Super Ellipse, Parameterization. Definition of CAD Tools, Graphics standards, Graphics software: requirements of graphics software, Functional areas of CAD, Efficient use of CAD software.	**30**	**1**
II	Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparameterization of a Surface patch, Sixteen-point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B Spline Surface. Surface modeling, Solid modeling, Alternate Classification of	**30**	**1**

	Geometric Modeling Forms, Fundamental of Surface Design, Polygonal Surfaces, Surface Patch, Explicit & Implicit equation of surfaces, Parametric Equations of Surfaces Quadric Surfaces Superquadrics Blobby Objects Bezier Surfaces Solids: Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids ,Surface and Curves in a Solid ,Solid Modeling.		
III	Analysis of Manufacturing Systems, Classification of Manufacturing System, Analysis of Manufacturing Operation, Material Handling System. Computer Control System, concept of Computer Integrated Manufacturing (CIM), impact of CIM on personnel, Role of manufacturing engineers in CAM. Technology for CIM System, Trend in Information Technology, Telecommunication, Software, Information System Department, International Standards and OSI.	**30**	**1**
IV	Concept of Group Technology and Its Application, Classification and Coding Techniques, Approach to process planning, Different CAPP systems: applications and benefits. Production Planning and management in CIM System, System Evolution, Material Control Within CIM, Traditional Production Planning and Control, Master Production Schedule (MPS), Material Requirement planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRPII).	**30**	**1**

Reference Books:

1. Mathematical Elements of Computer Graphics, Rogers and Adams, McGraw Hill.
2. CAD CAM Theory and Practice: I. Zeid, Tata-McGraw Hill
3. Computer-Aided Design, R K Srivastava, Umesh Publications, Delhi,
4. Geometric Modeling: Michael E. Mortenson, John Wiley
5. Aided Manufacturing by Chang. Wysk, Wang: Prentice Hall.
6. P. Radhakrishnan / V. Raju / S. Subramanyam, “CAD / CAM / CIM” Computer.

EXPERIMENTAL STRESS ANALYSIS LAB (MME4102P)

Experiments: Minimum 5 experiments out of following in details.

1. Study of preparation of circular disk or any model from photo-elastic sheet.
2. Study the casting of Photo-elastic Sheet.
3. Study the Stress freezing of photo-elastic model.
4. Study and demonstration of Reflection polariscope.
5. Study and demonstration of Fringe sharpener and multiplier
6. Study of fixing of strain gages to the specimen
7. Study of separation of principle stresses using any method of stress separation
8. Study of stress and strain in cantilever beam using strain gages
9. Study of fringe constant using circular disk.
10. Study and determination of stresses using at least three photo-elastic models.

CAD/CAM LAB (MME4107P)

Experiments: Minimum 8 experiments out of following in details:

1. Creating a Simple Object (Part 1) (About 3D axes, datum planes, orientation in space, rotation etc. in Pro-E)
2. Creating a Simple Object (Part 2) (Create features like holes, chamfers etc.)
3. Modeling Utilities (Parent-child relations, redefining sketches, and rerouting or changing references.)
4. Datum and sketcher tools, Patterns and Copies, Sweep and Blends
5. Assembly Fundamentals and operations.
6. Study of milling simulation using CAPSMILL software.
7. Study of turning simulation using CAPSTURN software.
8. Study of turning exercise in Production lathe using single tool.
9. Study on Mechatronics and controls.
10. Study of multi-axial machining in CNC machining center–EDM–EDM wire cut– rapid prototyping.

THEORY OF ELASTICITY (MME4201)

Course Objective:

1. To learn various mathematical and physical aspects of deformation.
2. To learn stress strain relationship in two dimensional Cartesian coordinates.
3. To learn the formulation of elasticity equations and stress function variants.
4. To learn the usage of different mathematical technique to solve complex problem formulations.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the stress stiffness and generalized failure models.
2. To understand the mathematical techniques to solve engineering equations.
3. To identify and appreciate the different analogies in two dimensional stress problems.
4. To understand different type of stresses in various cylinders.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Definition and Notation for forces and stresses, Components of stresses, equations of Equilibrium Specification of stress at a point, Principal stresses and Mohr's diagram in three dimensions Boundary conditions, Stress components on an arbitrary plane Stress invariants, Octahedral stresses Decomposition of state of stress, Stress transformation. Method of Analysis	**30**	**1**
II	Deformation, Strain Displacement relations, Strain components. The state of strain at a point, Principal strain, Strain transformation, Compatibility equations Cubical dilatation. Stress -Strain Relations and the General Equations of Elasticity Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems. Deformation and flow theories of Plasticity, Strain at a point, Bending of beams, Pure bending, Rotating Disk	**30**	**1**
III	Saint-Venant's principle of super position and reciprocal, Two Dimensional Problems in Cartesian Co-Ordinates, Airy's stress function, investigation for	**30**	**1**

	simple beam problems, Use of Fourier series to solve two dimensional problems. True Stress-Strain curve, Strain rate effect		
IV	Two Dimensional Problems in Polar Co-Ordinates, General equations, stress distribution symmetrical about a force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate, Thermal Stresses: Introduction, Thermo-elastic stress-strain relations, Thin circular disc, Long circular cylinder, Torsion of Prismatic Bars: Torsion of Circular and elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled open and closed tubes, Elastic Stability: Axial compression of prismatic bars.	**30**	**1**

Reference Books:

1. Timoshenko and Goodier (2017). Theory of Elasticity. McGraw Hill Book Company.
2. Dym C. L and Shames. I. H (1973). Solid Mechanics: A variation Approach, McGrawHill New York.
3. SitharamT.G (2008). Applied Elasticity" Interline publishing.
4. SrinathL.S. (2010). Advanced Mechanics of Solids. Tata McGraw Hill Company.
5. Sadhu Singh (1978). Theory of Elasticity. Khanna publisher.

MODELING AND SIMULATION ANALYSIS (MME4202)

Course Objective:

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.
3. To learn the differentiation between the continuous and discrete systems in accordance with simulation modeling.
4. To understand static and dynamic models and fundamentals of model evaluations.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the physical modelling technique.
2. To understand the different type of mathematical model.
3. To understand the basic simulation method.
4. To understand the basic of simulation of mechanical system.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Concept of system, System environment, Stochastic activities, Continuous & discrete system, System modeling Types of models: Static physical model, Dynamic physical model, Static mathematical model, Dynamic mathematical model	30	1
II	System studies: Corporate model, Environment segment, Production segment, Management segment, System analysis, System design, System postulation Physical Modeling: Concept of System and Environment, Non-Linear Systems, Stochastic Activities, Static and Dynamic Models, Principles of Modeling, Basic Simulation Modeling, Role of Simulation in Model Evaluation and Studies, Advantages of Simulation.	30	1

III	System Simulation: Techniques of Simulation, Monte Carlo Method, Experimental Nature of Simulation, Numerical Computation Techniques, Continuous System Models, Numerical computational technique for continuous models and discreet models, distributed lag model	**30**	**1**
IV	Simulation of Mechanical Systems: Simulation of Manufacturing Systems, Simulation of Waiting Line Systems, Job Shop with Material Handling and Flexible Manufacturing Systems, Simulation Software for Manufacturing, Study of Simulation software MatLab, Simul8	**30**	**1**

Reference Books:

1. Geoffrey Gordon (2004). System Simulation. Prentice Hall.
2. Robert E. Shannon (2006). System Simulation: The Art and Science. Prentice Hall.
3. J. Schwar Ziebach and K.F. Gill Edward Arnold (1992). System Modeling and Control. Ebufb.net.
4. Charles M Close and Dean K. (2004). Modelling and Analysis of Dynamic Systems, Frederick Houghton Mifflin.
5. Allan Carrie John (1989). Simulation of manufacturing, Wiley & Sons.

