COURSE SCHEME

FOR

B.E. – MECHANICAL ENGINEERING

2016

Nature of Course	CODE
Core-Foundation Courses	**CF**
Core-Professional Courses	**CP**
Generic Electives	**GE**
Professional Electives	**PE**
Project Based Courses	**PR**

Nature of Course	Credits to be Earned(As per Choice Based Credit System)								Total
	Semesters								
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	
Core-Foundation (CF) Courses	19.5	19	16	12	4.5	0	0	3	74
Core-Professional (CP) Courses	0	0	4.5	16	19.5	0	16.5	12.5	69
Professional & Generic Electives (PE/GE)	0	0	0	0		0	6.5	3.5	10
Project Based (PR) Courses	4	5	6	0		20	0	8	43
								Total	**196.0**

SEMESTER-I

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UEE001	ELECTRICAL ENGINEERING	CF	3	1	2	4.5
2	UHU003	PROFESSIONAL COMMUNICATION	CF	2	0	2	3.0
3	UMA003	MATHEMATICS - I	CF	3	1	0	3.5
4	UPH004	APPLIED PHYSICS	CF	3	1	2	4.5
5	UTA007	COMPUTER PROGRAMMING - I	CF	3	0	2	4.0
6	UTA008	ENGINEERING DESIGN - I	PR	2	4	0	4.0
		TOTAL		**16**	**7**	**8**	**23.5**

SEMESTER-II

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UCB008	APPLIED CHEMISTRY	CF	3	1	2	4.5
2	UEC001	ELECTRONIC ENGINEERING	CF	3	1	2	4.5
3	UES009	MECHANICS	CF	2	1	2*	2.5
4	UMA004	MATHEMATICS - II	CF	3	1	0	3.5
5	UTA009	COMPUTER PROGRAMMING - II	CF	3	0	2	4.0
6	UTA010	ENGINEERING DESIGN – II (6 SELF EFFORT HOURS)	PR	1	0	2	5.0
		TOTAL		**15**	**4**	**8**	**24.0**

* Each student will attend one Lab Session of 2 hrs in a semester for a bridge project in this course. (Mechanics)

SEMESTER-III

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UES010	SOLIDS AND STRUCTURES	CF	3	1	2	4.5
2	UES011	THERMO-FLUIDS	CF	3	1	2	4.5
3	UMA031	OPTIMIZATION TECHNIQUES	CF	3	1	0	3.5
4	UME306	MECHANICS OF MACHINES	CF	3	1	2	4.5
5	UTA002	MANUFACTURING PROCESSES	CF	2	0	3	3.5
6	UTA019	ENGINEERING DESIGN– III (6 SELF EFFORT HOURS)	PR	1	0	4	6.0
		TOTAL		**15**	**4**	**13**	**26.5**

SEMESTER-IV

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UEN002	ENERGY AND ENVIRONMENT	CF	3	0	0	3.0
2	UES012	ENGINEERING MATERIALS	CF	3	1	2	4.5
3	UMA007	NUMERICAL ANALYSIS	CF	3	1	2	4.5
4	UME408	MACHINE DESIGN-I	CP	3	2	0	4.0
5	UME410	MECHATRONIC SYSTEMS	CP	3	0	2	4.0
6	UME411	COMPUTER AIDED DESIGN & ANALYSIS (7 SELF EFFORT HOURS)	CP	3	0	3	8.0
		TOTAL		**18**	**4**	**9**	**28.0**

SEMESTER-V

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME404	MECHANICS OF DEFORMABLE BODIES	CP	3	1	0	3.5
2	UME501	APPLIED THERMODYNAMICS	CP	3	1	2	4.5
3	UME505	MANUFACTURING TECHNOLOGY	CP	3	0	3	4.5
4	UME513	DYNAMICS AND VIBRATIONS	CP	3	1	2	4.5
5	UME515	INDUSTRIAL ENGINEERING	CP	2	1	0	2.5
6	UTA012	INNOVATION AND ENTREPRENEURSHIP (5 SELF EFFORT HOURS)	CF	1	0	2	4.5
		TOTAL		**15**	**4**	**9**	**24.0**

SEMESTER-VI

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME696	PROJECT SEMESTER*	PR	-	-	-	20.0
		TOTAL		**-**	**-**	**-**	**20.0**

*TO BE CARRIED OUT IN INDUSTRY/RESEARCH INSTITUTION

OR

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME697	GROUP PROJECT	PR	-	-	-	13.0
2	UME605	RAPID PROTOTYPING	CP	2	1	2	3.5
3	UME833	INSPECTION AND QUALITY CONTROL	CP	3	1	0	3.5
		TOTAL		5	2	2	20.0

OR

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME698	START- UP SEMESTER**	PR	-	-	-	20.0
		TOTAL		-	-	-	20.0

** BASED ON HANDS ON WORK ON INNOVATIONS AND ENTREPRENEURSHIP

SEMESTER-VII

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME711	MACHINE DESIGN - II	CP	3	1	0	3.5
2	UME502	AUTOMOBILE ENGINEERING	CP	3	0	2	4.0
3	UME712	HEAT TRANSFER	CP	3	1	2	4.5
4	UME713	FLUID MECHANICS & MACHINERY	CP	3	1	2	4.5
5	UME793	CAPSTONE PROJECT - START	PR	0	0	2	-
6		ELECTIVE – I		3	1	0	3.5
7		GENERIC ELECTIVE		3	0	0	3.0
		TOTAL		18	54	8	23

SEMESTER-VIII

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UME803	REFRIGERATION AND AIR CONDITIONING	CP	3	1	2	4.5
2	UME807	GAS DYNAMICS & TURBO MACHINES	CP	3	1	0	3.5
3	UME705	MACHINING SCIENCE	CP	3	1	2	4.5
5	UHU005	HUMANITIES FOR ENGINEERS	CF	2	0	2	3.0
6	UME793	CAPSTONE PROJECT (8 SELF EFFORT HOURS)	PR	-	-	2	8.0
7		ELECTIVE – II		3	1	0	3.5
		TOTAL		**14**	**4**	**8**	**27.0**

LIST OF PROFESSIONAL ELECTIVES
ELECTIVE – I

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1.	UME832	FINITE ELEMENT METHODS	PE	3	1	0	3.5
2.	UME842	MECHANICS OF COMPOSITE MATERIALS	PE	3	1	0	3.5
3.	UME805	ROBOTICS ENGINEERING	PE	3	1	0	3.5
4.	UME721	TRIBOLOGY	PE	3	1	0	3.5
5.	UME722	SYSTEM MODELLING AND SIMULATION	PE	3	1	0	3.5
6.	UPE501	WORK STUDY AND ERGONOMICS ENGINEERING	PE	3	1	0	3.5
7.	UME732	CAM & INDUSTRIAL AUTOMATION	PE	3	1	0	3.5
8.	UME844	MACHINE TOOL DESIGN	PE	3	1	0	3.5
9.	UPE703	METAL FORMING	PE	3	1	0	3.5

ELECTIVE – II

SR. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1.	UME831	COMPUTATIONAL FLUID DYNAMICS	PE	3	1	0	3.5
2.	UME834	INTERNAL COMBUSTION ENGINES	PE	3	1	0	3.5
3.	UME852	POWER PLANT AND PROCESS UTILITY SYSTEMS	PE	3	1	0	3.5
4.	UME839	RENEWABLE ENERGY SYSTEMS	PE	3	1	0	3.5
5.	UME853	SOLAR ENERGY ENGINEERING	PE	3	1	0	3.5
6.	UME733	INDUSTRIAL METALLURGY	PE	3	1	0	3.5

GENERIC ELECTIVE

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UTD007	EMPLOYABILITY DEVELOPMENT SKILLS	GE	2	2	0	3.0
2	UHU006	INTRODUCTORY COURSE IN FRENCH	GE	3	0	0	3.0
3	UHU009	INTRODUCTION TO COGNITIVE SCIENCE	GE	3	0	0	3.0
4	UHU008	INTRODUCTION TO CORPORATE FINANCE	GE	3	0	0	3.0
5	UCS001	INTRODUCTION TO CYBER SECURITY	GE	3	0	0	3.0
6	UPH063	NANOSCIENCE AND NANOMATERIALS	GE	3	0	0	3.0
7	UEN004	TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT	GE	3	0	0	3.0
8	UMA066	GRAPH THEORY AND APPLICATIONS	GE	3	0	0	3.0
9	UMA061	ADVANCED NUMERICAL METHODS	GE	3	0	0	3.0
10	UBT509	BIOLOGY FOR ENGINEERS	GE	3	0	0	3.0

SEMESTER WISE CREDITS FOR BE (MECHANICAL ENGINEERING)

SEMESTER	CREDITS
FIRST	23.5
SECOND	24.0
THIRD	26.5
FOURTH	28.0
FIFTH	24.0
SIXTH	20.0
SEVENTH	23.0
EIGHTH	27.0
TOTAL CREDITS	**196.0**

UEE001: ELECTRICAL ENGINEERING

L T P Cr.
3 1 2 4.5

Course Objective: To introduce concepts of DC and AC circuits, electromagnetism, single-phase transformers, DC motor and generators.

DC Circuits: Kirchhoff's voltage and current laws; power dissipation; Voltage source and current source; Mesh and Nodal analysis; Star-delta transformation; Superposition theorem; Thevenin's theorem; Norton's theorem; Maximum power transfer theorem; Millman's theorem and Reciprocity theorem; Transient response of series RL and RC circuits.

Steady state analysis of DC Circuits: The ideal capacitor, permittivity; the multi-plate capacitor, variable capacitor; capacitor charging and discharging, current-voltage relationship, time-constant, rise-time, fall-time; inductor energisation and de-energisation, inductance current-voltage relationship, time-constant; Transient response of RL, RC and RLC Circuits.

AC Circuits: Sinusoidal sources, RC, RL and RLC circuits, Concept of Phasors, Phasor representation of circuit elements, Complex notation representation, Single phase AC Series and parallel circuits, power dissipation in ac circuits, power factor correction, Resonance in series and parallel circuits, Balanced and unbalanced 3-phase circuit - voltage, current and power relations, 3-phase power measurement, Comparison of single phase and three phase supplysystems.

Electromagnetism: Electromagnetic induction, Dot convention, Equivalent inductance, Analysis of Magnetic circuits, AC excitation of magnetic circuit, Iron Losses, Fringing and stacking, applications: solenoids andrelays.

Single Phase Transformers: Constructional features of transformer, operating principle and applications, equivalent circuit, phasor analysis and calculation of performance indices.

Motors and Generators: DC motor operating principle, construction, energy transfer, speed-torque relationship, conversion efficiency, applications, DC generator operating principle, reversal of energy transfer, emf and speed relationship, applications.

Laboratory Work:

Network laws and theorems, Measurement of R,L,C parameters, A.C. series and parallel circuits, Measurement of power in 3 phase circuits, Reactance calculation of variable reactance choke coil, open circuit and short circuit tests on single phase transformer, Starting of rotating machines, Magnetisation curve of DCgenerator.

Course Learning Outcomes (CLO):

After the completion of the course the students will be able to:

1. Learn about applications of networks laws and theorems to solve electric circuits.

2. Represent AC quantities through phasor and compute AC system behaviour during steady state.
3. Learn about principle, construction, characteristics and application of Electro-Mechanical energy conversion devices**.**

Text Books:

1. *Hughes, E., Smith, I.M., Hiley, J. and Brown, K., Electrical and Electronic Technology, Prentice Hall(2008).*
2. *Nagrath, I.J. and Kothari, D.P., Basic Electrical Engineering, Tata McGraw Hill(2002).*
3. *Naidu, M.S. and Kamashaiah, S., Introduction to Electrical Engineering, Tata McGraw Hill(2007).*

Reference Books:

1. *Chakraborti, A., Basic Electrical Engineering, Tata McGraw□Hill(2008).*
2. *Del Toro, V., Electrical Engineering Fundamentals, Prentice□Hall of IndiaPrivate Limited(2004)*

Evaluation Scheme:

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

UHU003: PROFESSIONAL COMMUNICATION

L T P Cr
2 0 2 3.0

Course objective: To introduce the students to effective professional communication.The student will be exposed to effective communication strategies and different modes of communication.The student will be able to analyze his/ her communication behavior and that of the others.By learning and adopting the right strategies, the student will be able to apply effective communication skills,professionally and socially.

Effective communication: Meaning, Barriers,Types of communication and Essentials.Interpersonal Communicationskills.

Effective Spoken Communication: Understanding essentials of spoken communication,Public speaking, Discussion Techniques,Presentation strategies.

Effective Professional and Technical writing: Paragraph development, Forms of writing,Abstraction and Summarization of a text;Technicalities of letter writing,internal and external organizational communication.Technical reports, proposals and papers.

Effective non verbal communication: Knowledge and adoption of the right non verbal cues of body language, interpretation of the body language in professional context. Understanding Proxemics and other forms of non verbal communication.

Communicating for Employment: Designing Effective Job Application letter and resumes;Success strategies for Group discussions and Interviews.

Communication Networks in organizations: Types, barriers and overcoming the barriers.

Laboratory work:
1. Needs-assessment of spoken and written communication andfeedback.
2. Training for Group Discussions through simulations and roleplays.
3. Training for effectivepresentations.
4. Project based teampresentations.
5. Proposals and papers-review andsuggestions.

Minor Project (if any): Team projects on technical report writing and presentations.

Course Learning Outcomes (CLO):
On completion of course, the student will be able to:
1. Understand and appreciate the need of communication training.
2. Use different strategies of effective communication.
3. Select the most appropriate mode of communication for a given situation.

4. Speak assertively and effectively.
5. Correspond effectively through different modes of written communication.
6. Write effective reports, proposals and papers.
7. Present himself/ herself professionally through effective resumes and Interviews.

Text Books:
1. *Lesikar R.V and Flately M.E., Basic Business Communication Skills for the Empowering the Internet Generation. Tata Mc Graw Hill. New Delhi(2006).*
2. *Raman,M & Sharma, S.,Technical Communication Principles and Practice, Oxford University Press NewDelhi.(2011).*
3. *Mukherjee H.S.,Business Communication-Connecting at Work,Oxford University Press New Delhi, (2013).*

Reference Books:
- *Butterfield, Jeff.,Soft Skills for everyone,Cengage Learning NewDelhi,(2013).*
- *Robbins, S.P., & Hunsaker, P.L.,Training in Interpersonal Skills,Prentice Hallof India, New Delhi,(2008).*
- *DiSianza,J.J & Legge,N.J.,Business and Prfofessional Communication,Pearson Education India NewDelhi,(2009).*

Evaluation Scheme:

S.No	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (Group Discussions; professional presentations;panel discussions;public speaking;projects,quizzes)	40

UMA003: MATHEMATICS - I

L T P Cr
3 1 0 3.5

Course Objectives: To provide students with skills and knowledge in sequence and series, advanced calculus and calculus of several variables which would enable them to devise solutions for given situations they may encounter in their engineeringprofession.

Applications of Derivatives: Mean value theorems and their geometrical interpretation, Cartesian graphing using first and second order derivatives, Asymptotes and dominant terms, Graphing of polar curves, Applied minimum and maximum problems.

Sequences and Series: Introduction to sequences and Infinite series, Tests for convergence/divergence, Limit comparison test, Ratio test, Root test, Cauchy integral test, Alternating series, Absolute convergence and conditionalconvergence.

Series Expansions: Power series, Taylor series, Convergence of Taylor series, Error estimates, Term by term differentiation and integration.

Partial Differentiation: Functions of several variables, Limits and continuity, Chain rule, Change of variables, Partial differentiation of implicit functions, Directional derivatives and its properties, Maxima and minima by using second order derivatives.

Multiple Integrals: Change of order of integration, Change of variables, Applications of multiple integrals.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to
1) apply the knowledge of calculus to plot graphs of functions, approximate functions and solve the problem of maxima and minima.
2) determine the convergence/divergence of infinite series.
3) evaluate multiple integrals and their applications to engineering problems.
4) analyse and design mathematical problems encountered in engineering applications.

Text Books:
1) *Thomas, G.B. and Finney, R.L., Calculus and Analytic Geometry, Pearson Education (2007), 9th ed.*

2) *Stewart James, Essential Calculus; Thomson Publishers (2007), 6thed.*

Reference Books:
1) *Wider David V, Advanced Calculus: Early Transcendentals, Cengage Learning(2007).*
2) *Apostol Tom M, Calculus, Vol I and II, John Wiley(2003).*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include assignments/quizzes)	25

UPH004: APPLIED PHYSICS

L T P Cr
3 1 2 4.5

Objectives:

To introduce the student to the basic physical laws of oscillators, acoustics of buildings, ultrasonics, electromagnetic waves, wave optics, lasers, and quantum mechanics and demonstrate their applications in technology. To introduce the student to measurement principles and their application to investigate physical phenomena

Oscillations and Waves: Oscillatory motion and damping, Applications - Electromagnetic damping – eddy current; *Acoustics:* Reverberation time, absorption coefficient, Sabine's and Eyring's formulae (Qualitative idea), Applications - Designing of hall for speech, concert, and opera; *Ultrasonics:* Production and Detection of Ultrasonic waves, Applications - green energy, sound signaling, dispersion of fog, remote sensing, Car's airbag sensor.

Electromagnetic Waves: Scalar and vector fields; Gradient, divergence, and curl; Stokes' and Green's theorems; Concept of Displacement current; Maxwell's equations; Electromagnetic wave equations in free space and conducting media, Application - skindepth.

Optics: *Interference:* Parallel and wedge-shape thin films, Newton rings, Applications as Non-reflecting coatings, Measurement of wavelength and refractive index. *Diffraction:* Single and Double slit diffraction, and Diffraction grating, Applications - Dispersive and Resolving Powers. *Polarization:* Production, detection, Applications – Anti-glare automobile headlights, Adjustable tint windows. *Lasers:* Basic concepts, Laser properties,Ruby, HeNe, and Semiconductor lasers, Applications – Optical communication and Optical alignment.

Quantum Mechanics: Wave function, Steady State Schrodinger wave equation, Expectation value, Infinite potential well, Tunneling effect (Qualitative idea), Application - Quantum computing.

Laboratory Work:

1. Determination of damping effect on oscillatory motion due to variousmedia.
2. Determination of velocity of ultrasonic waves in liquids by stationary wave method.
3. Determination of wavelength of sodium light using Newton's rings method.
4. Determination of dispersive power of sodium-D lines using diffractiong rating.
5. Determination of specific rotation of cane sugarsolution.
6. Study and proof of Malus' law inpolarization.
7. Determination of beam divergence and beam intensity of a given laser.
8. Determination of displacement and conducting currents through adielectric.
9. Determination of Planck'sconstant.

Micro project: Students will be given physics-based projects/assignments using computer simulations, etc.

Course Learning Outcomes (CLO):

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

1. Understand damped and simple harmonic motion, the role of reverberation in designing a hall and generation and detection of ultrasonic waves.
2. Use Maxwell's equations to describe propagation of EM waves in a medium.
3. Demonstrate interference, diffraction and polarization of light.
4. Explain the working principle of Lasers.
5. Use the concept of wave function to find probability of a particle confined in a box.
6. Perform an experiment, collect data, tabulate and report them and interpret the results with error analysis

Text Books

1. *Beiser, A., Concept of Modern Physics, Tata McGraw Hill (2007) 6^{th}ed.*
2. *Griffiths, D.J., Introduction to Electrodynamics, Prentice Hall of India (1999) 3^{rd}ed.*
3. *Jenkins, F.A. and White, H.E., Fundamentals of Optics, McGraw Hill (2001) 4^{th}ed.*

Reference Books

1. *Wehr, M.R, Richards, J.A., Adair, T.W., Physics of The Atom, Narosa Publishing House (1990) 4^{th}ed.*
2. *Verma, N.K., Physics for Engineers, Prentice Hall of India (2014)1^{st}ed.*
3. *Pedrotti, Frank L., Pedrotti, Leno S., and Pedrotti, Leno M., Introduction to Optics, Pearson Prentice Hall^{TM} (2008) 3^{rd}ed.*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include assignments/quizzes)	40

UTA007: COMPUTER PROGRAMMING – I

L	T	P	Cr
3	0	2	4.0

Course Objective: This course is designed to explore computing and to show students the art of computer programming. Students will learn some of the design principles for writing good programs.

Introduction to 'C++' programming: Fundamentals, Structure of a C++ program, Compilation and linking processes.

Expressions and Console I/O: Basic Data types, Identifier Names, Variables, Scope, Type qualifiers, Storage class specifier, Constants, Operators, Reading and writing characters, Reading and writing strings, Formatted and console I/O, cin(), cout(), Suppressing input.

Statements: True and False, Selection statements, Iteration statements, Jump statements, Expression statements, Block statements.

Arrays and Strings: Single dimension array, two-dimension array, Strings, Array of strings, Multi-dimension array, Array initialization, Variable length arrays.

Structures, Unions, Enumerations, and Typedef: Structures, Array of structures, passing structures to functions, Structure pointers, Arrays and structures within structures, Unions, Bit-fields, Enumerations, typedef.

Introduction to Object Oriented Programming with C++: Objects and Classes, basic concepts of OOPs (Abstraction, Encapsulation, Inheritance, Polymorphism), Constructors/Destructor, Copy constructor, Dynamic Constructor, Overloading (Function and Operator).

