COURSES SCHEME

&

SYLLABUS

FOR

B.E.

MECHANICAL

ENGINEERING

2014

COURSES SCHEME & SYLLABUS FOR B.E. MECHANICAL ENGINEERING

SEMESTER – III

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1	UMA032	NUMERICAL AND STATISTICAL METHODS	3	1	2	4.5
2	UHU003	HUMAN VALUES, HUMAN RIGHTS AND IPR	2	1	0	2.5
3	UEN001	ENVIRONMENTAL STUDIES	3	0	0	3.0
4	UES031	FLUID MECHANICS	3	1	2	4.5
5		APPLIED THERMODYNAMICS	3	1	2	4.5
6		KINEMATICS OF MACHINES	3	1	0	3.5
7		MACHINE DRAWING	1	4	0	3.0
TOTAL			**18**	**9**	**6**	**25.5**

SEMESTER – IV

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1	UMA031	OPTIMIZATION TECHNIQUES	3	1	0	3.5
2	UHU031	ORGANIZATIONAL BEHAVIOR	3	1	0	3.5
3	UES032	MATERIAL SCIENCE AND ENGINEERING	3	1	2	4.5
4		COMPUTER AIDED GEOMETRIC MODELING AND ANALYSIS	2	4	0	4.0
5		DYNAMICS OF MACHINES	3	1	0	3.5
6		INSPECTION AND QUALITY CONTROL	3	1	2	4.5
7		MECHANICS OF DEFORMABLE BODIES	3	1	0	3.5
TOTAL			**20**	**10**	**4**	**27.0**

SEMESTER – V

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		INDUSTRIAL ENGINEERING	3	1	0	3.5
2		AUTOMOBILE ENGINEERING	3	0	2	4.0
3		INDUSTRIAL METALLURGY AND MATERIALS	3	1	0	3.5
4		MACHINE DESIGN	3	1	0	3.5
5		MANUFACTURING TECHNOLOGY	3	0	2	4.0
6		HEAT AND MASS TRANSFER	3	1	2	4.5
7		INDUSTRIAL AUTOMATION	3	1	0	3.5
		DESIGN PROJECT (WITH 8 SELF-EFFORT HOURS)	0	0	2	5.0
TOTAL			**21**	**5**	**8**	**31.5**

SEMESTER – VI

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		PROJECT SEMESTER*	-	-	-	12.0
TOTAL			**-**	**-**	**-**	**12.0**

OR

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		PROJECT	-	-	-	2.0
2		PRODUCT DESIGN AND DEVELOPMENT	3	1	0	3.5
3		PRODUCTION AND INVENTORY CONTROL	3	1	0	3.5
4		ELECTIVE II	3	0	0	3.0
TOTAL			**9**	**2**	**0**	**12.0**

* TO BE CARRIED OUT IN INDUSTRY/RESEARCH INSTITUTION.

SEMESTER – VII

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		ADVANCED MACHINE DESIGN	3	2	0	4.0
2		COMPUTER AIDED MANUFACTURING	3	0	2	4.0
3		FLUID MACHINERY	3	1	2	4.5
4		MECHANICAL VIBRATIONS	3	1	0	3.5
5		MACHINING SCIENCE	3	1	2	4.5
6	UHU 081	ENGINEERING ECONOMICS	3	1	0	3.5
7		CAPSTONE PROJECT PART-I (STARTS)	0	0	4	0.0
TOTAL			**18**	**6**	**10**	**24.0**

SEMESTER – VIII

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		MECHATRONICS	3	0	2	4.0
2		REFRIGERATION AND AIR CONDITIONING	3	1	2	4.5
3		TURBOMACHINES	3	1	0	3.5
4		CAPSTONE PROJECT PART-II (CONTINUES) WITH 6 HOURS OF SELF-EFFORT.	0	0	6	8.0
5		ELECTIVE III	3	1	0	3.5
6		ELECTIVE IV	3	1	0	3.5
TOTAL			**15**	**4**	**10**	**27.0**

ELECTIVE-II

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		WORK STUDY AND METHODS ENGINEERING	3	0	0	3.0
2		LEAN MANUFACTURING	3	0	0	3.0
3		FACILITY PLANNING	3	0	0	3.0
4		ERGONOMICS ENGINEERING	3	0	0	3.0

ELECTIVE-III

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		COMPUTATIONAL FLUID DYNAMICS	3	1	0	3.5
2		INTERNAL COMBUSTION ENGINES	3	1	0	3.5
3		POWER PLANT ENGINEERING	3	1	0	3.5
4	UME	RENEWABLE ENERGY SYSTEMS	3	1	0	3.5
5		GAS TURBINES AND JET PROPULSION	3	1	0	3.5
6		MODERN AUTOMOBILE ENGINEERING	3	1	0	3.5

ELECTIVE-IV

SR. NO.	COURSE NO	TITLE	L	T	P	CR
1		FINITE ELEMENT METHODS	3	1	0	3.5
2		MECHANICS OF COMPOSITE MATERIALS	3	1	0	3.5
3	UME	ROBOTICS ENGINEERING	3	1	0	3.5
4		MACHINE TOOL DESIGN	3	1	0	3.5
5		DYNAMICS OF RIGID BODIES	3	1	0	3.5
6		TRIBOLOGY OF BEARINGS	3	1	0	3.5
7		RAPID PROTOTYPING	3	1	0	3.5

UMA032 NUMERICAL AND STATISTICAL METHODS

L	T	P	Cr
3	1	2	4.5

Course Objective: The main objective of this course is to motivate the students to understand and learn various numerical and statistical techniques to solve mathematical problems representing various engineering, physical and real life problems.

Floating-Point Numbers: Floating-point representation, Rounding, Chopping, Error analysis, Condition and instability.

Non-Linear Equations: Bisection, Secant, Fixed-point iteration and Newton-Raphson methods, Order of convergence.

Linear Systems and Eigen-Values: Gauss elimination method (using Pivoting strategies), Gauss-Seidel iteration method and its convergence, Rayleigh's power method for eigen values and eigen vectors.

Interpolation: Newton form of polynomials, Finite differences, Newton's forward, Lagrange and Newton's divided difference interpolation formula with error analysis.

Numerical Integration: Newton cotes quadrature formulae (with error) and Gauss - Legendre quadrature formulae.

Differential Equations: Solution of initial value problems using Taylor series, Euler's and Runge Kutta (up to fourth order) methods.

Random Variables: Basic concepts of probability, Discrete and continuous random variables, Probability mass/density functions, Cumulative distribution functions, Mathematical expectation, Variance and covariance.

Probability Distributions: Introduction to binomial and poisson distribution, Geometric, Uniform, Normal and exponential distribution.

Linear Regression and Correlation: Linear regression, Least square principle and the fitted model, Correlation and regression (two variables only).

Sampling Distribution: Sampling distribution of mean and variance, Chi square distribution and F distribution.

Hypothesis Testing: General concepts, Testing a statistical hypothesis.

Laboratory Work:

Laboratory experiments will be set in consonance with the materials covered in theory.

Course Learning Outcomes (CLO):

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

1. understand error, source of error and its affect on any numerical computation and also analyzing the efficiency of any numerical algorithm.
2. learn how to obtain numerical solution of nonlinear equations using Bisection, Newton – Raphson and fixed-point iteration methods.
3. solve system of linear equations numerically using direct and iterative methods.
4. understand the methods to construct interpolating polynomials with practical exposure and also the various approaches dealing with the data using theory of probability.
5. analyze the different samples of data at different level of significance using various hypothesis testing.

Text Books:

1. *Conte, S.D. and Boor, C.D., Elementary Numerical Analysis: An Algorithmic approach, (Third Edition), Tata McGraw Hill, New York (2006).*
2. *Jain, M.K., Iyengar, S. R. K. and Jain, R. K., Numerical Methods for Scientific and Engineering Computation, New Age International Publishers (2008).*
3. *Johnson, R.A., Miller and Freund's Probability and Statistics for Engineers, Pearson Education (2006).*
4. *Meyer P.L., Introduction to Probability and Statistical Applications, Oxford & IBH (2007).*

Reference Books:

1. *Atkinson, A.E., An Introduction to Numerical Analysis, Wiley Publication, Second Edition (2011).*
2. *Chapra, S.C. and Caule, R.P., Numerical Methods for Engineers, McGraw-Hill, (1989).*
3. *Walpole E Ronald, Myers H. Raymond, Myers L. Sharon, Keying Ye, Probability and Statistics for Engineers and Scientists, Pearson Education (2005).*

UHU003: HUMAN VALUES, HUMAN RIGHTS AND IPR

L	T	P	Cr.
2	1	0	2.5

Course Objectives: The course has been designed to enable students to understand the concept of values and different types of values, and to establish the theoretical foundation for the study of important values and their major dimensions. It will also help in understanding the meaning of moral and ethical values and need for ethics in professional life. The course also covers the concept and classification of human rights and their significance in the modern-day world. The course will also enable them to understand the nature and character of IPRs and their role in economic development.

Values: Concept, Types, Rokeach Value Survey.

Different Kinds of Values: Individual, Societal, Material, Psychological, Cultural, Moral And Ethical, Spiritual; The Burgeoning Crises at Each of these levels.

Modern Approach to the Study of Values: Analyzing Individual Human Values such as Creativity, Freedom, Wisdom and Love; Value Spectrum for a Good Life; The Indian Concept of Values, Comparison of eastern and western concept of values.

Ethics: Values, Morals and Ethics; Need for Ethics in Professional Life; Kohlberg's Theory of Moral Development and Its Applicability to Engineers.

Professional Ethics: Values in Work Life; Professional Ethics and Ethos; Codes of Conduct, Whistle-Blowing, Corporate Social Responsibility, Case Studies on Ethics in Business.

Human Rights: Meaning and concept of Human Rights; Notion and Classification of Rights: Natural, Moral and Legal Rights; Three Generations of Human Rights; Civil and Political Rights; Economic, Social and Cultural Rights; Collective/Solidarity Rights.

Introduction to IPR: Nature and Enforcement, International Character of IPRs, Role of IPRs in Economic Development.

Patents: Introduction To Patents, Object of Patent Law, Inventions not Patentable, Obtaining Patents, Rights and Obligations of a Patentee.

Copyrights: Introduction to Copyrights, Subject-Matters of Copyright, Rights Conferred by Copyright, Infringement, Assignment and Licensing Of Copyrights, Copyright Societies, International Copyright, Performers' Rights.

Trademarks: Functions, Significance and Types of Trademarks, Distinctiveness and Deceptive Similarity, Registration Procedure, Trademark Registry, Grounds for Refusal of Registration of Trademarks, Concurrent Use, Character Merchandising.

Trade Secrets: Meaning, Types of Trade Secrets, Statutory Position of Trade Secrets in India, Proofs Required in Trade Secret Litigation Case.

Some Other Types of Intellectual Properties: Role and Significance, Current Status of GIs as Intellectual Property Rights, Nature and Significance of Industrial designs.

Course Learning Outcomes (CLO):
The students after studying this course will be able to appreciate the significance of values and ethics in both personal and professional life, and to be able to respect and uphold human rights. Additionally, they will be able to appreciate the significance of Intellectual Property as a very important driver of growth and development in today's world and be able to statutorily acquire and use different types of intellectual property in their professional life.

Text Books:

1. *Narayanan, P., Intellectual Property Law, Eastern Law House (2007).*
2. *Tripathi A.N., Human Values, New Age International (P) Ltd (2008).*
3. *Rhona K. M. Smith: Textbook on International Human Rights: Oxford University Press (2011).*

Reference Books/Journals:

1. *Robbins, S.P., Organizational Behavior, Prentice Hall of India (2007).*
2. *Journal of Intellectual Property Rights, published by National Institute of Science Communication, CSIR.*

UEN001 ENVIRONMENTAL STUDIES

L	T	P	Cr
3	0	0	3.0

Definition and Scope: Importance, Public awareness and education.

Natural Resources: Introduction, Renewable and non-renewable, Forest, water, mineral, food, energy and land resources, Individual and conservation of resources, equitable use of resources.

Ecosystems: Concept, Structure, Function, Energy flow, Ecological succession, Forest, grassland, desert and aquatic ecosystems - Introduction, characteristic features, structure and function.

Biodiversity: Genetic, Species and ecological diversity, Bio-geographical classification of India, Value and hot spots, Biodiversity at global, national and local levels, India as mega-biodiversity nation, Threats to biodiversity, Endangered and endemic species of India, Conservation of Biodiversity, Endangered and endemic species, Conservation of biodiversity.

Pollution: Definition, Causes, effects and control measures of the pollution – Air, soil, Noise, Water, Marine and Thermal and Nuclear Pollution, Solid waste management, Role of Individual in Prevention of Pollution, Pollution case studies, Disaster management.

Social Issues: Sustainable development, Water conservation, Environmental ethics, Climatic change, Wasteland reclamation, Environmental protection acts and issues.

Human Population and the Environment: Population growth, Environment and human health, Human rights, HIV/AIDS, Value education, Women and child welfare, IT in human health and environment, Case studies.

Text Books:

1. *Bharucha, E., Textbook of Environmental Studies for undergraduate courses, Universities Press (2005).*
2. *Chapman, J.L. and Reiss, M.J., Ecology - Principles and Application, Cambridge University Press (LPE) (1999).*
3. *Joseph, B., Environmental Studies, Tata McGraw Hill (2005).*

Reference Books:

1. *Miller, G.T., Environmental Science - Working with the Earth, Thomson (2006).*
2. *Wright, R.T., Environmental Science -Towards a sustainable Future, Prentice Hall of India (2008).*

UES031 FLUID MECHANICS

L	T	P	Cr
3	1	2	4.5

Course Objective: To understand the fundamentals of fluid mechanics; pressure exerted by fluids; and measurement of pressure, forces on submerged bodies.

Introduction: Physical properties of fluids, Types of fluids.

Fluid Statics: Basic equation for pressure field, Measurement of pressure, Hydrostatic forces on immersed plane and curved surfaces, Buoyancy and flotation.

Fluid Kinematics: Methods of describing fluid motion, Velocity and acceleration of a fluid particle, Type of fluid flows, Displacement of a fluid particle, Circulation and vorticity, Continuity equation, Velocity potential and stream function, flow net**.**

Fluid Dynamics: Euler's equation, Bernoulli's equation ant its applications, Momentum equation and its applications, Kinetic energy and momentum correction factors.

Flow Though Pipes: Energy losses, HGL and TEL, Concept of equivalent pipe, Pipes in series and parallel, Flow through a siphon, Flow through branched pipes, Transmission of power.

Flow Measuring Devices: Venturimeter, Orificemeter, Pitot tube, Rotameter, Circular orifice, Notches.

Dimensional Analysis: Methods of dimensional analysis, Model studies.

Open Channel Flow: Types of channels, Classification of flows, Uniform flow formulae.

Turbines And Pumps: Brief description of types and working of turbines and pumps.

Laboratory Work:
Verification of Bernoulli's Theorem, Calibration of Venturimeter, Determination of hydrostatic force and its location on a vertically immersed surface, Calibration of orifice meter, To check the stability of a ship model, Determination of friction factor for pipes of different materials, Determination of hydraulic coefficients of an orifice, Verification of momentum equation, Determination of loss coefficients for various types of pipe fittings, Calibration of a triangular notch, To check the calibration of rotameter, Visualization of laminar and turbulent flow, Plotting of flow net, Determination of coefficient of discharge of circular orifice using variable head method.

Course Learning Outcomes (CLO):
The students would be able to:

1. Describing fluid in motion
2. Measurement flow in pipes and in open channel
3. Design equivalent pipe; and evaluate Energy losses in flow in pipe

Text Books:

1. *Streeter, V.L., Wylie E. B. and Bedford, K.W., Fluid Mechanics, McGraw Hill Book Company(2008).*
2. *Jain, A.K., Fluid Mechanics including hydraulic machines, Khanna Publishers (2012).*
3. *Kumar D.S., Fluid Mechanics and Fluid Power Engineering, S. K. Katari (2012.)*

Reference Books:

1. *Subramanya, K., Theory and Application of Fluid Mechanics, Tata McGraw Hill(2010).*
2. *Modi P.N. and Seth S.M., Hydraulics and Fluid Mechanics, Standard Book House(2010).*
3. *Shames I.H., Mechanics of Fluid, McGraw Hill(2008).*
4. *Fox, R.W. and McDonald, A.T., Introduction to Fluid Mechanics, John Wiley and Son(2008).*
5. *Potter, M.C., Wiggert, D.C. and Ramadan, B.H., Mechanics of Fluids, Cengage Learning(2012).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

APPLIED THERMODYNAMICS

L	T	P	Cr
3	1	2	4.5

Course Objectives: To introduce the principles of the conversion of fossil fuel energy to useful power. To introduce fundamental thermodynamic operating principles and phenomena of IC engines.