FINITE ELEMENT METHOD (MME4203)

Course Objective:

1. To enable the students understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics.
2. To understand the characteristics of various finite elements.
3. To learn 2D and 3D problem formulation and usage of FEM packages.
4. To learn the stress developed in beams and shafts.

Learning Outcome:

At the end of the course student should be able to:

1. To apply the knowledge of mathematics and engineering to solve problems in structural engineering by approximate and numerical methods.
2. To design a new component or improve the existing components using FEA.
3. To solve the problems in solid mechanics and heat transfer using FEM.
4. To use commercial FEA packages like ANSYS and modern CAD/CAE tools for solving real life-problems.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to finite difference method and finite element method, Mathematical formulation of FEM, Step involve in FEM, Approaches of FEM- Discrete, Variation and Weighted Residual, Direct Problems-Spring, Hydraulic Network, Resistance Network and Truss Systems. Equilibrium of continuum-Differential formulation, Energy Approach.	30	1
II	1-D Field and Beam Bending Problems-Formulation using Galerkin and Raleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing, Interpolation polynomials. Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 1-D heat conduction, heat transfer through thin fins; Potential flow problems	30	1
III	2-D and Axis-symmetric Field and Stress Problems-Formulation using Galerkin and Raleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing, Thin plate	30	1

	problems, Vibration of shafts and beams. Triangular (CST, LST): Shape function, Jacobian matrix, strain displacement matrix, stress-strain relationship matrix, force vector. Quadrilateral Elements (Q4, Q8): Shape function, Jacobian matrix, strain displacement matrix, stress-strain relationship matrix, force vector.		
IV	3-D Field and Stress Problems-Formulation using Galerkin and Raleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing, Eigen value and time dependent problems, Discussion about preprocessors, postprocessors and finite element packages. Formulation of dynamic problems, consistent and lumped mass matrices for 1-D and 2-D element, Solution of eigen value 1-D problems: Transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method.	**30**	**1**

Reference Books:

1. Zienkiewicz, O.C. and R.L. Taylor, R.L. (2000). The Finite Element Method. McGraw Hill.
2. Reddy J.N. (2006). An Introduction to Finite Element Method. McGraw Hill.
3. K.J. Bathe (2006). Finite Element Procedure in Engineering Analysis. Printice Hall.
4. Krishnamoorthy, C.S. (1994). Finite Element Analysis. Tata McGraw Hill.

MODELING AND SIMULATION ANALYSIS LAB (MME4202P)

Minimum 05 experiment of the following

1. Study of simulation software Like MATLAB, SIMUL8.
2. Simulation of Queuing systems.
3. Modeling and Simulation of Manufacturing System.
4. Generation of Random number.
5. Modeling and Analysis of Dynamic Systems.
6. Simulation mass spring damper system.
7. Simulation of hydraulic and pneumatic systems.
8. Simulation of Job shop with material handling and Flexible manufacturing systems.

MICRO ELECTRO-MECHANICAL SYSTEMS (GE45611)

Course Objective:

1. To understand the basic concepts of MEMS.
2. To enhance the knowledge of sensors and actuators.
3. To familiarize with the properties and applications and explore the MEMS/ NEMS devices and their applications.
4. To learn the processes and fundamentals of etching and micromachining processes.

Learning Outcome:

At the end of the course student should be able to:

1. Use Nanomaterial and polymers for various industrial applications.
2. To design MEMS devices for various applications.
3. To demonstrate the knowledge of devices used in MEMS/NEMS.
4. To understand the concepts and application of micromachining.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Intrinsic Characteristics of MEMS. Introduction to Micro Fabrication Silicon Based MEMS Processes–New Materials Review of Electrical and Mechanical Concepts in MEMS, Semiconductor Devices–Polymer and Optical MEMS: Overview of microelectronics manufacture and Microsystems technology, Applications of MEMS in various industries.	**30**	**1**
II	Sensors and Actuators-I: Electrostatic Sensors Parallel Plate Capacitors Applications – Interdigitated Finger Capacitor Comb Drive Devices Thermal Expansion, Thermal Couples, Thermal Resistors – Applications – Magnetic Actuator, Micro-Magnetic Components, Case Studies of MEMS in Magnetic Actuators. Actuation using Shape Memory Alloys.	**30**	**1**
III	Sensors and Actuators Piezo-resistive Sensors – Piezo-resistive Sensor Materials. Stress Analysis of Mechanical Elements. Applications to Inertia, Pressure, Tactile and Flow Sensors. Piezoelectric Sensors and Actuators. Piezoelectric Effects–Piezoelectric Materials, Applications to Inertia, Acoustic, Tactile and Flow Sensors, Bulk Micro manufacturing-surface micro machining–LIGA–SLIGA-Micro system packaging materials - die level - device level - system level -	**30**	**1**

	packaging techniques – die preparation – surface bonding - wire bonding - sealing.		
IV	Micromachining: Silicon Anisotropic Etching Anisotropic Wet Etching, Dry Etching of Silicon Plasma Etching Deep Reaction Ion Etching (Dry)Isotropic Wet Etching Gas Phase Etchants Case Studies - Basic Surface Micromachining Processes Structural and Sacrificial Materials – Acceleration of Sacrificial Etch – Striction and Antistriction Methods – Assembly of 3d MEMS – Foundry Process, Micro system packaging, Packing Technologies, Assembly of Microsystems, Reliability in MEMS mechatronics.	**30**	**1**

Reference Books:

1. Chang Liu (2006). Foundations of MEMS. Pearson.
2. James J. Allen (2005). Micro electro mechanical system design, CRC Press.
3. Nadim Maluf (2000). An introduction to Micro electro mechanical system design. Artech House.

FLEXIBLE MANUFACTURING SYSTEMS (GE45612)

Course Objective:

1. To learn principles and application of FMS, CNC and DNC.
2. To learn hardware and software implication in design and implementation of FMS.
3. To learn part programming and robot programming as applicable in industrial setting.
4. To lean the use of AGV and Supervisory systems.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the importance and application of FMS and Numeric Controls in industrial setting.
2. To understand the concept and application of scheduling, planning and control.
3. To appreciate the importance and usage of supervisory systems in manufacturing.
4. To design and develop material handling systems.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction, Purpose and Definition Architecture of FMS, CNC and DNC. Computer Control System: Computer Function, FMS Data File, System Reports Planning The FMS, Analysis Method For FMS, Application and Benefits.	30	1
II	Hardware and of Software's Auxiliary Devices in FMS MS Operation Control Production Scheduling In FMS, FMS Scheduling Rules FMS Capacity Planning and Control. Design and Manufacturing Attributes. Parts Classification and Coding.	30	1
III	Part Programming in FMS, Tool Data Base - Clamping Devices and Fixtures Data Base. Robotics, Introduction, Classification Hardware Details of Robot Elements Principles of Robot Programming.	30	1
IV	Automated Guided Vehicles Classification and Elements Supervisory Systems Application on Welding Assembly, Material Handling, Conveyors, Industrial Robots in Material Handling and Economics of FMS Technology.	30	1

Reference Books:

1. H K Shivanand (2006). Flexible Manufacturing System, New Age International.
2. Thomas J Drozda, Judy D Stranahan, Gloria Farr (2003). Flexible Manufacturing Systems, Society of Manufacturing.
3. A Raouf, M Ben Daya, Raouf (1995). Flexible Manufacturing Systems: Recent Developments. Elsevier.