Pointers: Pointer variables, Pointer operators, Pointer expressions, Pointers and arrays, multiple indirection, Pointer initialization, Pointers to arrays, dynamically allocated arrays, Problems with pointers, Pointers and classes, pointer to an object, this pointer.

Functions: General form of a function, understanding scope of a function, Function arguments, Command line arguments, Return statement, Recursion, Function prototype, Pointers to functions, Friend function and class.

Pre-processor and Comments: Pre-processor, #define, #error, #include, Conditional compilation directives, #undef, Single line and multiple line comments.

File I/O: Streams and files, File system basics, fread() and fwrite(), fseek() and random access I/O, fprintf() and fscanf(), Standardstreams.

Laboratory Work:

To implement Programs for various kinds of programming constructs in C++ Language.

Course Learning Outcomes (CLO):

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

1. write, compile and debug programs in C++language.
2. use different data types, operators and console I/O function in a computerprogram.
3. design programs involving decision control statements, loop control statements and case controlstructures.
4. understand the implementation of arrays, pointers and functions and apply the dynamics of memory by the use ofpoiners.
5. comprehend the concepts of structures and classes: declaration, initialization and implementation.
6. apply basics of object oriented programming, polymorphism andinheritance.
7. use the file operations, character I/O, string I/O, file pointers, pre-processor directives and create/update basic datafiles.

Text Books:

- *Kanetkar Y., Let Us C++, BPB Publications,2nded.*
- *Balaguruswamy E., Object Oriented Programming with C++, McGraw Hill,2013.*

Reference Books:

1. *Brian W. Kernighan, Dennis M. Ritchie, The C++ Programming Language, Prentice Hall)*
2. *Schildt H., C++: The Complete Reference, Tata Mcgraw Hill,2003.*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include assignments/quizzes)	35

UTA008 ENGINEERING DESIGN - I

L	**T**	**P**	**Cr**
2	**4**	**0**	**4.0**

Course Objectives: This module is dedicated to graphics and includes two sections: manual drawing and AutoCAD. This course is aimed at to make the student understand dimensioned projections, learn how to create two-dimensional images of objects using first and third angle orthographic projection as well as isometric, perspective and auxiliary projection, to interpret the meaning and intent of toleranced dimensions and geometric tolerance symbolism and to create and edit drawings using drafting software AutoCAD.

Engineering Drawing

1. Introduction
2. Orthographic Projection: First angle and third angle projectionsystem
3. IsometricProjections
4. AuxiliaryProjections
5. PerspectiveProjections
6. Introduction to MechanicalDrawing
7. Sketching engineeringobjects
8. Sections, dimensions andtolerances

AutoCAD

1. Management of screen menuscommands
2. Introduction to drawing entities
3. Co-ordinate systems: Cartesian, polar and relativecoordinates
4. Drawing limits, units of measurement andscale
5. Layering: organizing and maintaining the integrity ofdrawings
6. Design of prototype drawings astemplates.
7. Editing/modifying drawing entities: selection of objects, object snap modes, editing commands,
8. Dimensioning: use of annotations, dimension types, properties and placement, adding text to drawing

1. Micro Projects /Assignments:
2. Completing the views - Identification and drawing of missing lines in the projection of objects
3. Missing views – using two views to draw the projection of the object in the thirdview, primarily restricting to Elevation, Plan and Profile views
4. Projects related to orthographic and isometric projections

a. Using wax blocks or soap bars to develop three dimensional object from given orthographic projections
b. Using wax blocks or soap bars to develop three dimensional object, section it and color the section
c. Use of AUTOCAD as a complementary tool for drawing the projections ofthe objects created in (1) and (2).

5. Develop the lateral surface of different objects involving individual or a combinationof solids like Prism, Cone, Pyramid, Cylinder, Sphere, etc
6. To draw the detailed and assembly drawings of simple engineering objects/systems with due sectioning (where ever required) along with bill of materials.
   e.g. Rivet joints, simple bearing, wooden joints, Two plates connected with nut and bolt etc.

Course Learning Outcomes (CLO):
Upon completion of this module, students will be able to:
1. creatively comprehend geometrical details of common engineeringobjects
2. draw dimensioned orthographic and isometric projections of simple engineeringobjects.
3. interpret the meaning and intent of toleranced dimensions and geometric tolerance symbolism;
4. create the engineering drawings for simple engineering objects usingAutoCAD
5. manage screen menus and commands usingAutoCAD
6. operate data entry modes and define drawings geometrically in terms of Cartesian, polar and relative coordinates inAutoCAD
7. create and edit drawings making selections of objects, discriminating by layering and using entities, object snap modes, editing commands, angles and displacements using AutoCAD

Text Books:
   1. *Jolhe, D.A., Engineering Drawing, Tata McGraw Hill,2008*
   2. *Davies, B. L.,   Yarwood, A., Engineering Drawing and Computer Graphics,* Van Nostrand Reinhold *(UK),1986*

Reference Books:
   1. *Gill, P.S., Geometrical Drawings, S.K. Kataria & Sons, Delhi(2008).*
   2. *Gill, P.S., Machine Drawings, S.K. Kataria & Sons, Delhi(2013).*
   3. *Mohan, K.R., Engineering Graphics, Dhanpat Rai Publishing Company (P) Ltd, Delhi (2002).*

4. *French, T. E., Vierck, C. J. and Foster, R. J., Fundamental of Engineering Drawing & Graphics Technology, McGraw Hill Book Company, New Delhi(1986).*

5. *Rowan, J. and Sidwell , E. H., Graphics for Engineers, Edward Arnold, London(1968).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Mid semester test (formal written test)	25
2	End semester test (formal written test)	40
3	Sessional: (may include the following) Continuous evaluation of drawing assignments in tutorial/ regular practice of AutoCAD tutorial exercises & Individual independent project work/drawing and AutoCAD assignment	35

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

SEMESTER-II

UCB008: APPLIED CHEMISTRY

L   T   P   Cr
3   1   2   4.5

Course objective: The course aims at elucidating principles of applied chemistry in industrial systems, water treatment, engineering materials and analytical techniques.

Electrochemistry: Specific, equivalent and molar conductivity of electrolytic solutions, Migration of ions, Transference number and its determination by Hittorf`s method, Conductometric titrations, types of electrodes, concentration cells, Liquid junction potential.

Phase Rule: States of matter, Phase, Component and Degree of freedom, Gibbs phase rule, One component and two component systems.

Water Treatment and Analysis: Hardness and alkalinity of water: Units and determination,External and internal method of softening of water: carbonate, phosphate, calgon and colloidal conditioning,Lime-soda Process, Zeolite process,Ion exchange process, mixed bed deionizer, Desalination of brackish water.

Fuels: Classification of fuels, Calorific value, Cetane and Octane number, fuel quality, Comparison of solid liquid and gaseous fuels, properties of fuel, alternative fuels: biofuels, power alcohol, synthetic petrol.

Chemistry of Polymers: Overview of polymers, types of polymerization, molecular weight determination, tacticity of polymers, catalysis in polymerization, conducting, biodegradable polymers and inorganic polymers.

Atomic spectroscopy: Introduction to atomic spectroscopy, atomic absorption spectrophotometry and flame photometry.

Molecular Spectroscopy: Beer-Lambert`s Law, molecular spectroscopy, principle, instrumentation and applications of UV-Vis and IR spectroscopy.

Laboratory Work

Electrochemical measurements: Experiments involving use of pH meter, conductivity meter, potentiometer.

Acid and Bases: Determination of mixture of bases.

Spectroscopic techniques: Colorimeter, UV-Vis spectrophotometer.

Water and its treatment: Determination of hardness, alkalinity, chloride, chromium, iron and copper in aqueous medium.

Course Learning Outcomes (CLO):

 The students will be able to reflect on:

1. concepts of electrodes in electrochemical cells, migration of ions, liquid junction potential and conductometrictitrations.
2. atomic and molecular spectroscopy fundamentals like Beer`s law, flame photometry,atomic absorption spectrophotometry, UV-Vis and IR.
3. water and its treatment methods like lime soda and ionexchange.
4. concept of phase rule, fuel quality parameters and alternativefuels.
5. polymerization, molecular weight determination and applications as biodegradable and conductingpolymers.
6. laboratory techniques like pH metry, potentiometry, colourimetry, conductometry and volumetry.

Text Books

1. *Ramesh, S. and Vairam S. Engineering Chemistry, Wiley India (2012)1^{st}ed.*
2. *Puri, B.R., Sharma,L.R., and Pathania, M.S. Principles of Physical Chemistry, Vishal Publishing Co.(2008).*
3. *Aggarwal, S. Engineering Chemistry: Fundamentals and Applications, Cambridge University Press (2015).*

Reference Books

1. *Brown, H., Chemistry for Engineering Students, Thompson,1^{st}ed*
2. *Sivasankar, B., Engineering Chemistry, Tata McGraw-Hill Pub. Co. Ltd, New Delhi(2008).*
3. *Shulz, M.J. Engineering Chemistry, CengageLearnings (2007)1^{st}ed.*

 Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Mid semester test	25
2	End semester test	40
3	Sessional: (May include Quizzes/Assignments/Lab Evaluation)	35

UEC 001: ELECTRONIC ENGINEERING

L T P Cr
3 1 2 4.5

Course objective: To enhance comprehension capabilities of students through understanding of electronic devices, various logic gates, SOP, POS and their minimization techniques, various logic families and information on different IC's and working of combinational circuits and their applications.

Semiconductor Devices: p- n junction diode: Ideal diode, V-I characteristics of diode, Diode small signal model, Diode switching characteristics, Zener diode

Electronics Devices and Circuits: PN Diode as a rectifier, Clipper and clamper, Operation of Bipolar Junction Transistor and Transistor Biasing, CB, CE, CC (Relationship between α, β, γ) circuit configuration Input-output characteristics, Equivalent circuit of ideal and real amplifiers, Low frequency response of amplifiers, Introduction to Field Effect Transistor and its characteristics

Operational Amplifier Circuits: The ideal operational amplifier, The inverting, non-inverting amplifiers, Op-Amp Characteristics, Frequency response of op-amp, Application of op-amp

Digital Systems and Binary Numbers: Introduction to Digital signals and systems, Number systems, Positive and negative representation of numbers, Binary arithmetic, Definitions and basic theorems of boolean Algebra, Algebraic simplification, Sum of products and product of sums formulations (SOP and POS), Gate primitives, AND, OR, NOT and Universal Gate, Minimization of logic functions, Karnaughmaps.

Combinational and Sequential Logic: Code converters, multiplexors, decoders, Addition circuits and priority encoder,Master-slave and edge-triggered flip-flops,Synchronous and Asynchronous counters, Registers

Logic families: N and P channel MOS transistors, CMOS inverter, NAND and NOR gates, General CMOS Logic, TTL and CMOS logic families, and their interfacing.

Laboratory Work:
Familiarization of CRO and Electronic Components, Diodes characteristics Input-Output and Switching characteristics, BJT and MOSFET Characteristics, Zener diode as voltage regulator, Transistorized Series voltage regulator. Half and Full wave Rectifiers with and without filter circuit, Half and full adder circuit implementation, Decoder, DMUX and MUX, Binary/BCD up/down counters.

Course Learning Outcomes (CLO):

The student will be able to:

1. Demonstrate the use of semiconductor diodes in variousapplications.
2. Discuss and Explain the working of transistors and operational Amplifiers, theirconfigurations andapplications.
3. Recognize and apply the number systems and BooleanAlgebra.
4. Reduce Boolean Expressions and implement them with LogicGates.
5. Analyze, design and Implement combinational and sequentialcircuits.
6. Analyze and differentiate logic families, TTL andCMOS.

Text Books:

1. *M. M. Mano and M.D. Ciletti, Digital Design, Pearson, Prentice Hall,2013.*
2. *Milliman, J. and Halkias, C.C., Electronic Devices and Circuits, Tata McGraw Hill,2007.*
3. *Donald D Givone, Digital Principles and Design, McGraw-Hill,2003.*

Reference Books:

1. *John F Wakerly, Digital Design: Principles and Practices, Pearson,(2000).*
2. *N Storey, Electronics: A Systems Approach, Pearson, Prentice Hall,(2009).*
3. *Boylestad, R.L. and Nashelsky, L., Electronic Devices & Circuit Theory, Perason(2009).*

Evaluation Scheme:

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

UES 009: MECHANICS

L T P Cr
2 1 2* 2.5

Course Objectives: The objective of this module is to help students develop the techniques needed to solve general engineering mechanics problems. Students will learn to describe physical systems mathematically so that their behaviour can bepredicted.

Review of Newton's law of motion and vector algebra

Equilibrium of bodies: Free-body diagrams, conditions of equilibrium, torque due to a force, statical determinacy.

Plane trusses: Forces in members of a truss by method of joints and method of sections.

Friction: Sliding, belt, screw and rolling.

Properties of plane surfaces: First moment of area, centroid, second moment of area etc.

Virtual work: Principle of virtual work, calculation of virtual displacement and virtual work.

Work and energy: Work and energy, work-energy theorem, principle of conservation of energy, collisions, principles of momentum etc.

Dynamics of Rigid Bodies: Newton's Laws, D'Alembert's Principle, Energy Principles.

Experimental project assignment/ Micro project: Students in groups of 4/5 will do project on Model Bridge Experiment: This will involve construction of a model bridge using steel wire and wood.

Course Learning Outcomes (CLO):

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

1) Determine resultants in plane forcesystems.
2) Identify and quantify all forces associated with a staticframework.
3) Solve problems in kinematic and dynamicsystems.

Text Books

1) *Shames, I. H. Engineering Mechanics: Dynamics, Pearson Education India(2002).*
2) *Beer, Johnston, Clausen and Staab, Vector Mechanics for Engineers, Dynamics, McGraw-Hill Higher Education(2003).*

Reference Books

1) *Hibler, T.A., Engineering Mechanics: Statics and Dynamics, Prentice Hall(2012).*
2) *Timoshenko and Young, Engineering Mechanics, Tata McGraw Hill Education Private Limited(2000).*

Evaluation Scheme

Sr. No.	Evaluation Elements	Weights (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizzes)	25

UMA004 MATHEMATICS - II

L T P Cr
3 1 0 3.5

Course Objectives: To introduce students the theory and concepts of differential equations, linear algebra, Laplace transformations and Fourier series which will equip them with adequate knowledge of mathematics to formulate and solve problems analytically.

Linear Algebra: Row reduced echelon form, Solution of system of linear equations, Matrix inversion, Linear spaces, Subspaces, Basis and dimension, Linear transformation and its matrix representation, Eigen-values, Eigen-vectors and Diagonalisation, Inner product spaces and Gram-Schmidt orthogonalisation process.

Ordinary Differential Equations: Review of first order differential equations, Exact differential equations, Second and higher order differential equations, Solution techniques using one known solution, Cauchy - Euler equation, Method of undetermined coefficients, Variation of parameters method, Engineering applications of differential equations.

Laplace Transform: Definition and existence of Laplace transforms and its inverse, Properties of the Laplace transforms, Unit step function, Impulse function, Applications to solve initial and boundary value problems.

Fourier Series: Introduction, Fourier series on arbitrary intervals, Half range expansions, Applications of Fourier series to solve wave equation and heat equation.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to:
1. solve the differential equations of first and 2nd order and basic application problems described by these equations.
2. find the Laplace transformations and inverse Laplace transformations for various functions. Using the concept of Laplace transform students will be able to solve the initial value and boundary value problems.
3. find the Fourier series expansions of periodic functions and subsequently will be able to solve heat and wave equations.
4. solve systems of linear equations by using elementary row operations.
5. identify the vector spaces/subspaces and to compute their bases/orthonormal bases. Further, students will be able to express linear transformation in terms of matrix and find the eigen values and eigen vectors.

Text Books:

1. Simmons, G.F., Differential Equations (With Applications and Historical Notes), Tata McGraw Hill (2009).
2. Krishnamurthy, V.K., Mainra, V.P. and Arora, J.L., An introduction to Linear Algebra, Affiliated East West Press (1976).

Reference Books:

1. Kreyszig Erwin, Advanced Engineering Mathematics, John Wiley (2006), 8th ed.
2. Jain, R.K. and Iyenger, S.R.K , Advanced Engineering Mathematics, Narosa

    Publishing House(2011), 11^{th}ed.

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include assignments/quizzes)	25

UTA009: COMPUTER PROGRAMMING – II

L T P Cr
3 0 2 4.0

Course Objective: Understand fundamentals as well as advanced topics of object oriented programming in java. To help students understand fundamentals of programming such as variables, conditional and iterative execution, methods, I/O and thread communication followed by data structure implementation.

Introduction to Java: History and evolution of Java, Java vs other popular languages, Java programming environment, fundamental of Java programming language, primitive data types and variables, floating point types, literals, variables, type conversion and casting, arithmetic operators, bit wise operators, relational, Boolean expressions, statements and blocks, control flow statements selection, iteration and jump statements.

ObjectOrientedProgrammingConceptsinJava: Objectsandclasses,declaringobjects,constructors, this keyword, method overloading and constructor overloading, nestedclasses.

Inheritance and Exception Handling: Defining, applying and implementing interfaces; method overriding, super and final keywords, polymorphism, generics, defining, finding and importing packages, exceptions handling with try, catch, throw, throws and finally keywords, wrapper classes.

I/O and Threads: Binary I/O, file handling, thread model, creating a thread, synchronization, inter thread communication, thread lifecycle.

DataStructuresinJava: Arrays,theuseofclassestoencapsulatedatastoragestructuresandtheclass

interface.Searching,insertion,anddeletioninarraysandorderedarrays.Linearsearchingandbinary searching. Simple Sorting: the bubble sort, selection sort, and insertion sort. Stacks and Queues: the stack, queue, and priority queue. Linked Lists: linked lists, including doubly linked lists and double- ended lists. Recursion: Towers of Hanoi puzzle and the mergesort.

Laboratory Work:
Main focus is on implementing basic concepts of object oriented programming and to enhance programming skills to solve specific problems.

Course Learning Outcomes (CLO):
On completion of this course, the students will be able to:
1. comprehend the concepts of Object Oriented Computing inJava.
2. implement decision statements and loopingstatements.
3. grasp the concepts of input and output handling from console andfiles.
4. develop applications to demonstrate use of datastructures.

Text Books:
1. Deitel H. and Deitel P., JAVA - How to Program, Pearson Education(2003).
2. Hortsmann CS., Cornell G., Core Java Volume I-Fundamentals, Prentice Hall,(2012).

3. Data Structures & Algorithms in Java. RobertLafore.

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weight age (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include assignments/quizzes)	40

UTA010: ENGINEERING DESIGN-II

L   T   P   Cr

1   0   2   5.0

Course Objectives: To develop design skills according to a Conceive-Design-Implement-Operate (CDIO) compliant methodology. To apply engineering sciences through learning-by-doing project work. To provide a framework to encourage creativity and innovation. To develop team work and communication skills through group-based activity. To foster self-directed learning and critical evaluation.

To provide a basis for the technical aspects of the project a small number of lectures are incorporated into the module. As the students would have received little in the way of formal engineering instruction at this early stage in the degree course, the level of the lectures is to be introductory with an emphasis on the physical aspects of the subject matter as applied to the 'Mangonel' project. The lecture series include subject areas such as Materials, Structures, Dynamics and Digital Electronics delivered by experts in the field.

This module is delivered using a combination of introductory lectures and participation by the students in 15 "activities". The activities are executed to support the syllabus of the course and might take place in specialised laboratories or on the open ground used for firing the Mangonel. Students work in groups throughout the semester to encourage teamwork, cooperation and to avail of the different skills of its members. In the end the students work in sub-groups to do the Mangonel throwing arm redesign project. They assemble and operate a Mangonel, based on the lectures and tutorials assignments of mechanical engineering they experiment with the working, critically analyse the effect of design changes and implement the final project in a competition. Presentation of the group assembly, redesign and individual reflection of the project is assessed in the end.

Breakup of lecture details to be taken up by med:

Lec no.	Topic	Contents
Lec 1	Introduction	The mangonel project. History. Spreadsheet.
Lec 2	Projectile motion	No drag, design spread sheet simulator for it.
Lec 3	Projectile motion	With drag, design spread sheet simulator for it.
Lec 4	Structures failure	Static loads
Lec 5	Structures failure	Dynamic loads
Lec 6	Redesigning the mangonel	Design constraints and limitations of materials for redesigning the mangonel for competition as a group.
Lec 7	Manufacturing	Manufacturing and assembling the mangonel.
Lec 8	Simulation in engineering design	Simulation as an analysis tool in engineering design.
Lec 9	Role of modelling & prototyping	The role of modelling in engineering design.

Breakup of lecture details to be taken up by ECED:

Lec No.	Topic	Contents
Lec 1-5	Digital Electronics	Prototype, Architecture, Using the Integrated Development Environment (IDE) to Prepare an Arduino Sketch, structuring an Arduino Program, Using Simple Primitive Types (Variables), Simple programming examples. Definition of a sensor and actuator.

Tutorial Assignment / Laboratory Work:
Associated Laboratory/Project Program: T- Mechanical Tutorial, L- Electronics Laboratory, W- Mechanical Workshop of "Mangonel" assembly, redesign, operation and reflection.