Review of Thermodynamic Laws, Vapour Power Cycles: Rankine cycle and Modified Rankine cycle; Losses; Internal and stage efficiencies; Reheat, regenerative and binary cycles, combustion, enthalpy and internal energy of reaction; Enthalpy of formation; Adiabatic flame temperature; Heating values of fuels, boiler performance; Equivalent evaporation; Boiler efficiency; Boiler trial, heat balance, boiler draught, chimney height, and fan power, fluidized bed boilers, alternate fuels for fossil fuel based power plants, IGCC.

I. C.Engines: Review of air cycles(Otto, diesel and dual), classification and application, Combustion in S.I. engine: Flame propagation, pre-ignition, detonation, engine variables effects, mixture requirements, fuel rating; Fuel supply system, combustion in C.I. Engine, delay period, knocking, engine variables effects, fuel requirements, rating, combustion chambers; Fuel supply system, engine cooling and lubrication, performance of engines: Variable and constant speed tests as per ISI standards, performance curves, heat balance, emissions from IC and SI engines

Laboratory Work:

Study of Nestler Boiler, Lancashire Boiler, Babcock and Wilcox boiler, Locomotive boiler, mountings and accessories of a boiler, Petrol/ Diesel Engine (Both two stroke and Four Stroke), Two Stroke Krimo Engine, Multi cylinder petrol engine, Dual fuel engine test rig, Industrial visit to thermal power plant.

Course Learning Outcomes (CLO):
The students will be able to:

1. apply the first and second laws of thermodynamics for the complete thermal analysis of vapor power cycle.
2. study the performance parameters of IC engines. Fuel injection, combustion, lubrication, cooling, heat transfer, friction and other factors affecting engine power, efficiency and emission.
3. Derive and analyze Otto, Diesel, Dual cycle thermal efficiencies.

Text Books:

1 *Pulkrabek, W. W., Engineering Fundamentals of Internal Combustion Engines, Pearson education Asia, New Delhi (2007).*
2 *Vasandani, V. P. and Kumar, D. S., Heat Engineering, Metropolitan Book Company, New Delhi (2003).*

Reference Books:

1 *Heywood, J. B., Internal Combustion Engine, McGraw Hill, New Delhi (1988).*
2 *Joel, R., Basic Engineering Thermodynamics, Pearson Education Asia, New Delhi (1996).*
3 *Granet, I., Thermodynamics & Heat Power, Pearson Education Asia, New Delhi (2003).*

4 Ganeshan, V., Internal Combustion Engines, Tata McGraw Hill, New Delhi (2007).
5 Nag, P. K., Power Plant Engineering, Tata McGraw Hill, New Delhi (2008).

KINEMATICS OF MACHINES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To learn actual mechanisms and their kinematic characteristics (displacement, velocity and acceleration) used in the analysis, design and development of machines and to study existing machines for better understanding.

Motion Analysis: Kinematics links, Pairs and chains, Type of motions, Type of mechanisms, Inversion of mechanisms, Velocity analysis of different mechanism by vector and instantaneous method, Acceleration analysis of different mechanism, Coriolis acceleration.

Gear Drives: Law of Gearing, Types of gears, Types of Profiles, Gear terminology, Gear Trains, Types and applications of gear trains, Train value, Analysis of Simple, Compound, Inverted and Epicyclical gear trains.

Cam Mechanism: Types of Cams and Followers, Types of follower motions, Construction of cam profiles, Analysis of motion of follower, Operating different types of cam.

Steering Mechanism, Hook's Joint.

Synthesis: Introduction to Synthesis of mechanisms.

Course Learning Outcomes (CLO):
The students will be able to:

1. Select appropriate combination of mechanism to analyze and design new machines and to study existing machines for improvements.

Text Books:

1. *Rattan, S. S., Theory of Machines, Tata McGraw Hill (2009).*
2. *Bevan, T., Theory of Machines, CBS Publisher (2005).*

Reference Books:

1. *Ghosh, A. and Malik, A.K., Theory of Mechanism and Machines, East West Press (2009).*
2. *Shigley, J. E., Kinematics Analysis of Mechanism, McGraw-Hill (1995).*
3. *Myszka, D. S., Machines & Mechanisms: Applied Kinematic Analysis, Pearson Education (2004).*

MACHINE DRAWING

L	T	P	Cr
1	4	0	3.0

Course Objectives: Introduction to Mechanical drawing standards, symbols, conventions and rules. Introduce standards, types, working, uses and design variations of components and assemblies used in machines. Impart knowledge related to principles, methods and techniques used in Manual Drafting and Computer Aided Drafting tools for use in communication of mechanical engineering design for manufacture. Assemble components given only component drawings and make sectioned views of the mechanical system assembly and interpret its working.

Introduction to Mechanical Drawing: Classification of drawings, Principles of drawing, Conventions according to IS, Sectional Views and rules of sectioning, Machining and Surface Finish symbols indicating tolerances in dimensioning, Detailed Drawings.

Manual Drafting and Computer Aided Drafting using s/w like Pro-desktop or Pro-E or AutoCAD, Standards, Types, Practical applications and working of:

(a) Machine Components: Screw fasteners, Keys cotters and joints, Shaft couplings, Pipe joints and fittings, Riveted joints and welded joints.

(b) Assemblies: Bearings (Plumber Block, Footstep, Swivel), Hangers and Brackets, Steam and I.C. Engine Parts, Machine components, Valves.

Case Studies in Computer Plots and Industrial Blueprints.

Laboratory Work:

Manual Drafting (MD) and/or Computer Aided Drafting (CAD) (using s/w like Pro-E or AutoCAD) of: (a) Machine Components: Screw fasteners, Keys cotters and joints, Shaft couplings, Pipe joints and fittings, Riveted joints and welded joints. (b) Assemblies: Bearings (Plumber Block, Footstep, Swivel), Hangers and Brackets, Engine Parts, Machine components, Valves.

Exercise in computer plots of drawings/ blueprints.

Course Learning Outcomes (CLO):
The students will be able to:

1. Use standards used in machine drawing of machine components and assemblies.
2. Create and read production drawings for mechanical components and systems and deduce their functions.
3. Use manual drafting or CAD tools for making drawings of machine components and assemblies.
4. Assemble components given only component drawings and make sectioned views of the mechanical system assembly and interpret its working.

Text Books:

1. *Gill, P.S., Machine Drawing, S.K.Kataria and Sons (2013).*
2. *Bhatt, N.D., Machine Drawing, Charotar Publishing House (2008).*

Reference Books:

1. *Pohit, G., Machine Drawing with AutoCAD, Pearson Education Asia (2007).*
2. *French, T. E. and Vierck, C. J., Graphic Science and Design, McGraw Hill (2000).*
3. *Dhawan, R.K., Machine Drawing, S.Chand & Company Limited (2003).*
4. *Narayana, K.L., Kannaiah P. and Reddy, K.V., Machine Drawing, New Age International Publishers (2002).*

UMA031 OPTIMIZATION TECHNIQUES

L	T	P	Cr
3	1	0	3.5

Course Objective: The main objective of the course is to formulate mathematical models and to understand solution methods for real life optimal decision problems. The emphasis will be on basic study of linear programming problem, Integer programming problem, Transportation problem, Two person zero sum games with economic applications and project management techniques using PERT and CPM.

Scope of Operations Research: Introduction to linear and non-linear programming formulation of different models.

Linear Programming: Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex method, Exceptional cases in LP, Duality theory, Dual simplex method, Sensitivity analysis, Parametric linear programming.

Integer Programming: Branch and bound technique.

Transportation and Assignment Problem: Initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, Optimal solutions.

Network Analysis: Shortest path problem, Dijkastra's algorithm, Minimum spanning tree problem, Maximum flow problem.

Project Management: Construction of networks, Network computations, Floats (free floats and total floats), Red flagging rule, Critical path method (CPM), Crashing.

Nonlinear Programming: Concept of convexity and concavity, Maxima and minima of functions of n-variables, Lagrange multipliers, Kuhn-Tucker conditions for constrained optimization, One dimensional search methods, Fibonacci, Gradient methods for unconstrained problems.

Course Learning Outcomes (CLO):

After Completion of this course, the students would be able to:

1. Formulate and solve linear programming problems.
2. Solve the problems on networks models such as Transportation, Assignment, Shortest path, minimal spanning tree, and Maximal flow.
3. Solve the problems of Project Management using CPM.

Text Books:

1. *Chandra, S., Jayadeva, Mehra, A., Numerical Optimization and Applications, Narosa Publishing House, (2013).*
2. *Taha H.A., Operations Research-An Introduction, PHI (2007).*

Recommended Books:

1. *Bazaarra Mokhtar S., Jarvis John J. and Shirali Hanif D., Linear Programming and Network flows, John Wiley and Sons (1990).*
2. *Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons, (2010).*
3. *Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004).*

UHU 031-ORGANIZATIONAL BEHAVIOR

L	T	P	Cr
3	1	0	3.5

Course Objective: To understand the complexity of human behavior and factors affecting individual differences and their relevance in the global world**.** To learn the dynamics of leadership and motivation for effective functioning in the organization.

Introduction to Organizational Behavior, Today's Organizations, Contemporary Challenges, Foundations of Organizational Behavior, and Individual Behavior: Personality, Values, Attitudes, and Motivation Theories. Employees Motivation in Organization. Management by Objectives, Learning Processes, Reward and Punishment, Shaping Behavior.

Foundations of Group Behavior: Group Development Process, Group Decision Making Techniques, Leadership, Power & Politics, Conflict Process, Negotiations, Inter- Group Relations, Team Working, and Stress Management.

A Macro perspective of Organizational Behavior, Organizational Structure: Key Elements, Types and Basic Models, Work Designs, Organizational Change and Learning Organizations.

Organizational Behavior: Future Challenges, Gender Diversity at Work Place, Changing World Scenario, Role of external Environment.

Achieving Competitive Advantage Management of change, International issues in Organizational Behavior.

Current issues in Organizational Behavior: Techno-stress, Combating stress, Role of Positive Psychology.

Course Learning Outcomes (CLO):
After completing the course, the students will be able to:

1. Understand the basics of Organizational Behavior as an interdisciplinary Course.
2. Understand the different levels of analysis: Individual, Group, Organization.
3. Understand the effect of personality, Learning, Attitudes of an individual in an Organization.
4. Understand the role of Motivation and Leadership in an organization and how an individual as a leader can motivate his/her employees and utilize Group dynamics in Organization.
5. Understand the concept of Power and Politics, and Conflict management and its relevance.
6. Understand how organization functions as whole, Organizational Culture, Organizational Design, and Organizational Change.

Text Books:

1. *Robbins, S.P. Organizational Behavior, PHI, New Delhi.*
2. *Luthans, F. Organizational Behavior, Irwin McGraw Hill.*
3. *Susan Nolen-Hoeksema,S; Geoffrey Loftus ,G,& Wagenaar,W Atkinson & Hilgard's Introduction to Psychology Wadsworth Cengage learning.*

UES032: MATERIALS SCIENCE AND ENGINEERING

L	T	P	Cr
3	1	2	4.5

Crystal Structure and Chemical Bonding: Materials and their classification, Mechanical, Chemical, Electrical properties, Structure-property relationship in engineering materials, Miller Indices, Crystal planes and directions, Determination of crystal structure using X-rays, Chemical bonding in solids, Primary and Secondary bonds.

Structure of Solids: Crystalline and non-crystalline materials, Inorganic solids, Silicate structures and its applications.

Crystal Imperfections: Point defects, Line defects, Surface defects, Movement of Dislocation, Dislocation energy.

Diffusion: Laws of diffusion, Temperature dependence of diffusion coefficient, Determination of activation energy.

Mechanical Properties of Materials: Elastic, Anelastic and Viscoelastic behaviour, Plastic behaviour of solids, Critical shear stress, Twinning and slipping phenomenon, Creep.

Equilibrium Diagram: Solids solutions and alloys, Gibbs phase rule, Isomorphous and eutectic phase diagrams and their construction, Lever arm rule, Application of phase diagrams, Zone refining.

Corrosion Process: Corrosion, Cause of corrosion, Types of corrosion, Protection against corrosion.

Conducting and Resistor Materials: Conducting and resister materials, Coefficient of thermal expansion, Matthiessen and Nordheim rules for alloys and their engineering application.

Semiconductors: Semiconducting materials, Element and compound semiconductors their properties and applications.

Magnetic Materials: Magnetic materials, Soft and hard magnetic materials their properties and applications.

Dielectric Materials: Dielectric materials, Polarization, Dielectric loss and dielectric breakdown, Ferro, Piezo-and Pyroelectric materials, their properties and applications.

Biomaterials and Applications: Biomaterials with reference to biopolymer and bioceramics.

Modern Materials: Introduction and application to nanomaterials, Smart materials and structures, Optical materials, Superconducting materials, Materials for nuclear and space applications.

Laboratory Work:

1. To determine Curie temperature of a ferrite sample and to study temperature dependence of permeability in the vicinity of curie temperature.
2. To study cooling curve of a binary alloy.
3. Determination of the Young's modulus and Ultimate strength of a given fiber strand.
4. To determine the dielectric constant of PCB laminate.
5. Detection of flaws using ultrasonic Flaw Detector (UFD).
6. To study the intensity response of L.D.R and voltage response of a V.D.R.
7. To prepare two metallic specimens for metallographic examination and measure their grain size.
8. Estimation of band-gap energy of Germanium.
9. To determine the light intensity response of a Silicon Solar Cell.
10. To determine the resistivity of a given sample using four probe method.
11. To determine Fiber and void fraction of a glass fiber reinforced composite specimen.

12. To investigate creep of a given wire at room temperature.
13. To estimate the Hall coefficient, carrier concentration and their mobility in Ge Crystal using Hall Effect.
14. To estimate the Band-gap of energy of Ge Crystal using Four Probe Technique.
15. To Study the Corrosion behavior of metallic materials.

Text Books:

1. *Smith, W.F., Principles of Materials Science and Engineering: An Introduction, Tata Mc-Graw Hill (2008).*
2. *Raghavan, V., Introduction to Materials Science and Engineering, PHI, Delhi (2005).*
3. *Callister, W.D., Materials Science and Engineering, John Wiley & Sons, Singapore (2002).*

Reference Books:

1. *Kasap, S. O., Principles of Electronic Engineering Materials, Tata-Mc-Graw Hill (2007).*
2. *Van Vlack, L H., Elements of Material Science and Engineering, Thomas Press, India (1998)*

COMPUTER AIDED GEOMETRIC MODELING AND ANALYSIS

L	T	P	Cr
2	4	0	4.0

Course Objectives: Exposure to CAD tools for use in mechanical engineering design conceptualization, Geometric modelling, communication, analysis and optimization. Impart knowledge related to principles, methods and techniques of 3D modelling in parametric CAD software. Design evaluation and optimization using CAD, CAE software. Use of CAD models for further use in CAM and CAE uses in mechanical engineering.

Fundamentals of CAD: Introduction, Application of computers in stages of the design process, Benefits of CAD.

Use of CAD Software like Creo/Pro-Engineer: Techniques and functions used for parametric solid modeling, Surface modeling, Assembly modeling, Drawing creation and detailing, Use of CAD data for CAM and CAE.

Geometric Modeling: Parametric sketching, Constrained model dimensioning, Material addition and removal for extruded, Revolved, Swept and Blended features, Construction features of points, Axis, Curves, Planes, Surfaces. Feature and its parent-child relationships, References. Parametric modeling, User defined parameters, Relations. Advanced features for non-parallel blends, Helical sweep, Swept blend, Variable section sweeps, and surface boundary blend. Top-down vs. bottom-up design. Assembly modeling. Flexible component assembly. Automatic production drawing creation and detailing. File formats for data transfer.