COMPUTER AIDED PROCESS PLANNING (GE45613)

Course Objective:

1. To understand the process planning in production environment.
2. To understand the CAPP and GT concepts and applications.
3. To appreciate the need and demand of computer aided process planning and its constituents.
4. To understand the various concept of dimensioning and tolerances in part and assembly design.

Learning Outcome:

At the end of the course student should be able to:

1. To learn design and implementation of decision tree and appreciate the decision support system.
2. To appreciate the capacity building the usage and the application of capacity planning.
3. To learn the usage and advantage of computer application in manufacturing design and process planning.
4. To appreciate the various concept of decision and process planning.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: The Place of Process Planning in the Manufacturing Cycle Process Planning and Production Planning-Process Planning and Concurrent Engineering, CAPP, Group Technology, Conventional Tolerance, Geometric Tolerance, Geometric Modeling for Process Planning.	**30**	**1**
II	Part Design, Representation Design, Drafting Dimensioning, Conventional Tolerance, Geometric Tolerance, CAD-Input/Output Devices, Topology, Geometric Transformation, Perspective Transformation, Data Structure-Geometric Modeling for Process Planning. GT Coding, OPITZ System, the MICLASS System.	**30**	**1**
III	Process Engineering and Process Planning Experience Based Planning, Decision Table and Decision Trees, Process Capability Analysis, Process Planning Variant Process Planning Generative Approach-Forward and Backward Planning, Input Format. Process Planning	**30**	**1**

	Software -CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.		
IV	Computer Aided Process Planning Systems: Logical Design of Process Planning Implementation Considerations Manufacturing System Components Production Volume. An Integrated Process Planning Systems: Totally Integrated Process Planning Systems-an Overview-Modulus Structure-Data Structure-Operation-Report Generation, Expert Process Planning	**30**	**1**

Reference Books:

1. Gideon Halevi and Roland D. Weill (1995). Principle of process planning- A Logical Approach. Chapman & Hall.
2. Nanua Singh (1996). Systems Approach to Computer Integrated Design and Manufacturing. John Wiley &Sons.
3. Jianbin Xue and De Gruyer (2018). Integration of CAD/CAPP/CAM. Science Press.
4. Xun Xu (2009). Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations. University of Auckland, New Zealand.

QUALITY ENGINEERING (GE45614)

Course Objective:

1. To enable the students understand the principles of Quality Engineering.
2. To provide students details of quality planning and TQM techniques.
3. To learn the application and usage of control charts and in production environment.
4. To appreciate the inbuilt quality and designed quality.

Learning Outcome:

At the end of the course student should be able to:

1. To learn to implement TQM tools and techniques in contemporary industries.
2. To apply the holistic approach of quality engineering.
3. To understand the concept and value of quality by design.
4. To understand the design and implementation of FMEA.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	The Meaning and Origin of CIM, The Changing Manufacturing and Modern Quality Philosophies, Statistics Fundamentals for Quality Engineering.	30	1
II	X-Bar, R and S Control Charts, Process Capability, Case Study of Variables, Quality Problem, Quality Problem Diagnosis, Robust Design Case Study, Tolerance Overview of Quality Planning, Improvement and Control.	30	1
III	Individuals Control Chart, Exponentially, Weighted, Moving Average, Chart Attribute, Control Charts, Two Case Studies Employing Attribute Control Charts.	30	1
IV	Robust Design, Introduction Two Level Factorial Designs, Model Building with Two Level Designs, Two Level Fractional Factorial Designs.	30	1

Reference Books:

1. Richard Devor, Tsong-how Chang and John Sutherland (1992), Statistical Quality Designand Control, Macmillan.
2. Pignatiello, Joseph J. Jr. and John S. Ramberg (1995), Process Capability Studies andIndices: Fundamental Issues.

3. Montgomery, D.C. Statistical Quality Control, Wiley.
4. Joiner, Brian L. (1994), Fourth Generation Management: The New Business Consciousness, McGraw Hill.
5. Gitlow, Oppenheim and Oppenheim (1994), Quality Management: Tools and Methods forImprovement, Irwin.
6. Juran, J. M. and Gryna, F. (1993), Quality Planning and Analysis, 3rd ed., McGraw-Hill.
7. Juran, J. M. (1989), Quality Control Handbook, McGraw-Hill.

ADVANCE WELDING TECHNOLOGY (GE45615)

Course Objective:

1. To acquire knowledge about the behavior and properties of metal joining processes.
2. To acquire knowledge about various methods of welding, cold and hot working and forming.
3. To understand different welding techniques of plasma, arc and gas welding processes.
4. To understand the modern and non-conventional welding processes.

Learning Outcome:

At the end of the course student should be able to:

1. To learn the need and application of different welding processes.
2. To appreciate the need and suitability of particular welding method.
3. To learn the different types of defects and the quality of welds.
4. To learn various testing and inspection methods for welds in engineering application.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	A Review of Various Metal Joining Techniques Welding, Brazing, Soldering and Adhesive Bonding, Welding Compared with Other Processes of Fabrication. Environmental issues in welding, Introduction to engineering materials.	30	1
II	Classification of Welding Processes, Application of Welding Processes, Fusion Welding: Mechanism of Arc Initiation and Maintenance, Temperature Distribution techniques, Scope and Limitations of Manual Metal Arc, TIG, MIG, Submerged Arc. Mechanisms of metal transfer in consumable electrode process, Power source design, Preheating, Selection and comparison of different processes for a particular application, safety issue in different welding process.	30	1
III	Electro slag Welding. Plasma Arc and Electro Gas Welding, Various Gas Welding Processes E.G. Oxyacetylene, Oxy-Hydrogen Welding Processes, Resistance Welding, Modern Welding Processes Viz. Electron Beam, Ultrasonic Explosive, Laser Beam Processes and Their Applications. Fundamentals of welding automation, Principles of robotic welding,	30	1

	Welding software, Economics of weld fabrication.		
IV	Solid State Welding Processes Viz. Friction, Diffusion Cold Pressure Process and their Applications. Oxygen Cutting, Plasma Arc Cutting, Laser Cutting Processes. Scope and Application, Welding Defect and Remedies, Weld Cracking and Prevention Testing and Inspection of Welds. Fundamentals of optics and fibre optics, Dissimilar material welding, Laser welding including micro-welding and hybrid processes.	**30**	**1**

Reference Books:

1. Welding Hand Book.
2. Metal Casting and Joining – John.K.C- PHI Publications.
3. Welding & Welding Technology- Richard L Little. Mc Graw Hill.
4. Welding Principles and Practices – EdwardR. Bohnart , Mc Graw Hill, 4th Edition.

ENGINEERING DESIGN (GE45616)

Course Objective:

1. To introduce integrated approach to the design of complex engineering systems.
2. To understand the different design methods and models.
3. To understand the impact and implication of material selection and design for manufacturing and assembly.
4. To understand the various statistical approach to assess and design the quality of product.