Title for the weekly work in 15 weeks	Code
Using a spread sheet to develop a simulator	T1
Dynamics of projectile launched by a Mangonel - No Drag	T2
Dynamics of projectile launched by a Mangonel - With Drag	T3
Design against failure under static actions	T4
Design against failure under dynamic actions	T5
Electronics hardware and Arduino controller	L1
Electronics hardware and Arduino controller	L2
Programming the Arduino Controller	L3
Programming the Arduino Controller	L4
Final project of sensors, electronics hardware and programmed Arduino controller based measurement of angular velocity of the "Mangonel" throwing arm.	L5
Assembly of the Mangonel by group	W1
Assembly of the Mangonel by group	W2
Innovative redesign of the Mangonel and its testing by group	W3
Innovative redesign of the Mangonel and its testing by group	W4
Final inter group competition to assess best redesign and understanding of the "Mangonel".	W5

Project: The Project will facilitate the design, construction and analysis of a "Mangonel". In addition to some introductory lectures, the content of the students' work during the semester will consist of:
1. the assembly of a Mangonel from a Bill Of Materials (BOM), detailed engineering drawings of parts, assembly instructions, and few prefabricated parts ;
2. the development of a software tool to allow the trajectory of a "missile" to be studied as a function of various operating parameters in conditions of no-drag and drag due to air;
   3. a structural analysis of certain key components of the Mangonel for static and dynamic stresses using values of material properties which will be experimentally determined;
   4. the development of a micro-electronic system to allow the angular velocity of the throwing arm to be determined;
   5. testing the Mangonel;

6. redesigning the throwing arm of the Mangonel to optimize for distance without compromising its structural integrity;
7. an inter-group competition at the end of the semester with evaluation of the group redesign strategies.

Course Learning Outcomes (CLO):

Upon completion of this module, students will be able to:

1. simulate trajectories of a mass with and without aerodynamic drag using a spreadsheet based software tool to allow trajectories be optimized;
2. perform a test to acquire an engineering material property of strength in bending and analyze the throwing arm of the "Mangonel" under conditions of static and dynamic loading;
3. develop and test software code to process sensor data;
4. design, construct and test an electronic hardware solution to process sensor data;
5. construct and operate a Roman catapult "Mangonel" using tools, materials and assembly instructions, in a group, for a competition;
6. operate and evaluate the innovative redesign of elements of the "Mangonel" for functional and structural performance;
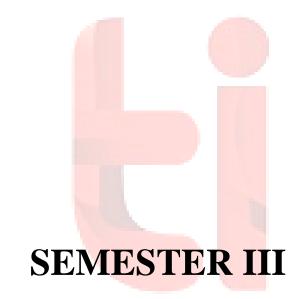
Text Books:

1. *Michael Mc Roberts, Beginning Arduino, Technology in action publications.*
2. *Alan G. Smith, Introduction to Arduino: A piece of cake, Create Space Independent Publishing Platform (2011)*

Reference Book:

1. *John Boxall, Arduino Workshop - A Hands-On Introduction with 65 Projects, No Starch Press (2013)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	-
2	EST	-
3	Sessional: (may include the following) Mechanical Tutorial Assignments	30
	Electronics Hardware and software Practical work in Laboratory	30
	Assessment of Mechanical contents in Lectures and Tutorials and Electronics contents in Lectures and Practical.	10
	Project (Assembly of the "Mangonel", innovative redesign with reflection, prototype competition, Final Presentation and viva-voce	30

SEMESTER III

UES010: SOLID AND STRUCTURES

L T P Cr
3 1 2 4.5

Course Objectives: This subject aims to develop an understanding of the stresses and strains that develop in solid materials when they are subjected to different types of loading and to develop an understanding of the conditions at failure of such materials. Further to this subject aims at to introduce the fundamental concepts of structural mechanics.

Axial Stress and Strain: Concept of stress, strain, elasticity and plasticity; one-dimensional stress-strain relationships; Young's modulus of elasticity, shear modulus and Poisson's ratio; two-dimensional elasticity; isotropic and homogeneous materials; ductile and brittle materials; statically determinate and indeterminate problems, compound and composite bars; thermal stresses. Torsion of shafts; buckling of struts, concept of factor of safety.

Shear Force and Bending Moment Diagrams: Types of load on beams, classification of beams; axial, shear force and bending moment diagrams: simply supported, overhang and cantilever beams subjected to any combination of point loads, uniformly distributed and varying load and moment, equation of condition, load function equation,

Bending & Shear Stresses in beams: Derivation of flexural formula for straight beams, concept of second moment of area, bending stress calculation for beams of simple and built up sections, Flitched beams. Shear stress formula for beams, shear stress distribution in beams

Transformation of Stress and Strain: Transformation equations for plane stress and plane strain, Mohr's stress circle, relation between elastic constants, strain measurements, strain rosettes.

Deformations: Governing differential equation for deflection of straight beams having constant flexural rigidity, double integration and Macaulay's methods for slopes and deflection, unit load method for deflection of trusses

Laboratory Work: The following experiments will be performed in the lab:
1. Calculation of tensile strength
2. Experimental verification of Theory of bending (Calculation of bending stress and deflections at various points in the beam theoretically and verifying the same experimentally) and indirect evaluation of the modulus of elasticity.
3. Torsion: Study the behavior of circular shafts under torsion and analysis of failure and indirect evaluation of the modulus of rigidity.

Experimental project assignment: Students in groups of 4/5 will do a project covering any of the following topics:
1. Tensile strength of bars
2. Flexural strength of beams
3. Torsion of shafts

Course Learning Outcomes (CLO):

After completion of this course, thestudents will be able to:

1. Evaluate axial stresses and strains in various determinate and indeterminate structural systems
2. Draw Shear Force Diagram and Bending Moment Diagram in various kinds of beams subjected to different kinds of load
3. Calculate load carrying capacity of columns and sturts and their buckling strength.
4. Evaluate various kinds of stresses (axial, bending, torsional and shearing) in various structural elements due to different type of external loads.
5. Determine deformations and deflections in various kinds of beams and trusses

Text Books:

1. *Popov, E.P. and Balan, T.A., Engineering Mechanics of Solids, Prentice Hall of India (2012).*
2. *Singh, D.K., Mechanics of Solids, Pearson Education (2008).*

Reference Books:

1. *Shames, I. H. and Pitarresi, J. M., Solid Mechanics, Prentice Hall of India (1996).*
2. *Crandall, S.H., Dahl, N.C. and Lardner, T.J., An Introduction to Mechanics of Solids, McGraw Hill International, Tokyo(1969).*

Evaluation Scheme

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

UES011: THERMO-FLUIDS

	L	T	P	Cr.
	3	1	2	4.5

Course Objective: To understand basic concepts of fluid flow and thermodynamics and their applications in solving engineering problems

Fluid Mechanics

Introduction: Definition of a fluid and its properties

Hydrostatics: Measurement of pressure, thrust on submerged surfaces

Principles of Fluid Motion: Description of fluid flow; continuity equation; Euler and Bernoulli equations; Pitot total head and static tubes, venturi-meter, orifice-meter, rotameter; Momentum equation and its applications

Pipe Flow: Fully developed flow; laminar pipe flow; turbulent pipe flow, major and minor losses; Hydraulic gradient line (HGL) and total energy line (TEL)

Boundary Layer: Boundary layer profile; displacement, momentum and energy thickness

Thermodynamics

Introduction: Properties of matter, the state postulate, energy, processes and thermodynamic systems;

Properties of Pure Substances: property tables, property diagrams, phase change, equations of state (ideal gas);

Energy: Energy transfer by heat, work and mass;

First Law of Thermodynamics: Closed system, open system, steady-flow engineering devices;

Second Law of Thermodynamics: Statements of the Second Law, heat engines, refrigeration devices, reversible versus irreversible processes, the Carnot cycle.

Laboratory/Project programme

List of Experiments

- Verification of Bernoulli's theorem
- Determination of hydrostatic force and its location on a vertically immersed surface
- Determination of friction factor for pipes of different materials
- Determination of loss coefficients for various pipe fittings
- Verification of momentum equation
- Visualization of laminar and turbulent flow, and rotameter
- Calibration of a venturi-meter
- Boundary layer over a flat plate

Sample List of Micro-Projects

Students in a group of 4/5 members will be assigned a micro project.

1. Design a physical system to demonstrate the applicability of Bernoulli's equation
2. Determine the pressure distribution around the airfoil body with the help of wind tunnel
3. Demonstrate the first law of thermodynamics for an open system, for example: a ordinary hair dryer
4. Develop a computer program for solving pipe flow network.

Course Learning Outcomes (CLO):

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

1. Analyze and solve problems of simple fluid based engineering systems including pressures and forces on submerged surfaces
2. Analyze fluid flow problems with the application of the mass, momentum and energy equations
3. Evaluate practical problems associated with pipe flow systems
4. Conceptualize and describe practical flow systems such as boundary layers and their importance in engineering analysis
5. Estimate fluid properties and solve basic problems using property tables, property diagrams and equations of state
6. Analyze and solve problems related to closed systems and steady-flow devices by applying the conservation of energy principle
7. Analyze the second law of thermodynamics for various systems and to evaluate the performance of heat engines, refrigerators and heat pumps.

Textbooks
   1. *Kumar, D. S, Fluid Mechanics and Fluid Power Engineering, S. K. Kataria (2009)*
   2. *Cengel and Boles, Thermodynamics: an Engineering Approach, McGraw-Hill (2011)*

Reference Books
   1. *Jain, A. K., Fluid Mechanics: including Hydraulic Machines, Khanna Publishers (2003)*
   2. *Rao, Y.V. C, An Introduction to Thermodynamics, Universities Press (2004*

Evaluation Scheme

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

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.

Integer Programming: Branch and bound technique.

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

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

Game Theory: Two person zero-sum game, Game with mixed strategies, Graphical method and solution by linear programming.

Course Learning Outcomes (CLO):

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

1) Formulate and solve linear programming problems.
2) solve the transportation and assignment problems
3) solve the Project Management problems using CPM
4) to solve two person zero-sum games

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

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May includeassignments/quizzes)	25

UME306 MECHANICS OF MACHINES

L	**T**	**P**	**Cr**
3	**1**	**2**	**4.5**

Course Objectives: To introduce different types of mechanisms forming different subsystem of machines. To impart the knowledge of vector and matrix methods for position, velocity and acceleration analysis with software tools. To carryout force analysis of engine mechanism analytically. To impart knowledge of force analysis and balancing of rotors. To introduce fundamentals of single degree of freedom vibrating system.

Review of Mechanics: Fundamentals of rigid body mechanics, Newton's laws, D'Alemberts principle, Free body diagrams.

Kinematics of Machines: Introduction to linkages, gears, screws and cam mechanics, belts, rope, and chain drives as subsystems of machines.

Linkage Mechanisms: Links, kinematic pairs, degree of freedom, inversions, mechanisms, transmission angle and mechanical advantage. Vector and matrix methods for position, velocity and acceleration analysis with relevant software tools.

Friction: Screw friction, clutch plate friction and bearings.

Balancing: Balancing of rotating and reciprocating masses, single cylinder and multi-cylinder in-line engines, Field balancing of rotors.

Vibrations: Introduction to free and forced single degree of freedom, undamped and damped vibrations, Equilibrium and energy methods, vibration isolation and transmissibility.

Laboratory Work:
Students shall perform experiments based on
1. Centrifugal force
2. Slider Crank mechanism.
3. Cam and follower mechanism.
4. Balancing of rotating and reciprocating masses
5. Gyroscopic effect

Micro Project: Projects for performing position, velocity and acceleration analysis of mechanisms like 4-bar chain, slider crank chain, quick return mechanism etc. to be undertaken which could be correlated to real life situations.

Experiments to be designed by students:
Students shall design and fabricate experimental set-ups. For example
1. Studying and evaluating the performance parameters of different mechanisms.
2. Studying and evaluating static and dynamic coefficient of friction for different pairs of materials.

Course Learning Outcomes (CLO):

Upon completion of this module, students will be able to:

1. select and analyze a set of mechanisms to achieve desired motion transformation.
2. use analytical methods and software tools for analysis of mechanisms.
3. evaluate and carry out balancing of rotors.
4. determine the unbalance and evaluate the balancing strategies in multi cylinder in-line engines.
5. formulate equations of motion, evaluate the responses of different real life vibration problems and suggest methods for vibration isolation.

Text Books:

1. *J. J. Uicker, G. R. Pennock, and J. E. Shigley, Theory of Machines and Mechanism, Oxford Press (2009).*
2. *Dam B. Marghit, Mechanisms and Robotics analysis with MATLAB, Springer (2009).*
3. *T. Bevan, The Theory of Machines, (Pearson Edu. India) CBS Publishers (1944).*

Reference Books:

1. *A. K. Ghosh and A. K. Mallik, Theory of Mechanisms and Machines, Affiliated East-West press Pvt. Ltd. (1993).*
2. *C. E. Wilson and J. P. Saddler, Kinematics and Dynamics of Machines, Pearson Publishers (2003).*
3. *B. Crossland and I. Morrison, Mechanics of Machines, Longman Publishers (1970).*
4. *J. Hannah and R. C. Stephens, Mechanics of Machines, Elementary Theory and Examples, International Ed (1970).*
5. *S. S. Rattan, Theory of Machines, Tata Mc Graw Hill (2012).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (may include Minor Projects/Including carry home assignments/ Lab Experiments)	40

UTA002 MANUFACTURING PROCESSES

L T P Cr

2 0 3 3.5

Course Objectives: This course introduces the basic concepts of manufacturing via machining, forming, joining, casting and assembly, enabling the students to develop a basic knowledge of the mechanics, operation and limitations of basic machining tools. The course also introduces the concept of metrology and measurement of parts.

Machining Processes: Principles of metal cutting, Cutting tools, Cutting tool materials and applications, Geometry of single point cutting tool, Introduction to multi-point machining processes – milling, drilling and grinding, Tool Life, Introduction to computerized numerical control (CNC) machines, G and M code programming for simple turning and milling operations, introduction of canned cycles.

Metal Casting: Principles of metal casting, Introduction to sand casting, Requisites of a sound casting, Permanent mold casting processes.

Metal Forming: Forging, Rolling, Drawing, Extrusion, Sheet Metal operations.

Joining Processes: Electric arc, Resistance welding, Soldering, Brazing.

Laboratory Work:

Relevant shop floor exercises involving practices in Sand casting, Machining, Welding, Sheet metal fabrication techniques, CNC turning and milling exercises, Experiments on basic engineering metrology and measurements to include measurements for circularity, ovality, linear dimensions, profiles, radius, angular measurements, measurement of threads, surface roughness.

Basic knowledge and derivations related to above measurements, uncertainties, statistical approaches to estimate uncertainties, Line fitting, static and dynamic characteristics of instruments will be discussed in laboratory classes.

Assignments: Assignments for this course will include the topics: Manufacturing of micro-chips used in IT and electronics industry and use of touch screens. Another assignment will be given to practice numerical exercises on topics listed in the syllabus.

Micro Project: Fabrication of multi-operational jobs using the above processes as per requirement by teams consisting of 4-6 members. The use of CNC machines must be part of micro project. Quality check should be using the equipment available in metrology lab.

Course Learning Outcomes (CLO):

Upon completion of this module, students will be able to:

1. analyze various machining processes and calculate relevant quantities such as velocities, forces, powers etc.;
2. suggest appropriate process parameters and tool materials for a range of different operations and workpiece materials;

3. understand the basic mechanics of the chip formation process and how these are related to surface finish and process parameters;

4. recognize cutting tool wear and identify possible causes and solutions;

5. develop simple CNC code, and use it to produce components while working in groups.

6. perform calculations of the more common bulk and sheet forming, casting and welding processes and given a particular component.

7. select the most appropriate manufacturing process to achieve product quality through the efficient use of materials, energy and process.

Text Books:

1. *Degarmo, E. P., Kohser, R. A. and Black, J. T., Materials and Processes in Manufacturing, Prentice Hall of India (2002).*

2. *Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, Pearson Education Asia (2000).*

Reference Books:

1. *Chapman, W. A. J., Workshop Technology, Vol.1 & II, Arnold Publishers (2001).*

2. *Zimmer E. W. and Groover, M. P., Computer Aided Designing and Manufacturing, Prentice Hall of India (2008).*

3. *Pandey, P. C. and Shan, H. S., Modern Machining Processes, Tata McGraw Hill (2004).*

4. *Mishra, P. K., Non-Conventional Machining, Narosa Publications (2006).*

5. *Campbell, J. S., Principles of Manufacturing, Materials and Processes, Tata McGraw Hill Company (1995).*

6. *Lindberg, A. R., Process and Materials of Manufacture, Prentice Hall of India (1998).*

Evaluation Scheme:

Sr. No.	Evaluation elements	Weightage (%)
1	MST	25
2	EST	40
3	Sessional: (may include the following) Assignment, Sessional (includes Regular Lab assessment and Quizzes Project (including report, presentation etc.)	35

UTA019: ENGINEERING DESIGN- III

L T P Cr

1 0 4 6.0

Course Objective: Understanding of Arduino microcontroller architecture and programming, Interfacing of Arduino board with various I/O devices. Serial data transmission using Arduino board. Learning of ARM processor Instruction set and programming concepts.

Arduino Microcontroller: Features of Ardunio Microcontroller, Architecture of Arduino, Different boards of Arduino, Arduino Interfacing and Applications, Anatomy of an Interactive Device like Sensors and Actuators, A to D converters and their comparison, Blinking an LED, LCD Display, Driving a DC and stepper motor, Temperature sensors, Serial Communications, Sending Debug Information from Arduino to Your Computer, Sending Formatted Text and Numeric Data from Arduino, Receiving Serial Data in Arduino, Sending Multiple Text Fields from Arduino in a Single Message, Receiving Multiple Text Fields in a Single Message in Arduino. Light controlling with PWM.

Introduction to ARM Processor: Features of ARM processor, ARM Architecture, Instruction set, ARM Programming

Programming of Arduino: The Code designing step by step. Taking a Variety of Actions Based on a Single Variable, Comparing Character and Numeric Values, Comparing Strings, Performing Logical Comparisons, Performing Bitwise Operations, Combining Operations and Assignment, Using Embedded techniques to program Arduino microcontroller, Understanding the libraries of Arduino programming language and applying for circuit design

TASK 1:
- Introduction to Uno board and interfacing of Uno board with PC and Interfacing of LED and I/O ports of Uno board.
- Interfacing of DC motor with Uno Board, speed and direction control of motors and interfacing of keyboard with Arduino.
- Interfacing of IR Sensor and Ultrasonic sensor with Arduino board on inclined surface.
- Interfacing of Gyro sensor, Accelerometer Sensor and Ultrasonic sensor with Arduino board on inclined surface.
- Control of buggy through Zig-bee transmission and reception using PC.

TASKS 2:
- To make buggy move in circular defined patron at given speed and radius without any sensors through programming only.
- To make buggy intelligent to sense path and follow that path using IR sensor.

- The buggy should able to sense Obstacles in the path and should stop without colliding with the obstacle and able to follow different path by bypassing the obstacle.
- To make buggy climb an inclined path with given speed using accelerometer and gyro sensor and come down on the same inclined surface with given speed.
- Make the buggy's five in number to move front, back, right and left together by taking command from PC through Zig-bee sensor.

Course Learning Outcomes (CLO):

The student should be able to:

1. Apply the engineering process of problem solving.
2. Clearly demonstrate group working, including task sub-division and integration of individual contributions from the team.
3. Develop practical experimental skills in electronic circuit testing.
4. Develop practical experimental skills in software system testing.
5. Recognize issues to be addressed in a combined hardware and software system design.
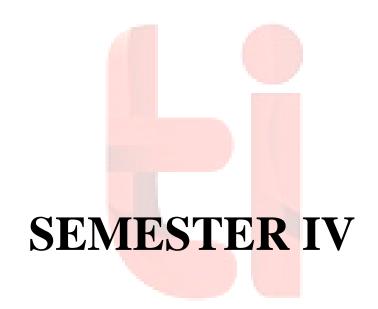6. Implement project tracking and code version control.

Text Books:

1. *Michael McRoberts, Beginning Arduino, Technology in action publications.*
2. *Alan G. Smith, Introduction to Arduino: A piece of cake, Create Space Independent Publishing Platform (2011)*

Reference Book:

1. *John Boxall, Arduino Workshop - A Hands-On Introduction with 65 Projects, No Starch Press; 1 edition (2013).*

SEMESTER IV

UEN002: ENERGY AND ENVIRONMENT

L	T	P	Cr
3	0	0	3.0

Course Objectives:

The exposure to this course would facilitate the students in understanding the terms, definitions and scope of environmental and energy issues pertaining to current global scenario; understanding the value of regional and global natural and energy resources; and emphasize on need for conservation of energy andenvironment.