Software Productivity Enhancement Tools: Cosmetic features, Chamfers, Rounds, Standard holes and sketched holes, Draft, Ribs, Shell. Feature patterns, Duplication, Grouping, Suppression. Part family table for Group Technology. Software automation and customization tools. Coloring and rendering. Simplified views. Assembly animation.

Geometric Model Based Analysis: Model measures, Evaluation and analysis. Mass property analysis, Assembly analysis. Design of customized analysis features. Design parameter sensitivity analysis, Feasibility and optimization studies. Mechanism design and assembly for kinematic and dynamic analysis. Linear elastic mechanical stress analysis using software like Pro-Mechanica for industrial design.

Course Learning Outcomes (CLO):
The students will be able to:

1. Translate production drawings to 3D CAD models.
2. Use parametric CAD software for Geometric Modeling of Mechanical Designs.
3. Evaluate and optimize the design using CAD, CAE software.
4. Use 2D / 3D CAD in future courses like Project Semester, Mechanical System Design - project work, CAM, etc.

Text Books:

1. *Gill, P.S., Machine Drawing, S.K.Kataria Publishers (2013).*
2. *Dhawan, R. K., Machine Drawing, S. Chand & Company Limited (2003).*

Reference Books:

1. *Creo / Pro-E Software Manuals, Training materials and literature provided by supplier.*
2. *Shyam Tikku and Prabhakar Singh, Pro/Engineer (Creo Parametric 2.0) for Engineers and Designers, Dreamtech Press (2013)*
3. *Kelley, D. S., Pro/Engineer Wildfire 3.0 Instructor, Tata McGraw Hill (2008).*
4. *Groover, M. P. and Zimmer, E. W., CAD/CAM, Pearson Education Asia (2008).*

DYNAMICS OF MACHINES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To learn different parameters and principles needed to calculate forces and torques in friction devices (belts, pulleys, bearings, brakes, clutches), balancing of rotating and reciprocating masses, and some important devices like gyroscope, gears and gear trains etc. in totality.

Force Analysis: Static and dynamic force analysis of mechanisms.

Flywheel: Turning moment diagrams, Fluctuation of energy, Coefficient of fluctuation of energy and speed, Application in engines and punching presses.

Governors: Function, Types, Force analysis and their Characteristics.

Friction Devices: Fundamentals of friction, Pivots and Collars, Plate and Cone Clutches, Centrifugal Clutches, Friction in mechanism.

Belts Ropes and Chain Drives: Types of belt drives, Velocity ratio, Slip, belt length, Crowning of pulleys, V-belts, Condition for transmission of maximum power, Centrifugal tension, Chain drive, Types of chains, Merits and demerits of chain drive over belt drive.

Brakes and Dynamometers: Short shoe brakes, Pivoted shoe brakes, Long shoe brakes, Band brakes, Different types of Dynamometers.

Gears: Interference, Minimum number of teeth on gear and pinion to avoid interference, Path of contact and arc of contact.

Balancing: Balancing of rotating and reciprocating masses, Balancing of inline and v-engines.

Gyroscope: Gyroscopic effect, Application in ships, Vehicles etc.

Course Learning Outcomes (CLO):
The students will be able to:

1. Integrate kinematics with dynamics to study, analyze and design new machines, and performance enhancement of existing machines.

Text Books:

1. *Rattan, S. S., Theory of Machines, Tata McGraw Hill (2009).*
2. *Bevan, T., Theory of Machines, CBS Publisher (2005).*

Reference Books:

1. *Ghosh, A. and Malik, A.K., Theory of Mechanism and Machines, East West Press (2009).*
2. *Shigley, J. E., Kinematics Analysis of Mechanism, McGraw Hill (1995).*

INSPECTION AND QUALITY CONTROL

L	T	P	Cr
3	1	2	4.5

Course Objectives: Understand the objectives, functions, and economic aspects of industrial inspection. Understand the essential components/ economics for building quality and study the evolution of the concepts/ tools of quality engineering. Study the basics and applications of various statistical quality control techniques and also process capability analysis. Study and understand the concepts of quality improvement process and the associated quality tools. Understand the scope and significance of engineering metrology

Inspection, Quality, Process and Control: The basic concepts, Objectives and functions of inspection in industry, Meaning and significance of quality, Essential components of quality, Phases or elements for building quality, Evolution of the concepts of quality, Spiral of progress of quality, Changing scope of quality activities, Quality Circles, Quality system economics, Hidden quality costs, Economic models of quality costs, Quality loss function.

Statistical Process Control: Understanding the process, Process data collection and presentation, Process variability, Process control, Variable control charts ($\overline{X}-R, \overline{X}-S$ etc.), Attribute control charts(p, np, c, μ) , Cumsum charts, Acceptance sampling.

Process Capability Analysis: Need and significance, Process capability for variable data, Process capability indices, Interpreting the indices, Use of control chart and process capability data.

Process Improvement: Quality improvement process, Quality tools for process improvement viz. Pareto Charts, C & E analysis, Scatter Diagrams, Stratification.

Six Sigma Process Quality: Introduction, DMAIC process, role of design of experimentation, Parametric design.

Engineering Metrology: Scope of engineering metrology, Types of measurement methods, Characteristics of a measurement system (Range/span, Precision/Accuracy, Hysteresis, Dead Zone, Drift, Sensitivity), Calibration process, Line measurement and end measurement, Importance of surface texture, Gauge R & R, Radius and Curvature measurement, Angle measurement, Thread and Gear measurement.

Course Learning Outcomes (CLO):

The students will be able to:

1. Understand the importance of quality and the role of industrial inspection in achieving it.
2. Understand the phases and components for building quality and to learn about quality system economics.
3. Apply various SPC and quality tools for the purpose of overall quality improvement.
4. Learn the basic concepts involved in the working of instruments for line and angle measurements.

Text Books:

1 *Oakland, J. S., Statistical Process Control, Butterworth and Heinemann, New York (2008).*
2 *Gupta, I. C., Engineering Metrology, Dhanpat Rai and Sons, New Delhi (2007).*

Reference Books:

1 *Grant, E. L. and Leavenworth, R.S., Statistical Quality Control, McGraw Hill International, New York (2008).*
2 *Besterfield, D.H., Total Quality Management, Pearson Education Asia, New Delhi (2003).*
3 *Juran, J. M. and Gryna, F. M., Quality Planning & Analysis, Tata McGraw Hill, New Delhi (1995).*

MECHANICS OF DEFORMABLE BODIES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To perform three dimensional stress and deformation analyses for structures exposed to axial, torsional, shear, bending loads, when acting either independently or in combination. To use the concepts of principal stresses and strains to calculate maximum stresses and strains and determine the critical loads for failure of a structure under static loads. Use linear elastic relationships between stress and strain to predict deformations of a structure or determine stresses from strain measurements. Methods for solving complex problems involving analysis of structures like bending of curved beams, unsymmetrical bending of beams and determining shear centre, critical loads for columns, stresses in pressure vessels.

Three-Dimensional Stress Analysis: Stresses on an arbitrary plane, Principal stresses and stress invariant, Mohr's stress circles, Differential equations of equilibrium in Cartesian and cylindrical coordinates, Three-dimensional strain analysis, Rectangular strain components, Principal strains and strain invariant, Compatibility conditions.

Stress-Strain Relations: Generalized Hooke's law, Stress-strain relations for isotropic materials.

Energy Methods: Principle of superposition, Work done by forces- elastic strain energy stored, Maxwell-Betti's theorem, Castigliano's theorems, Strain energy expressions, Fictious load method, Statically indeterminate problems.

Unsymmetrical Bending: Flexure formula for unsymmetrical bending, Shear centre and its determination for various sections.

Curved Flexural Members: Winkler-Bach formula, Stresses in curved beams having rectangular, Circular and trapezoidal sections, Stresses in rings and chain links.

Thick and Thin Cylinders: Thick Cylinders and Rotating Discs, Lame's theory for stresses in thick cylinders, Composite tubes, Shrink fits and Laminated cylinders, Thin rotating rings, Stresses in rotating discs and cylinders, Discs of uniform strength.

Elastic Stability: Euler's buckling load, Beam-column equations, Beam column with concentrated load, Critical load for columns with different end conditions.

Theories of Elastic Failure: Various theories of failure, Significance and applications, Graphical comparison for plane stress case.

Course Learning Outcomes (CLO):
The students will be able to:

1. Carry out three dimensional stresses and strain analysis in loaded elastic members.
2. Develop governing equations and their solutions for analysis of structures.

Text Books:

1. *Srinath, L.S., Advanced Mechanics of Solids, Tata Mc-Graw Hill (2008).*
2. *Shames, I.H., Mechanics of Deformable Solids, Prentice Hall of India (2000).*

Reference Books:

1. *Popov, E.P., Engineering Mechanics of Solids, Prentice Hall of India (2006).*
2. *Ryder, G.H., Strength of Materials, B.I. Publishers (2005).*
3. *Kumar K. and Ghai, R. C., Advanced Mechanics of Materials, Khanna Publishers (1986).*

INDUSTRIAL ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objectives: To equip the students to objectively study business functions in order to critically evaluate the effectiveness and efficiency of processes, tools and equipment manpower utilization, machinery, workplace layout, environment, methods of working, through a structured analysis approach. To cultivate working knowledge in the area of Inventory Management using conventional and contemporary techniques of inventory management in manufacturing environment. To develop knowledge and skills in product design for its proper value analysis and engineering. To develop improved techniques/methods commensurate with the existing conditions and ensuring smooth embedding of the new improved methods in any manufacturing and business organization

Introduction to Industrial Engineering: Relevance of industrial engineering for achieving performance excellence in industry.

Productivity Management*:* Productivity measurement and improvement, Resource waste minimization, Lean manufacturing.

Plant Location & Layout*:* Factors effecting plant location, Selection of plant site, Quantitative techniques of plant location decision, Plant layout, Principles of layout design, Methods for evaluation of a layout, Quantitative techniques of developing layouts.

Materials Management: Objectives and functions, Procurement, Types of inventories, Inventory costs, Inventory control models, Determination of EOQ (under deterministic conditions), MRP, Bill of materials.

Product Engineering: Product design considerations, Product development, Detailing, Value Engineering and its role in product design and cost rationalization.

Work Science: Purpose and scope, Productivity and work-study, Method Study and Work Measurement, Principles of Motion Economy, Elements of Work Sampling, Predetermined Motion Time Systems, Principles of Work Design.

Ergonomics: Role of Ergonomics in industry, Introduction to anthropometry, Task analysis to reduce Musclo-Skeletal disorders, Posture analysis, Introduction to bio-mechanics, Effect of physical environment on performance.

Maintenance Management: Objectives, Nature of maintenance problems, Maintenance strategies, Organization, Maintenance Information Systems, Spare Parts Management, Maintenance Cost Control, Introduction to Total Productive Maintenance.

Course Learning Outcomes (CLO):

The students will be able to:

1. Evaluate and improve the business process for effective utilization of all the industrial resources.
2. Manage and plan the general inventory in industry.
3. Develop better methods for workplace improvement and new products.

Text Books:

1. *Shankar, R., Industrial Engineering and Management, Galgotia Publications (2003).*
2. *Monks, J. G., Production/Operations Management, McGraw Hill (2004).*

Reference Books:

1. *Chitale, A. K. and Gupta, R. C., Product Design and Manufacturing, McGraw Hill (2005).*
2. *Sanders, M. and McCormic, E., Human factors in Engineering, McGraw Hill (1993).*
3. *Work Study, ILO, Geneva (1992).*
4. *Curie, R., Introduction to Work Study, McGraw Hill (1992).*

AUTOMOBILE ENGINEERING

L	T	P	Cr
3	0	2	4.0

Course Objectives: To deliver basic knowledge of different components of automobiles.

Introduction: Conventional motor vehicle, vehicle classification, frame and frameless construction, vehicle dimensions, power requirements, vehicle performance, gear ratio for maximum acceleration, stability of two wheel drive and four wheel drive vehicles.
Clutch and Transmission: Single-Plate clutch, multi-plate clutch, dry clutch, wet clutch, centrifugal, semi-centrifugal clutch, servo clutch mechanism, requirements for manual and automatic transmission, their type and constructional detail.
Steering and Suspension: Steering mechanisms and steering system including power steering, steering geometry, suspension principle, rigid axle suspension and independent suspension, suspension system elements, hydraulic suspension, pneumatic suspension, leaf spring, Mc-pherson strut.
Drive Line: Propeller shaft, universal joint, constant velocity joint, slip joint, differential, axle and hub.
Braking System: Introduction to braking system and their types, ABS, brake compensation.
Wheel and Tyres: Disc pressed wheels, alloy wheels, multi-piece wheels, tyre description, types and manufacturing, tubed and tubeless tyres, radial tyres , tyre specifications and coding, tread pattern, aqua-planing.
Emission control devices: Catalytic convertor and its types, EGR.
Vehicle Electronics: Electrical and electronic systems in automobiles, starting motor drives,
automotive accessories and safety features in automobile.
Trouble shooting in various components.
Trends in automobile sector: Hybrid, solar powered vehicles.

Laboratory Work:
Study of vehicle chassis and construction, study of single plate and multi-plate clutch in an automobile, construction and working of following gear boxes: Contact mesh gear box; synchronous gear box, parts of automatic transmission system, components of suspension system of automobile (2 wheel, 4 wheel), steering system of an automobile, electric system, starting system, braking system of an automobile, study of radiator, study of turbocharger and supercharger, study of differential, axles, study of propeller shaft, universal joints and slip joint, study of catalytic convertor; Visit to automobile service station for troubleshooting exercises; Group assignments on above topics.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the performance parameters and power requirements of a vehicle.
2. understand the concept of manual and automatic working of different components of automobiles.
3. understand the fundamental knowledge of mechanisms used to transfer energy from engine to the wheels.

Text Books:

1 *Hiller, V. A. W., Fundamentals of Motor Vehicle Technology, Nelson Thornes, UK (2012).*
2 *Giri, N. K., Automobile Mechanics, Khanna Publishers, New Delhi (2011).*

Reference Books:

1 *Garrett, T. K., Newton, K. and Steeds, W., The Motor Vehicle, Butterworth-Heinemann, Great Britain, London (2001).*
2 *Norton, A. A., Book of the Car, Automobile Association, London (1977).*
3 *Heinz, H., Advance Vehicle Technology, Arnold Publishers, Butterworth-Heinemann, London (1999).*
4 *Crouse, W. and Anglin, D., Automotive Mechanics, Tata McGraw Hill, New Delhi (2006).*
5 *Heinz, H, Engine and Vehicle Technology, Arnold Publishers, Butterworth-Heinemann, London (2002).*

INDUSTRIAL METALLURGY AND MATERIALS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To identify and understand the variables which affect the mechanical properties of alloys. To study the role of equilibrium diagrams in controlling the microstructure of materials especially iron-carbon systems.

Equilibrium Diagrams: Phases and their significance, components, degrees of freedom, Gibb's phase rule, equilibrium heating/ cooling, classification of phases in binary alloys, equilibrium diagrams for single component systems, coring and its effects in Type I systems, factors and techniques for elimination of coring, equilibrium diagrams for binary systems having unlimited solubility in liquid and solid states, equilibrium diagrams for binary eutectic systems, inverse lever rule.

Iron-Carbon Systems: Components and phases of Iron-Carbon system, Iron and Iron Carbide diagram, invariant reactions of Iron-Carbon systems, critical temperatures and critical temperature lines.

Kinetics of Austenite Transformations: Kinetics of formation of austenite in eutectoid steels, factors affecting the decomposition of austenite, classification of steels on basis of austenite grain growth when heated beyond the upper critical temperature, austenite grain size, Time Temperature Transformation diagrams (TTT Diagrams), features of super cooled austenite transformation.

Heat Treatment of Steels: Need and main steps in heat treatment processes, classification of heat treatment processes on basis of heat treatment temperature and on the basis of purpose, various types of annealing, normalising, hardening and tempering treatments, factors affecting the hardenability of steels.