Learning Outcome:

At the end of the course student should be able to:

1. To learn the product life cycle stages and human factor involvement
2. To learn the computer and design techniques for structural and shape optimization
3. To learn value analysis and pitfalls in implementing value engineering
4. To learn the concept of designed quality in product planning and designing

Course Contents:

Module	Course Topics	Total Hours	Credits
I	The design process: Morphology of Design. Design drawings - Computer Aided Engineering, Designing of standards and Concurrent Engineering, Technological Forecasting - Market Identification, Competition Bench marking Systems, Engineering - Life Cycle Engineering Human Factors in Design -Industrial Design.	30	1
II	Design Method: Creativity and Problem Solving, Product Design Specifications & Conceptual design, Decision theory, Embodiment Design, Detail Design, Mathematical Modeling, Simulation Geometric Modeling, Finite Element Modeling, Optimization Search Methods - Geometric Programming Structural and Shape Optimization.	30	1
III	Material Selection Processing and Design Material selection Process, Economics - Cost Vs Performance, Weighted property Index, Value Analysis Role of Processing and Design, Classification of Manufacturing Process, Design for Manufacturing and Design for Assembly, Design for castings, Forging, Metal Forming, Machining and Welding Residual stresses - Fatigue, Fracture and Failure.	30	1

IV	Engineering Statistics and Reliability Probability – Distributions, Test of Hypothesis, Design of Experiments and Reliability Theory, Design of Reliability, Reliability centered Maintenance (RCM). Quality Engineering: Total Quality Concept, Quality Assurance and Statistics Process Control, Taguchi Methods-Robust Design Failure Model Effect Analysis.	**30**	**1**

Reference Books:

1. Dieter George E., (2012) Engineering Design–A Materials and Processing Approach. McGraw-Hills.
2. Hill, (1991), International Edition Mechanical Engg. Scuam's Series.
3. Singhley, (2014), Mechanical Engineering Design, McGraw-hills.
4. Pahl, G., Bitz, W. (2007), Engineering Design, Springer.

OPTIMIZATION FOR ENGINEERING DESIGN (GE45617)

Course Objective:

1. To provide students the knowledge of optimization techniques and various approaches.
2. To enable the students apply mathematical and computational skills needed for the practical utility of Optimization techniques.
3. To introduce students to research methods and current trends in engineering optimization.
4. Application of optimization techniques in design of various mechanical members.

Learning Outcome:

At the end of the course student should be able to:

1. To apply various techniques in industrial optimization problems.
2. To solve simple optimization problem for commonly used mechanical members.
3. To illustrate the use of OT tools in a wide range of applications in industries.
4. To explain current topics and advanced techniques of optimization for industrial solutions.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: General Characteristics of Mechanical Elements, Adequate and Optimum Design, Principles of Optimization, Formulation of Objective Function, Design Constraints Classification of Optimization Problem. Review of basic calculus concepts – Global optimality. Complementary Geometric Programming (C.G.P)	**30**	**1**
II	Optimization Techniques: Single Variable and Multivariable Optimization, Techniques of Un-Constrained Minimization, Golden Section, Random Pattern and Gradient Search Methods - Interpolation Methods; Optimization with Equality and Inequality Constraints Direct Methods-Indirect Methods Using Penalty Functions. Cauchy's steepest descent method, Conjugate gradient method. Integer programming (I.P): Graphical representation. Gomory's cutting plane method. Bala's algorithm for zero-one programming problem. Branch-and-bound method, Sequential linear discrete Programming, Generalized penalty function method.	**30**	**1**

III	Lagrange's Multipliers, Geometric Programming and Stochastic Programming, Multi Objective Optimization, Genetic Algorithms and Simulated Annealing Techniques. Quadratic programming problem, Multi-objective optimization - Lexicographic method.	**30**	**1**
IV	Engineering Applications: Structural Applications Design of Simple Truss Members. Design Applications-Design of Simple Axial, Transverse Loaded Members for Minimum Cost, Maximum Weight, Design of Shafts and Torsionally Loaded Members Design of Springs, Dynamic Applications-Optimum Design of Single, Two Degree of Freedom Systems, Vibration Absorbers. Application in Mechanisms-Optimum Design of Simple Linkage Mechanisms. Ant colony optimization - Tabu search – Neural-Network based Optimization – Fuzzy optimization techniques – Applications. Use of Matlab to solve optimization problems.	**30**	**1**

Reference Books:

1. Johnson Ray, C. (1990). Optimum Design of mechanical elements. Wiley, John & Sons.
2. Goldberg, D.E. (1989). Genetic algorithms ion search, Optimization and machine. Barnen, Addison-Wesley, New York.
3. Kalyanamoy Deb (2012). Optimization for Engineering Design algorithms and Examples. Prentice Hall.

THEORY OF VIBRATION (GE45618)

Course Objective:

1. To understand the concepts of harmonics, natural frequency and equivalent system.
2. To understand the free and forced vibrations with transmissibility.
3. To understand multi degree freedom for damped and un-damped systems.
4. To understand the concept of numerical analysis and different methods.

Learning Outcome:

At the end of the course student should be able to:

1. To analyze free and forced vibrations of machines, engines and structures.
2. To calculate the torsional vibration of circular shafts.
3. To understand the vibration of continuous system.
4. To understand the utility and application of dampers.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Types of vibrations, S.H.M, Harmonic Motion, Superposition of Simple Harmonic Motions, Beats, Fourier Analysis. Single Degree Freedom System, Free Vibration, Natural Frequency, Equivalent Systems, Energy Method for Determining Natural Frequency, Response to Initial Disturbance, Torsional Vibrations, Damped Vibrations, Vibrations of Systems with Viscous Damping, Logarithmic Decrement.	30	1
II	Single Degree Freedom, Forced Vibration, Harmonic Excitation with Viscous Damping, Steady State Vibrations, Forced Vibrations with Rotating and Reciprocating Unbalance, Support Excitation, Vibration isolation and transmissibility, Force transmissibility, Motion transmissibility, Isolators and mount types, and Vibration Measuring Instruments, Displacement, Velocity and Acceleration Measuring Instruments.	30	1
III	Two Degree Freedom Systems, Principal Modes, Double Pendulum, Torsional System with Damping, Coupled System, Un-damped Dynamic Vibration Absorbers, Centrifugal Pendulum Absorbers, Dry Friction Damper. Multi Degree Freedom System: Exact Analysis, Un-damped Free and Forced Vibrations of Multi-Degree Freedom Systems, Influence Coefficients, Flexibility coefficient, Stiffness coefficients, Vibration of strings, Reciprocal Theorem, Principal Coordinates,	30	1

	Continuous Systems- Longitudinal Vibrations of Bars, Torsional Vibrations of Circular Shafts.		
IV	Multi Degree Freedom System: Numerical Analysis, Rayleigh's, Dunkerely's Methods for finding natural frequencies for multi-rotor system, Overhang shaft/beam Critical Speed of Shafts: Shaft with One Disc with and Without Damping, Multi-Disc Shafts, Secondary Critical Speed.	**30**	**1**

Reference Books:

1. J. Srinivasan (2008). Textbook of Mechanical Vibrations, PHI
2. G. K. Groover (2008). Mechanical Vibrations, New Chand & Bros, Roorkee, India.
3. Mechanical Vibrations by W. T. Thomson.
4. J.S. Rao and K Gupta (2002). Mechanical Vibrations, New Age.

ADVANCED MANUFACTURING PROCESSES (GE45621)

Course Objective:

1. To acquire basic knowledge about the behavior and properties of aspect of manufacturing and concepts of CAD modeling.
2. To acquire knowledge about various methods of advance manufacturing welding, cold and hot working and forming.
3. To understand forging, moulding and powder metallurgy processes in detail and application of these in manufacture of a product.