Environment pollution, global warming and climate change: Air pollution (local, regional and global); Water pollution problems; Land pollution and food chain contaminations; Carbon cycle, greenhouse gases and global warming; Climate change – causes and consequences; Carbon footprint; Management of greenhouse gases at the source and at the sinks

Ecology, Structure and functioning of natural ecosystems: Ecology, ecosystems and their structure, functioning and dynamics; Energy flow in ecosystems; Biogeochemical cycles and climate; Population and communities

Natural resources: Human settlements and resource consumption; Biological, mineral and energy resources; Land, water and air; Natural resources vis-à-vis human resources and technological resources; Concept of sustainability; Sustainable use of naturalresources

Agricultural, industrial systems and environment: Agricultural and industrial systems vis-à- vis natural ecosystems; Agricultural systems, and environment and natural resources; Industrial systems and environment

Energy technologies and environment: Electrical energy and steam energy; Fossil fuels, hydropower and nuclear energy; Solar energy, wind energy and biofuels; Wave, ocean thermal, tidal energy and ocean currents; Geothermal energy; Future energy sources; Hydrogen fuels; Sustainable energy

Group assignments: Assignments related to Sanitary landfill systems; e-waste management; Municipal solidwaste management; Biodiversity and biopiracy; Air pollution control systems; Water treatment systems; Wastewater treatment plants; Solar heating systems; Solar power plants; Thermal power plants; Hydroelectric power plants; Biofuels; Environmental status assessments; Energy status assessments, etc.

Course Learning Outcomes (CLO):

After the completion of this course, the student will be able to -

1. Correlate major local and regional environmental issues with changes in ecology and human health
2. Monitor and document the development and dynamics of ecosystems in experimental or naturalmicrocosms
3. Define and document local resource consumption patterns and conservationstrategies

4. Define opportunities available for energy conservation and for use of renewable energy resources in local and regionalentities.

Text Books:

1. *Bharucha, E., Textbook of Environmental Studies, 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(2006).*
4. *Eastop, T.P. and Croft, D.R. Energy Efficiency for Engineers and Technologists, Longman and Harow(2006)*

Reference Books:

1. *Miller, G.T., Environmental Science- Working with Earth, Thomson(2006).*
2. *Wright, R.T., Environmental Science-Towards a sustainable Future, Prentice Hall (2008) 9^{th}ed.*
3. *O'Callagan, P.W., Energy Management, McGraw Hill Book Co. Ltd.(1993).*

Evaluation Scheme:

S.No	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (Quizzes/assignments/group presentations)	20

UES012:ENGINEERING MATERIALS

L T P Cr
3 1 2 4.5

Course Objectives: The objective of the course is to provide basic understanding of engineering materials, their structure and the influence of structure on mechanical, chemical, electrical and magnetic properties.

Structure of solids: Classification of engineering materials, Structure-property relationship in engineering materials, Crystalline and non-crystalline materials, Miller Indices, Crystal planes and directions, Determination of crystal structure using X-rays, Inorganic solids, Silicate structures and their applications.Defects;Point, line and surface defects.

Mechanical properties of materials: Elastic, Anelastic and Viscoelastic behaviour, Engineering stress and engineering strain relationship, True stress - true strain relationship, review of mechanical properties, Plastic deformation by twinning and slip, Movement of dislocations, Critical shear stress, Strengthening mechanism, and Creep.

Equilibrium diagram: Solids solutions and alloys, Gibbs phase rule, Unary and binary eutecticphase diagram, Examples and applications of phase diagrams like Iron - Iron carbide phase diagram.

Electrical and magnetic materials: Conducting and resister materials, and their engineering application; Semiconducting materials, their properties and applications; Magnetic materials, Soft and hard magnetic materials and applications; Superconductors; Dielectric materials, their properties and applications. Smart materials: Sensors and actuators, piezoelectric, magnetostrictive and electrostrictive materials.

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

Materials selection: Overview of properties of engineering materials, Selection of materials for different engineering applications.

Laboratory Work and Micro-Project:

Note: The micro-project will be assigned to the group(s) of students at the beginning of the semester. Based on the topic of the project the student will perform any of the six experiments from the following list:

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 elastic modulus and ultimate strength of a given fiber strand.
4. To determine the dielectric constant of a PCB laminate.
5. Detection of flaws using ultrasonic flaw detector (UFD).
6. To determine fiber and void fraction of a glass fiber reinforced composite specimen.
7. To investigate creep of a given wire at room temperature.

8. To estimate the Hall coefficient, carrier concentration and mobility in a semiconductorcrystal.
9. To estimate the band-gap energy of a semiconductor using four probe technique.
10. To measure grain size and study the effect of grain size on hardness of the given metallic specimens.

Course Learning Outcomes (CLO):
On completion of the course, the student will be able to:
1. classify engineering materials based on its structure.
2. draw crystallographic planes and directions.
3. distinguish between elastic and plastic behavior of materials.
4. Distinguish between Isomorphous and eutectic phase diagram.
5. classify materials based on their electrical and magnetic properties.
6. propose a solution to prevent corrosion.

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

Reference Books:
1. S. O. Kasap, Principles of Electronic Engineering Materials; Tata Mc-Graw Hill, 2007.
2. L. H. Van Vlack, Elements of Material Science and Engineering; Thomas Press, India, 1998.
3. K. G. Budinski, Engineering Materials – Properties and selection, Prentince Hall India, 1996

Evaluation Scheme

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

UMA007 NUMERICAL ANALYSIS

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 techniques to solve mathematical problems representing various engineering, physical and real life problems.

Floating-Point Numbers: Floating-point representation, rounding, chopping, error analysis, -conditioning and stability.

Non-Linear Equations: Bisection, secant, fixed-point iteration, Newton method for simple and multiple roots, their convergence analysis and order of convergence.

Linear Systems and Eigen-Values: Gauss elimination method using pivoting strategies, LU decomposition, Gauss--Seidel and successive-over-relaxation (SOR) iteration methods and their convergence, ill and well conditioned systems, Rayleigh's power method for eigen-values and eigen-vectors.

Interpolation and Approximations: Finite differences, Newton's forward and backward interpolation, Lagrange and Newton's divided difference interpolation formulas with error analysis, least square approximations.

Numerical Integration: Newton-Cotes quadrature formulae (Trapezoidal and Simpson's rules) and their error analysis, Gauss--Legendre quadrature formulae.

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

Laboratory Work: Lab experiments will be set in consonance with materials covered in the theory. Implementation of numerical techniques using MATLAB.

Course Learning Outcomes (CLO):
Upon completion of this course, the students will be able to**:**
   a. understand the errors, source of error and its effect on any numerical computations and also analysis the efficiency of any numerical algorithms.
   b. learn how to obtain numerical solution of nonlinear equations using bisection, secant, Newton, and fixed-point iteration methods.
   c. solve system of linear equations numerically using direct and iterative methods.
   d. understand how to approximate the functions using interpolating polynomials.
   e. learn how to solve definite integrals and initial value problems numerically.

Texts Books:
   a. *Curtis F. Gerald and Patrick O. Wheatley, Applied Numerical Analysis, Pearson, (2003) 7th Edition,*
   b. *M. K. Jain, S .R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers (2012), 6th edition.*

c. *Steven C. Chappra, Numerical Methods for Engineers, McGraw-Hill Higher Education; 7 edition (1 March 2014)*

References Books:
a. *J. H. Mathew, Numerical Methods for Mathematics, Science and Engineering, Prentice Hall, (1992) 2nd edition,*
b. *Richard L. Burden and J. Douglas Faires, Numerical Analysis, Brooks Cole (2004), 8th edition.*
c. *K. Atkinson and W. Han, Elementary Numerical Analysis, John Willey & Sons (2004), 3rd Edition.*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weight age (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include assignments/quizzes)	15
4.	Laboratory Evaluation	20

UME408 : MACHINE DESIGN - I

L	T	P	Cr
3	2	0	4.0

Course Objectives: Provide students with the ability to apply design procedure with specific design tools representing empirical, semi-empirical and analytical approaches. Using analytical and computer aided design with real world problems.

The detailed design of mechanical systems considers realistic examples from the mechanical laboratories/workshop. Design a mechanical power transmission system given the power to be transmitted, speed ratio, orientation and center distance of the shafts. Design will include:

1. Selection of materials, standard sizes of parts, for all the components.
2. Pulley with belt
3. Flexible Coupling
4. Stepped shaft and keys
5. Ball bearing
6. Gears
7. Threaded fasteners with cover plates
8. Stress concentration under static and fluctuating loading

Failure analysis, factor of safety, types of loading, selection of appropriate materials, lubrication, design for manufacturing, fits and tolerance will also be covered for the use in all the above case based designs.

NB: *Open book test will be conducted and ASTM or equivalent standard will be used.*

Micro Project/ Research Assignment:
The students work in groups to redesign angle cutter/ power tool or other mechanical systems. Project activity include group formation and selection of team leader, communication, dismantling, taking measurements, preparation of questionnaire, feedback from manufacturer/consumer, redesign and reassemble the device/assembly to its original state, computer usage in modelling and drafting and analysis, presentation(at least three in a semester), final technical report and daily diary.

Research assignment will constitute collection of literature required for designing of mechanical drives/system (used in machine tools or automobiles). Design assignment should include problem formulation, material selection, force analysis, designing of components on the basis of stress analysis and production drawings. Use suitable CAD/CAE tools.

Course Learning Outcomes (CLO):

Upon completion of this module, students will be able to:

1. conduct a failure analysis for the design/sizing of mechanical components
2. calculate stresses involved with static/ fatigue loading
3. design and analyze a real engineering system through projects
4. represent machine elements with a free body diagram and solve for unknown reactions
5. select the suitable materials and manufacturing considerations.

Text Books:

1. *Shigley, J., Mechanical Engineering Design, McGraw Hill, New York (2014).*
2. *Bhandari, V. B., Design of Machine Elements, Tata McGraw Hill, New Delhi (2010).*

Reference Books:

1. *Norton, R.L., Machine Design: An Integrated Approach, Pearson Education, New Delhi (2009).*
2. *Juvinall, R. C. and Marshek, K. M., Fundamental of Machine Component Design, John Wiley & Sons, New York (2011).*
3. *Sharma, C. S. and Purohil, K., Design of Machine Elements, Prentice Hall, New Delhi (2009).*
4. *Spotts, M. F. and Shoup, T. E., Design of Machine Elements, Pearson Education, New Delhi (2003).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (may include the following) Assignments/Micro Projects, Presentation, Technical Report	40

UME410 : MECHATRONIC SYSTEMS

L	T	P	Cr
3	0	2	4.0

Course Objectives: The course imparts 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 and 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, sequential controllers.

SISO 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, feedback control.

MIMO Control Systems: Effect of pole-zero cancellations, frequency vs time-domain control, state-space representation, linear transformations in state-space representation, system characteristics from state-space representation, implementation in CST toolbox of MATLAB.

Dynamic Systems Modeling: Equations of motion of mechanical, hydraulic, thermal, electric and pneumatic systems, modeling of motors and generators, solving the dynamic model in MATLAB environment.

Sensors: 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, digital signal, AD and DA conversion, Shannon's sampling theorem,

Electronic Elements in Mechatronic System: Introduction to microprocessors and microcontrollers.

Laboratory Work: Experiments based on Lego kit, Tetrix kit, microcontroller based kits, different sensors, interfacing with PC, modeling and control through servo motors, data acquisition related experiments like Quanser Qube and SRV-02 workstation in MATLAB/Simulink/Labview environment.

Minor Project: Students in a group of 4/5 will carry out minor project on any one of the following topics:

● Assemble a robotic device using LEGO or Tetrix kits using appropriate sensors and actuators, interface with a computer and code the robot to perform various tasks.
● Develop some mechatronics applications using different hardware available like motors, sensors, micro-controllers, pneumatic controls, electro-pneumatic controls and motion controls.
● Develop the dynamic model of a realistic system like inverted pendulum (based on QuanserQube) in frequency-domain and time-domain approach. Learn interfacing of the system with a PC in MATLAB/Simulink/Labview environment and analyze the stability and performance of the system using a data acquisition card
● Derive the transfer function that describes the rotary motion of the rotary servo load shaft (based on Quanser SRV02 Workstation) and develop a feedback controller in Matlab/Simulink/Labview environment to control the position and speed of the rotary servo load shaft.

Course Learning Outcomes (CLOs):
The students will be able to:
1.   calculate the output to input relation of any physical model in the form of a transfer function using block diagram reduction and signal flow graphs.
2.   develop the block diagram of any mechatronic system after analyzing the key inputs, outputs, sensors, transducers and controllers of any physical device.
3.   develop the state-space representation of the physical model and analyze the performance and stability of the system in MATLAB environment.
4.   interface different sensors, actuators, micro-controllers and data acquisition cards of a given mechatronic device to the computer/laptop.
5.   analyze the key features of different type of controllers and develop a suitable controller 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).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional (Including assignments/lab work/project/ quizzes etc.)	30

UME411: COMPUTER AIDED DESIGN AND ANALYSIS   (WITH PROJECT)

	L	T	P	Cr
	3	0	3	8.0

Course Objectives: Introduce components and assemblies used in machines and use of 3D parametric CAD, CAE software for mechanical design. To provide an experiential learning environment using projects done by student groups, while applying CAD, CAE software tools to design mechanisms and structures for mechanical design evaluation, optimization of mass properties, static-stresses, deformations, etc. with experimental validation of simulation models.

Standards, types, applications and working of following components and assemblies:
Machine Components: Screw fasteners, Riveted joints, Keys, Cotters and joints, Shaft couplings, Pipe joints and fittings.
Assemblies: Bearings, Hangers and brackets, Steam and IC engine parts, Valves, Some important machine assemblies.
Mechanical Drawing: Machining and surface finish symbols and tolerances in dimensioning.
CAD: Introduction to CAD, CAM, CAE software in product life cycle.
Geometric Modelling: Parametric sketching and modelling, constrained model dimensioning, Relating dimensions and parameters. Feature and sequence of feature editing. Material addition and removal for extrude, revolve, blend, helical sweep, swept blend, variable section sweep. References and construction features of points, axis, curves, planes, surfaces. Cosmetic features, representation of welded joints, Draft and ribs features, chamfers, rounds, standard holes. Assembly modelling. Automatic production drawing creation and detailing for dimensions, BOM, Ballooning, sectioned views etc.
Productivity Enhancement Tools in CAD Software: Feature patterns, duplication, grouping, suppression. Top-down vs. bottom-up design.
CAE: Part and assembly mass property analysis. Customized analysis features. Sensitivity analysis of dimension and parameters, Automatic feasibility study and shape optimization.
Mechanism Motion Analysis: Kinematic joints used in mechanism assembly. Motion of kinematic chains, Plot coupler curve. Analysis of Mechanisms for interference, position, velocity, acceleration and bearing reactions.
Analysis of Static Stress, Deflection, Temperature etc. using software like 'Pro-Mechanica', 'SolidWorks Simulation' as a black-box. Analysis of mechanical parts and assemblies. Using shells, beams and 2D for Plane strain/ plane stress or axisymmetric simplifications.

Project: Students will undertake projects individually or in groups to study the design of a simple mechanical system, make geometric models of the parts, assembly, evaluate the design and CAD automated drafting of production drawings of the system. CAE analysis will be used to evaluate and redesign the system to optimize it for conditions of use. Testing on a physical prototype to validate the CAE results and a technical report presenting and

discussing the learnings from the project, will be the conclusion of the project. Projects could be mechanisms, simple machines / machine tools, simple products / assemblies, structures studied in course of solids and structures / mechanics of machines, machine design etc.

Course Learning Outcomes (CLO):

The students will be able to:

1. interpret mechanical drawings for components, assemblies and use parametric 3D CAD software tools in the correct manner for creating their geometric part models, assemblies and automated drawings.

2. create assembly of mechanism from schematic or component drawing and conduct position/ path/ kinematic / dynamic analysis of a mechanism in motion using CAD software tools.

3. evaluate design and create an optimized solution using commercial CAD, CAE software as black box for required analysis of mass properties/ stress, deflection / temperature distribution etc. under realistic loading and constraining conditions.

4. Produce design reports for Geometric modelling, Assembly, drawings, analysis, evaluation of results, reflection and suggestions for design evaluation and improvement

Text Books:

1 Singh Ajeet, Machine Drawing, The McGraw-Hill Companies (2010)

2 Kelley David S., Pro/ENGINEER Wildfire #.0 Instructor, Tata McGraw Hill (2011). Or of latest software release used in laboratory.

3 Shih Randy H., Introduction to Finite Element Analysis Using Creo Simulate #.0, SDC Publications, USA (ISBN: 978-1-58503-670-7, ISBN (Book + Software on Disk): 978-1-58503-731-5 (2011). Or of latest software release used in laboratory.

Reference Books:

1 Gill, P.S., Machine Drawing, S.K.Kataria and Sons (2013).

2 Dhawan, R.K., Machine Drawing, S.Chand& Company Limited (2011).

3 Shyam Tikku and Prabhakar Singh, Pro/ENGINEER (Creo Parametric #.0) for Engineers and Designers, Dreamtech press (2013). Or of latest software release used in laboratory.

4 Toogood Roger Ph.D., P. Eng., Zecher Jack P.E., Creo Parametric #.0 Tutorial and MultiMedia DVD, SDC Publications, USA (2012), ISBN: 978-1-58503-692-9, ISBN (Book + Software on Disk): 978-1-58503-730-8. Or of latest software release used in laboratory.

5 Shih Randy H., Parametric Modeling with Creo Parametric #.0-An Introduction to Creo Parametric #.0, SDC Publications, USA (2011) ISBN: 978-1-58503-661-5, ISBN (Book + Software on Disk): 978-1-58503-729-2. Or of latest software release used in laboratory.

6 Guide books in software help and online books at ptc.com

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	Sessional tests / assignments on software	30
2	Projects on modeling, assembly, drawing, Analysis of mass properties, stress, deflection, temperature, kinematics, dynamics etc. as relevant to the project. With Technical Reports of each.	70

NB: Tests and projects on software will be open book examination.

SEMESTER-V

UME404: MECHANICS OF DEFORMABLE BODIES

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective for this course is to develop the basic skills and knowledge required to analyze displacement field, stress, strain and failure in deformable solids using analytical solutions. This course also introduces an overview of important structural engineering design philosophies. This understanding will include concepts such as curved beam, unsymmetrical bending, helical spring, pressure vessel etc.

Three-Dimensional Stress Analysis: Stresses on an arbitrary plane, principal stresses and stress invariant, 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, fictitious load method, statically indeterminate problems.

Brief introduction of Unsymmetrical Bending, Curved Flexural Members, Thick Cylinders and Rotating Discs and Helical Springs.

Theories of Elastic Failure: Various theories of failure, significance and applications.

Research Assignment:

Research assignment will constitute collection of literature, problem formulation required for failure analysis of different mechanical components, stress distribution for pressure vessels used for boilers, model a beam, pressure vessel, explosion of a pipeline, torsion spring, automobile suspension, tail pipe support etc. Analytical vs. FEA comparison exercises using MATLAB for coding and result display. This assignment also includes technical report writing and seminar presentation.

Course Learning Outcomes (CLOs):

The students will be able to:

1. calculate the state of stress at the critical point of the object.
2. analyze the failure analysis under static loading in ductile and brittle materials using different theories of failures.
3. calculate deflection at any point on a solid structure using Castigliano's theorems.
4. determine the distribution of circumferential and radial stress along the thickness of thick cylinders.
5. model real structures using fundamental component analysis.
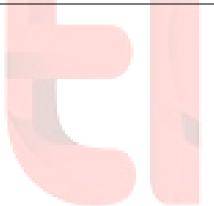6. use contemporary s/w tools of MATLAB and FEA commercial packages for solving and displaying results.

Text Books

1   Srinath, L.S., Advanced Mechanics of Solids, Tata Mc-Graw Hill (2005).

2   Popov, E.P., Engineering Mechanics of Solids, Prentice Hall of India (2006).

3   Boresi,A.P. and Schmidt, R.J. Advanced Mechanics of Materials, Wiley (2002).

Reference Books

1   Shames, I.H., Mechanics of Deformable Solids, Prentice Hall of India (2000).

2   Kumar K. and Ghai, R. C., Advanced Mechanics of Materials, Khanna Publishers (1986).

3   Ryder, G.H., Strength of Materials, B.I. Publishers (2005).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Minor Project/Tutorials/Quizes)	25

UME501: APPLIED THERMODYNAMICS

	L	T	P	Cr
	3	1	2	4.5

Course Objectives: This course introduces the principles of the conversion of fossil fuel energy to useful power, concept of Rankine cycle, heat balance sheet and draught system of the boiler. This course also introduces fundamental thermodynamic operating principles, phenomena of I.C. engines and performance parameters of I.C. engines.

Vapour Power Cycles: Rankine cycle and modified Rankine cycle, reheat, regenerative and binary cycles, types of fuels, combustion stoichiometry, minimum air, excess air, heating values of fuels, boiler performance, equivalent evaporation, boiler efficiency and heat balance sheet of boiler

Jet Propulsion: Simple Brayton cycle, principle of propulsion, jet engines and their classification, thrust work, thrust power, propulsion efficiency and overall thermal efficiency.

I.C. Engines: Introduction, classification and application, combustion in S.I. engine, flame propagation, pre-ignition, detonation, engine variables effects, mixture requirements, fuel rating, fuel supply systems, combustion in C.I. engine, delay period, knocking, engine variables effects, fuel requirements, 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 S.I. and C.I. engines, supercharged and turbocharged engines.

Laboratory Work: Assembly of petrol and diesel engine components, study of design parameters of petrol and diesel engine, study of performance of petrol and diesel engines (Kirloskar diesel engine, Rusten diesel engine, Krimo oil engine, VCR engine, dual fuel engine, MORSE test.)