Surface Heat Treatment (Case Hardening) Methods: General features of surface hardening processes, flame and Induction hardening of steel; Chemical heat treatment of steels: carburising, nitriding, and cyaniding of steels.

Alloy Steels: Effect of various alloying elements in steel, structural and wear resistant steels, carbon and alloy tool steel, high Speed Steels.

Introduction to composite materials.

Exposure to different metallurgical equipment; Industrial visits.

Course Learning Outcomes (CLO):

The students will be able to:

1. understand the kinetics of formation and decomposition of austenite and the various heat treatment processes.
2. study the composition, properties, applications of alloy steels to understand their commercial utility.
3. identify, analyze, and solve problems related to concepts of industrial metallurgy.

Text Books:

1 Avner, S.E., Introduction to Physical Metallurgy, McGraw Hill, New Delhi (2009).

2 Singh, V., Physical Metallurgy, Standard Publishers, New Delhi (2002).

Reference Books:

1 *Callister, W.D., Materials Science and Engineering: An Introduction, John Wiley and Sons Inc., US (2007).*

2 *Hill, R.E.R., Physical Metallurgy Principles, Affiliated East-West Press, New Delhi (2008).*

3 *Rajan, T.V., Sharma, C.P and Sharma, A., Heat Treatment: Principles & Techniques, Prentice Hall of India, New Delhi (2006).*

4 *Lakhtin, Y., Engineering Physical Metallurgy, CBS Publishers and Distributors, New Delhi (2005).*

MACHINE DESIGN

L	T	P	Cr
3	1	0	3.5

Course Objectives: To present the basic knowledge of design procedure for simple components like keys, cotters, shafts, pipe joints, pulleys, seals and gaskets under static and fatigue loading.

Design Processes: Introduction, standards and preferred numbers, stress-concentration, endurance limit, fatigue and reliability considerations, factor of safety and its selection, selection of materials, review of theories of failure, tolerance, type of fits, selection of fits, limits.

Design of Shaft: Shafts subject to combined loading; subjected to fatigue loading.

Analysis and Design of Fasteners and Joints: Key and keyed joints, cotter and knuckle joints, riveted joints, boiler joints, structural joints, welded joints, bolts and bolted joints with and without initial tightening loads; Bolted, riveted and welded joint under eccentric loading.

Couplings: Rigid and Flexible types.
Design of other Mechanical Components: Power screws, pipe joints: circular, oval and square flanged pipe joints, seals and gaskets, pulleys and flywheels.

Assignments related to design and drawings of the above components.
Machine Design data issued by Mechanical Engineering Department is only to be used.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the principles, process and requirements for design of machine elements.
2. select the suitable materials.
3. design simple components like fasteners, shafts, couplings etc.

Text Books:

1. *Bhandari, V. B., Design of Machine Elements, Tata McGraw Hill, New Delhi (2007).*
2. *Shigley, J., Mechanical Engineering Design, McGraw Hill Book Company Inc., New York (2003).*

Reference Books:

1 *Spotts, M. F. and Shoup, T. E., Design of Machine Elements, Pearson Education, New Delhi (2003).*
2 *Juvinall, R. C. and Marshek, K. M., Fundamental of Machine Component Design, John Wiley & Sons, New York (2005).*
3 *Norton, R.L., Machine Design: An Integrated Approach, Pearson Education, New Delhi (2006).*
4 *Sharma, C. S. and Purohil, K., Design of Machine Elements, Prentice Hall, New Delhi (2003).*

MANUFACTURING TECHNOLOGY

L	T	P	Cr
3	0	2	4.0

Course Objectives: To expose the students to the principles of the metal joining methods with principle of operations and power sources for different welding techniques, process parameters and their effects on joint quality, joint quality checking, weld ability issues. To impart the knowledge on metal cutting mechanics, cutting force, stress, strain etc, effect of process parameters, grinding and abrasive machining techniques. To study metal forming techniques, extrusion, rolling, drawing, and sheet metal forming and shearing operations, some design aspects and knowledge about process behavior.

Metal Casting: Review of sand casting, sand testing, machine moulding, cupola, charge estimating, inspection of castings, casting defects; Shell moulding; investment casting; die casting; centrifugal casting.

Welding: Review of welding processes, weldability, principles and application of TIG and MIG welding, friction and inertia welding, hard facing and metallizing, welding defects.

Metal Cutting: Machinability, factors affecting machinability; Milling, milling cutters and milling machines.

Grinding and other abrasive finishing processes, grinding wheel selection, surface grinding, centreless grinding, abrasive finishing Processes.

Metal Forming: Hot and cold forming, forming processes, forging machines, forging design considerations, forging defects; High energy rate forming processes.

Shaping Non- metallic materials: Basic manufacturing processes for processing of plastics and ceramics.

Powder Metallurgy; Rapid Prototyping and Tooling.

Laboratory Work:

Experimental work pertaining to study & use of sand testing equipment, performance on MIG & resistance welding, exercises on horizontal & vertical milling machines, planer, shaper, centreless & surface grinders, performance in foundry shop for hollow casting, experiment on die-casting; Experiment on blow molding; Experiment on NDT (Dye penetrant/ ultrasonic testing/ magnetic particle) and DT of welded joints (Tensile/ bending test); Profile cutting in vertical milling machine; Experiment on cylindrical grinding and TIG welding; Industrial visit.

Course Learning Outcomes (CLO):

The students will be able to:

1. apply the knowledge of metal casting for different requirements, quality; calculation of charge constituents, designing of gating and riser systems, casting solidification and quality of casting.
2. understand the basic principle of metal cutting and forming operations.
3. understand the processing of non-metallic materials, preparation and processing of plastics for different applications, Powder metallurgy and Rapid prototyping and tooling.

Text Books:

1 *Rao, P.N., Manufacturing Technology: Foundry, Forming & Welding, Tata Mc-Graw Hill, New Delhi (2003).*

2 *Rao, P.N., Manufacturing Technology: Metal Cutting & Machine Tools, Tata Mc-Graw Hill, New Delhi (2003).*

Reference Books:

1 *Ostwald, J.M., Manufacturing Processes & systems, John Wiley & Sons (Asia) Pvt Ltd, Singapore (2007).*

2 *Champbell, J.S., Principle of Material and Process, Tata Mc-Graw Hill, New Delhi (1995).*

3 *Singh, C.K., Manufacturing Technology, Pearson Education Asia, New Delhi (2002).*

4 *Doyle, L.E., Manufacturing Process & Materials for Engineers, Prentice Hall of India, New Delhi (1984).*

5 *Lindberg, R.A., Manufacturing Process & Materials, Prentice Hall of India, New Delhi (2006).*

6 *Degarmo, E.P., Materials and Processes in Manufacturing, Prentice Hall of India, New Delhi (2002).*

HEAT AND MASS TRANSFER

L	T	P	Cr
3	1	2	4.5

Course Objectives: To present the principles of heat transfer through various modes and to relate to their practical applications and design aspects.

Heat Conduction: General heat conduction equation in rectangular, polar and spherical co-ordinates, one dimensional heat conduction, concept of thermal resistance, series and parallel connections, variable thermal conductivity, composite walls, critical insulation thickness, unsteady heat conduction: Systems with negligible internal resistance, Biot and Fourier number and their significance, lumped heat capacity analysis. Use of Hiesler and Grober Charts. Heat transfer from extended surfaces: Types and applications of fins, heat transfer through rectangular and circular fins. Fin effectiveness and efficiency, error estimation in temperature measurement in thermo well.

Heat Convection: Dimensional analysis, momentum and energy equation for boundary layers over a flat plate; Forced and Natural convection: Empirical equations for plates, pipes and spheres; Thermal boundary layer (in heat convection), dimensional analysis, physical significance of dimensionless numbers, Reynolds analogy for laminar flow, tube bundles.

Heat Exchangers: Classification, LMTD and effectiveness-NTU methods, design criteria, fouling factors and standards, heat pipe.

Boiling and Condensation: Pool boiling curves, forced boiling, techniques for enhancement of boiling, Nusselt's theory of condensation, condensation number, filmwise and dropwise condensation.

Thermal Radiation: Nature of thermal radiation, definitions of absorbitivity, reflectivity, transmissivity, monochromatic emissive power. Total emissive power and emissivity, concept of black body & gray body, Kirchoff's law, Wein's law and Planck's law. Deduction of Stefan Boltzman equation. Lambert cosine rule, intensity of radiation. Energy exchange by radiation between two black surfaces. Geometric shape factor. Radiation network method, network for two surfaces which see each other and nothing else, radiation shields.

Mass Transfer: Fick's Law, equimolal diffusion, isothermal evaporation, mass transfer coefficients, humidification operations.

Latest Development in Heat Transfer Technology: Nanofluids and other new technologies.

Laboratory Work: Thermal conductivity of insulating powder, heat transfer through composite wall, thermal conductivity of lagging material on pipe / metal rod, thermal conductivity by two slab guarded hot plate method, heat transfer coefficient in natural convection, forced convection heat transfer from a heated pipe, forced convection heat transfer through pin-finance, emmisivity of a test plate, critical heat flux in pool boiling, verification of Stefan Boltzmann's law of radiation, study the phenomenon of drop wise and film wise condensation, study the working of two phase heat transfer unit, performance of parallel flow and counter flow heat exchanger, super thermal conducting heat pipe and comparison with the best conductor; demonstration in Nano fluid laboratory; Industrial visit.

Examination through open book

Course Learning Outcomes (CLO):

The students will be able to:

1. understand and calculate the conduction heat transfer in different geometries (plane wall, cylinder, sphere).
2. understand the heat transfer in natural and forced convection conditions, boiling and condensation.
3. understand and calculate the radiation heat transfer in different geometries.
4. Apply the above principles to design practical systems.

Text Books:

1 Holman, J.P., Heat Transfer, McGraw-Hill Book Company, Singapore (2008).

2 Cengel, Y., Heat Transfer- A practical approach, Tata McGraw Hill, New Delhi (2007).

Reference Books:

1 Krieth, F and Bohn, M., Principles of Heat Transfer, Thomson Learning, Australia (2002).

2 Long, C., Essential Heat Transfer, Pearson Education Asia, New Delhi (1999).

3 Incropera, F.P. and DeWitt, D.P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, Singapore (2006).

INDUSTRIAL AUTOMATION

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce the need, evolution, and motivation for Industrial Automation. Familiarization with basic concepts and different automation strategies being used in practice worldwide.

Introduction to Factory Automation and Integration: Basic concepts and scope of industrial automation, socio-economic considerations, modern developments in automation in manufacturing and its effect on global competitiveness. Need and implications of automation in manufacturing. Different types of production systems and automation. Hard/fixed automation.

Introduction to Hydraulics/Pneumatics: Basic elements of hydraulics/pneumatics, electro-pneumatic controls and devices, electro-pneumatic systems, fluid power control elements and standard graphical symbols for them, construction and performance of fluid power generators, hydraulic and pneumatic actuators, their design and control devices. Sequence operation of hydraulic /pneumatic actuators. Applications in manufacturing. Hydraulic & pneumatic valves for pressure, flow & direction control, servo valves and simple servo systems with mechanical feedback, solenoid. Different sensors for hydraulic, pneumatic & electro-pneumatic systems.

Design of Pneumatic and Electro-pneumatic Logic Circuits: Logic circuits to be designed for a given time displacement diagram or sequence of operation. Pneumatic safety and control circuits and their applications to clamping, traversing and releasing operations.

Programmable Logic Controllers (PLC): PLC for design demonstration, programming and interface the hardware with software for modern manufacturing applications.

Automatic Transfer Machines: Classifications, analysis of automated transfer lines, without and with buffer storage, group technology and flexible manufacturing system.

Assembly Automation: Types of assembly systems, assembly line balancing, performance and economics of assembly system.

Course Learning Outcomes (CLO):
The students will be able to:

1. measure the output of any physical system with the help of various sensors and transducers and able to evaluate the performance of any physical system.
2. understand the various components of Hydraulics/Pneumatics Electro-pneumatic systems and methods to design, construct and evaluate such systems.
3. study the design of pneumatic logic circuits for a given time displacement diagram for pneumatic safety and remote control circuits

Text Books:

1 *Esposito, A., Fluid Power with Applications, Prentice Hal of India, New Delhi (2005).*
2 *Majumdar, S. R., Pneumatic Systems, Tata McGraw Hill, New Delhi (1995).*

Reference Books:

1 *Auslander, D. M. and Kempf, C. J., Mechatronics: Mechanical System Interfacing, Prentice Hall Inc., New Jersey (1996).*

2 *Deppert, W. and Stoll, K., Pneumatic Control, Vogel Verlag, Wurzburg, Germany (1987).*

3 *Herbert, E.M., Hydraulic Control System, John Wiley & Sons, New York (1991).*

4 *Hall, D.V., Microprocessors & Interfacing: Programming & Hardware, McGraw Hill, New York (2006).*

5 *Mukhopadhaya, A. K., Microprocessors, Microcomputers and their Applications, Wheeler Pub, New Delhi (2003).*

6 *Fitch, E.C and Surjaatmadja, J.B., Introduction to Fluid Logic, McGraw Hill, New York (1978).*

UMEXXX DESIGN PROJECT

L	T	P	Cr
0	0	2	5.0

Course Objectives: To develop design skills according to a Conceive-Design-Implement-Operate (CDIO) compliant methodology. To implement engineering skill and knowledge to complete the identified project work while encouraging creativity and innovation. To develop spirit of team work, communication skills through group-based activity and foster self-directing learning and critical evaluation.

For this course groups of the students shall be formulated in the fourth semester. Students shall be encouraged for self-learning. During summer break after second year students are expected to identify the problem of their choice through interactions with industry, R&D labs and other reputed institutions. Students shall make presentation of their effort of problem formulation in first fortnight of the fifth semester and shall complete project. Students shall be making periodic presentation during fifth semester for continuous evaluation and monitoring.
At the end of this project each group shall be required to submit a detailed technical report, daily diary and presentations related to the project undertaken.

Course Learning Outcomes (CLO):
The students will be able to:

1. design and analyze the given mechanical engineering system/ component.
2. demonstrate team work.
3. create production drawings for mechanical components and systems using manual drafting and CAD tools.

PRODUCT DESIGN AND DEVELOPMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce the basis of product design along with the requirements of a good product design.

General: Product design objectives, concept, terminology, principles, requirements of a good product design, product types and design considerations for engineering, product life cycle, product specification and range, safety, liability and warranty aspects, patents and copyrights.

Product Development – Technical and Business Concerns: Technology forecasting and technology S-Curve (Technology Stage), mission statement and technical questioning, economic analysis of product, customer needs and satisfaction, customer population and market segmentation, customer needs-types and models, gathering customer needs information, analysis of gathered information.

Designing for Specific Requirements: Design features and requirements with regard to manufacturing and assembly, safety, ergonomics, energy conservation, storage, transportation and maintence, quality and reliability as a factor in product design, quality v/s cost, packaging design, role of national and international standards.

Visual Design: Objectives, form, function, material and process, relationship, product graphics, role of color.

Product Detailing: Need and objectives, considerations affecting detailing decisions, illustration of detailing.

Product Development: Concepts and objectives, information sources, role of innovation in product development and competitiveness, part approval process, advanced product quality planning, design failure mode and effect analysis, use of computers in product design and development, introduction to reverse engineering and rapid prototype development, the CAD-CAM link.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the basic product design objectives and requirements.
2. understand the different design principles like designing for manufacturing and assembly, maintenance, storage, transportation etc.
3. understand the visual design with respect to form, function, material, process, colour etc.

Text Books:

1. *Neibel and Draper, Product Design and Process, McGraw Hill, New York (2004).*
2. *Mayal, Industrial Design, McGraw Hill, New York (1999).*
3. *Trott, Innovation Management and New Product Development, Pearson Education Asia, New Delhi (2007).*

Reference Books:

1. *Asimov, M., Fundamentals of Engineering Design, PHI, New Delhi (2000).*
2. *Chitale and Gupta, Product Design and Manufacturing, PHI, New Delhi (2007).*

PRODUCTION AND INVENTORY CONTROL

L	T	P	Cr
3	1	0	3.5

Course Objectives: To expose the students to the various broad functions under production planning and control. To study the role of process planning especially routing, scheduling functions etc. in effective operations management.