Learning Outcome:

At the end of the course student should be able to:

1. To use the principles of foundry and casting.
2. To choose materials in a manufacturing process based on their properties.
3. To conduct experiments on various manufacturing processes.
4. To demonstrate an ability to solve engineering problems in welding and powder metallurgy processes.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	CAD: Co-Ordinate Transformations Three Dimensional Curve and Surface Geometry, Types and Mathematical Representation of Curves and Surfaces, Parametric Description of Analytic and Synthetic Curves, Curve and Surface Design, Composite Curves and Spines, Composite Surfaces, Types and Mathematical Representation of Solids: Half Spaces, Boundary Representation (B-Rep), Constructive Solid Modeling (CSG), Sweep Representation, Solid Modeling Based Application. Introduction of Advanced Machining Processes and its applications.	**30**	**1**
II	CAM: Stock Boundary Definition and Generation of Machining Paths from CAD Database. Cutter Paths for Numerical Control. CAD-CAM Interface, Advanced Casting Processes.	**30**	**1**
III	Flexible Manufacturing System: Management Decisions, Distributed Processing In FMS, Interfacing Computer, M/C Tool Controllers and Industrial Robots. Quantitative Analysis of FMS, Social Issues. A Brief Overview of Non-Traditional Machining Processes. Welding Processes-Details of electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding.	**30**	**1**

IV	Analysis of Mechanical, Thermal and Electrochemical Type Non-traditional Machining Processes. Analysis of Micro-Machining Process. Tool Design for Selected Non-Traditional Machining Process, A Comparative Study of Various Processes. Application of CNC Concepts to Non-Traditional Machining Process Machines. Computer Aided Process Planning of Non-traditional Processes. Precision Machining and High-Speed Machining.	**30**	**1**

Reference Books:

1. Grover (2016). Automation, Production System, & CIM, Prentice Hall
2. C. McMahon and J. Browne (2002). CAD CAM, Addison-Wesley.
3. Chang. Wysk, Wang (2006). Computer Aided Manufacturing, Prentice Hall.

RESEARCH AND AI IN MFG. SYSTEMS (GE45622)

Course Objective:

1. To learn the concept of artificial intelligence and its application.
2. To learn various knowledge base expert systems.
3. To learn implementation and implication of various expert systems.
4. To learn the process and failure diagnosis of various systems and relevant case studies.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the utility of expert systems.
2. To understand designing, selection and application of various systems.
3. To appreciate the usage of various knowledge base system in manufacturing and production.
4. To understand the real life production scenarios by means of case studies.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Artificial Intelligence: Definition and Scope Application Areas; Knowledge Based System (Expert System) Definition, Justification, Structure Characterization. Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions.	**30**	**1**
II	Knowledge Sources, Expert Knowledge Acquisition, Knowledge Representation, Knowledge Base Interference Strategies–Forward and Backward Chaining. Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT and Cellular Manufacturing.	**30**	**1**
III	Expert System Languages, ES Building Tools or Shells, Typical examples of Shells. Expert System software for manufacturing application in CAD, CAPP, MRP Adaptive Control. Robotics, Process control, Different Type of Control System Such as Sensors, Actuators and other Control System Components.	**30**	**1**

IV	Fault diagnosis, Failure Analysis Process Selection, GT, Linking expert systems to other software such as DBMS, MIS, MDS, Process control and office automation. Case studies of typical application in tool selection, Process Selection, Part classification, Inventory control, Process Planning etc. Automatic Material Handling Principles, Materials Handling Systems, Pallet Design, Loading Unloading Station Design.	**30**	**1**

Reference Books:

1. J Paulo Davim (2010). Artificial Intelligence in Manufacturing Research Nova Science Publishers Inc.
2. Kaushik Kumar, Divya Zindani, J. Paulo Davim (2021). Artificial Intelligence in Mechanical and Industrial Engineering. CRC Press.
3. Jhon and Andrew Kusiak Artificial Intelligent Hand book. https://doi.org/10.1016/C2013-0-07690-6.
4. Introduction to Artificial Manufacturing Expert System. Dan. W. Patter

COMPUTER GRAPHICS AND PRODUCT MODELLING (GE45623)

Course Objective:

1. To learn the basics of computer graphics and hardware software requirement.
2. To learn various modeling techniques.
3. To learn various type of surfaces and curve and their representation.
4. To learn managing product development and understanding customer needs.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the need and applicability of computer graphics.
2. To understand operations and technique required for geometric modeling.
3. To understand the mathematics behind the surface and curve generation.
4. To understand the business model for new project.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to computer graphics–Historical evolution, Issues and challenges, Definition of Computer Graphics, Graphics hardware, Types of system, Input/output devices, Graphics standards, Data structure and Data base models, Modes of graphics operation.	30	1
II	Geometric modeling: Types and Mathematical representation of curves, Parametric representation of analytic and synthetic curves, Types and Mathematical representation of surfaces, Parametric representation of analytic and synthetic surface, Matrix representation, Homogeneous coordinate system.	30	1
III	Plane, Surface, Ruled surface, Surface of revolution, Hermite, Bi-Cubic surface, Beizer surface, B-Spline surface, Sculptured surface, Surface manipulation, Displaying evaluating points and curves, Segmentation, Trimming, Integration, Projection and Transformations engineering application, Graphics hardware and software.	30	1
IV	Managing product development- Introduction, Business models for new products, Managing product development, Understanding customer needs–Identifying new product opportunities, Market research for new product development, Organizing product	30	1

	development- Product architecture, Design of manufacturing and prototyping.		

Reference Books:

1. Schaum’s (2000). Outline of Theory and Problems of Computer Graphics by Roy A. Plastoc & Gordon Kelley, McGraw hill.
2. Hill (2007). Computer Graphics using open GL Pearson Education.
3. Foley (2013). Computer Graphics, Person Education.
4. S. S. Pande (2012). Computer graphics and product modeling for CAD/CAM. Alpha Science.

NUMERICALS METHODS FOR MANUFACTURING PROCESSES (GE45625)

Course Objective:

1. To learn different simulation and numerical methods used for manufacturing processes.
2. To learn the different issues faced in manufacturing settings and their implications.
3. To learn digital implementation in product life cycle.
4. To learn automated and integrated manufacturing concepts and methods.

Learning Outcome:

At the end of the course student should be able to:

1. To understand different simulation and numerical technique to optimize manufacturing processes.
2. To understand the challenges and numerical solutions to mitigate such challenges.
3. To understand processes and issues in computer integration of manufacturing facility.
4. To understand the communication and information system in manufacturing environment.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Review of Manufacturing process such as Casting, forming, welding, machining. System Simulation Techniques of Simulation, Monte Carlo Method, Manufacturing Problems, System Approach to Manufacturing Problems, Principle of Modeling in Mathematical and Physical Form, Types of Models. Effect of process variables on manufacturing processes, requirement of optimization of process parameters. Importance of numerical simulation and modelling.	**30**	**1**
II	Simulation in Modeling. Advantages and Disadvantages of modeling and simulation. Sources of System Error, Stability of Linear and Non-Linear System, Adaptive Control, System Optimization Techniques.	**30**	**1**
III	Product Design and Part Configuration Project Scheduling By PERT, GERT, Flow Graph, Productive	**30**	**1**

	Maintenance, Automation of Production, Computer Aided Design, Computerized Layout Planning, Automated Process Planning, Automated Operation Planning.		
IV	Automatic and Computer Integrated Manufacturing, Automated Assembly and Testing Information Systems for Manufacturing. Fundamentals of Information Systems, Production Information and Management Systems.	**30**	**1**

Reference Books:

1. Philip P. Ostwald (2008). Manufacturing Process & system. Wiley.
2. E. Paul Degarmo, JT Black RA Kosher (2008). Materials & Process in Manufacturing Prentice Hall of India.
3. Wu B Kluwer Aca (2002). Manufacturing Systems Design and Analysis.
4. Papadopulos H T Chapman (1993). Queuing Theory in Manufacturing Systems Analysis and Design. Springer.
5. Altiok Tayfor (1997) Performance Analysis of manufacturing Systems. Springer.