Micro Project: Students in a group of 4/5 will carry out micro project on preparation of heat balance sheet of fossil fuel based power plant/ I.C. engine (petrol, diesel and dual fuel engine) **(10% weightage of total marks shall be given to this micro project)**

Course Learning Outcomes (CLOs):
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. analyze simple Brayton cycle and determine the performance parameters of jet engine.
3. draw heat balance sheet of a boiler.
4. determine the performance parameters of I.C. engines in an engine test rig.
5. derive and analyze Otto, Diesel and Dual cycle air standard thermal efficiencies.

Text Books

1   Pulkrabek, W. W., Engineering Fundamentals of Internal Combustion Engines, Pearson education Asia, New Delhi (2007).

2   Yadav, R., Steam & Gas Turbines and Power Plant Engineering, Central Publishing House, Allahabad (2000)

Reference Books

1   Heywoold, 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).

6   Vasandani, V. P. and Kumar, D. S., Heat Engineering, Metropolitan Book Company, New Delhi (2003).

Evaluation Scheme:

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

UME505 : MANUFACTURING TECHNOLOGY

L	T	P	Cr
3	0	3	4.5

Course objective: The objective of this course is to introduce to the students different modes of solidification in metal casting and design of gating, riser system required for casting. The students will understand the principles of the metal cutting in single and multi-point cutting, estimating the cutting force and power requirements. The students will also understand the principle of different arc and gas welding process and know the utilization of heat during welding. The students will study bulk metal forming and sheet metal shearing operations and calculate the force, power requirements during different forming processes. Further the students will also study different manufacturing processes for plastics and ceramics.

Metal Casting: Review of sand casting, sand testing, inspection of castings, casting defects; investment casting; die casting; centrifugal casting, machine moulding, Shell moulding; cupola, charge estimating
Welding: Review of welding processes, weldability and heat balance in welding, principles and application of TIG and MIG welding, friction and inertia welding, welding defects.
Metal Cutting: Principles of orthogonal and oblique cutting, shear angle relationships, Machinability, factors affecting machinability; Milling, milling cutters and milling machines. Grinding, grinding wheel selection, surface grinding, centerless grinding.
Metal Forming: Hot and cold forming, forming processes, forging machines, forging design considerations, forging defects; High energy rate forming processes.
Manufacturing of plastics & ceramics: Basic manufacturing processes for processing of plastics & ceramics. Powder Metallurgy; Additive Manufacturing.

Laboratory Work: Experimental work pertaining to study & use of sand testing equipment, Performance in foundry shop for hollow casting, Experiment on die-casting, performance on MIG welding, TIG welding & resistance welding, exercises on horizontal & vertical milling machines, planer, shaper, centerless & surface grinders, profile cutting in vertical milling machine; experiment on blow molding.
Micro Project: Students in a group of 4/5 will carry out micro project on fabrication of a multi-operation job that includes machining, forming, casting and joining of dissimilar metals.

Course Learning Outcomes (CLOs):
The student will be able to:
1. decide suitable casting technique for a particular application based on the differentiation in process salient features, evaluate the molding sand property for sand casting process.
2. design the gating and riser system for the casting process and calculate the charge constituents in liquid metal
3. determine the welding machine characteristics, calculate heat balance, estimate the size of weld and decide suitable welding technique for different applications.

4. calculate the shear angle, strain, strain rate, velocities during metal cutting and estimate the cutting force, power during single and multipoint cutting operations.
5. calculate the force and power requirements during different bulk metal forming processes estimate the die or punch size for a suitable sheet metal shearing operation.

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   Champbell, J.S., Principle of Material and Process, Tata Mc-Graw Hill, New Delhi (1995).
2   Ostwald, J.M., Manufacturing Processes & systems, John Wiley & Sons (Asia) Pvt Ltd, Singapore (2007).
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).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessional (Lab Assignments/Quizzes/Project)	35

UME513 : DYNAMICS AND VIBRATIONS

	L	T	P	Cr
	3	1	2	4.5

Course Objectives: This course deals with the dynamics of various physical systems like flywheels, governors, gyroscopes etc. In continuation to the topics covered in Mechanics of Machines, this course reviews the detailed concepts of single-DOF vibrating systems. Moreover, the aim of this course is to model and analyze two- and multi-DOFs systems with their applications in the real world

Dynamics: Equivalent dynamical systems, Dynamic force analysis in engines.

Flywheel and Governors: Turning moment diagram of the engines, Flywheel design, Types of governors and their applications.

Motion transmission devices: Belt drives, Rope drives, Spur gear, Interference in gears, Gear trains.

Gyroscopes: gyroscopic action in automobiles, gyroscopes and their role in stabilization in ships, and airplanes.

Vibrations:

Single-DOF Systems: Free, forced, undamped and damped systems. Logarithmic decrement, Equivalent viscous and Coulomb damping, support excitation and vibrations due to unbalanced mass, vibration absorbers.

Two Degree of Freedom Systems: Free and Forced vibrations with and without damping, Principal and normal modes, coupling of modes.

Multi Degree of Freedom Systems: Various methods of analysis of multi degree freedom systems, numerical methods, Lagrange's equations, Application to torsional vibrations, Modal Analysis and its applications to realistic problems.

Laboratory Work:
Basic knowledge and experiments related to simple pendulum, compound pendulum, damping coefficient, critical speed, balancing of rotors.

Research Assignment: Group assignment for this course may include one of the following topics:
1. Natural frequencies of physical systems
2. Modal analysis of realistic systems
3. Suspension systems of vehicles
4. Vibration isolation of machines
5. Gyroscopic effect in aero planes and ships

Micro Project: Group project for this course may include one of the following topics:
1. Determine the natural frequencies of physical systems like, suspension system, bridge etc. (both using analytical and numerical approach)
2. Calculate the mode shapes and perform modal analysis analytically and validate the results obtained using commercial packages.

1. Determination of damping value experimentally using logarithmic decrement method and validate theoretically.
2. Develop simple 1-2 DOF system like inverted pendulum, measure the system response and relate to theoretical concepts for validation.

Course Learning Outcomes (CLOs):

The students will be able to:

1. apply engineering principle of mechanics to design motion transmission devices and flywheels.
2. determine the appropriate parameters for stability of a vehicle using the concept of gyroscopic action.
3. derive the dynamic model of real-life problems and verify the natural frequencies and mode shapes.
4. analyze two- and multi-DOF physical systems analytically and validate using a commercial package

Text Books:

1   J. J. Uicker, G. R. Pennock, and J. E. Shigley, Theory of Machines and Mechanism, Oxford Press[2009]

2   Grover, G. K., Mechanical Vibrations, Nem Chand and Bros, Roorkee (1996).
Ambekar, A. G., Mechanical Vibrations and Noise Engineering, Prentice Hall of India, New Delhi (2006).

Reference Books:

1   A. K. Ghosh and A. K. Mallik, Theory of Mechanisms and Machines, Affiliated East-West press Pvt. Ltd. [1993]

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

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

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

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessionals (Minor Project/Tutorials/Quizes)	30

UME515: INDUSTRIAL ENGINEERING

L	T	P	Cr
2	1	0	2.5

Course Objectives: This course introduces the concept, tools, and techniques of industrial engineering viz. control charts, acceptance sampling, concepts of line balancing, work measurement, and production management etc., to enable the students to develop knowledge and skills in using and integrating these tools.

Introduction: Introduction to industrial engineering, significance of system's approach in applying industrial engineering in the industry.

Productivity Management: Productivity measurement and improvement, resource waste minimization.

Plant Location & Layout: Factors affecting plant location, Selection of plant site, Quantitative techniques of plant location decision, Plant layout, Principles of layout design, Evaluation of a layout, Line balancing technique for product layout.

Quality Engineering: Variation and its types, essential dimensions of quality, seven quality tools, quality system economics, statistical quality control, applications of control charts for variables and attributes, process capability analysis, introduction to six sigma, acceptance sampling.

Production/ Operations Management: Demand forecasting, aggregate planning, master production scheduling, type of inventories, inventory costs, inventory control models, EOQ (under deterministic conditions), ERL, materials requirements planning, JIT, SMED, kaizen, poka-yoke.

Work Study: Purpose and scope, method study and work measurement, principles of motion economy, principle of work sampling, MOST etc.

Ergonomics: Role of ergonomics in industry, introduction to anthropometry, posture analysis, effect of physical environment on performance.

Micro Projects: Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a micro project in the field of industrial engineering. Students will be assigned projects in the areas of facilities design, work study, quality, ergonomics etc. Each group will be required to submit a report (and presentation).

Course Learning Outcomes (CLOs):
The students will be able to:
1. analyze lacunae in existing layout of a shop floor in manufacturing and service organizations and develop an improved plant layout.
2. apply quality engineering tools for process control and improvement.
3. develop a production schedule using information/ data from different functional areas.
4. determine the optimum time standards using work study principles and human factors in engineering.

Text Books:

1   Monks, J. G., Production/Operations Management, McGraw Hill (2004).

2. Shankar, R., Industrial Engineering and Management, Galgotia Publications (2012).

Reference Books:

1.   Grant, E.L., Statistical Quality Control, McGraw Hill (2008).

2.   Sanders, M. and McCormick, E., Human factors in Engineering, McGraw Hill (1993).

3.   Montegomery, D.C., Introduction to Statistical Quality Control, Wiley (2005).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include Assignments/Tutorials/Quizzes)	25

UTA012: INNOVATION AND ENTREPRENEURSHIP

L T P Cr
1 0 2* 4.5
[*] 2 hours every alternate week.
5– Self Effort Hours.

Course Objectives: This course aims to provide the students with a basic understanding in the field of entrepreneurship, entrepreneurial perspectives, concepts and frameworks useful for analysing entrepreneurial opportunities, understanding eco-system stakeholders and comprehending entrepreneurial decision making. It also intends to build competence with respect business model canvas and build understanding with respect to the domain of startup venture finance.

Introduction to Entrepreneurship: Entrepreneurs; entrepreneurial personality and intentions - characteristics, traits and behavioural; entrepreneurial challenges.

Entrepreneurial Opportunities: Opportunities- discovery/ creation, Pattern identification and recognition for venture creation: prototype and exemplar model, reverse engineering.

Entrepreneurial Process and Decision Making: Entrepreneurial ecosystem , Ideation, development and exploitation of opportunities; Negotiation, decision making process and approaches**,** - Effectuation and Causation.

Crafting business models and Lean Start-ups: Introduction to business models; Creating value propositions - conventional industry logic, value innovation logic; customer focused innovation; building and analysing business models; Business model canvas , Introduction to lean startups, BusinessPitching.

Organizing Business and Entrepreneurial Finance: Forms of business organizations; organizational structures; Evolution of organisation, sources and selection of venture finance options and its managerial implications.Policy Initiatives and focus; role of institutions in promoting entrepreneurship.

Course learning outcome (CLO):
Upon successful completion of the course, the students should be able to:

1. Define the fundamentals of entrepreneurship
2. Explain the role of entrepreneurial process and entrepreneurial decision making.
3. Describe various Business Models and design a business model canvas.
4. Evaluate various forms of Enterprises and sources of raising finance for start-up ventures.
5. Articulate the latest developments and challenges in the entrepreneurship domain in India

Text Books:

1. *Ries, Eric(2011), The lean Start-up: How constant innovation creates radically successful businesses, Penguin Books Limited.*
2. *Blank, Steve (2013), The Startup Owner's Manual: The Step by Step Guide for Building a Great Company, K&S Ranch.*
3. *S. Carter and D. Jones-Evans, Enterprise and small business- Principal Practice and Policy, Pearson Education (2006)*

Reference Books:

1. *T. H. Byers, R. C. Dorf, A. Nelson, Technology Ventures: From Idea to Enterprise, McGraw Hill (2013)*
2. *Osterwalder, Alex and Pigneur, Yves (2010) Business Model Generation.*
3. *Kachru, Upendra, India Land of a Billion Entrepreneurs, Pearson*
4. *Bagchi, Subroto, (2008), Go Kiss the World: Life Lessons For the Young Professional, Portfolio Penguin*
5. *Bagchi, Subroto, (2012). MBA At 16: A Teenager's Guide to Business, Penguin Books*
6. *Bansal, Rashmi, Stay Hungry Stay Foolish, CIIE, IIM Ahmedabad*
7. *Bansal, Rashmi, (2013). Follow Every Rainbow, Westland.*
8. *Mitra, Sramana (2008), Entrepreneur Journeys (Volume 1), Booksurge Publishing*
9. *Abrams, R. (2006). Six-week Start-up, Prentice-Hall of India.*
10. *Verstraete, T. and Laffitte, E.J. (2011). A Business Model of Entrepreneurship, Edward Elgar Publishing.*
11. *Johnson, Steven (2011). Where Good Ideas comes from, Penguin Books Limited.*
12. *Gabor, Michael E. (2013), Awakening the Entrepreneur Within, Primento.*
13. *Guillebeau, Chris (2012), The $100 startup: Fire your Boss, Do what you love and work better to live more, Pan Macmillan*
14. *Kelley, Tom (2011),The ten faces of innovation, Currency Doubleday*
15. *Prasad, Rohit (2013), Start-up sutra: what the angels won't tell you about business and life, Hachette India.*

SEMESTER-VI

UME697: GROUP PROJECT

L   T   P   Cr
-   -   -   13.0

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.

Scope of work:

For this course groups of the students shall be formulated with one student acting as group leader and students shall be encouraged for self-learning. During this project work students are expected to identify the problem of their choice through interactions with industry, R&D labs and other reputed institutions. Subsequently, each group shall make presentation of their effort of problem formulation in fourth-fifth week of the semester followed by completion of project work. Apart from this each group shall be making periodic presentation during 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 (CLOs):
The students will be able to:
1. identify a problem based on the need analysis of community /industry/ research.
2. create a flowchart of methodology for solving the identified problem
3. demonstrate team work with work division, team meetings and communications among team members.
4. write technical report for the project work and present the same through power point presentations or posters.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	Regular Evaluations	30
2.	Final Evaluation- Presentation and Report, Daily diary	70

UME605: RAPID PROTOTYPING

L	T	P	Cr
2	1	2	3.5

Course objectives: This course introduces the basic fundamentals of rapid prototyping, its fabrication methodology, different techniques of part fabrication, materials and various areas of defects and improvements in RP. The course also introduces the concept of reverse engineering.

Introduction: Classification of manufacturing processes, Introduction to rapid prototyping (RP), Basic Principles of RP, Steps in RP, Advantages of RP.

Classifications of Different RP Techniques: Based on raw material, Based on layering technique and energy sources.

Design of CAD Models for RP: Transformations, Curves, Surface Modeling, Solid modeling for RP.

Process Technology in RP: Stereo-lithography (SL), Selective laser sintering, Ballistic particle manufacturing, Fused deposition modeling, Laminated object manufacturing, Solid ground curing, Beam inference solidification, Laser engineered net shaping (LENS), 3D Printing.

STL files for RP: STL file generation, Defects in STL files and repairing algorithms, other Interface formats.

Research Areas in RP: Study of Slicing methods & design of support structures, Part deposition orientation studies, study of shrinkage compensation and accuracy.

Reverse Engineering: Introduction to reverse engineering and its integration with rapid prototyping

Laboratory Work:
1. To generate Solid Models with the given dimensions using s/w like Pro-E or SolidWorks.
2. To fabricate a prototype in RP Facility after removing STL file defects.
3. To estimate the surface roughness and shrinkage of the developed prototype.
4. To generate MATLAB codes for the slicing, transformations and surfaces involved in Rapid Prototyping.
5. The students will be doing a project realizing the application of RP technology for product development.

Course Learning Outcomes (CLO):

On completion of this course the student will be able to

1. Develop physical prototype applying the fundamental concepts of rapid prototyping.
2. Develop a solid model applying the concepts of transformations & solid modelling.
3. Analyze different rapid prototyping systems based on their principles of operation and materials used.
4. Analyze & detect the errors in STL files and implement the repair algorithms associated with the errors.
5. Calculate layer thickness, orientation and shrinkage compensation in different layering techniques.

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. *Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New Dehi, 2005.*

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, iSmithersRapra Publishing, 2000.*
3. *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.*
4. *Zeid, I., Mastering CAD/CAM, Tata McCraw Hill, 2006.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessional (Assignments/Quizzes/Presentations)	35

<div align="center">**UME833 INSPECTION AND QUALITY CONTROL**</div>

	L	**T**	**P**	**Cr**
	3	**1**	**0**	**3.5**

Course Objectives: This course enables the students to understand the organization and procedures for industrial inspection. It helps in developing an understanding with regards to the basic concepts/ tools of quality engineering. The course helps to study the development, operational procedure, and applications of control charts to signify their role in quality control. The course enables the students to study, design and use acceptance sampling plans. The course introduces the concept of process capability analysis to gage process performance.

Industrial Inspection: 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, control chart for variables ($\overline{X} - R, \overline{X} - S$ charts etc.), control charts for attributes, (p, c charts etc.), acceptance sampling.

Process Capability Analysis: Need and significance, process capability for variable data, process capability indices (c_p, c_{pk}, $c_{pm \; etc.}$), interpreting the indices, use of process capability data.

Process Improvement: Quality improvement process, quality tools for process improvement viz. Pareto charts, C & E analysis, scatter diagrams etc.

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

Research Assignments: Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic in the field of inspection and quality control. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, major findings and gaps in the existing literature. The topics may include review of latest trends in procedures for industrial inspection, special control charts for variables and attributes, designing for six sigma processes, latest research in field of acceptance sampling etc.

Course Learning Outcomes (CLOs):
The students will be able to:
1. identify and analyze the functions and organization of industrial inspection.
2. apply and analyze the seven Ishikawa's tools and conduct quality cost analysis.
3. analyze various control charts for quality control of the different production processes

4. evaluate through process capability studies if a given process is proficient in meeting customer's specifications

Text Books

1   Juran, J.M. and Gryna, F.M, Quality Planning & Analysis, McGraw Hill (2001).
2   Gupta, I. C., Engineering Metrology, Dhanpat Rai and Sons, New Delhi (2007).

Reference Books

1   Grant, E.L., Statistical Quality Control, McGraw Hill (2008).
2   Feignbaum, A.V., Total Quality Control, McGraw Hill (1991).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May include Assignments/Tutorials/Quizzes)	25

SEMESTER-VII

UME711 : MACHINE DESIGN – II

L	T	P	CR
3	1	0	3.5

Course objectives: The objective for this course is to apply design procedure of the machine elements using analytical approach and mechanical engineering design theory to identify machine elements in the design of commonly used mechanical systems. The course also introduces the concept of computer based techniques in the analysis, design and/or selection of machine components.

The detailed design of mechanical systems based on realistic examples will be followed in understanding the design philosophy, design concepts, load distribution, and performing design calculations of different sub systems of transmission and braking system of an automobile. The subsystems of components such as clutch, gearbox, universal joints, propeller shafts, differential gearbox, axle, bearings, brakes, springs etc would be covered. Material selections, failure analysis, factor of safety, lubrication, fits and tolerance aspects will also be covered in all the above case based designs. Use of ASTM or equivalent standards.
NB: *Open book test will be conducted.*

Research Assignment:
Research assignment will constitute collection of literature, problem formulation required for design consideration of automotive sub systems using FEA. This assignment will also include technical report writing and seminar presentation.

Course Learning Outcomes (CLOs):
The students will be able to:
1. select the suitable materials and manufacturing considerations.
2. determine suitable module and specifications of gears from strength and wear considerations.
3. apply different theories for designing friction clutches and brakes.
4. select bearings for a given load carrying capacity.
5. design and analyze real engineering systems through research assignments.

Text Books:
1 *Shigley, J., Mechanical Engineering Design, McGraw Hill, New York (2014),10th edition*
2 *Bhandari, V. B., Design of Machine Elements, Tata McGraw Hill, New Delhi (2010), 3rd edition*

Reference Books:
1 *Norton, R.L., Machine Design: An Integrated Approach, Pearson Education, New Delhi (2009), 3rd edition*
2 *Juvinall, R. C. and Marshek, K. M., Fundamental of Machine Component Design, John Wiley & Sons, New York (2011), 5th edition*

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

4   Logan D., A First Course in the Finite Element Method, SI Version, Cengage Learning (2011)

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments, Presentation, Technical Report)	25

<center>**UME502 : AUTOMOBILE ENGINEERING**</center>

	L	T	P	CR
	3	0	2	4.0

Course Objectives: To deliver basic knowledge of different components of automobiles and expose the students with performance parameters of a vehicle. Course provides the learning of design procedure of various components and factors affecting operation of vehicle on road. Objective also involves the enhancement of fault diagnosis and troubleshooting capabilities.

Introduction: Conventional motor vehicle, vehicle classification, frame and frameless construction, vehicle dimensions, power requirements, vehicle performance, gear ratio for maximum acceleration, stability of vehicles.

Clutch and Transmission: Clutch Fundamentals, Different type of clutches, Torque transmitted through clutch, Energy lost during engagement, Energy dissipated due to clutch slippage, requirements for manual and automatic transmission, their type and constructional detail.

Steering and Suspension: Steering mechanisms and steering system including power steering, turning radius calculation, Steering gear ratio, Forward and reverse efficiency of steering gear, Inertia torque effecting steering, suspension principle, rigid axle suspension and independent suspension, Mechanics of an independent suspension system.

Drive Line: Introduction to driveline components, Critical speed of Propeller shaft, speed variations of Hooke Joint, differential gear ratio.