Production Control: Necessity of planning and control, functions of production control department; various functions under production control, factors determining control procedure, types of control.

Short term and long term trends in business, financial aspects of planning, analysis of machine capacity, capacity and manpower requirement planning.

Process Planning: Routing, routing procedures, progress reporting and expediting methods; Shop floor control.

Scheduling: Loading, departmental and shop schedule charts, Gantt charts, multiple-dimension rule, employee scheduling, and various priority rules.

Inventory Management and Control: Importance of inventory control, methods of inventory control, ordering quantity to order, economic run lengths.

Applications of Computers in production control and inventory control activities.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the necessity and functions under production control.
2. understand the role of inventory management and control.

Text Books:

1 *Monks, J. G., Operations Management: Theory and Problems, McGraw Hill, New York (1987).*

2 *Krajewski, L. J., Ritzman, L. P. and Malhotra, M. K., Operations Management, Prentice Hall of India, New Delhi (2009).*

Reference Books:

1 *Ebert, J and Adams, D.J., Production/Operations Management, Prentice Hall of India, New Delhi (2007).*

2 *Chase, R. B., Aquilano, N. J. and Jacob, F. R., Production and Operations Management: manufacturing and services, Tata McGraw Hill, New Delhi (1999).*

ADVANCED MACHINE DESIGN

L	T	P	Cr
3	2	0	4.0

Course Objectives: To expose the students to the design and analysis of different gears, brakes, clutches, belts, chain, ropes, bearings and springs.

Spur Helical, Bevel, Worm and Worm Wheel Gears: Introduction to types, force analysis and application; Gear tooth failure, beam strength and wear strength of gear tooth, materials and manufacture.

Brakes and Clutches: Introduction to types, construction, application and force analysis, band brakes, block brakes, expanding shoe brakes, disk brakes, single and multiple plate clutches.

Selection of Chains, Wire Ropes and V-belts: Introduction to types, construction, application and force analysis; Design considerations, recommendations and characteristics; Selection from manufacturer's catalogue, designation.

Sliding and Selection of Rolling Element Bearings: Hydrodynamic and hydrostatic lubrication, Raimondi and Boyd method of solution to Reynold's equation; Bearing design-selection of parameters and materials; Selection of rolling element bearings from manufacturer's catalogue, infinitely long journal bearing and infinitely short journal bearing with pressure development and load carrying capacity, step bearing, plane slider bearing.

Close-coiled and Leaf Springs: Introduction to types and applications, compression and extension helical closed coil springs, concentric springs; Design of helical springs and multi-leaf (semi elliptic) springs, spring materials.

Data issued by Mechanical Engineering Department to be used during examination.

Course Learning Outcomes (CLO):
The students will be able to:

1. do the force analyses on different gear types i.e., spur, helical, bevel and worm.
2. do the force analysis of block brake; analysis and design of band brake, internal expanding brake, external expanding brake and disc brake.
3. design a single, multiple and cone clutch, flat and v-belts, chains and ropes.
4. understand the hydrodynamic, hydrostatic and rolling element bearing.
5. analyze and design the closed coiled helical spring, concentric spring and leaf spring.

Text Books:

1 *Bhandari, V. B., Design of Machine Elements, Tata McGraw Hill, New Delhi (2007).*

2 *Shigley, J., Mechanical Engineering Design, McGraw Hill Book Company Inc., New York (2003).*

Reference Books:

1 *Spotts, M. F. and Shoup, T. E., Design of Machine Elements, Pearson Education, New Delhi (2003).*

2 *Juvinall, R. C. and Marshek, K. M., Fundamental of Machine Component Design, John Wiley & Sons, New York (2005).*

3 *Norton, R. L., Machine Design: An Integrated Approach, Pearson Education, New Delhi (2006).*

4 *Bathe, K. J., Finite Element Procedures, Printice Hall of India, New Delhi (1996).*

COMPUTER AIDED MANUFACTURING

L	T	P	Cr
3	0	2	4.0

Course Objectives: To expose the students to the basics of NC, CNC, DNC machines. To make them understand the concept of writing the manual part program on CNC milling and lathe machines. To introduce the students to the different components of Computer Integrated Manufacturing systems.

Fundamentals of CAM: Programmable automation, automation and CAM. Numerical control of machine tools. Adaptive control of machine tools, Industrial robots, programming methods, applications. CNC design features to improve accuracy and productivity. Manual part programming.

Computer Aided Part Programming: Introduction and demonstration of use of Pro/E CAM Software or equivalent in: Computer Aided Part Programming, machining simulation, process planning, route sheet development and Post processing.

Computer Integrated Manufacturing Systems & Integrated CAD/CAM System: Components of CIMS, types of CIMS, CAD/CAM integration, FMS and CIMS, Group Technology.

Automated Material Handling & Storage: AGVs, ASRS, Carousel.

Computer Aided Manufacturing Planning Systems: CAPP, computer aided production management, inventory management, MRP-I and MRP-II, shop floor control, computer aided process monitoring and control, computer aided quality control and inspection.

Laboratory Work:

Exercises on manual part programming of CNC machines: Lathe- Complete machining of a part with: Taper, concave and convex arc, grooving, central drilling and threading. Milling- Complete machining of a part with: Taper, concave and convex arc, pocketing and drilling, radius compensation. Robot programming: Programs for pick place, welding path, manufacturing, and assembly operations. Practical setup and programming exercise using CNC milling, CNC lathe and robotic arm. Practical on the machines to be conducted as per lab instructions and guidance of the teacher incharge of practical.

Course Learning Outcomes (CLO):

The students will be able to:

1. write a manual part program for a given component on CNC milling and lathe machine.
2. understand the basics of CNC machines and robotic arm.
3. understand the use of computers in group technology, process planning, manufacturing, inventory, shop floor control, quality control, material handling and storage system.

Text Books:

1 Groover, M. P., Automation, Production Systems, and Computer Integrated Manufacturing, Pearson Education Asia, New Delhi (2008).

2 Koren, Y., Computer Control of Manufacturing Systems, McGraw Hill, New York (2005).

Reference Books:

1 *Groover, M. P. and Zimmers, E. W., CAD/CAM, Pearson Education Asia, New Delhi (2005).*

2 *Koren, Y. and Joseph, B. U., Numerical Control of Machine Tools, Khanna Publishers , New Delhi (1999).*

3 *Kundra, T. K., Rao, P. N. and Tewari, N. K., Numerical Control and Computer Aided Manufacture, Tata McGraw Hill, New Delhi (2003).*

FLUID MACHINERY

L	T	P	Cr
3	1	2	4.5

Course Objectives: To expose the students to the basic fundamentals of Momentum Equation, Euler's equation for energy transfer, Impact of jets, turbines and pumps.

Viscous Flow: Momentum Equation, Navier Stokes Equation and its derivation, aerofoil theory, lift and drag.

Principles of Hydraulic machines, impulse momentum equation, Euler's equation for energy transfer, impact of jets.

Hydraulic Turbines: Classification, head losses, efficiencies, hydropower plant, various elements, impulse and reaction turbines, components, selection of design parameters, size calculations, work, efficiency, governing, similarity relations and unit quantities, specific speed, cavitation.

Hydraulic Pumps: Classification, selection, installation, centrifugal pumps, head, vane shape, pressure rise, velocity vector diagrams, work, efficiency, design parameters, multistaging, operation in series and parallel, submersible pumps, NPSH, specific speed.

Reciprocating Pumps: Indicator diagram, work, efficiency, effect of acceleration and friction, air vessels.

Other Hydraulic Devices: Hydraulic ram, airlift pump, jet pump, centrifugal jet-pump, fluid coupling, torque converter.

Laboratory Work: Performance of Pelton turbine, Francis turbine, Kaplan turbine, Centrifugal pump, Reciprocating pump, Hydraulic Ram, Study of Hydraulic pump models, Cavitation test rig.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the working principle of the hydropower plant, selection of design parameters, size calculations of the hydro turbine component.
2. understand the governing, similarity relations and unit quantities for pump and turbine.
3. understand the basic working principle of pumps, centrifugal and reciprocating pumps, their design parameters.

Text Books:

1 White, F. M., Viscous Fluid Flow, McGraw Hill, New York (2006).
2 Wright, T., Fluid Machinery, CRC Press, USA (2009).

Reference Books:

1 Douglas J. F., Gasiorek, J. M. and J. A. Swaffield, Fluid Mechanics, Addison-Wesley Longman Inc., Edinburgh, U.K (1995).
2 Rattan, S.S., Fluid Machines and Hydraulic Machines, Khanna Publishers, New Delhi (2004).
3 Panton, R.L., Incompressible Fluid Flow, John Wiley & Sons, New Jersey (2005).

MECHANICAL VIBRATIONS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce the fundamentals of free and forced mechanical vibrations for single, two and multi degree of freedom systems.

Fundamentals of Vibration: Simple Harmonic motion, natural frequencies and resonance.

Free and Forced Vibrations of Single Degree of Freedom system: Newton's Second Law, D'Alembert's Principle, Rayleigh's method, springs in combinations, types of damping, logarithmic decrement, equivalent viscous damping, support excitation, vibration isolation and transmissibility, vibration measuring instruments.

Two Degree of Freedom Systems: Free and Forced vibrations with and without damping, principal and normal modes, vibration absorbers.

Multi Degree of Freedom Systems: Various methods of analysis of multi degree freedom systems, influence coefficients, coupling of modes, numerical methods, Lagrange's equation Dunkerley's equation, Holzer's method, application to torsional vibrations.

Vibration of Continous Systems: Wave equation, transverse vibration of strings, longitudinal vibration of bars, lateral vibrations of beam.

Whirling of Shafts: Critical speed and effect of damping.

Introduction to Non-Linear Vibrations.

Introduction to Condition Monitoring of Machinery.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the principles of the single degree of freedom systems of all types with applications.
2. understand the fundamentals of two degree of freedom systems and their applications.
3. understand the multi degree of freedom systems of all types with their exact and approximate solutions along with their applications.

Text Books:

1 Grover, G. K., Mechanical Vibrations, Nem Chand and Bros, Roorkee (2009).

2 Ambekar, A. G., Mechanical Vibrations and Noise Engineering, Prentice Hall of India, New Delhi (2006).

Reference Books:

1 *Rao, S. S., Mechanical Vibrations, Addison Wesley Publishing Company, New York (1995).*

2 *Kelly, S. G., Mechanical Vibrations, Schaum's Outlines, Tata McGraw Hill, New Delhi (2007).*

3 *Rao, J. S. and Gupta, K., Introductory Course on Theory and Practice of Mechanical Vibrations, New Age International Publication, New Delhi (1996).*

4 *Srinivasan, P., Mechanical Vibration Analysis, Tata McGraw Hill, New Delhi (1995).*

MACHINING SCIENCE

L	T	P	Cr
3	1	2	4.5

Course Objectives: To provide in-depth knowledge of conventional and advanced machining processes.

Machining with Single Point Cutting Tool: Mechanism of chip formation, orthogonal and oblique cutting, type of chips, machining parameters, cutting force and power requirement in single point turning process, Merchant's circle theory, shear angle relationships, specific cutting pressure, friction and thermal aspects of machining.

Machining with Multi-Point Cutting Tools: Nature of cutting with multi-point cutting tools, mechanism of chip formation in milling and grinding, grinding process and its specific features, mechanics of grinding operation.

Tool Wear: Tool life, definition & factors affecting tool life, Taylor's tool life equation, cutting fluids, their, characteristics & applications, factors affecting machinability, factors influencing surface quality, dimensional accuracy and material removal rate in machining, calculation of economic cutting speed, high efficiency zone.

Jigs and Fixtures: Definition and importance of jigs and fixtures in production, principles of location and clamping, essential requirements of jigs/fixtures, types of jigs and fixtures.

Modern Machining Methods: Comparison of non-conventional and conventional methods of machining, process parameters, material removal rate and application of electric-discharge machining (EDM), electro-chemical machining (ECM), ultra-sonic machining (USM), electron beam machining (EBM) & laser beam machining (LBM), Abrasive Jet Machining (AJM); Water Jet Machining (WJM); Abrasive flow machining process (AFM); Plasma Arc Machining.

Laboratory Work:

Experiments relating to Tool Makers Microscope, cutting angles of a single point turning tool, point angle of a twist drill; Machining of metallic materials; Chip reduction coefficient and shear angle; Calibration of two component Strain Gauge Type Force dynamometer; Cutting forces in turning; Tool Flank Wear; Effect of Speed, feed and depth of cut on power consumption; Tool-Tip Temperature; Alignment Tests; Electro Discharge Machine; Laser Beam Machining; Spark test; Abrasive Blaster setup.

Course Learning Outcomes (CLO):

The students will be able to:

1. understand the principles of machining using Merchant's circle theory as well as frictional and thermal aspects of machining.
2. design the conditions for the maximum tool life and factors influencing surface quality, dimensional accuracy and material removal rate in machining.
3. develop the models for determining the MRR, SR and tool design for different NTMM like EDM, ECM, USM, EBM, LBM, AJM, WJM etc.

Text Books:

1 *Pandey, P. C. and Singh, C. K., Production Engineering Sciences, Standard Publishers, New Delhi (2004).*

2 *Ghosh, A. and Bhattacharya, Manufacturing Science, Tata McGraw Hill, New Delhi (2003).*

Reference Books:

1 *Shaw, M.C., Metal Cutting, Tata McGraw Hill, New Delhi (1997).*

2 *Venkatesh, V.C., Techniques in Metal Cutting, Prentice Hall of India, New Delhi (1997).*

3 *Juneja, B. L. and Sekhon, G. S., Metal Cutting, New Age International, New Delhi (2003).*

4 *Mehta, N. K., Machine Tools, Tata McGraw Hill, New Delhi (2002).*

UHU-081: ENGINEERING ECONOMICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective of the course is to help students to understand the concepts of Economics, get awareness about the economic environment and possess an understanding of market competition and their pricing strategies. The course will enable them to know about Financial Markets, PNational Income Accounting, Inflation and Deflation. It will prepare Engineering students to analyze Cost/Revenue data and carry out economic analyses for decision making.

Engineering Economics: Definitions**,** Scope and Significance
Demand and Supply: Meaning of Demand and supply, Determinants of demand and Supply
Demand Forecasting: Purpose of Forecasting Demand, Determinants of demand forecasting, Methods of Demand Forecasting, Criteria for the good forecasting method.
Cost of Production: Explicit and Implicit costs, Marginal, Incremental and Sunk costs, Opportunity cost, Short-run cost function, Total Average and Marginal costs, Long-run costs, Break-even analysis.
Theory of Production: Law of Variable Proportions and Laws of returns to scale.
Markets Structures and Pricing Theory: Pricing in Different Markets: Perfect competition, Monopoly, Monopolistic competition and Oligopoly.
Investment Decision: Capital Budgeting, Methods of Project Appraisal (Payback Period, IRR, NPV, BCR).

National Accounting: Meaning, Methods and Current Trends.

Inflation &Deflation: Meaning, Measures and Impact on Indian economy.

Globalization and Foreign Direct Investment :Meaning, Recent Indian Policy Towards FDI and Globalization, Impact of FDI & Globalization on Indian Economy.

Exchange Rate: Meaning, Determinants of exchange rate, Measurement of Exchange Rate.

Overview of Financial Markets: Capital Market & Money Market.

Course Learning Outcomes (CLO):
The students after studying this course will:
1. Possess a deep understanding of the concepts and principles of Economics.
2. Be able to develop analytical skills essential for engineers to help to take decisions.
3. Better understand the markets and their pricing strategies
4. Possess an understanding of the pre-requisites of investing and will be able to carry out and evaluate benefit/cost, breakeven analyses on one or more economic alternatives.
5. Acquire an in-depth knowledge about Financial markets, Foreign Exchange Market, National Income Accounting, Inflation and Deflation.