PRODUCT DEVLOPMENT (GE45626)

Course Objective:

1. To acquire skills to design and develop products in a structured way.
2. To get aware with general design principles for manufacturability.
3. To understand the product economics in product design.
4. To learn the broad processes involved from ideation to prototyping of a product.

Learning Outcome:

At the end of the course student should be able to:

1. To understand product development process and review design of existing product considering reliability.
2. To be able to design a product according to requirement of market.
3. To be able to appreciate the value of aesthetics into the product design.
4. To use value engineering for product development.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to Product and Service Innovation, Opportunity identification and identifying customer needs Concept generation & product specification, Concept selection & testing. Challenges of Product Development; Successfully Product Development; Quality Aspect of Product Design; Market Research.	**30**	**1**
II	Product architecture & prototyping, Product and service design. Product Architecture Implication of Architecture Establishing the Architecture, Related System Level Design Issue.	**30**	**1**
III	Industrial Design Overview Design for Manufacturing and Assembly, Tolerancing, Design of Gauges: Design for Environment Robust Design, Prototyping Engineering Materials.	**30**	**1**
IV	Product development economics, Best practices in managing new products and services. Concurrent Engineering, Value Engineering Aesthetic Concepts: Visual Effect of Form and Colour Product Data	30	1

	Management. Innovation and Creativity in Product Design, Case Studies.		

Reference Books:

1. Karl T. Ulrich and Steven (1992). Product Design and Development. Irwin McGraw Hill.
2. A C Chitale and R C Gupta (2004). Product Design and Manufacturing. PHI.
3. Tim Jones, Jim Butterworth, Heinman (1997). New Product Development: Oxford.
4. Product Design for Manufacture and Assembly; Geoffrey Boothroyd, Peter Dewhurst and Winston knight.
5. Ouo and Wood (2003). Product Design, Pearson education.
6. W.H. Landon, (1998). Industrial Design for Engineers: Mayall, Hiffee books Ltd.
7. Applied Ergonomics (1998), Hand Book: Brien Shakel (Edited) Butterworth Scientitic, Landon.

AUTOMATION & CONTROL (GE45629)

Course Objective:

1. To learn the fundamentals of Automation and control processes.
2. To get acquainted with constructional features and other basic information of transmitters, actuators, manipulators etc.
3. To know about different types of controller systems.
4. To learn different types of electric drives.

Learning Outcome:

At the end of the course student should be able to:

1. To know the basics of automation and control processes.
2. To able to understand and learn about transmitters, actuators and manipulators.
3. To be able to understand types of controller system.
4. Students able to understand different types of electric drives.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction to automation and control, sensors & measurement system: Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH. Introduction of Robot Technology: Robot Physical Configuration, Basic Robot Motions, Types of Manipulators Constructional Features.	30	1
II	Estimation of errors and Calibration, Introduction to Process Control, Implementation of PID Controllers , Introduction to Sequence Control, PLCs and Relay Ladder Logic, Sequence Control: Scan Cycle, RLL Syntax, Structured Design Approach , The Hardware environment, Actuators and Transmission System Pneumatic, Hydraulic and Electrical Actuators and Their Characteristics and Control System, Advantages and Disadvantages of Various Kinematic Structures, Servo and Non-Servo Manipulators.	30	1
III	Control of Machine tools : Introduction to CNC Machines, Analysis of a control loop , Introduction to Actuators, Hydraulic Actuator Systems : Principles, Components and Symbols, Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems : System Components, Controllers and	30	1

	Integrated Control Systems, Artificial Intelligence: Logging Locomotion, Expert System, Concept of Spatial Description and Transformation, Manipulator Kinematics: Inverse Manipulator, Kinematics Jacobeans: Velocities and Static Forces: Manipulator Dynamics, Position Control of Manipulators, Force Control of Manipulators, Robot Programming Languages and Systems. Concept of Automation in Industry, Mechanization and Automation, Automatic Classification of Automation System.		
IV	Basics of Automated Work Piece Handling: Working Principles and Techniques, Job Orienting and Feeding Devices. Transfer Mechanism Automated Feed Out the Components, Performance Analysis. Assembly, Automation, Automatic Packaging and Automatic Inspection. Electric Drives: Introduction, Energy Saving with Adjustable Speed Drives, Step motors: Principles, Construction and Drives, DC Motor Drives: Introduction, DC-DC Converters, Adjustable Speed Drives, Induction Motor Drives: Introduction, Characteristics, Adjustable Speed Drives.	**30**	**1**

Reference Books:

1. Mikell P. Groover (2016). Automation Production Systems and Computer Aided Manufacturing, Pearson Education.
2. Roger S. Pressman, John Ernest Williams (1997). Numerical Controlled Computer Aided manufacturing by Press man and elements. Wiley, New York.
3. Shinskey, F.G. (1994). Feedback controllers for the process industries. McGraw-Hill.

MECHATRONICS (GE45631)

Course Objective:

1. To learn about the use of mechatronics in manufacturing and product design.
2. To learn about the fundamentals of electronics like sensors, micro-sensors and transducers etc.
3. To learn principle and application of stepper motors and servo drives.
4. To learn about various method of data acquisition and filtering.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the working of mechanical and electronics systems.
2. To understand the working of microprocessors, controllers and PLCs.
3. To understand the various sensors and their applicability in day to day life.
4. To understand the single and multi-channel data acquisition system and data logging.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Definition of mechatronics, Mechatronics in manufacturing, Products and design, Comparison between traditional and mechatronics approach, General concept of measurement, Basic block diagram, Stages of generalized measurement system.	**30**	**1**
II	Review of fundamentals of electronics, Data conversion devices, Sensors, Micro sensors and transducers, Signal processing devices, Relays, Contactors and timers. Microprocessors controllers and PLCs.	**30**	**1**
III	Signal conditioning, Linearization, Buffering sample and Hold circuit quantization, Multiplexer/DE multiplexer, Analog to Digital converters, Digital to Analog converters, Drives: Stepper motors, Servo drives. Cams, Systems controlled by camshafts, Electronic cams.	**30**	**1**
IV	Data Acquisition and conversion, General configuration, Single channel and Multi-channel data acquisition system, Digital filtering, Data logging, Introduction to digital transmission systems, PC based data acquisition system, CNC machines and part programming, Industrial robotics.	**30**	**1**

Reference Books:

1. Rangam C.S., Sarma, Mani G. R. (1997), Instrumentation -devices and Systems", Tata McGraw Hill.
2. Sawhney, A.K. (2012). A Course in Electrical and Electronic Measurements and instrumentation. Dhanpat Rai & Sons.
3. Doeblin, E.O. (2017). Measurement Systems, McGraw Hill.