Braking System: Introduction to braking system and their types, Stopping distance, Work done in braking and braking efficiency, ABS.

Wheel and Tyres: Disc pressed wheels, static and dynamic balancing of wheels, types and manufacturing, tubed and tubeless tyres, radial tyres , tyre specifications and coding.

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.

Trends in automobile sector: Hybrid, solar powered vehicles.

Trouble shooting in above modules.

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 differential, axles, study of propeller shaft, universal joints and slip joint, study of catalytic convertor; Practical determination of the gearbox and rear axle ratios of a vehicle without dismantling any of these, Visit to automobile service station for troubleshooting exercises; Group assignments on above topics.

Research Assignments:

● investigate different problems related to the design and functioning of engine performance through case studies at service station and find the corrective action.
● fault diagnosis of clutch and transmission assembly through real case studies of passenger vehicles.
● critically evaluate the performance of vehicle steering mechanism and its effect on turning radius, vehicle suspension and tyre wear through real case studies at vehicle service stations.
● prepare a technical report on the recent trends in automotive electronics and hybrid technologies used in the passenger vehicles.

(10% weightage of total marks shall be given to this assignment.

Course Learning Outcomes (CLOs):

The students will be able to:

1. evaluate the power requirement of a vehicle under different operating conditions.
2. calculate the energy losses and define the design parameters in different vehicle components
3. solve the technical issues related to vehicle design and malfunctioning of different components through fault-diagnosis and troubleshooting exercises of real case studies performed at the vehicle service stations.

Text Books:

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

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).

Evaluation Scheme:

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

UME712: HEAT TRANSFER

L	T	P	Cr
3	1	2	4.5

Course objective: To impart knowledge on the principles of heat transfer through conduction, convection and radiation modes. To impart knowledge on heat transfer during phase-change processes, such as boiling and condensation. To impart knowledge on the practical aspects of the theories of heat transfer, such as design of heat exchangers. To enable students carry out laboratory tests verifying the various principles of heat transfer.

Conduction: Fourier's law, conduction equation, thermal resistance, critical radius of insulation, conduction with heat generation, unsteady state flow

Forced Convection Fundamentals: Velocity and thermal boundary layers and governing equations, dimensional analysis for convection, Reynolds analogy

Forced Convection for External Flows: Laminar, turbulent and separated flows; flat plates, cylinders in cross flow, tube arrays

Forced Convection for Internal Flows: Entrance region and fully developed flow, laminar and turbulent flows in pipes and ducts

Free Convection: Principles, governing equations, dimensional analysis, correlations

Boiling and Condensation: Modes of boiling, mechanisms of condensation, correlations

Heat Exchanger Performance and Design: Heat exchanger types, overall heat transfer coefficient, log mean temperature difference, effectiveness, methodology for design

Radiation: Fundamental concepts and definitions, radiation exchange between surfaces

Laboratory Work:

Laboratory work will include determination of thermal conductivity and thermal resistance of solids and fluids, heat transfer coefficients for different cases of forced and natural convections, emissivity for thermal radiation, LMTD for heat exchangers.

Assignment

Students in groups of 3 to 4 will select any topic of their choice within the broad boundaries of the course related. The students need to review the existing design of any heat transfer equipment/process, analyze and propose possible improvements. Deliverables are report/presentation/Journal or Conference paper/poster presentation, short video film etc (any optional mode).

Course Learning Outcomes (CLOs):

The students will be able to:

1. apply the principles of conduction, convention and radiation mode of heat transfer to solve heat transfer problems.
2. design a heat exchanger through analysis of the thermal performance of heat exchangers and recognize and evaluate the conflicting requirements of heat transfer optimization and pressure drop minimization.

3. calibrate equipment, acquire, tabulate and analyze useful data in the laboratory, checks for repeatability and reproducibility.
4. assess thermal systems and develop conceptual designs of improved systems

Text Books:

1 Cengel, Y., Heat Transfer - A practical approach, Tata McGrawHill, New Delhi (2007)
2 Incropera, F.P. and DeWitt, D.P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, Singapore (2006)

Reference Book:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	20
2.	EST	40
3.	Sessionals	40

UME713 : FLUID MECHANICS AND MACHINERY

L	T	P	Cr
3	1	2	4.5

Course Objectives: Students will expose to the basic fundamentals of momentum equation, basics theory of fluid dynamics, Euler's equation for energy transfer, impact of jets. To study the working principle of the hydropower plant, hydro turbine component, basic working principle of pump, centrifugal pumps, design parameters of the centrifugal pump, reciprocating pump, indicator diagram.

Fluid Dynamics: Fluid Kinetics, Buckingham's Pi method, similarity relation, Stream function and velocity potential functions for standard flow patterns uniform flow, source/sink, doublet and free vortex ; combination of uniform flow with certain flows to obtain flow patterns of various shapes such as flow past a half body, a cylinder,

Viscous Flow: Momentum Equation, Navier Stokes Equation and its derivation, Aerofoil theory, Lift and Drag.

Hydraulic Turbines: Principles of Hydraulic machines, Impulse momentum equation, Euler's equation for energy transfer, Impact of jets.

hydropower plant, Classification, head losses and efficiencies, various elements, impulse and reaction turbines, components, selection of design parameters, size calculations, work, efficiency, governing, , specific speed, cavitation.

Hydraulic Pumps: classification, selection, installation, centrifugal pumps, head, vane shape, pressure rise, velocity vector diagrams, work, efficiency, design parameters, multi staging, operation in series and parallel, NPSH, specific speed. submersible pumps, axial flow pump

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

Laboratory Work: Performance of Pelton Wheels, Francis turbine, Kaplan turbine, Centrifugal pump, Reciprocating pump, Hydraulic Ram, Study of Hydraulic pump models. Simulation of flow in pipe, bend and pump using CFD software ANSYSY FLUENT

Research Assignment:

Research assignment given to the students in group related to flow simulation in pipe, nozzle, diffuser etc using ANSYS FLUENT CFD tool.

Course Learning Outcomes (CLOs):

The students will be able to:

1. develop dimensionless groups using Buckingham's Pi method
2. determine the drag and lift forces of various shapes.
3. determine the various flow characteristics of pumps and turbine
4. simulation of fluid machinery problem using commercial CFD tools

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).

Evaluation Scheme:

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

CAPSTONE PROJECT

	L	T	P	Cr
UME793: Semester VII (Starts)	0	0	2	--
UME793: Semester VIII (Completion)	0	0	2	8.0

Course Objectives: A design project based course to implement integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters. Design a mechanical system from component level to assembly using CAD and CAE tools individually or in a team and generate a design project report with production drawings using drawing standards, symbols, conventions and rules. 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. Analyze the prototype manufactured for improvement in design, manufacturing and function.

Scope of work:

Capstone project shall be comprising of two parts. Part-I is focused on an integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters wherein mechanical systems are to be designed satisfying requirements like reliability, fatigue loading, optimized design, manufacturability, assembly, installation, maintenance, transportation-to-site, economic, environmental, social, political, ethical, health and safety and sustainability considerations. Part-I builds around use of a system design approach by incorporating learnings from various courses already studied by the students and the use of relevant design codes and standards (ASTM or equivalent) and software tools specific to the selected project.

Each student group led by a team leader will develop a system design project involving need analysis, problem definition, analysis, synthesis, optimization. assembly and detailed production drawings will be prepared for the presentation of the design along with a printed report, power point/ poster presentation and soft copy submission of CAD and CAE work for final evaluation by a committee. CAE software like Pro Engineer, Pro Mechanica, Solidworks, ANSYS along with a spread sheet may be used for the design modeling, synthesis, optimization, analysis and preparing production drawings.

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

Design details evolved in Capstone Project Part-I will be used for the manufacture of prototype in Part-II of Capstone project work. Use of conventional / unconventional manufacturing processes along with CAM and RP technologies may be made for the fabrication of the physical prototype. The final manufacturing and working of the system will be required to be analyzed.

Capstone project-II shall be evaluated for 70% of the marks which shall essentially consist of power point / poster presentation and submission of a group project report. The report must contain the project planning, work distribution and contribution of group members, detailed design procedures and use of standards like IS, ASTM or other industry equivalent standards

in design, production planning, scheduling, details of manufacturing / fabrication work and analysis of the working of the final product, reflection on the design experience, learning in different stages of work as a team and references. The course concludes with a final showcase using poster/ presentation along with comprehensive viva.

Course Learning Outcomes (CLOs):

The students will be able to:

1. design a mechanical system implementing an integrated system design approach applying knowledge accrued in various professional courses.
2. work in a design team lead by a team leader and demonstrate team work.
3. design, analyze and 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, use of design standards, industry standards.
4. create production drawings for mechanical components and systems using manual drafting and CAD tools following relevant standards and conventions.
5. read production drawings for mechanical components and systems and plan a production based on it.
6. use suitable manufacturing and fabrication processes for manufacturing a prototype.
7. assemble a mechanical system after manufacturing its components and analyze its working.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	Semester VII Problem definition, Regular evaluation.	15
2.	Semester VII Final Design Detailing.	15
3.	Semester VIII Regular evaluation	10
4.	Semester VIII Final Evaluation showcase, project website and Report	60

SEMESTER-VIII

UME803 : REFRIGERATION & AIR CONDITIONING

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course provides an introduction of different types of refrigeration systems and enables the students to analyze their performance using basic concepts of thermodynamics. This course also introduces the concept of psychometrics, air conditioning processes, air conditioning systems and refrigeration & air conditioning system components.

Air and Vapour Compression Refrigeration: Reversed Carnot cycle, air refrigeration cycle, aircraft refrigeration cycles, vapour compression refrigeration cycles, actual vapour compression cycle, advanced vapour compression refrigeration systems, compound compression and multi load systems, cryogenics refrigeration, cascade system and thermoelectric systems.

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, ozone depletion and global warming.

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

Air Conditioning: Psychrometric properties of air, psychrometric processes, comfort charts, air conditioning load calculations, types of air conditioning systems. Demonstration of HVAC software 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

Research Assignment: Working of various components of air conditioning unit in library/ auditorium/ice plants/ shopping malls/ hospitals/ theatres/cold storage/milk plants.

Course Learning Outcomes (CLOs):
The students will be able to:
1. determine the COP for different types of air refrigeration systems
2. determine the COP for vapour compression systems and heat pump
3. perform thermodynamic analysis of absorption refrigeration systems and steam jet refrigeration system
4. perform the load calculations for the different type of air conditioning systems
5. identify and determine the heating and cooling loads for air conditioning systems involving practical applications like; rooms/halls/restaurant/ theatre/auditorium etc

Text Books:

1   Domkundwar and Arora, Refrigeration and Air conditioning, Dhanpat Rai and Co, New Delhi (1973), 8thEdition, 2009.

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).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	24
2.	EST	36
3.	Sessional (Including assignments/lab work/project/ quizzes etc.)	40

UME807 : GAS DYNAMICS & TURBO MACHINES

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: Students will be exposed to compressible flow, study of subsonic and supersonic flows through nozzles of gases and vapour, steam turbine designs and types, governing of steam turbines, gas turbine cycles and their thermal refinements, jet propulsion. Students will study basics of centrifugal, axial flow, screw, lobe and reciprocating compressors, performance and design characteristics of compressors, basic principles of condensers, types, draught, cooling towers.

Basic concepts of Gas Dynamics: Stagnation Properties, Speed of sound and Mach Number and Mach angle, one dimensional isentropic flow, Critical Conditions stagnation values, Stagnation temp. Change, governing equations, Rayleigh lines, Fanno lines.

Normal Shock Waves: Formation of shock waves, weak waves, compression waves. Governing relations of the Normal shock, Pressure. Temperature, Density, Mach number across shock.

Flow through Nozzles and Diffusers: Converging diverging nozzle, area ratio for complete expansion, effect of varying back pressure on nozzle flow, losses in nozzle, supersonic flow.

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.

Compressors: Positive displacement and non-positive displacement; reciprocating, centrifugal and axial flow type; characteristic curves of compressors.

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.

Gas Turbines: Brayton cycle, Ericsson cycle, effect of intercooling, reheating and regeneration, open and closed gas turbine cycle.

Research Assignments:
1. Steam and gas turbine design.
2. Methodology for improving power to weight ratio, turbine efficiency calculations.
3. Turbine blade cooling and attachment methods to rotor drum
4. Steam turbine maintenance and troubleshooting studies at thermal power plants
5. Condenser design

Course Learning Outcomes (CLOs):

The students will be able to:

1. Derive and apply thermodynamic and fluid terminology to turbo machines.
2. Draw the velocity triangles in turbo machinery stages operating at design and off-design conditions.
3. Determine methods to analyze flow behavior depending upon nature of working fluid and geometric configuration of turbo machine.
4. Determine methodologies to evaluate solutions for efficiency, effectiveness and sustainability

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).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (Including assignments/labwork/project/ quizzes etc.)	25

UME705: MACHINING SCIENCE

L	T	P	Cr
3	1	2	4.5

Course objective: The objective of this course is to expose the students about the principles of the metal cutting in single and multi-point cutting, estimating the cutting force and power requirements. This course also cultivates the ability to develop and optimize the non-conventional machining methods resulting in creation and distribution of value in engineering applications.

Machining with Single Point Cutting Tool: Mechanism of chip formation, machining parameters, Relationship of shear angle, shear strain, strain rate, velocity relationships, Estimation of cutting force and power using Merchant's circle theory, Lee and Shaffer theory, Palmer and Oxley theory, Power and energy relationships, friction and thermal aspects of machining

Machining with Multi-Point Cutting Tools: Mechanism of chip formation with multi-point cutting tools, Expression for chip thickness, chip length in in milling and grinding, Force and power requirement in milling and grinding

Tool Wear: Tool life, factors affecting tool life, Taylor's tool life equation, Universal machinability index, factors affecting machinability, factors dimensional accuracy and material removal rate in machining, calculation of economic cutting speed, Gilberts model for economic tool life, Determination of optimal cutting speed for maximum production, Maximum profit cutting speed, Determine of high efficiency zone

Non-conventional Machining Methods: Working principle, applications and modeling of material removal rate in Ultrasonic Machining, Abrasive jet machining, Electric-Discharge Machining, Electro-Chemical Machining, Laser Beam Machining processes

Laboratory Work

Experimental work pertaining to determination of chip reduction coefficient, Shear angle; Cutting force measurements in milling and drilling operations, Effects of speed, feed and depth of cut on power consumption , tool tip temperature, experiments on USM, EDM and LBM, Abrasive shot blasting machine

Research assignment

Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic related to parametric analysis and optimization of process parameters involved in various conventional machining processes. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, gaps in the existing literature, key findings etc.

Course Learning Outcomes (CLOs):

The students will be able to:

1. calculate cutting forces and power requirement during single point cutting, multi-point cutting operations
2. develop mathematical models to predict material removal rate surface quality for different process parameters in different non-conventional machining methods
3. design the conditions for the maximum tool life and factors influencing surface quality, dimensional accuracy and material removal rate in machining
4. analyze the thermal and frictional aspects of machining parameters used in manufacturing industries

Text Books

1 Ghosh, A. and Mallik, A.K., Manufacturing Science, Affiliated East-West Press Pvt. Ltd, New Delhi (2013).

2 Bhattacharyya , A. Metal Cutting Theory and Practice, New Central Book Agency Ltd, Calcutta (2000).

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

4 Mehta, N.K., Metal Cutting and Design of Cutting Tools, Jigs & Fixtures, McGraw Hill Education (India) Private Limited, New Delhi (2015)

Reference Books

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

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

3 Hofy, H.E., Advanced Manufacturing Process, B and H Publication (1998).

Evaluation Scheme:

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

UHU005: HUMANITIES FOR ENGINEERS

L	T	P	Cr
2	0	2	3.0

Course Objectives: The objective of the course is to understand the interplay between, psychological, ethical and economic principles in governing human behaviour. The course is designed to help the students to understand the basic principles underlying economic behaviour, to acquaint students with the major perspectives in psychology to understand human mind and behavior and to provide an understanding about the how ethical principles and values serve as a guide to behavior on a personal level and within professions.

UNIT I: PSYCHOLOGICAL PERSPECTIVE

Introduction to Psychology: Historical Background, Psychology as a science. Different perspectives in Psychology.

Perception and Learning: Determinants of perception, Learning theories, Behavior Modification.

Motivational and Affective basis of Behaviour: Basic Motives and their applications at work. Components of emotions, Cognition and Emotion. Emotional Intelligence.

Group Dynamics and Interpersonal relationships.

Development of self and personality.

Transactional Analysis.

Culture and Mind.

Practicals:
1. Experiments on learning and behaviour modification.
2. Application of Motivation Theories: Need based assessment.
3. Experiments on understanding Emotions and their expressions.
4. Personality Assessment.
5. Exercises on Transactional analysis.
6. Role plays, case studies, simulation tests on human behaviour.

UNIT II: HUMAN VALUES AND ETHICAL PERSPECTIVE

Values: Introduction to Values, Allport-Vernon Study of Values, Rokeach Value Survey, Instrumental and Terminal Values.

Value Spectrum for a Good Life: Role of Different Types of Values such as Individual, Societal, Material, Spiritual, Moral, and Psychological in living a good life.

Moral and Ethical Values: Types of Morality, Kant's Principles of Morality, Factors for taking ethical decisions, Kohlberg's Theory of Moral Development.

Analyzing Individual human values such as Creativity, Freedom, Wisdom, Love and Trust.

Professional Ethics and Professional Ethos, Codes of Conduct, Whistle-blowing, Corporate Social Responsibility.

Laboratory Work:

Practical application of these concepts by means of Discussions, Role-plays and Presentations, Analysis of Case studies on ethics in business and CSR.

UNIT III: ECONOMIC PERSPECTIVE

Basics of Demand and Supply

Production and cost analysis

Market Structure: Perfect and Imperfect Markets.

Investment Decisions: capital Budgeting, Methods of Project Appraisal.

Macroeconomic Issues: Gross domestic product (GDP), Inflation and Financial Markets.

Globalisation: Meaning, General Agreement on Trade and tariffs (GATT), World Trade Organisation (WTO). Global Liberalisation and its impact on Indian Economy.

Laboratory Work:

The practicals will cover numerical on demand, supply, market structures and capital budgeting, Trading games on financial markets, Group discussions and presentations on macroeconomic issues. The practicals will also cover case study analysis on openness and globalisation and the impact of these changes on world and Indian economy.

Micro Project: Global Shifts and the impact of these changes on world and Indian economy.

Course Learning Outcomes (CLO):

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

1. Improve the understanding of human behavior with the help of interplay of professional, psychological and economic activities.
2. Able to apply the knowledge of basic principles of psychology, economics and ethics for the solution of engineering problems.
3. Explain the impact of contemporary issues in psychology, economics and ethical principles on engineering.

Text Books:

1. *Morgan, C.T., King, R.A., Weisz, J.R., & Schopler, J. Introduction to Psychology, McGraw Hill Book Co(International Student (1986).*
2. *A. N. Tripathi, Human Values, New Age International (P) Ltd (2009).*
2. *Krugman, Paul and Wells Robin, Economics, W.H. Freeman & Co Ltd. Fourth Edition (2015).*
3. *Rubinfeld Pindyck. Microeconomic Theory and application, Pearson Education New Delhi (2012).*
4. *Samuelson, Paul, A. and Nordhaus, William, D. Economics, McGraw Hill, (2009).*
5. *Mankiw, Gregory N. Principles of Macroeconomics, South-Western College Pub., (2014).*
6. *Gregory, Paul R. and Stuart, Robert C. The Global Economy and Its Economic Systems, 2013 South-Western College Pub (2013).*

Reference Books:

1. *Atkinson, R.L., Atkinson, R.C., Smith, E.E., Bem, D.J. and Nolen-Hoeksema, S. (2000). Hilgard's Introduction to Psychology, New York: Harcourt College Publishers.*

2. *Berne, Eric (1964). Games People Play – The Basic Hand Book of Transactional Analysis. New York: Ballantine Books.*

3. *Ferrell, O. C and Ferrell, John Fraedrich Business Ethics: Ethical Decision Making & Cases, Cengage Learning (2014).*

4. *Duane P. Schultz and Sydney Ellen Schultz, Theories of Personality, Cengage Learning, (2008).*

5. *Saleem Shaikh. Business Environment, Pearson (2007).*

6. *Chernilam, Francis International Buisness-Text and Cases, Prentice Hall (2013).*

7. *Salvatore, Dominick, Srivastav, Rakesh., Managerial Economics: Principles with Worldwide Applications, Oxford, 2012.*

8. *Peterson H. Craig. and. Lewis, W. Cris. Managerial Economics, Macmillan Pub Co; (1990).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	45
3	Sessionals (Include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	30

CAPSTONE PROJECT

	L	T	P	Cr
UME793: Semester VII (Starts)	0	0	2	--
UME793: Semester VIII (Completion)	0	0	2	8.0

Course Objectives: A design project based course to implement integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters. Design a mechanical system from component level to assembly using CAD and CAE tools individually or in a team and generate a design project report with production drawings using drawing standards, symbols, conventions and rules. 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. Analyze the prototype manufactured for improvement in design, manufacturing and function.