Text Books:

1. *Salvatore, D. and Srivastav, R., Managerial Economics: Principles and Worldwide Applications, Oxford University Press, Sixth Edition (2008).*

2. *Peterson, H. Craig, Lewis, W. Chis. and Jain, Sudhir K. Managerial Economics, Prentice Hall of India (2006).*
3. *Robert Pindyck and Daniel Rubinfeld Microeconomics, Prentice Hall (2009).*

Reference Books:

1. *Pandey, I.M. Financial Management, Vikas Publication (2010).*
2. *Kishore, Ravi, M. Financial Management, Taxmann Publication (2009).*
3. *Dutt, R. and Sundaram, K.P.M., Indian Economy, S. Chand & Company Ltd. (2012).*

CAPSTONE PROJECT PART-I (STARTS)

L	T	P	Cr
0	0	4	0.0

Course Objectives: A design project based course to implement integrated approach to the design of mechanical systems using concepts of mechanisms, dynamics of machines, and mechanical design courses studied in the previous semesters. Work on a mechanical design problem individually or in a team. Design a mechanical system from component level to assembly using CAD and CAE tools. Produce a design project report with production drawings using drawing standards, symbols, conventions and rules.

A project based course to teach Integrated approach to the design of mechanical systems using concepts of mechanisms, dynamics of machines, and mechanical design courses studied in the previous semesters. The mechanical systems are to be designed satisfying requirements like reliability, fatigue loading, optimized design, manufacturing, assembly, installation, maintenance, cost and transportation-to-site aspects. Use of a system design approach using various courses already studied by the students and the use of software tools specific to the selected project.

Each student either individually or in a group, will be assigned a mechanical system design project involving problem definition, mechanism selection, analysis, synthesis, optimization and drafting. Assembly and detailed production drawings will be prepared for the presentation of the design along with a printed report, PPT presentation and soft copy submission of CAD and CAE work for final evaluation by a committee. CAE softwares like ProEngineer, ProMechanica, SolidWorks, Cosmos, ANSYS along with a spread sheet may be used for the design modeling, synthesis, optimization, analysis and preparing production drawings.

Capstone project-I shall be evaluated for 30% of the marks in the VII semester and marks shall be carried forward to the next semester.

Course Learning Outcomes (CLO):
The students will be able to:

1. design a mechanical system implementing an integrated system design approach applying various professional courses.
2. work individually or in a design team.
3. design and analyze components of a mechanical system.
4. optimize the design of a mechanical system considering various requirements like reliability, fatigue loading, optimized design, manufacturing, assembly, installation, maintenance, cost and transportation-to-site aspects.
5. create and production drawings for mechanical components and systems using manual drafting and CAD tools for making drawings of machine components and assemblies.
6. demonstrate team work

CAPSTONE PROJECT PART-II

L	T	P	Cr
0	0	6	8.0

Course Objectives: Produce prototype of the design made in Capstone Project Part-I. Plan the production of a mechanical system given the detailed drawings. Schedule and execute a production plan for the components and assemble the working prototype of the mechanical system designed in Capstone Project Part-I. Analyse the prototype manufactured for improvement in design, manufacturing and function.

The Capstone Project Part-I will be used for the prototype manufacture in this course. The final manufacturing and working of the system will analysed.

Use of conventional / unconventional manufacturing processes along with CAM and RP technologies may be made for the fabrication of the physical prototype.

Capstone project-II shall be evaluated for 70% of the marks while 30% marks shall be carried forward from the previous semester

PPT presentation and submission of a project report on production planning, scheduling, manufacturing, fabrication work and analysis of the working of the final system for final evaluation by a committee along with comprehensive viva.

Course Learning Outcomes (CLO):

The students will be able to:

1. use standards used in production drawing of machine components and assemblies.
2. read production drawings for mechanical components and systems and plan a production based on it.
3. use manufacturing and fabrication processes for manufacturing a prototype.
4. assemble a mechanical system after manufacturing its components and analyze its working.
5. demonstrate team work.

MECHATRONICS

L	T	P	Cr
3	0	2	4.0

Course Objectives: To impart interdisciplinary knowledge to study modern products like household appliances, digital cameras, mobiles etc., which falls under the mechatronics domain. the aim of this course to make a bridge between mechanical, electronics, instrumentation, computer and controls field.

Introduction: Evolution of mechatronics, integrated mixed systems. integration of mechanical engineering, electronics & control engineering and computer science, design process, measurement system, control system, basic elements of open loop and closed loop control system, block diagram representation of mechatronics system, programmable logic controllers, analogue and digital control system, sequential controllers, examples of various mechatronics systems.

Sensors and Transducers: Performance terminology, static and dynamic characteristics, displacement, position and proximity sensors, velocity and motion sensors, stress, strain and force measurements using strain gauges, force, fluid pressure, liquid flow and liquid level sensors, light sensors, temperature sensors.

Signal Conditioning and Digital Signals: Basic conditioning process, operational amplifiers, filtering, pulse modulation, digital signal, AD and DA conversion, Shannon's sampling theorem, Nyquist criterion, review of logic circuits.

Electrical Actuators: Relay, direct current motors, stepper motors, piezoelectric actuators.

Control Systems: Performance specifications, transfer functions, block diagram reduction techniques, signal flow graphs, sensitivity analysis, frequency response. stability, controller types and their design using frequency domain and Laplace domain method, PID control.

Dynamic Systems Modeling: Equations of motion of mechanical, hydraulic, thermal, electric and pneumatic systems, transforming physical model to mathematical model, linearization of the dynamic model.

Data Processing and Control: Introduction to microprocessors, microcontrollers, PLC and their processing.

Laboratory Work:

Demonstration of Lego kits, Tetrix kits, microcontroller kit, PLC trainer and different sensors, Projects on all the mentioned kits.

Course Learning Outcomes (CLO):
The students will be able to:

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

Text Books:

1 *Bolton, W., Mechatronics: A Multidisciplinary Approach, Pearson Education, New Delhi (2008).*
2 *Kamm, M.L.J., Mechatronics, Prentice Hall of India, New Delhi (2007).*

Reference Books:

1 *Auslander, D. M. and Kempf, C. J., Mechatronics: Mechanical System Interfacing, Prentice Hall, New Jersy (1996).*
2 *Necsulescu, D., Mechatronics, Pearson Education, New Delhi (2002).*
3 *Alciatore, D. G. and Histand, M. B., Introduction to Mechatronics and Measurement System, McGraw Hill, New Delhi (2005).*

REFRIGERATION AND AIR CONDITIONING

L	T	P	Cr
3	1	2	4.5

Course Objectives: To study the various types of the refrigeration cycle, working of refrigeration and air conditioning systems.

Vapour Compression and Air Cycle Refrigeration: Reversed carnot cycle, air refrigeration cycle, aircraft refrigeration cycle, vapour compression refrigeration cycle, actual vapour compression cycle. Advanced Vapour Compression refrigeration systems, Compound compression and multi load systems; Cryogenics refrigeration, cascade system.

Vapour Absorption Refrigeration: Water vapour refrigeration systems, steam jet refrigeration; vapour absorption refrigeration systems, single effect and double effect vapour absorption systems.

Refrigerants: Desirable properties of common refrigerants, alternative refrigerants, refrigerator retrofitting procedure. Impact on environment by traditional refrigerants, refrigeration & associated equipment, concept of ozone depletion and global warming.

Refrigeration System Components: Compressors, expansion devices, condensers, evaporators.

Air Conditioning: Psychometric properties of air, psychometric processes, comfort charts, air conditioning load calculations, types of air conditioning systems. Demonstration of HVAC softwares related to psychometric processes & HVAC systems.

Laboratory Work:
Experiments relating to measurement of performance parameters related to Refrigeration Bench, air conditioning test rig; Cold Storage Plant; Heat Pump Characteristics; Experimental Ice Plant; Cascade Refrigeration System; Rail Coach Air Conditioning Unit; Study of safety devices, cutting, flaring of tubes, hermetically sealed compressor unit etc.

Industrial visit to ice making plant and centralized Air conditioning system in the university.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the basic working principle of refrigeration and air conditioning.
2. understand the different types of refrigerants, thermodynamic properties and leak detection components used in RAC systems.
3. perform the calculation for COP, EPR, power requirements etc. of single evaporators, multi evaporator, multi compressors refrigeration systems, cascade systems and water refrigeration system etc.
4. understand the psychometry related processes and perform the air conditioning load calculations for the room air and outside air required in winter or summer air conditioning systems.

Text Books:

1 *Arora, C. P., Refrigeration & Air Conditioning, Tata McGraw Hill, New Delhi (2000).*
2 *Stoecker, W. F. and Jones J. W., Refrigeration and Air Conditioning, McGraw Hill, New York (1982).*

Reference Books:

1 *Dossat, R. J., Principles Of Refrigeration, Pearson Education, Singapore (2004).*
2 *Ameen, A., Refrigeration and Air Conditioning, Prentice Hall of India, New Delhi (2004).*

TURBOMACHINES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To present the basics of compressible flow and operation of turbo-machines.

Principle of Turbo machines, impulse momentum equation, Euler's equation for energy transfer.

Compressible Flow: Stagnation properties, speed of sound and Mach number, one dimensional isentropic flow, isentropic flow through nozzles, shock waves and expansion waves, Fanno line Rayleigh line flow, air flow and steam flow through nozzles.

Steam Turbines: Steam nozzles, isentropic flow, critical pressure ratio, maximum discharge, throat and exit areas, effect of friction, supersaturated flow. Stream Turbines, types, impulse turbine, velocity and pressure compounding, reaction turbine, degree of reaction, reheat & regenerative cycles for turbines, losses, partial admission factor, overall efficiency, governing.

Gas Turbines: Brayton cycle, Ericsson cycle, effect of intercooling, reheating and regeneration, open and closed gas turbine cycle, jet propulsion, turbo jet, ram jet, turbo-prop.

Compressors: Positive displacement and non-positive displacement; Reciprocating, centrifugal and axial flow type, screw compressor, vane compressor, rotary lobe compressor, other elements of industrial compressors system, selection criteria of compressors; Characteristic curves of compressors.

Fans and Blowers: Types of fans and blowers, characteristics curves, fan laws.

Steam Condensers: Classification and types, jet condensers- parallel flow, counter flow and ejector type, Edwards's air pump, shell and tube, shell and coil etc, cooling towers-natural draught, induced draught and forced draught.

Industrial visits

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the operating principles and constructional details of steam and gas turbines, compressors, fans and blowers, cooling towers and condensers.
2. relate the above towards designing, practical systems.

Text Books:

1 *Cohen, H., Sarvnamattoo, H. I. H., and Rogers, G. F., Gas Turbine Theory, Pearson Education, New Delhi (1996).*
2 *Vasandani, V. P. and Kumar, D. S., Heat Engineering, Metropolitan Books, New Delhi (2003).*

Reference Books:

1 *Kearton, W. J., Steam Turbine Theory and Practice, CBS Publishers and Distributors, New Delhi (1990).*
2 *Joel, R., Basic Engineering Thermodynamics, Pearson Education, New Delhi (1996).*
3 *Yahya, S. M., Turbines, Compressors & Fans, Tata McGraw Hill, New Delhi (2005).*
4 *Dixon, S. L., Fluid Mechanics and Thermodynamics of Turbomachinery, Butterworth-Heinemann, London (2005).*

WORK STUDY AND METHOD ENGINEERING

L	T	P	Cr
3	0	0	3.0

Course Objectives: To impart knowledge about the concept of productivity, basic work content, excess work content and total work content. To inculcate knowledge about method study, tools used for recording processes, path of movement and work place, procedure for critical examination of operations with the objective of developing a new method. To impart knowledge about work measurement techniques, equipment and its application in shop floor operations for productivity improvement. To educate the use of pre-determined motion time systems and standard data for pro-actively determining time standard of operations

Introduction: Definition, Scope, Historical review and areas of application of work study in industries, Inter-relation between method study and work measurement, Human aspects, Reaction of management and labor, Role in improving plant productivity and safety.

Method Study: Objectives and step-wise procedure for method analysis, Recording & evaluation techniques, Micro-motion and macro motion study, Therbligs and simo-charts, Principle of motion economy, Normal work areas and design of work places, Principles of work design, Multiple activity chart, Flow process chart, String diagram, Travel charts, Layout Design.

Work Measurement: Work measurement objectives, Techniques & criteria for selection of technique, Stop watch time study, Systems of performance ratings, Calculation of standard time, Introduction to allowances, Production study, Work sampling, MTM& work factor system, Standard data usage, Engineered time standard, Computers in work study, Predetermined motion time system (PMTS). Job evaluation & merit rating Wage payment plans, Incentive schemes.

Course Learning Outcomes (CLO):
The student will be able to:

1. Develop a case for productivity improvement in any manufacturing or service industry scenario
2. Independently conduct a method study in any organization with the objective of improving a process, material movement system or design of a work place
3. Develop time standards for operations, identify production bottlenecks and improvise operations
4. Develop methods of working and corresponding time standards for new operations

Text Books:

1. *Niebel, B.W., Motion & Time Study, McGraw Hill Higher education (1992).*
2. *Kanawaty, G., Work Study, ILO, Geneva, (1992).*

Reference Books:

1. *Mundel, M., and Danner, D. L., Motion & Time Study, Englewood Cliffs, NJ, Prentice Hall, (1994).*
2. *Curie, R., Introduction to Work Study, McGraw Hill (1992).*
3. *Barnes, R. M., Motion & Time Study, John Wiley & Sons (1980).*

LEAN MANUFACTURING

L	T	P	Cr
3	0	0	3.0

Course Objectives: To introduce the philosophy behind 'Lean Manufacturing' by giving a background of the Toyota Production System. Discussion of different 'lean' tools and their significance in improving the workplace. Highlighting the importance of employee involvement, training and culture.

Lean Production: Introduction, background, and lean thinking, importance of philosophy, strategy, culture, alignment, focus and systems view. Discussion of Toyota Production System.

Lean Production Preparation: System assessment, process and Value-stream mapping, sources of waste.

Lean Production Processes, Approaches and Techniques: importance of focusing upon flow. Tools include: Workplace organization – 5S, Stability, Just-In-Time – One piece flow – Pull, Cellular systems, Quick change and set-up reduction methods, Total productive maintenance, Poka-Yoke– mistake proofing, quality improvement, Standards, Leveling and Visual management, Six Sigma.

SMED: Single minute exchange of dies – theory and practice of the SMED system, the structure of production, Set-up operations, Fundamentals of SMED, Techniques for applying SMED, Basic examples of SMED.

Employee Involvement: Teams, Training, Supporting and encouraging involvement – Involving people in the change process; communication; importance of culture.

Concurrent Engineering: Obeya in Toyota's new product development process, cross-functional teams, use of computer technology, information management for simultaneous engineering.

Course Learning Outcomes (CLO):

The students will be able to

1. Identify and understand the key requirements and concepts in lean manufacturing to initiate a continuous improvement change program in a manufacturing organisation.
2. Apply the tools in lean manufacturing to analyse a manufacturing system and plan for its improvements.

Text Books:

1. *Liker, J, The Toyota Way, McGraw-Hill (2004).*
2. *Liker, J and Meier, D., The Toyota Way Fieldbook, McGraw-Hill (2006).*

Reference Books:

1. *Womack, J and Jones, D, Lean Thinking, Free Press (2003).*
2. *Womack, J and Jones, D and Roos, D., The Machine that Changed the World, Rawson Associates (1990).*
3. *Dennis, P., Lean Production Simplified, Productivity Press (2007).*
4. *Shingo, S., A Revolution in Manufacturing: The SMED System, Productivity Press (1985).*

FACILITIES PLANNING

L	T	P	Cr
3	0	0	3.0

Course objectives: Provide students with the ability to apply plant layout design procedure to design a new facility and ability to select a suitable location for new facility with the use of different techniques.

Facilities Planning: Need for facilities planning, Importance of plant layout in plant design, Classifications of production process structures, Types of layout.

Plant Location: Factors affecting plant location, Optimum decision on choice of plant location, Quantitative techniques for making plant location decision.

Planning Design And Presentation: Principles of plant layout design, Procedure for plant layout design, Evaluate alternative layouts, Characteristic features suitability and applications of different types of layout installation of layout, Quantitative techniques for developing alternative layouts, Design of process and product layouts, Line balancing techniques.