TRIBOLOGY (GE45632)

Course Objective:

1. To learn about the scope and application of tribology
2. To learn about different type of friction and governing laws
3. To learn about the surface quality and various pattern of wear
4. To lean about lubrication and governing principles and mathematical equations

Learning Outcome:

At the end of the course student should be able to:

1. To understand the importance of contact surface design
2. To appreciate the friction and design for friction methods
3. To understand the surface quality and impact on performance
4. To understand the lubrication mechanism

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Historical Background, Practical Importance, and Subsequent Use in The Field of Tribology, Definition and Scope of Tribology, Contact of Solids, Surface Topology, Surface Interaction.	**30**	**1**
II	Friction: Definitions, Types, Friction Laws, Modern Theory of Dry Solid Friction, Mechanism of Rolling Friction, Friction of Elastomers, Measurement Methods, Friction of Metals and Non-Metals.	**30**	**1**
III	Surface Roughness: Standardization, Measurement, Statistical Analysis of Surface. Wear: Definition, Classification, Theories of Adhesives, Abrasives Surface Fatigue and Corrosive Wear Miscellaneous Wear Theory Such as Erosive, Cavitation and Fretting Wear, Testing Methods; Wear Debris Analysis; Wear Reduction Methods.	**30**	**1**
IV	Lubrication: Lubrication of Bearing, Lubricant, Mineral Oil, Grease, Solid Lubricant, Lubrication Regime, Viscous Flow, Reynolds Equation and Its Limitations, Types of Industrial Lubricants and Their Standard Grades, Hydrodynamic Lubrication, Hydrostatic Lubrication, Boundary Lubrication.	**30**	**1**

Reference Books:

1. P Sahoo (2002). Engineering Tribology, Prentice Hall of India
2. D.F. Moore (1975). Principles and Applications of Tribology Pergamon Press
3. Basu, Sengupta & Ahuja (2005). Fundamentals of Tribology. Prentice Hall of India

DESIGN OF PRESSURE VESSELS (GE45633)

Course Objective:

1. To acquire skills to design and develop pressure vessels in a structured way.
2. To get aware with general design principles for manufacturability of industrial vessels.
3. To learn the stress behavior encountered in vessel design.
4. To learn the broad processes and issues involved in support modeling.

Learning Outcome:

At the end of the course student should be able to:

1. To understand pressure vessel design and manufacturing process.
2. To understand the various types of stresses commonly experienced by a pressure vessel.
3. To be able to appreciate the value of support structure and design implications.
4. To understand the cause and remedy of failure of pressure vessel.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Membrane theory of thin shells stresses in cylindrical, spherical shells, General theory of membrane stresses in vessel under internal pressure and its application to ellipsoidal, Toripherical end closures, bending of circular plates and determination of stresses in simple supported and clamped circular plate Introduction to ASME code and formulae. Thermal Stresses	**30**	**1**
II	Junction stresses, opening and reinforcements Discontinuity stresses, Stress concentration in plate having circular hole due to bi-axial loading Theory of reinforced opening and reinforcement limits. Design of Nozzle	**30**	**1**
III	Supports for vertical & horizontal vessels Design of base plate and support lugs Types of anchor bolt, its material and allowable stresses. Design of saddle supports. Flexibility factor and stress intensification factor	**30**	**1**
IV	Buckling of vessels under external pressure. Elastic Buckling of Circular ring and cylinders under external pressure, collapse of thick walled cylinders or tubes	**30**	**1**

	under external pressure. Design for Circumferential stiffness. Design fort stiffening rings Buckling under combined external combined external pressure and axial loading.		

Reference Books:

1. Subhash Reddy Gaddam (2020). Design of Pressure Vessels. CRC Press.
2. Harvey J F, (2001). Pressure vessel design. CBS publication.
3. Brownell. L.E and Young E.D, (2018). Process equipment design. Wiley Eastern India.

NON LINEAR VIBRATION (GE45634)

Course Objective:

1. To understand the concepts of vibration and control.
2. To understand the rotating machines and vibrations.
3. To understand the non-linear vibration systems and nonlinear elastic properties.
4. To understand the concept of noise, measurement control and absorbers.

Learning Outcome:

At the end of the course student should be able to:

1. To analyze linear and nonlinear vibrations.
2. To understand vibration isolation and vibration absorbers.
3. To understand the concept time domain & frequency domain analysis of signals.
4. To understand the concept of fundamental of noise control, source control and path control.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Overview of linear vibrations and contrasting with nonlinear vibrations, Various sources and type of nonlinearities in mechanical systems, Transient vibrations, Response of a single degree of freedom, System to step any arbitrary excitation, Convolution (Duhamel's) integral, Impulse response functions.	30	1
II	Vibration control balancing of rotating machine, In-situ balancing of rotors, Control of natural frequency of damping, Vibration isolation and Vibration absorbers.	30	1
III	Vibration Measurement, FFT analyzer, Signal analysis, Time domain & frequency domain analysis of signals. Experimental modal analysis, Machine conditioning and monitoring fault diagnosis, Non-Linear vibration, Systems with non-linear elastic properties, Free vibrations of system with non-linear elasticity and damping, Phase –plane technique, Duffing's equation, Jump phenomenon, Forced vibration of the van der Pol equation showing entrainment.	30	1
IV	Noise and its Measurement, Sound waves, Governing equation and its propagation, Fundamentals of noise Decibel, Sound meter, Allowed exposure levels and time by B>I>S, Fundamental of Noise control and source control, Path control enclosures, Noise	30	1

	absorbers, Noise control at receiver, Stroboscopic and Poincare maps as an alternate means to study nonlinear vibrations.		

Reference Books:

1. P Sahoo (2002). Engineering Vibrations by, Prentice Hall of India.
2. D.F. Moore (1975). Principles and Applications of Vibration. Pergamon Press.
3. Steven H. Strogatz, (2014). Nonlinear Dynamics and Chaos by Westview Press.
4. D. W. Jordan and P. Smith (2009). Nonlinear Ordinary Differential Equations. Oxford University Press.

ADVANCED COMPOSITE MATERIAL (GE45635)

Course Objective:

1. To learn the need and use of composites.
2. To learn different types of composites and types of reinforcements.
3. To learn ceramic matrix composites and constituents interactions.
4. To learn mechanics, properties and failure of composites.