Scope of work:

Capstone project shall be comprising of two parts. Part-I is focused on an integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters wherein mechanical systems are to be designed satisfying requirements like reliability, fatigue loading, optimized design, manufacturability, assembly, installation, maintenance, transportation-to-site, economic, environmental, social, political, ethical, health and safety and sustainability considerations. Part-I builds around use of a system design approach by incorporating learnings from various courses already studied by the students and the use of relevant design codes and standards (ASTM or equivalent) and software tools specific to the selected project.

Each student group led by a team leader will develop a system design project involving need analysis, problem definition, analysis, synthesis, optimization. assembly and detailed production drawings will be prepared for the presentation of the design along with a printed report, power point/ poster presentation and soft copy submission of CAD and CAE work for final evaluation by a committee. CAE software like Pro Engineer, Pro Mechanica, Solidworks, ANSYS along with a spread sheet may be used for the design modeling, synthesis, optimization, analysis and preparing production drawings.

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

Design details evolved in Capstone Project Part-I will be used for the manufacture of prototype in Part-II of Capstone project work. Use of conventional / unconventional manufacturing processes along with CAM and RP technologies may be made for the fabrication of the physical prototype. The final manufacturing and working of the system will be required to be analyzed.

Capstone project-II shall be evaluated for 70% of the marks which shall essentially consist of power point / poster presentation and submission of a group project report. The report must contain the project planning, work distribution and contribution of group members, detailed

design procedures and use of standards like IS, ASTM or other industry equivalent standards in design, production planning, scheduling, details of manufacturing / fabrication work and analysis of the working of the final product, reflection on the design experience, learning in different stages of work as a team and references. The course concludes with a final showcase using poster/ presentation along with comprehensive viva.

Course Learning Outcomes (CLOs):

The students will be able to:

8. design a mechanical system implementing an integrated system design approach applying knowledge accrued in various professional courses.
9. work in a design team lead by a team leader and demonstrate team work.
10. design, analyze and 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, use of design standards, industry standards.
11. create production drawings for mechanical components and systems using manual drafting and CAD tools following relevant standards and conventions.
12. read production drawings for mechanical components and systems and plan a production based on it.
13. use suitable manufacturing and fabrication processes for manufacturing a prototype.
14. assemble a mechanical system after manufacturing its components and analyze its working.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	Semester VII Problem definition, Regular evaluation.	15
5.	Semester VII Final Design Detailing.	15
6.	Semester VIII Regular evaluation	10
4.	Semester VIII Final Evaluation showcase, project website and Report	60

ELECTIVE-I

UME832: FINITE ELEMENT METHODS

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: To expose the students to the basics 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, introduction to p and h type of formulations.

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

Minor Project:

Students will be given different components related to machines/structures and will be asked to analyze these components using ANSYS or related analysis software packages. Students will also be asked to make their own codes for simple problems using MATLAB and compare their results with any of the commercial packages.

The components will be analyzed using different linear / higher order elements *i.e.*, triangular, axisymmetric, quadrilateral, tetrahedral and hexahedral elements.

Course Learning Outcomes (CLOs):

The students will be able to:

1. apply the procedure involved to solve a problem using Finite Element Methods.
2. develop the element stiffness matrices using different approach.
3. analyze a 2D and 3D problem using different types of elements.
4. solve problems using the available commercial package.

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).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Minor Project/Tutorials/Quizes)	25

UME842: MECHANICS OF COMPOSITE MATERIALS

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: The objective for this course is to develop an understanding of the elastic analysis of composite materials. This course also introduces the concept of unidirectional composites, short fiber composites, orthotropic lamina, laminated plates and beams.

Introduction: Definition, characteristics, classification, fabrication of composites, 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 laminae stresses and strains.

Analysis of Laminated Plates and Beams: Introduction, governing equations for plates, equilibrium equations, equilibrium equations in terms of displacements, application of plate theory, bending, Buckling, analysis of laminated beams, governing equations for laminated beams.

Research Assignment:

Research assignment will constitute collection of literature, problem formulation (mathematical model) required for design consideration and experimental characterization (mechanical testing), environmental issues, metal and ceramic matrix composites, nanocomposites, bio-composites etc. The students work in groups to test samples of composite materials, scan for defects, SEM study etc. This assignment also includes technical report writing and seminar presentation.

Course Learning Outcomes (CLOs):

The students will be able to:

1. determine the properties of fiber and matrix of composite material in different orientations.
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. determine the failure strength of a laminated composite plate.

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.andIshai,O., Engineering Mechanics of Composite Materials, 2nd edition, Oxford University Press, (2005).

Reference Books:

1   Mallick, P.K., Fiber-Reinforced Composites: Materials, Manufacturing, and Design, Second edition, CRC Press (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).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments, Presentation, Technical Report)	25

UME805: ROBOTICS ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course introduces the basic concepts, standard terminologies, applications, design specifications, and the mechanical design aspects of robotics related to kinematics, trajectory planning, dynamics, control and simulation of serial industrial robotic manipulators.

Introduction: Definition of robot, types and classifications, standard terminologies related to robotics, key design specifications used for selection of serial robotic manipulators for various applications, robotic applications in modern automated industries, research and non-industrial environments.

Robot Kinematics: Homogeneous co-ordinates and co-ordinate transformations, Forward and inverse kinematics for serial robotic manipulators, the concept of Jacobian, kinematics simulation in MATLAB environment and using Robo Analyser.

Robot Dynamics: Introduction to Lagrangian formulations for serial robotic manipulators, actuator dynamics.

Trajectory Generation: Joint-Space trajectory generation, Cartesian space trajectory generation, Path generation at run time, simulation of trajectory-related problems.

Robot Control: Open-loop and Closed-loop control, Model-based control, Trajectory following control.

Course Learning Outcomes (CLOs):

The students will be able to:

1. identify and formulate the desired robotic design specifications for a particular application.
2. develop and simulate the forward kinematics model using D-H conventions..
3. develop the inverse kinematics model of a serial manipulator.
4. develop and analyze the mathematical model for robotics trajectory planning, resolved motion rate control and dynamics for a given serial robotic manipulator.
5. apply the joint- and Cartesian-based schemes to control the manipulators in different applications.

Text books:

1. Schilling, R.J., Fundamentals of Robotics Analysis and Control, Prentice Hall of India (2006).

2. Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill (1987).

3. Craig, J.J., Introduction to Robotics: Mechanics and Control, prentice Hall (2004).

Reference Books:
1. *Deb, S.R., Robotics and Flexible Automation, McGraw Hill (2004).*
2. *Saha, S.K., Introduction to Robotics, McGraw Hill (2008).*
3. *Niku, S.B., Introduction to Robotics: Analysis, system, application, Dorling kingsley (2006).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Including assignments/ Tutorials/ Quizes etc.)	25

UME721 : TRIBOLOGY

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: The objective for this course is to develop an understanding of the Tribological behavior of different machine elements. This course also introduces the concept of lubricants, analysis of friction and wear, bearings and other tribological applications.

Introduction: Definition of Tribology, surface characterization techniques, contact of engineering surfaces- Herzian and non- Hertzian contacts, different Bearings, types and properties of lubricants, lubricant additives, introduction to nano Tribology.

Friction: Causes of friction, adhesion theory, junction growth theory, laws of rolling friction, friction instability.

Wear: Wear mechanism, adhesive wear, abrasive wear, corrosive wear, fretting wear, Tribological behavior of some common engineering materials.

Bearings: Classification of fluid film lubrication, Reynold's equation, lubricant flow and shear stresses, mechanism of pressure development, load carrying capacity and flow characteristics of infinitely long and short journal bearing, analysis of finite journal bearing.

Applications: Forging, metal forming, hydrodynamic press, brakes of automobile, cutting tools, machine tools, IC engines, cooling systems using energy dissipation and tribological methods.

Research Assignment: Research assignment will constitute collection of data from industry and other sources and analysis of tribological for bearing, forging, metal forming, hydrodynamic press, brakes of automobile, cutting tools, machine tools, IC engines, cooling systems etc. This also includes technical report writing and seminar presentation.

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

1. identify different wears and causes of friction in different contact surfaces.
2. calculate load carrying capacity of hydrostatic bearings.
3. analyze real life problem in Tribology.

Text Books:

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

2 Arnell R. D., Davies P. B., Halling J. and Whomes T. L. , Tribology: Principles and Design Applications, First edition, Springer-verlag (1991).

3 Hutchings I.M., Tribology: Friction and wear of engineering materials, Edward Arnold, London, (1992).

Reference Books:

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

2   *Sahoo P., Engineering Tribology, PHI, New Delhi (2005).*

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

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments/ Presentation, Technical Report)	25

UME722: SYSTEM MODELLING AND SIMULATION

L	**T**	**P**	**Cr**
3	**1**	**0**	**3.5**

Course Objectives: The objective for this course is to develop an understanding of the interaction of different components of a system. This understanding will include concepts such as analysis of rigid bodies, structural systems, hydraulic systems, thermal systems, electronic and mechatronic systems, multibody systems and control strategies.

Modelling in Multi-Energy Domain Through Bond Graphs: Introduction to bond graphs, power variables of bond graphs and models of simple circuits, reference power directions, bond graph elements and their constitutive relations, causality, generation of system equations from bond graph models, the idea of activation.

System Modelling: Modelling of a system of rigid bodies, structural systems, hydraulic systems, thermal systems, electronic and mechatronic systems.

Modelling of Multibody Systems: Mechanisms, manipulators and vehicles.

Advanced topics in Bond Graph Modelling of Physical Systems: Elements of multi-bond graphs, Thermo-mechanical bond graphs and continuous systems and other systems of typical interest.

Control System: Modelling systems for control strategies in physical domain i.e. P, PI, PID, overwhelming and impedance control. Stability of systems from signal flow graph using Routh's criterion.

Research Assignment:

Numerical prototyping as modelling for design and synthesis using computational tools SYMBOLS for the systems like bicycle vehicle, parallel manipulator with overwhelming control, Rapson slide, inverted pendulum, car moving over bump etc

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Course Learning Outcomes (CLOs):

The students will be able to:

1. frame bond graphs of systems using power variables, reference power directions, causality.
2. generate the system equations from bond graph models.
3. make signal flow graph from the bond graph model and predict stability using Routh's criterion.
4. create different control systems using bond graph.

Text Books:

1 A. Mukherjee, R. Karmakar, A.K. Samantaray, Bond Graph in Modeling, Simulation and fault Identification, CRC Press, FL (2006).

2 D.C. Karnopp, D.L. Margolis, R.C. Rosenberg, System Dynamics, Modeling and Simulation of Mechatronic Systems, John Wiley & Sons, NY (2000).

Reference Books:

1   B OuldBouamama , J Thoma , Jean U Thom, Modelling and Simulation in Thermal and Chemical Engineering: A Bond Graph Approach, Springer, New York (2000).

2   Dean Karnopp, Vehicle Dynamics, Stability, and Control, CRC Press, (2013).

3   R. Merzouki, A.K. Samantaray, P.M. Pathak, B. OuldBouamama, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer, New York (2012).

4   Borutzky, W., Bond graphs: a methodology for modelling multidisciplinary dynamic systems, SCS Publishing House, Erlangen, San Diego (2004)
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Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments/Tutorials/Quizes)	25

ELECTIVE-II

UPE501 : WORK STUDY AND ERGONOMICS ENGINEERING

	L	T	P	Cr
	3	1	0	3.5

Course objective: This course introduces the role of Work Study in the industry and how productivity issues in the industry can be addressed by the application of Work Study, while stimulating critical thinking on the techniques of Method Study and Work Measurement. The course also introduces the concept of conducting time studies and production studies to assess time standards and production standards for fulfilling production goals in an organization. The course further introduces the scope of ergonomics and the application of ergonomic principles to workplace design and work organisation and culminates with the concept of evaluating the impact of various human factors to design of safe workplace environment.

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

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.

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, Standard data usage, Engineered time standard, Predetermined motion time system (PMTS).

Ergonomics Engineering

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

Research Assignment:

- Conduct an ergonomic study of jobs with varying degrees of risk and difficulty
- Use tools of method study to critically examine existing methods of working in job and suggest improvements

Course Learning Outcomes (CLOs):
The students 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. apply principles of good ergonomic design of work areas and equipment
5. identify, explain and evaluate the impact of various personal attributes (anatomical, physiological and anthropometric) on proper safe working practice

Text Books:

1. *Niebel, B.W., Motion & Time Study, 9th Edition McGraw Hill Higher education (1992).*
2. *Kanawaty, G., Work Study, ILO, Geneva, 4th revised edition (1992).*
3. *Barnes, R. M., Motion & Time Study, 7th edition, John Wiley & Sons (1980).*
4. *Bridger, R.S., Introduction to Ergonomics, McGraw Hill (2008).*
5. *Halender, M., A guide to Human Factors and Ergonomics. Taylor & Francis, Second Edition, 2006*

Reference Books:

1. *Mundel, M., and Danner, D. L., Motion & Time Study, 7th Edition, Englewood Cliffs, NJ, Prentice Hall, (1994)*
2. *Curie, R., Introduction to Work Study, McGraw Hill (1992).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UME732: CAM & INDUSTRIAL AUTOMATION

L	T	P	Cr
3	1	0	3.5

Course objective: To impart the students an understanding of standard terminologies, conventions, processes, design, operational characteristics, applications and interfacing of key components of contemporary automation technologies used in computer numeric control (CNC) systems, hydraulic, pneumatic, electro-pneumatic and PLC based automation systems. The course introduces the students to the advanced CNC part programming techniques for milling and turning centers. Also this course introduces the students to various automation system devices and control elements used in modern automatic manufacturing environments.

Introduction: Need and types of automation in manufacturing systems, automation strategies, automation technologies.

CNC part programming: fundamental concepts in computer numeric control (CNC):types, definition and designation of control axes, special constructional and design characteristics of CNC machine tools, standard tooling for CNC turning and milling centers, work holding and tool setting procedures for CNC turning and milling centers, use of standard canned cycles for CNC turning and milling centers, introduction to automatic part programming using standard CAM software.

Computer numerical control: types and functions of CNC systems, interpolator systems, control loop circuit elements in point to point (PTP) and contouring CNC system, interpolation schemes for linear and circular interpolations, types and functions DNC (direct numeric control) and adaptive control systems.

Introduction to robotics: design terminologies, specifications and classification of industrial robots, types of joints, functions of a robotic controller in work cell environment, robotic interface with external peripheral devices and robot programming methods.

Introduction to hydraulics, pneumatics and electro-pneumatic controls and devices: Basic elements of hydraulics, pneumatics and electro-pneumatic systems, Fluid power control elements and their standard graphical symbols, construction and mounting of hydraulic & pneumatic cylinders, hydraulic & pneumatic valves for pressure, flow and direction control, solenoid valves, sensors and actuators for hydraulic, pneumatic, and electro-pneumatic systems, PLC and sensors for automation systems

Hydraulics, pneumatic and electro-pneumatic logic control circuits: Design and operation of hydraulics, pneumatic and electro-pneumatic logic control circuits, sequence control, time displacement diagrams and their applications, circuit design approach and real time examples, electro-pneumatic & electro hydraulic systems control using relay logic circuits, pneumatic safety and their applications to clamping, traversing and releasing operations.

Automated material transfer, handling, storage and identification systems: AGVs, ASRS, carousel, and RFID technologies.

Hands-on design and operation of automatic systems employing hydraulic, pneumatic, electro pneumatic, PLC based control system and assignments on manual and automatic CNC part programming.

Minor Project: Students in a group of 5/6 will carry out micro project/ a research assignment on the following topics:

● Automatic/ manual generation of toolpath data for machining of a part shape in milling or turning center in consultation with the course instructor. Each student group will submit a report on the procedure followed for executing the given assignment along with the part machine on specified CNC machining center.

● Design and fabrication of an automatic modular system for implementation of automation in a manufacturing system using hydraulic, pneumatic, electrical or combination of these systems. The virtual simulation Fluid SIM software can be used for initial design and analysis and then small prototype projects using either of pneumatic, electro-pneumatic, PLC and/or motion control, need to be fabricated.

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

1. apply the underlying fundamentals of automation strategies, industrial automation and CNC technology.
2. develop a complete machining plan for precision parts using an appropriate CNC machining centers.
3. design and simulate an automation system for manufacturing automation based on pneumatic, hydraulic or electro-hydraulic control using logic circuits and control elements.
4. design and develop a complete automation solution for a recognized need.

Text Books:
1. *Koren, Y., Computer Control of Manufacturing systems, McGraw Hill (2009).*
2. *Suh Suk-Hwan, Kang Seong-Kyoon, Chung Dae-Hyuk, Stroud Ian., Theory and Design of CNC Systems, 2008, Springer-Verlag London Limited*
3. *Groover, M. P., Automation, Production System & Computer Integrated Manufacturing, Pearson Education Asia (2009).*
4. *Majumdar, S. R., Pneumatic Systems, McGraw Hill (2005).*
5. *Esposito, A., Fluid Power with Applications, Sixth Edition, Pearson Education (2009).*
Reference Books:
1. *Manuals of CAD/CAM Software Package on CAM Module and CNC Machines.*
2. *Nakra, B. C., Theory and Applications of Automatic Controls, Revised 2nd Edition, New Age International Publishers (2014).*
3. *Morriss, S. B., Automated Manufacturing Systems, McGraw Hill (2006).*

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

5. *John R. Hackworth & Frederick D. Hackworth Jr, Programmable Logic Controllers – Programming Methods and Applications, Pearson (2011).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (Including assignments/ Minor Projects/ Quizes etc.)	25

UME844: MACHINE TOOL DESIGN

L	T	P	Cr
3	1	0	3.5

Course objectives: The objective of this course is to develop the basic skills and understanding on the working principles, mechanics, technological capabilities, design philosophy of machine tool elements and their subsystems.

Introduction: Classification of machine tools, General requirements of machine tool design, Engineering design process applied to machine tools.

Machine tool drives: Mechanical, hydraulic and electrical drives, speed and feed regulations, design of speed box and feed box.

Design of machine tool structures: Basic design procedure of machine tool structures for strength & stiffness, dynamics of machine tools, design of bed, head stock, housing, etc., design of spindles and spindle supports, design of hydrostatic, hydrodynamic and antifriction guideways, design calculations for lead screw and ball recirculating power screw assemblies.

Design considerations in CNC machine tools: Special features, constructional details and design considerations in CNC machines.

Note: A case study approach will be followed in understanding the design philosophy and design processes of conventional machine tools like lathes, shaper, milling machines and drilling machines.

Research Assignment:

Students in the group will submit a research assignment or design project based on the design and analysis of machine tool/components.

Design assignment will include literature review on the recent technology developments, identification of the operational requirements and industrial applications of the selected machine tool, selection of drive system and control system, designing of various structural components.

Design project may include refining the existing design of the selected machine, preparation of questionnaire and feedbacks, geometric modeling, engineering analysis and optimization of modeled structural components and generating engineering drawings of the complete machine or subsystems of a selected machine. Every group will be required to present their works and submit a final technical report at the end of the semester.

Course Learning Outcomes (CLOs):

The students will be able to:

1. analyze the design philosophy and design process adopted for the development of machine tools.
2. analyze the constructions and structural behavior of a machine tool.
3. analyze the drive and control systems used in machine tools
4. design the components and subsystems of a given machine.

Text Books:

1. *Mehta, N. M., Machine Tool Design & Numerical Control, McGraw Hill (2012), 3rd ed.*

2. *Shigley, J., Mechanical Engineering Design, McGraw Hill, New York (2014),10th ed.*

3. *Rao P.N., Manufacturing Technology: Metal cutting and Machine Tools, McGraw Hill (2013), 3rd ed.*

Reference Books:

1. *Basu, S. K. and Pal, D.K., Design of Machine Tools, Allied Publishers (2008), 5th ed.*

2. *Acherkhan, N.S., Machine Tool Design, University Press of the Pacific, (2000).*

3. *Boothroyd G and Knight Wiston A., Fundamentals of Machining And Machine Tools, CRC Press (2005), 3rd Edition.*

4. *Sharma, P. C., A Text Book Of Machine Tools & Tool Design, S. Chand Limited,(2005)*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments /Tutorials/Quizzes)	25

UPE703 METAL FORMING

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: This course imparts knowledge and principles for deciding yielding criteria during forming of metals, analysis of different bulk metal forming processes using different analysis approach. The course also helps to analyze and understand the process mechanics during different metal forming processes and reflects the importance of various controlling process parameters in determining force, power requirements etc.

Fundamentals of Metal Forming: Description of stress-strain behavior, Principal quantities, Mohrs Circle, Elastic vs. Plastic deformation, Strain hardening, Hot, Cold and Warm working of metals, strain rate characteristics of materials, Concept of yield surface/function, Different theories of yielding: von-Mises and Tresca yield criteria, Concept of formability, forming limit diagram, metal forming analysis through ideal work, Slip line field, Upper bound and Slab Method

Metal Forming Processes: Bulk forming Vs. Sheet metal forming, Classification of metal forming processes: Rolling, Forging, Extrusion, Drawing and Sheet metal operation.

Sheet Metal Working Processes: Bendability, determination of work load and spring back, Shearing of sheet metals, die and punch design for different shearing operations

Rolling: Rolling principle, Rolling Mills, process parameters, pressure distribution and roll separating force, rolling pressure, driving torque and power requirements, Rolling defects

Forging: Forging operation, Forging types, Determination of forces in disc forging considering sticking and slipping, Forging defects.