Material Handling: Principles of material handling, Classification of material handling systems, different forms and sizes of materials, Characteristic features of key material handling equipment, Concept of unit load, safety aspects in material handling system.

Course Learning Outcomes (CLO):
The student will be able to:

1. To select a suitable location amongst the available locations for setting up a new facility
2. To decide about the particular production process flow strategy
3. To design a layout for the new facility to suit the company's production process structure
4. To select proper type of equipment for storage and movement of material

Text Books:

1. *Tompkins, J. A., White, J. A., Bozer, Y.A. and Tanchoco, J.M.A., Facilities Planning, John Wiley (2003).*
2. *Muther, R., Practical Plant Layout, McGraw Hill Book Company (1995).*

Reference Books:

1. *Sheth, V., Facilities Planning and Materials Handling, Marcel Decker (1995).*
2. *Agarwal, G.K., Plant Layout and Material Handling, Jain Publishers (1997).*

ERGONOMICS ENGINEERING

L	T	P	Cr
3	0	0	3.0

Course Objectives: This course is dedicated to making the students understand the ergonomic principles in workplace design and work organisation. It is aimed at enabling the students to identify and evaluate the impact of various human factors to design of safe workplace environment.

General: Man in industrial work environments, Ergonomics as multidisciplinary fields, Importance and justification and ergonomics problems, Man-machine-environment system.

Anthropometry: Significance of human body measurement in design of equipment, Facilities, Work place and operation, Static and dynamic anthropometry, Anthropometric data.

Task Analysis: Task description, Posture measurement, RULA & REBA analysis and evaluation, Lifting & lowering tasks, Lifting index, Lifting & carrying tasks, NIOSH lifting equation.

Biomechanics: Introduction to levers of Human Body, Ligaments & Tendons, Joints. Kinetics to include forces producing motion.

Man-Environment Interface: Environmental factors of temperature, Humidity, Lighting and noise in industry, Effect of environmental factors on human performance, Measurement and mitigation of physical and mental fatigue, Basics of environment design for improved efficiency.

Design of Display and Control: Need for information display, Elements of information theory, Reaction time, Methods and types of displays, Design of audio and visual displays, Design of hand and foot operated control device, Design of human-computer interface.

Course Learning Outcomes (CLO):

The students will be able to:

1. identify, explain and evaluate the impact of various personal attributes (anatomical, physiological and anthropometric) on proper, safe working practice.
2. assess the effect of physical environment factors on comfort and performance.
3. apply principles of good ergonomic design to work areas and equipment.
4. apply various task analysis tools to posture measurement, lifting, lowering and carrying tasks.
5. comprehend the need for information display and the ergonomic design of different display and control devices.

Text Books:

1. *Bridger, R.S., Introduction to Ergonomics, McGraw Hill (2008).*
2. *Sanders, M. and McCormick E., Human Factors in Engineering & Design, McGraw Hill (1993).*

Reference Books:

1. *Maynard, H. B., Industrial Engineering Hand Book, McGraw Hill (1992).*
2. *David, A., Practice & Management of Industrial Ergonomics, Prentice Hall (1986).*
3. *Singleton, W. T., Introduction to Ergonomics, WHO, Geneva (1972).*

COMPUTATIONAL FLUID DYNAMICS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To expose the students to the governing equations for fluid flow and different turbulence models used to solve the flow equation for turbulent flow. To introduce the numerical methods used to solve the partial differential equations.

Introduction: Motivation and role of Computational Fluid Dynamics; Concept of modeling and simulation.

Governing Equations: Continuity equation; Momentum equation; Energy equation; Various simplifications; Dimensionless equations and parameters; Convective and conservation forms; Incompressible inviscid flows Basic flows; Source panel method; Vortex panel method.

Nature of Equations: Classification of PDE, general behavior of parabolic, elliptic and hyperbolic equations; Boundary and initial conditions.

Finite Difference Method: Discretization; Various methods of finite differencing; Stability; Method of solutions.

Incompressible Viscous Flows: Stream function-vorficity formulation; Primitive variable formulation; Solution for pressure; Applications to internal flows and boundary layer flows.

Finite Volume Method: Finite volume method for steady state heat conduction in rectangular geometry. Introduction to convection schemes, Convection-Diffusion systems Upwind differencing, 2D convection diffusion equation.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the governing equations for different fluid flow.
2. solve the fluid flow problem using CFD.
3. understand the basics of Finite Volume and Difference Methods.

Text Books:

1 *Versteeg, H. and Malalasekra, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education, New Delhi (2008).*

2 *Wendt, J. F., Computational Fluid Dynamics: An Introduction, Springer, New York (2009)*

Reference Books:

1 *Muralidhar, K and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa, New Delhi (1995).*

2 *Jaluria, Y and Torrance, K.E., Computational Heat Transfer, Hemisphere Publishing Company, New York (1986)*

3 *Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Company, New York (1980)*

INTERNAL COMBUSTION ENGINES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To expose the students to the working and constructional features of internal combustion engines.

Introduction: Composition of cylinder gases, thermodynamic properties of fuel-air mixture before and after combustion, variation in specific heats, deviations of actual cycle from Ideal conditions, comparison of air standard and fuel air cycles, effect of operating variables, analysis using combustion charts.

Actual Air Cycles and their Analysis: Introduction, comparison of air standard cycles and actual cycles, time loss factor, heat loss factor, exhaust blowdown.

S.I Engines: Carburation, calculation of air fuel ratio supplied by carburetor, MPFI, combustion, ignition systems, combustion chambers in S.I. engines.

C.I Engines: Fuel injection, fuel injection computations in CI engines, distributor fuel injection rotary pump CAV type DPC, electronically controlled unit pump injector diesel fuel injection system, CRDI, combustion, swirl and inlet ports design, combustion: DI and IDI models, supercharging, turbocharging and matching of turbocharging.

Engine Lubrication: Friction and lubrication, performance, ISI codes, emission and its control, two stroke engine: scavenging, standards.

Alternate Fuels for both SI and CI Engines: Alcohols, hydrogen, CNG, LPG, producer gas, biogas and biodiesels.

Recent Trends in I.C. Engines: Dual-fuel engines, multifuel engines, stratified charge engine, Sterling engine, variable compression ratio engine.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the fundamentals of fuels, combustion, heat transfer, lubrication, fluid mechanics and thermodynamics as applied in the operation of I.C. engines.
2. know the emerging trends in I. C. engines.

Text Books:

1 Ganesan, V., I. C. Engines, Tata McGraw Hill, New Delhi (2007).

2 Pulkrabek, W. W., Engineering Fundamentals of the Internal Combustion Engines, Pearson Education, New Delhi (2007).

Reference Books:

1 Heisler, H., Advance Engine Technology, ButterWorth Hienemann, USA (2000).

2 Heywood, J. B., Internal Combustion Engine Fundamentals, McGraw Hill, New York (1988).

3 Stone, R., Introduction to Internal Combustion Engines, Pearson Education, New Delhi (1999).

POWER PLANT ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand the basic principles, layouts, systems and components, economics, operation and maintenance aspects of different types of power plants.

Energy sources for generation of electric power, types of power plant- their special features and applications, present status and future trends.

Hydroelectric Power Plant: Classifications, components and their general layout, hydroelectric survey, rainfall run-off, hydrograph, flow duration curve, mass curve storage capacity, site selection.

Thermal Power Plant: General introduction, developing trends, essential features, site selection, coal-its storage, preparation, handling, feeding and burning, ash handling, dust collection.

Gas Turbine Power Plant: Field of use, components, plant layout, comparison with steam power plants, operation of combined steam and gas power plant.

Nuclear Power Plant: Nuclear fuels, nuclear energy, main components of nuclear power plant layout, nuclear reactors- types and applications, radiation shielding, radio-active waste disposal, safety aspects.

Power Plant Economics: Load curves, terms and definitions, effect of load on power plant design, methods to meet variable load, prediction of load, cost of electrical energy, selection of types of generation and generating equipment, performance and operating characteristics of power plants, load division among generators and prime movers, tariff methods of electrical energy.

Non- conventional Power Generation: Geothermal power plants, tidal power plant, wind power plant, solar power plant, electricity from city refuge, thermoelectric conversion system, thermo ionic conversion system, photo voltaic power system, fuel cells, magneto-hydrodynamic system.

Industrial visit to any power plant.

Course Learning Outcomes (CLO):

The students will be able to:

1. perform the calculations towards design of different power plant systems.
2. understand the industry norms and practices and environmental pollution aspects related to power plants.
3. understand the principle and working of various non-conventional power generation systems.

Text Books:

1 Nag, P. K., Power Plant Engineering, Tata McGraw-Hill, New Delhi (2005).

2 Ei-Wakil, M. M., Power Plant Engineering, McGraw-Hill, New York (1985).

Reference Books:

1 Drbal, L. F., Boston, P. G. and Westra, K. L., Power Plant Engineering, Springer, New York (1996).

2 Domkundwar and Arora, Power Plant Engineering, Dhanpat Rai and Co., New Delhi (2005).

UME RENEWABLE ENERGY SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce the primary renewable energy sources and to study the environmental issues associated with fossil fuel energy. To develop ability for designing renewable/hybrid energy systems that meet specific energy demands, are economically feasible and have a minimal impact on the environment. To educate about how to utilize local energy sources (renewable and non-renewable) to achieve the sustainable energy systems.

Introduction: Energy demand and availability, Energy resources, Environmental impact of conventional energy usage, Heat and Fluid flow concepts for energy systems.

Solar Energy: Introduction, Extraterrestrial solar radiation, Radiation at ground level, Collectors-solar cells, Applications of solar energy, Types of solar collectors, Storage and utilization, Solar water heating systems, Solar driers, Solar thermal power systems.

Energy from Biomass: Producer gas, Bio-gas, Bio-diesel and bio-ethanol.

Wind, Geo-thermal and Hydro Energy Sources: Wind energy systems, Types, Wind mill & farms, Performance and economics, Geothermal power plants, Tidal power plants, Micro and small hydro energy systems, Types, Special aspects.

Other Renewable Energy Resources: Thermoelectric conversion system, Thermo ionic conversion system, Photo voltaic power system, Fuel cells, Magneto-hydrodynamic system, Integrated Energy Systems, System design, Economics of Renewable Energy Systems.

Course Learning Outcomes (CLO):

1. Students should be able to identify the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and environmental concerns.
2. Students should be able to describe the factors that are required to consider when selecting sites for tapping renewable energy.
3. Students should be able to evaluate the financial costs, life cycle assessment and the benefits of renewable energy project.

Recommended Books:

1. *Bent, S., Renewable Energy Conversion, Transmission and Storage, Academic press (2007).*
2. *Duffie, J.A. and Beckmann, W.A., Solar Engineering of Thermal Processes, John Wiley (2006).*
3. *Kreith, F. and Kreider, J.F., Principles of Solar Engineering, McGrawHill (1978).*
4. *Veziroglu, T.N., Alternative Energy Sources -an International Compendium, McGraw-Hill (1978).*
5. *Sukhatma, S.P., Solar Energy Principle of Thermal Collection and Storage, McGrawHill (2009).*

GAS TURBINE AND JET PROPULSION

L	T	P	Cr
3	1	0	3.5

Course Objectives: The learner will be exposed to principles of thermodynamics, fluid mechanics and structural analysis to the design of gas turbine and jet engine. In addition the learner will be exposed to gas turbine cycles and modifications of gas turbine cycles.

Introduction: Development, classification and field of application of gas turbines, gas turbine cycle, multistage compression, reheating, regeneration combined and cogeneration, energy transfer between fluid and rotor, axi-symmetric flow in compressors and gas turbines.

Turbines: Classification - axial flow and radial flow turbines, impulse and reaction turbines, elementary vortex theory, aerodynamic and thermodynamic design considerations, blade materials, blade attachments and cooling, gas turbine power plants, plant performance and matching, applications of gas turbine power plants.

Jet Propulsion : Types of jet engines, principal and operation, thrust, energy flow through jet and variation of pressure and temperature, and velocity of fluid, thermodynamics of turbo jet, efficiency and performance, turbo prop, ram jet, pulse jet, comparison of various propulsive devices.

Rocket Propulsion: Types of rocket engines, basic theory, physics equations, classifications, liquid propellant rockets, its advantage, efficiency and performance, rocket projection and escape velocity.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the effect of intercooling, recuperator and reheat on gas turbine efficiency and specific work.
2. understand the basic designs of combustion chambers and cooling arrangements and emission problems from gas turbines.
3. main component and design criteria of jet propulsions.

Text Books:

1. *Cohen, H., Rogers, G.F.C., and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman (2008).*
2. *Oates, G.C., Aero-thermodynamics of Gas Turbine and Rocket Propulsion AIAA Education Series (1997).*
3. *Yahya, S.M, Turbines, Compressors and Fans, Tata McGrawHill (2005).*

Reference Books:

1. *Earl Logan, Jr. and Roy, R., Handbook of Turbomachinery, CRC Press (2003).*
2. *Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier (1978).*
3. *Ganesan, V., Gas Turbines, Tata McGrawHill (2003).*

MODERN AUTOMOBILE ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objectives: To prepare the students to critically evaluate the challenges and identify the role of electronics and software systems in a modern automobile. Students are taught basic automotive systems, underlying principles of construction and working, limitations of the conventional systems, the needs for electronic controls to improve the performance, safety and meet regulatory requirements. Also, they are motivated to explore potential new functions and applications by studying the physical systems, interacting with experts and users.

Body Aerodynamics and Modern Chassis: Uni-body construction, carbon fiber construction, monocoque construction, viscous air flow fundamentals, aerodynamics drag, after flow wake, aerodynamic lift, car body drag reduction, body panel shapes and taper, aerodynamic lift control, underbody air dams, rear end spoiler.

Automotive Electronics: Introduction to body computers, body computer module, electronic control units, microprocessors, high-side drivers, low-side drivers.

Advanced Automotive Lighting: Computer controlled headlight systems, automatic on/off with time delay, automatic headlight dimming, headlight leveling, adaptive headlights, daytime running lamps, adaptive Brake Lights, instrument panel dimming, fiber optics, lamp outage indicators, high intensity discharge headlamps, projector headlamps, LED lamps, cornering lights.

Driver Assistance System: Digital instrument cluster, travel information system, head-up display, night vision system, global positioning navigation system, lane change warning system, warning programs, traffic management system, hand's free communication and operation.

Automatic Transmission and Driveline: Drive by wire system, electronic shift transmission, direct shift gearbox, S-Tronic gearbox, paddle shift control, constantly variable transmission, cruise control, limited slip differential, differential lock, hill ascent function.

Modern Suspension and Steering: Active suspension system, magnetic fluid suspension, height adjustable suspension system, load sensing suspension, hydrogen suspension, variable gear ratio steering, speed sensitive steering, collapsible steering column.

Advance Safety and Passive Restraint System: Introduction, primary restraint system, secondary restraint system, passive seat belt systems, air bag systems, air bag deployment, passenger-side air bags, hybrid air bag, multistage air bag deployment, side-impact air bags, seat belt pre-tensioners, inflatable knee blockers, occupant classification systems, anti-whiplash headrest restraint system, NCAP crash test ratings.

New Generation Accessories: Climate control air conditioning, dual zone climate control, electronic defoggers, rain sensing wipers, electrochromic mirrors, power seats, electric adjustable memory seats, automatic door locks, keyless entry, anti-theft system, immobilizers, heated windshields.

Vehicles with Alternative Power Sources: Introduction, electric vehicles, hybrid vehicles, 42-volt systems, fuel cells.

Course Learning Outcomes (CLO):

The students will be able to:

1. understand the function of electronic systems in modern automobiles.
2. evaluate the use of modern electronics technology to improve the performance, safety, comfort and related issues.
3. synthesize and specify the addition of new features in existing electronic automotive subsystems for enhanced functionality.

Text Books:

1 *Hiller, V. A. W., Fundamentals of Motor Vehicle Technology, Nelson Thornes, UK (2012).*

2 *Hollembeak, B., Today's Technician: Advanced Automotive Electronic Systems, Cengage Learning, New Delhi (2010).*

Reference Books:

1 *Heisler, H., Advanced Vehicle Technology, SAE International.*

2 *Pike , J. A., Automotive Safety, SAE International.*

3 *Duffy, J.E., Modern Automotive Technology, SAE International.*

FINITE ELEMENT METHODS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To expose the students to the basic mathematical formulation of Finite Element Methods.