Learning Outcome:

At the end of the course student should be able to:

1. To understand the usefulness and applicability of different composites.
2. To understand the structure and composition of composites used in various domains.
3. To understand the impact and implication of orientation in composite strength
4. To appreciate the cause and effect of composite fracture.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Composites: Definition and Classification, Matrices and Their Properties. Importance of Glass, Ceramic and Carbon Fibres, Polyester, Epoxies, Thermosetting and Thermoplastic Materials. Fabrication, Structure. Properties and Application: Common Ceramic Matrix Composite Material and Their Properties, Interfaces in Composites, Interaction at The Interface. Polymer matrix composites (PMC): Reinforcement materials, types, characteristics and selection base matrix, process design of PMC's and applications	30	1
II	Types of Reinforcement Continuous Fiber, Short Fiber, Whisker, Glass Fiber, Carbon/Graphite Fiber, Natural Fiber, Boron Carbide Silicon Carbide Fiber. Quality and Testing; Material Testing, Mechanical Testing, Thermal and Environmental Testing, Flammability Testing, Non-Destructive Testing, Processing of thermoses composites: Hand layup method, compression and transfer moulding, pressure and vacuum bag process, filament winding, protrusion, reinforced RIM, RRIM, Injection moulding of thermoses, SMC and DMC, Advantages and limitations of each method.	30	1
III	Ceramic Matrix Composites: Fabrication, Properties, and Uses, Interface Reaction, Toughness; Specific Examples - Alumina Silicon Carbide, Mullitezirconia, Polymer-PZT Composites, Processing and Application.	30	1

IV	Mechanics of Properties of Composites: Density, Mechanical Properties, Mechanism of Load Transfer from Matrix to Fiber, Variation of Lamina Properties with Orientation, Tensile and Compressive Strength of Unidirectional Fiber Composite, Fracture in Composites, Debonding, Fiber Pull Out, Delamination Fracture. Morphological studies: Introduction, principle, theory, applications, advantages and limitations of - Optical microscopy, Scanning Electron Microscopy (SEM), TEM and AFM. Introduction: Hybrid polymer composite, Green composites and Nano composites - fabrication, Characterization and applications.	**30**	**1**

Reference Books:

1. Ehsan B. (2017). Advanced Composite Materials. De Gruyter Open Poland.
2. Ashutosh T., Mohammad Rabia A. (2016). Advanced Composite Materials Scrivener Publishing LLC.
3. Pilato, L., Michno, Michael J (1994). Advanced Composite Materials. Springer.
4. Pallavi V. (2019). Composites: a new era of restorative materials. LAP lambert Academic.

THEORY OF PLATE & VESSELS (GE45636)

Course Objective:

1. To acquire skills to design plate parts and vessels.
2. To get aware with general design principles and mathematical relationship between load and deformation.
3. To learn the stress behavior encountered in vessel design.
4. To learn the membrane theory and equilibrium equation of circular cylindrical shell.

Learning Outcome:

At the end of the course student should be able to:

1. To appreciate the challenges involved in plate and vessel design.
2. To understand the various concepts and theories for design of pressure vessel.
3. To be able to appreciate the value of support structure and design implications.
4. To understand the cause and remedy of failure due to variety of loads.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction: Thin and Thick plates, Small and Large deflection Theory of Thin Plates: Moment curvature relations, Stress resultants. Governing, Differential equation for cylindrical bending of plates - Cylindrical bending of uniformly loaded rectangular plates with simply supported edges - Cylindrical bending of uniformly loaded rectangular plates with built-in edges.	**30**	**1**
II	Analysis of Rectangular Plates: Navier solution for Plates with all edges simply supported, Distributed loads, Point loads and Rectangular patch load. Levey`s Method: Distributed load and Line load, Raleigh-Ritz approach for simple case in rectangular plates, Introduction to shear deformation theories.	**30**	**1**
III	Circular Plates: Analysis of circular plates under axi-symmetric loading, Moment curvature relations, Simply support and Fixed edges, Distributed load, Ring load, A Plate with a central hole.	**30**	**1**
IV	Circular cylindrical shells, Membrane Theory: Equilibrium equation, Strain displacement relations, Boundary conditions. Bending theory of cylindrical shells loaded symmetrically –Approximate solution by Schorer’s method, Beam method of analysis,	**30**	**1**

	Application to Pipes and Pressure Vessels.		

Reference Books:

1. Timoshenko, S. and Krieger, W. (2004). Theory of Plates and shells, McGraw Hill.
2. Ansel C. U. (1998). Stresses in plates and shells, McGraw Hill.
3. Ramaswamy, G.S. (2005). Design and Construction of Concrete shell Roofs, CBS Publications.
4. Chandrashekhara K. (1995). Analysis of Plates. New Age International.

THEORY OF MECHANISM (GE45638)

Course Objective:

1. To familiarize students with types of mechanisms, joints and degrees of freedom to perform position, velocity and acceleration analysis using graphical and analytical methods.
2. To provide students an understanding of different types of linkage, four- six bar mechanism and balancing of linkages.
3. To teach the basics of synthesis of simple mechanisms, path generation and CAM mechanisms.
4. To teach students the dynamics of mechanism and dimensional synthesis.

Learning Outcome:

At the end of the course student should be able to:

1. To demonstrate an understanding of the concepts of various mechanisms and pairs.
2. To conduct forward and inverse kinematics of robotic mechanism.
3. To design and develop the path of fixed and moving centroid.
4. To synthesize simple mechanisms for function, path generation and body guidance.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Review of Fundamentals of Kinematics Mobility Analysis Formation of One D.O.F. Multi-Loop Kinematics Chains, Network Formula, Gross Motion Concepts. The inflexion circle - Euler-Savary equation, Analytical and graphical determination of diameter of inflection circle - Bobbileier's construction, Collineation axis - Hartman's construction, Application of inflection circle to kinematic analysis - Polode curvature - General case and special case, Polode curvature in the four-bar mechanism - Coupler motion, Relative motion of the output and input links, Carter Hall circle, Circling-point curve (general case).	30	1
II	Kinematic Analysis, Position Analysis Vector Loop Equations for Four Bar, Slider Crank, Inverted Slider Crank - Geared Five Bar and Six Bar Linkages. Analytical Method for Velocity and Acceleration Analysis, Four Bar Linkage Jerk Analysis - Plane Complex Mechanism. Path Curvature Theory: Fixed and Moving Centroids', Inflection Points and Inflection Circle. Euler Savary Equation, Graphical Constructions,	30	1

	Cubic of Stationary Curvature. Type, number and dimensional synthesis, Spacing of accuracy points, Chebyshev polynomials, Motion and function generation, The complex number modeling in kinematic synthesis, The Dyad, Standard form, Freudentein's equation for three point function generation coupler curves, Robert's law,		
III	Synthesis of Mechanisms: Type Synthesis, Number Synthesis - Associated Linkage Concept. Dimensional Synthesis - Function Generation, Path Generation, Motion Generation. Graphical Methods, Cognate Linkage -Coupler Curve Synthesis, Design of Six Bar Mechanisms Algebraic Methods. Application of Instant Centre in Linkage Design. CAM Mechanism - Determination of Optimum Size of Cams. Cam dynamics - Forces in rigid systems, Mathematical models, Response of a uniform - Motion undamped cam mechanism - Analytical method, Follower response by phase - Plane method - Position error, Jump, Crossover shock - Johnson's numerical analysis.	**30**	**1**
IV	Dynamic of Mechanisms: Static Force Analysis with Friction, Inertia Force Analysis - Combined Static and Inertia Force Analysis. Shaking Force, Kineto static Analysis. Introduction to Force and Moment, Balancing of Linkages. Spatial Mechanism and Robotics, Kinematic Analysis of Spatial RSSR Mechanism - Denavit-Hartenberg Parameters. Forward and Inverse Kinematics of Robotic Manipulators. Kineto static analysis by superposition, and matrix approach, Time response of mechanisms, Analysis of spatial mechanisms.	**30**	**1**

Reference Books:

1. Sandor G.N. and Erdman A.G (1984). Advanced Mechanism Design Analysis and Synthesis. Prentice Hall.
2. Shigley, J.E., and Uicker, J.J. (1995). Theory of Machines and Mechanisms. McGraw Hill.
3. Amitabha Ghosh and Ashok Kumar Mallik (1999). Theory of Mechanism and Machines", EWLP, Delhi, 1999.
4. Nortron R.L. (1999). Design of Machinery. McGraw Hill.