Introduction: Finite element methods, history and range of applications.

Finite Elements: Definition and properties, assembly rules and general assembly procedure, features of assembled matrix, boundary conditions.

Continuum Problems: Classification of differential equations, variational formulation approach, Ritz method, generalized definition of an element, element equations from variations. Galerkin's weighted residual approach, energy balance methods.

Element Shapes and Interpolation Functions: Basic element shapes, generalized co-ordinates, polynomials, natural co-ordinates in one-, two- and three-dimensions, Lagrange and Hermite polynomials, two-D and three-D elements for C^o and C^1 problems, co-ordinate transformation, iso-parametric elements and numerical integration.

Application of Finite Element Methods to elasticity problems and heat conduction Problems.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the basic steps involved to solve a structural, thermal problem using Finite Element Methods.
2. derive the element stiffness matrices for 1D spring, 1D bar, 2D truss, 2D and 3D beam problems using direct, Galerkin and potential energy approach.
3. solve a problem using triangle, axisymmetric, quadrilateral, tetrahedral, hexahedral and isoparametric elements.
4. understand and develop the shape functions for 1D, 2D and 3D problems.

Text Books:

1 *Chandrupatla, T. R. and Belegundu, A. K., Introduction to Finite Elements in Engineering, Pearson Education, India (2001).*

2 *Huebner, K. H., The Finite Element Method for Engineers, John Wiley, New York (2001).*

Reference Books:

1 *Bathe, K.J., Finite Element Procedure in Engineering Analysis, Englewood Cliffs, Prentice Hall, New York (2001).*

2 *Zienkiewicz, O. C., The Finite Element Methods, Tata McGraw Hill, New Delhi (2002).*

3 *Reddy, J. N., An Introduction to Finite Elements Methods, McGraw Hill, New York (2001).*

4 *Stasa, F.L., Applied Finite Element Analysis for Engineers, Holt, Rinehart and Winston, New York (1995).*

MECHANICS OF COMPOSITE MATERIALS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To develop an understanding of the elastic analysis of composite materials. This understanding will include concepts such as analysis of unidirectional composites, short fiber composites, orthotropic lamina, laminated plates and beams.

Introduction: Definition, characteristics, classification, fabrication of composite, fiber-reinforced composites, applications of composites.

Properties of Unidirectional composites: Longitudinal behavior of unidirectional composites, initial stiffness, load sharing, longitudinal strength and stiffness, transverse stiffness and strength, prediction of shear modulus, prediction of poisson's ratio, failure modes.

Short-Fiber Composites: Introduction, theories of stress transfer, approximate analysis of stress transfer, average fiber stress, modulus and strength of short-fiber composites.

Analysis of an Orthotropic Lamina: Introduction, orthotropic materials, stress–strain relations and engineering constants, Hooke's law and stiffness and compliance matrices, general anisotropic material, compliance tensor and compliance matrix, maximum-stress theory, maximum-strain theory, maximum-work theory.

Analysis of Laminated Composites: Introduction, laminate strains, variation of stresses in a laminate, resultant forces and moments: synthesis of stiffness matrix, symmetric laminates, unidirectional, cross-ply, and angle-ply laminates, determination of laminate stresses and strains.

Analysis of Laminated Plates: Introduction, governing equations for plates, equilibrium equations, equilibrium equations in terms of displacements, application of plate theory, bending, buckling.

Design consideration, joints and experimental characterization (mechanical testing), environmental issues, metal and ceramic matrix composites, nanocomposites, biocomposites.

Course Learning Outcomes (CLO):

The students will be able to:

1. identify the properties of fiber and matrix materials used in commercial composites.
2. predict the elastic properties of both long and short fiber composites.
3. relate stress, strain and stiffness tensors using ideas from matrix algebra.
4. analyze a laminated plate in bending, including finding laminate properties from lamina properties.
5. predict the failure strength of a laminated composite plate.
6. develop knowledge of issues in fracture of composites and environmental degradation of composites.
7. understand the recent developments in composites, including metal and ceramic matrix composites.

Text Books:

1 *Agrawal, B.D. and Broutman, L. J., Analysis and Performance of Fiber Composites, John Wiley & Sons, New York (1990).*

2 *Daniel, I.M. and Ishai,O., Engineering Mechanics of Composite Materials, Oxford University Press, New York (2005).*

Reference Books:

1 *Mallick, P.K., Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, New Delhi (1993).*

2 *Herakovich, C.T., Mechanics of Fibrous Composites, John Wiley & Sons, New York (1998).*

3 *Christensen, R.M., Mechanics of Composite Materials, John Wiley & Sons, New York (1979).*

ROBOTICS ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objectives: To introduce the students to the basic terminologies, applications, design specifications, and mechanical design aspects both kinematics and dynamics of industrial robotics/ manipulators, sensors, actuators and image processing for robotic work cell control.

Introduction: Definition of a robot, types of robotic joints and motions, classifications of robot based on: Physical configurations, actuators and motion control; Terminologies used for robotics specification and selection for industrial applications; Types of end effectors; Applications of robotics.

Robot Kinematics: Homogeneous co-ordinates and co-ordinate transformations, kinematic parameters, use of Denavit-Hartenberg representation for finding arm equation of robotic arms, forward and inverse kinematics for basic industrial robotic configurations viz. Cartesian coordinate robot, SCARA configurations, and 5-axis and 6-axis articulated industrial robotic configurations.

Robot Dynamics: Introduction to Robot Dynamics.

Robot in Work Place: Work cell organization in robotics environment, function of work cell controller, robotic work cell design and control, introduction to robot trajectory planning.

Introduction to Robot Vision: Sensing and digitization of vision data, image processing: image data reduction, segmentation, feature extraction, object recognition, and training of vision system.

Methods of Robot Programming: Robot programing methods, introduction to basic robot programming languages, and various on-line and off-line robot programming methods.

Course Learning Outcomes (CLO):
The students will be able to:

1. understand the robot kinematics and trajectory planning.
2. work individually and/or with an interdisciplinary team for the purpose of manipulator design for a specific need using mechanical kinematic structure along with the understanding of requirements from robotic work cell controller and its programming, for enabling robotic manipulator to work in an integrated automated industrial environment.

Text Books:

1 *Groover, M. P., Weiss, M., Nagel, R. N. and Odrey, N. G., Industrial Robotics: Technology, Programming and Applications, McGraw Hill, New York (1986).*

2 *Lee, C.S.G., Fu, K.S and Gonzalez, Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill, New York (1990).*

Reference Books:

1 *Asada, H. and Slotine, J. E., Robot Analysis and Control, John Wiley & Sons, New York (1986).*

2 *Craig, J. J., Introduction to Robotics Mechanics and Control, Addison - Wesley Publishing Company, New York (1986).*

3 *Schilling, R.J., Fundamentals of Robotics Analysis & Control, Prentice Hall of India, New Delhi (1990).*

MACHINE TOOL DESIGN

L	T	P	Cr
3	1	0	3.5

Course Objectives: To explore various design aspects of machine tools elements like transmissions, structures, materials, kinematics, dynamics and construction of machine tools, etc. To understand concepts related to design of Die and Punch.

Introduction: General requirement of machine tool design, techno-economic pre-requisites.

Machine Tools: Kinematics structure & mechanical, hydraulic and electrical drives, design of hydrostatic, hydrodynamic and antifriction guideways, design of spindles, design of speed box and feed box, stepped and step less regulations of speed and feed diagram, ray diagram, layout of spindles drive and feed drive in machine tools, machine tool structures, design of bed, heard stock, spindle supports and power screws, machine tool dynamics.

Jigs and Fixtures Design: Applications in manufacturing, principle of location & clamping, types of locators and clamps, design of jigs and fixtures, selection of materials.

Die and Punch Design: Applications in manufacturing, design of various type of dies, selection of materials for casting and forging dies.

Course Learning Outcomes (CLO):
The students will be able to:

1. develop the conceptual design, manufacturing framework and systematic analysis of design problems on the machine tools.
2. apply the design procedures for different types of design problems such as gear box design, guide way design, shaft loading and its associated parts, rolling bearings, die design and jigs and fixtures and so on.
3. design, develop, and evaluate cutting tools and work holders for a manufactured product.

Text Books:

1 Mehta, N. K., Machine Tool Design & Numerical Control, McGraw Hill, New Delhi (2004).

2 Sen, G.C. and Bhattacharya, A., Machine Tools, Central Book Agency, New Delhi (1989).

Reference Books:

1 Pandey, P.C. and Singh, C.K., Production Engineering Sciences, Standard Publishers, New Delhi (2003).

2 Basu, S. K. and Palo, D.K., Design of Machine Tools, Allied Publishers, New Delhi (2008).

3 Acherkhan, N.S., Machine Tool Design, Mir Publishers, New Delhi (1983).

DYNAMICS OF RIGID BODIES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To build the foundation and framework for most of the branches of engineering like civil, mechanical, aerospace and agricultural engineering. The focus of this course is to develop the understanding of the students to predict the dynamic effects of force and motion, while carrying out the creative design functions of engineering.

Introduction: Review of rectilinear motion, curvilinear motion, rectangular coordinates, normal and tangential coordinates, polar coordinates, relative motion and constrained motion.

Plane Kinematics of Rigid Bodies: Rigid-body assumption, rotation, rotation about a fixed axis, absolute motion, relative velocity due to rotation, interpretation of the relative-velocity equation, instantaneous center of zero velocity, relative acceleration due to rotation, motion relative to rotating axes, time derivative of unit vectors, coriolis acceleration, rotating versus nonrotating systems.

Plane Kinetics of Rigid Bodies: General equations of motion, translation, fixed-axis rotation, general plane motion, work-energy relations, work-energy equations for differential motion, virtual work, impulse-momentum equations, inter-connected rigid bodies.

Kinematics of Three-Dimensional Rigid Bodies: Translation, fixed-axis rotation and parallel-plane motion of three-dimensional rigid bodies, rotation about a fixed point: Proper vectors, instantaneous axis of rotation, body and space cones, angular acceleration; General Motion: translating reference axis, rotating reference axis.

Kinetics of Three-Dimensional Rigid Bodies: Moments and products of inertia, principal axis, transfer principal for angular momentum, kinetic energy, momentum and energy equations of motion, parallel-plane motion.

Course Learning Outcomes (CLO):

The students will be able to:

1. have the basic knowledge of the mathematical and physical aspects of dynamics of rigid-bodies.
2. apply vector geometry to develop the equations of relative velocity and relative acceleration of rigid bodies in plane motion.
3. develop the direct equivalence between actual applied forces and couples and understand the resultant dynamic effects of rigid bodies.
4. develop the solid foundation of three-dimensional dynamics to solve many of the common space-motion problems.

Text Books:

1 Shames, Irving H., Engineering Mechanics- Statics and Dynamics, Pearson Education (2006).

2 Meriam, J. L. and Kraige, L. G., Engineering Mechanics – Dynamics, John Wiley & Sons (2002).

Reference Books:

1 *Beer, F. P. and Johnston, E. R., Vector Mechanics for Engineers – Statics and Dynamics, New Media Version (2007).*

2 *Nelson, E. W., Best, C. L., Mclean, W. G. and Potter, M. C., Schaum's Outline of Engineering Mechanics: Dynamics, Tata Mcgraw Hill (2010).*

TRIBOLOGY OF BEARINGS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To develop an understanding of the tribological analysis of bearings. This understanding will include concepts such as lubricants, analysis of friction and wear, hydrodynamic bearings, squeeze film bearings, hydrodynamic instability.

Introduction: Definition of tribology, different bearings, interdisciplinary approach, economic benefits, properties of lubricants, lubricant additives.

Friction and Wear: Causes of friction, adhesion theory, junction growth theory, laws of rolling friction, friction instability, adhesive wear, abrasive wear, corrosive wear, fretting wear.

Hydrodynamic Bearings: Hydrodynamic lubrication, elasto-hydrodynamic lubrication, classification of fluid film lubrication, Reynold's equation with different assumptions, lubricant flow and shear stresses, mechanism of pressure development, pressure development and load carrying capacity of infinitely long journal bearing, flow and load carrying capacity of narrow bearing, numerical solution of finite journal bearing.

Squeeze Film Bearings: Introduction, parallel surface bearing, step bearing, a circular cylinder near a plane and a parallel circular plate under squeeze film lubrication.

Hydrodynamic Instability: Introduction, mechanism, stiffness and damping coefficients, stability.

Course Learning Outcomes (CLO):

The students will be able to:

1. identify the properties of lubricants used in different bearings.
2. predict the different wears and causes of friction in different bearings.
3. analyze hydrodynamic lubrication for short and long bearing.
4. predict load carrying capacity of squeeze film bearings.
5. analyze hydrodynamic instability for different bearings.

Text Books:

1 *Majumdar B.C., Introduction to Tribology of Bearings, S. Chand Publishing, New Delhi (2010).*

2 *Khonsari, M.M., Booser, E.R., Applied Tribology: Bearing Design and Lubrication, John Wiley & Sons, UK (2008).*

Reference Books:

1 *Bhushan, B., Principles and Applications of Tribology, John Wiley & Sons, UK (2013).*

2 *Bowden, F.P., Tabor, D., Friction: Introduction to Tribology, Heinemann Educational Publishers, London (1974).*

RAPID PROTOTYPING

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective of this course is to provide the students with an understanding of the basic fundamentals of rapid prototyping followed by study of various rapid prototyping, rapid tooling, and reverse engineering technologies. The understanding and knowledge will be used to select appropriate technologies for product development purposes.

1. **Introduction**: Introduction to rapid prototyping (RP), Need of RP in context of modern production methods.
2. **Review of solid modelling techniques**: product design by curves, surfaces and solids.
3. **Basic Principles**: Basic Principles of RP, Steps in RP, Process chain in RP, RP integrated CAD-CAM environment, Advantages of RP.
4. **Classification of RP processes**: Based on raw material, Based on energy sources
5. **Rapid Prototyping Systems**: Sterolithography, Solid Ground Curing, Ballistic particle manufacture, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, 3D Printing, Laser Engineered Net Shaping etc.,
6. **Process planning for rapid prototyping**: STL file generation, Defects in STL files and repairing algorithms, Slicing and various slicing procedures.
7. **Problem areas of Rapid Prototyping**: Accuracy issues in RP, Strength issues of RP Parts, Surface roughness problem in RP, Part deposition orientation issues of RP Parts and other issues like build time, support structure, cost etc.,
8. **Rapid tooling techniques**: RTV Silicone Rubber Mold, Spray Metal Tooling, Vacuum Casting, Cast Resin Tooling, Electroforming, Direct AIM Tooling, Direct Metal Laser Sintering, Laminated Tooling, Laser Engineered Net Shaping.
9. **Reverse Engineering**: Introduction to reverse engineering and its integration with rapid prototyping.

Course Learning Outcomes (CLO):

The students will be able to:

1. understand the principle and philosophy of rapid prototyping.
2. understand the modern rapid prototyping techniques, how the different processes work and strengths as well as weaknesses of each technology.
3. understand the importance of Rapid Prototyping Technology over the existing traditional methods in present competitive scenario in terms of product development cycle and cost.
4. understand how the different rapid tooling processes work
5. understand the concept of reverse engineering and its integration with rapid prototyping.

Text Books:

1. *Chua, C.K., Leong, K.F., Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons Inc., (2000).*
2. *Pham, D.T., Demov, S.S., Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer-Verlag London Limited, (2001).*

3. *Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, (2006).*
4. *Zeid, I., Mastering CAD/CAM, Tata McCraw Hill, (2006).*

Reference Books:

1. *Patri, K. V., Weiyin, Ma, Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A., (2003).*
2. *Hague, R.J.M., Reeves, P.E., Rapid Prototyping, Tooling and Manufacturing, iSmithers Rapra Publishing, (2000).*
3. *Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New Dehi, (2005).*
4. *Hopkinson, N., Hague, R.J.M., Dickens, P.M., Rapid Manufacturing- An Industrial Revolution for the Digital Age, John Wiley & Sons Ltd., U.K., (2006).*