Extrusion: Principle of extrusion, Hot extrusion and Cold extrusion, Analysis of direct cold extrusion process through conical dies

Drawing: Principle of drawing, Drawing stresses, Limiting draw ratio, Factors affecting drawability, Determination of force and power in wire drawing, Determination of maximum allowable reduction

Research Assignment:

Assignment containing the analysis for any bulk or sheet metal forming process to obtain the variations of force, torque, power etc. with process parameters. Student should submit individual report with derivations of equations and results of parametric analysis.

Course Learning Outcomes (CLOs):

The student will be able to:
1. decide yielding of a material according to different yield theory for a given state of stress.
2. analyze the different bulk metal forming process mechanics using different analysis approach and calculate the force, power requirements etc.

3. calculate the die and punch sizes for different sheet metal operations and to calculate the required load for the process.
4. evaluate the effect of process parameters on the process mechanics during bulk metal forming.

Text Books
1   *Reddy, N.V. and Lal, G.K., Theory of Plasticity, Narosa Publication, New Delhi (2009).*
2   *Avitzur, B., Metal Forming Analysis, McGraw Hill, New York (1968).*

Reference Books
1.   *R.H. Wagoner and J. L. Chenot, Metal Forming Analysis, Cambridge University Press, 2001.*
2   *Dixit, P.M. and Dixit, U.S., Modeling of Metal Forming and Machining Processes, Springer-Verlag, London (2008).*
3.   *Ghosh, A. and Malik, A. K., Manufacturing Science, Affiliated East-West Press, New Delhi (1985).*
4.   *Bruno, E. L., High Velocity Forming of Metals, ASTME, New York (1970).*
5.   *Johnson, W and Millore, P.B., Plasticity for Mechanical Engineers, Van Nostrand, London (1962).*
6.   *Narayansamy, R., Metal Forming Technology, Ahuja Book Publishers, New Delhi (1995).*
7.   *Rowe, J. W., An Introduction to the Principles of Industrial Metal Working, Edward Arnold, London (1968).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UME733: INDUSTRIAL METALLURGY

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course identifies the key variables which affect the mechanical properties of mechanical engineering materials, especially alloys. It explains the role of TTT/ CCT diagrams in explaining changes in microstructure and properties of steels under various processing conditions. It enables the students to understand the kinetics of formation and decomposition of austenite phase and the various heat treatment processes for industrial processing of iron-carbon alloys. The course introduces the role of various surface hardening treatments. It enables the students to identify, analyze, and solve problems related to concepts of industrial metallurgy.

Alloy Systems: Binary systems having unlimited solubility in liquid and solid states (isomorphous systems), coring and its effects in isomorphous systems (Type I systems: Cu-Ni etc.), factors and techniques for elimination of coring, binary eutectic systems (Type II and III systems: Bi-Cd, Pb-Sn etc.), classification of phases in binary alloys, invariant reactions of iron-carbon systems, critical temperatures and critical temperature lines, transformations and microstructure evolution in steels.

Kinetics of Austenite Transformations: Kinetics of formation of austenite in 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, Continuous cooling transformation diagrams (CCT diagrams).

Heat Treatment of Steels: Need, main steps in heat treatment processes, classification of heat treatment processes on the basis of heat treatment temperature and on the basis of purpose, various types of annealing, normalizing, hardening and tempering treatments for industrial processing of steels. Temper embrittlement, factors affecting the hardenability of steels, methods to evaluate hardenability of steels.

Surface Heat Treatment (Case Hardening) Methods: General features of surface hardening processes, Flame hardening and induction hardening of steels; Chemical heat treatment of steels: need, general procedure, characteristics and applications of carburizing, nitriding, and cyaniding treatments of steels.

Strengthening Mechanisms for Alloys: Strengthening by grain refinement, effect of grain size on various mechanical properties, solid solution strengthening, strain hardening, precipitation hardening mechanisms for alloys, especially steels and aluminium.

Introduction to failure modes and their relation to the underlying causes like cracks, dislocations etc. Introduction to composite material systems.

Research Assignments:

Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic in the field of industrial metallurgy. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field.

Each group will be required to submit a report (and presentation) containing review of literature, summary, major findings and gaps in the existing literature. The topics may include review of commercial software for constructing phase diagrams, kinetics of formation and decomposition of austenite in steels, latest heat treatment and surface hardening procedures for commercial processing of steels. Topics may also include exploring various industrial alloys and explaining why a particular one is used: cost, ease of processing, compatibility to environment etc.

Course Learning Outcomes (CLOs):

The students will be able to:

1. describe the microstructures and phases that will occur in material alloys in general, and steels and eutectic series alloys in particular.
2. predict how microstructure will be affected by alloy composition and thermomechanical treatments.
3. describe the structure and processing of some typical steels; to compare the mechanical properties of these materials to those of composites explaining under what circumstances composites might be used in the industry.
4. select and analyze suitable surface heat treatment for a given alloy composition.
5. predict the failure loads in components to ensure their safe life.
6. appreciate the considerations involved in mechanical engineering materials selection: to use a systematic approach to the selection of the optimum material for a given mechanical engineering application.

Text Books:

1. *Higgins, R. A., Engineering Metallurgy-Applied Physical Metallurgy, Elsevier (2004).*
2. *Avner, S.E., Introduction to Physical Metallurgy, McGraw Hill (1997).*

Reference Books:

1. *Rajan, T.V., Sharma, C. P., Sharma, A., Heat Treatment Principles and Techniques, PHI Learning Private Limited (2011).*
2. *Abbaschian, R. and Reed-Hill, R., Physical Metallurgy Principles, Cengage Learning (2008).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

ELECTIVE-III

UME831: COMPUTATIONAL FLUID DYNAMICS

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: This course introduces the basic knowledge of governing equations for fluid flow and different turbulence models. The course also introduces the concept of numerical methods used to solve the partial differential equation. Further, solve the fluid flow problem using CFD tool.

Introduction: Motivation and role of computational fluid dynamics, concept of modeling and simulation. Benefits and limitations of CFD software tools.
Governing equations of fluid dynamics: Continuity equation, momentum equation, energy equation, various simplifications, dimensionless equations and parameters, convective and conservation forms, incompressible hermos flows, source panel method and vortex panel method.
Nature of equations: Classification of PDE, general Thermos of parabolic, elliptic and hyperbolic equations, boundary and initial conditions.
Finite difference method: Discretization, various methods of finite differencing, stability, method of solutions.
Finite Volume methods: Integral Approach, discretization & Higher order scheme.
Turbulence modelling: Turbulence, effect of turbulence on N-S equations, different turbulent modelling scheme, Error and uncertainty.
Incompressible Viscous Flows: Stream function-vorticity formulation, solution for pressure, applications to internal flows and boundary layer flows
Assignment: Research assignment given to the students in group related to flow simulation of different NACA profile aerofoil section, diesel injector, heat exchanger etc. using available CFD tools.

Course Learning Outcomes (CLOs):
The students will be able to:
1. derive and analyse the various types of fluid flow governing equations.
2. analyse the internal fluid flow phenomena of thermal and fluid system.
3. simulate engineering problems using commercial CFD tools

Text books:
1. *Ghosdastidar, P. S., Computer Simulation of Flow and Heat Transfer, McGraw Hill (1998)*
2. *Roache, P. J., Computational Fluid Dynamics, Hermosa (1998).*
3. *Wendt, J. F., Computational Fluid Dynamics An Introduction, Springer-Verlag (2008).*

Reference Books:

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessional (May include Project/Quizes/Assignments Evaluation)	35

UME834: INTERNAL COMBUSTION ENGINES

L	T	P	Cr
3	1	0	3.5

Course objectives: The students will learn to classify different types of internal combustion engines and their applications .Students will be exposed to fuel air cycles, combustion charts, two stroke engines. The students will study fuel supply systems in SI and CI engines, dual fuel and multi fuel engines, alternative fuels. Detailed study will be done on recent trends in IC engines, emission control strategies.

Introduction: Thermodynamic properties of fuel-air mixture before and after combustion, deviations of actual cycle from Ideal conditions, Analysis using combustion charts.

S.I. Engines: Design of carburation system, MPFI, combustion, ignition systems, Combustion chambers in S.I. engines.

C.I. Engines: Fuel injection, combustion, swirl & inlet ports design, Combustion: DI models, Supercharging, turbocharging & matching of turbocharging.

Engine Lubrication: Friction and lubrication, Performance, Two stroke engine: scavenging, standards.

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

Engine Emissions & Control Air pollution due to IC engines, engine emissions, exhaust gas recirculation, modern control strategies, Engine emissions standards and norms.

Research assignment: Preparation of Diesel emulsion with nanoparticles, biofuel and check for thermal, physical, chemical properties of fuel and emission characteristics at various loads. Examples of spark ignition and compression ignition engines and new technologies involve in fuel supply systems. Waste heat recovery in IC engines. Design of simple carburettor

Course Learning Outcomes (CLOs):
The students will be able to:
1. analyze the engine thermodynamic characteristics using fuel air cycles and combustion charts.
2. evaluate and analyze the parameters in the engine for issues of power generation, emissions and environmental impact, fuel economy.
3. analyze the effects of fuel composition on engine operation and mechanical limitations for ideal performance.
4. analyze the air induction and fuel supply processes for both SI and CI engines.
5. analyze the effect of spark timing, valve timing and lift, cylinder dimensions, compression ratio, combustion chamber design shape.

Text Books:

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

2   Heisler, H., Advance Engine Technology, Butter Worth Hienemann, USA (2000)

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

Reference Book:

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (Assignments/Tutorials/Quizes)	25

UME852: POWER PLANT AND PROCESS UTILITY SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course objectives: To impart knowledge on the principle of operation, layouts, components, construction, selection criteria and maintenance and troubleshooting aspects of different types of power plants and industrial utility systems. To impart knowledge on the methods of designing industrial processes and systems using design codes and standards and by developing computer program

Introduction: Energy sources for generation of electric power, types of power plant-their special features and applications, present status and future trends of energy resources, overview of utility systems, project implementation stages, load curves, tariff methods

Conventional Power Generation: site selection, plant layout, steam generators, turbines, fossil and nuclear fuels, pulverizes and coal feeding, mill reject, combustion in furnace, coal handling, ash handling, electrostatic precipitators and bag filters, water systems, condensers, cooling towers, safety aspects, waste disposals, cogeneration, hydroelectric power generation, turbine specific speeds

Non-Conventional Power Generation: Fluidized bed combustion, energy generation through wind, geothermal, tidal and solar energy, IGCC

Process Utility Systems: Bulk solids storage and transport systems – silo/hoppers, conveyors, selection and process and instrumentation diagram for pumps, fans and compressors, piping system design, pipe supports, different valves, fittings, instrumentation and data logging systems, industrial fire protection systems, dust hazards

Assignment(s):
Students in groups of 3 to 4:
● Will design the piping in super heater and re-heater tubes in boiler and will determine and compare the heat transfer rate at different locations. This is to be done using applicable pressure piping codes (ANSI/ASTM or equivalent).
● Will design an optimized material handling system (coal/ash transport system) by developing a computer program.
● Will select a compressor/pump model for a given duty and prepare the process flow diagram (P&ID).
● Will be introduced to the operation of a pilot plant, use of data logging and instrumentation, analysis of data and process modeling

Course Learning Outcomes (CLOs):

The students will be able to:

1. design system/process/components by applying the guidelines of codes, standards and catalogs
2. develop process flow diagrams (P&IDs)
3. assess troubleshooting requirements for selected systems, analyze and propose optimum solution
4. develop process flow models acquire/interpret/analyze data from loggers,

Text Books:

1. *Nag, P.K., Power Plant Engineering, McGraw-Hill (2007) 3rd ed.*
2. *Raja, A.K., Srivastava, A.P. & Dwivedi, M., Power Plant Engineering, New Age Int. (2006) 1st ed.*

Reference Books:

1. *Elanchezhian, C., Saravankumar, L., Ramnath, B. V., Power Plant Engineering, I-K Int. (2007) 1st ed.*
2. *Elliot, T.C., Chen, K., Swanekamp, R., Stanadard Handbook of Power Plant Engineering, McGrawhill Education (1998) 1st ed.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	20
2.	EST	40
3.	Sessionals	40

UME839 : RENEWABLE ENERGY SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course introduces various types of renewable energy resources, their characteristics and their advantages over conventional fuels. This course also introduces the technologies for harnessing these energy resources by using simple to advanced 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, solar photovoltaics.

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

Wind, Geo-thermal and Hydro Energy Sources: Wind energy systems, wind mill & farms, performance and economics, geothermal power plants, tidal power plants, Micro and small hydro energy systems.

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.

Research Assignment: Students in a group will submit a research assignment on the following topics:

(a) Application of solar energy for industrial process heating, desalination and cooling.

(b) Innovative applications of renewable energy to reduce the consumption of conventional fuels.

(c) Performance and Emission Characteristics of a Diesel Engine fueled with bio-diesel, bio-gas and producer gas.

Research assignment will constitute collection of literature from library/internet, plant visit and formulation and analysis of the problem. **(10% weightage of total marks shall be given to this assignment).**

Course Learning Outcomes (CLOs):

The students will be able to:

1. calculate the terrestrial solar radiation on an arbitrary tilted surface.
2. use flat plate solar collector mathematical model to calculate the efficiency and performance parameters of the same.
3. determine the plant efficiency of geothermal power plant.

4. select the factors that are required to consider when selecting sites for tapping renewable energy.

5. determine maximum efficiency and maximum obtainable power from a given wind turbine

Text Books:

1. Duffie, J.A. and Beckmann, W.A., Solar Engineering of Thermal Processes, John Wiley (2006) 3rd ed.

2. Rai, G.D., Non Conventional Energy Sources, Khanna Publishers(2014)5th ed.

Reference 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) 3rd ed.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include Project/Quizzes/Assignments Evaluation)	25

UME853: SOLAR ENERGY ENGINEERING

	L	T	P	Cr
	3	1	0	3.5

Course Objectives: The course intends to provide the fundamentals underlying solar energy utilization: Solar Thermal and Solar Photovoltaic. To impart the students, the ability to carry out heat transfer and optical analysis of these solar energy systems. To impart application based knowledge so that students are able to identify key parameters in solar energy utilization.

Introduction: Brief history of solar energy utilization - various approaches of utilizing solar energy, Economics, Energy life cycle analysis, Environmental considerations, Blackbody radiation approximation of solar energy-Planck's Distribution Law, Wien displacement law, Stefan - Boltzmann law. Photoelectric effect-Einstein's theory of photons.

Solar Radiation: Extra-terrestrial and terrestrial insolation, instruments used for measuring solar radiation, empirical correlation for predicting available solar radiation, computation of solar radiation on horizontal and tilted surfaces.

Design of Flat Plate Collectors: Selective surfaces- materials- optical and radiative properties, construction details, heat transfer analysis, estimation of losses, collector efficiency and standard testing procedures.

Design of Concentrating Collectors: Constructional details of various concentrating collectors- parabolic trough collectors, compound parabolic collector, paraboloid dish collectors, and central receiver collector, Designing concentrators and heat collector elements for achieving high optical and thermal efficiency, heat transfer analysis, estimation of losses, collector efficiency and standard testing procedures.

Storage of Solar Energy: Types of Energy Storage - Thermal Storage - Electrical Storage - Chemical Storage - hydro-storage.

Photovoltaic Basics: Structure and working of Solar Cells - Types, Electrical properties and behavior of Solar Cells – Cell properties and design.

Solar Power Plants: Solar Thermal Power Plants- Solar Power cycles (Vapour cycles, Organic cycles, Combined cycles, Binary Cycles. Stirling and other cycles) - basic construction and working. Photovoltaic Power Systems - System Integration - Energy Storage, PV Cell Interconnection and Module Fabrication - PV Modules and arrays - Basics of Load Estimation.

Other Solar Thermal Applications: Solar refrigeration and air-conditioning, solar pond, solar desalination.

Research Assignment: Students in groups shall choose one topic of their interest relevant to solar energy utilization. Each group shall be required to submit a term paper relevant to the same. A term paper shall essentially be original work discussing a topic in detail- new design/modification proposed and the supporting analysis. Each group shall be required to submit the completed term paper at the end of the semester.

Course Learning Outcomes (CLOs):

The students will be able to:

1. calculate incident solar irradiance (diffuse and direct components) on flat and inclined surfaces for a given geographical location
2. identify optimum heat transfer fluids for solar energy utilization.
3. select solar selective materials and optimum geometric configurations for harnessing solar energy.
4. draw thermal resistance diagrams relevant to the constituents elements of a given solar thermal system.
5. evaluate the thermal and optical performance of PV and solar thermal systems.
6.

Text Books:

1   Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, Fourth Edition.

2   Tiwari G.N. Solar Energy. CRC Press, New York (2002).

3   Nelson, J The Physics of Solar Cells. Imperial College Press, 2003. Thomas Markvart, Solar Electricity, John Wiley and Sons, 2001.

Reference Books:

1   SukhatmeS.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.

2   CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.

3   Fahrenbuch A. L. and. Bube R. H, Fundamentals of solar cells, Academic Press, 1983.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (may include the following) Assignments/Micro Projects, Presentation, Technical Report	40

GENERIC ELECTIVES

UPH063 NANOSCIENCE AND NANOMATERIALS

	L	T	P	Cr
	3	0	0	3.0

Course Objectives:
To introduce the basic concept of Nanoscience and advanced applications of nanotechnology,

Fundamental of Nanoscience: Features of Nanosystem, Free electron theory and its features, Idea of band structures, Density of states in bands, Variation of density of state and band gap with size of crystal,

Quantum Size Effect: Concepts of quantum effects, Schrodinger time independent and time dependent equation, Electron confinement in one-dimensional well and three-dimensional infinite square well, Idea of quantum well structure, Quantum dots and quantum wires,

Nano Materials: Classification of Nano Materials their properties, Basic concept relevant to application, Fullerenes, Nanotubes and nano-wires, Thin films chemical sensors, Gas sensors, Vapour sensors and Bio sensors,

Synthesis and processing: Sol-gel process, Cluster beam evaporation, Ion beam deposition, Chemical bath deposition with capping techniques and ball milling, Cluster assembly and mechanical attrition, Sputtering method, Thermal evaporation, Laser method,

Characterization: Determination of particle size, XRD technique, Photo luminescence, Electron microscopy, Raman spectroscopy, STEM, AFM,

Applications: Photonic crystals, Smart materials, Fuel and solar cells, Opto-electronic devices

Course Learning Outcomes (CLO):
Upon completion of the course, Students will be able to
1. discriminate between bulk and nano materials,
2. establish the size and shape dependence of Materials' properties,
3. correlate 'quantum confinement' and 'quantum size effect' with physical and chemical properties of nanomaterials,
4. uses top-down and bottom-up methods to synthesize nanoparticles and control their size and shape
5. characterize nanomaterials with various physico-chemical characterization tools and use them in development of modern technologies

Recommended Books:
1. Booker, R., Boysen, E., Nanotechnology, Wiley India Pvt, Ltd, (2008)
2. Rogers, B., Pennathur, S., Adams, J., Nanotechnology, CRS Press (2007)
3. Bandyopadhyay, A,K., Nano Materials, New Age Int,, (2007)
4. Niemeyer, C. N., and Mirkin, C, A., Nanobiotechnology: Concepts, Applications and Perspectives, Wiley VCH, Weinhein, Germany (2007)

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UEN004 TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

	L	T	P	Cr
	3	0	0	3.0

Course Objectives: To provide acquaintance with modern cleaner production processes and emerging energy technologies; and to facilitate understanding the need and application of green and renewable technologies for sustainable development of the Industry/society

Concepts of Sustainability and Industrial Processes: Industrialization and sustainable development; Cleaner production (CP) in achieving sustainability; Source reduction techniques - Raw material substitution; Process modification and equipment optimization; Product design or modification; Reuse and recycling strategies; Resources and by-product recovery from wastes; Treatment and disposal; CDM and Pollution prevention programs; Good housekeeping; CP audits,

Green Design: Green buildings - benefits and challenges; public policies and market-driven initiatives; Effective green specifications; Energy efficient design; Passive solar design; Green power; Green materials and Leadership in Energy and Environmental Design (LEED)

Renewable and Emerging Energy Technologies: Introduction to renewable energy technologies- Solar; wind; tidal; biomass; hydropower; geothermal energy technologies; Emerging concepts; Biomolecules and energy; Fuel cells; Fourth generation energy systems,

Course Learning Outcomes (CLOs):

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

1. comprehend basic concepts in source reduction, waste treatment and management
2. Identify and plan cleaner production flow charts/processes for specific industrial sectors
3. examine and evaluate present and future advancements in emerging and renewable energy technologies

Recommended Books

1. *Kirkwood, R,C, and Longley, A,J, (Eds,), Clean Technology and the Environment, Chapman & Hall, London (1995),*
2. *World Bank Group; Pollution Prevention and Abatement Handbook – Towards Cleaner Production, World Bank and UNEP; Washington DC (1998),*
3. *Modak, P,, Visvanathan, C, and Parasnis, M,, Cleaner Production Audit, Course Material on Cleaner Production and Waste Minimization; United Nations Industrial Development Organization (UNIDP) (1995),*
4. *Rao, S, and Parulekar, B,B,, Energy Technology: Non-conventional; Renewable and Conventional; Khanna Pub,(2005) 3rd Ed,*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UHU009 INTRODUCTION TO COGNITIVE SCIENCE

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L  T  P  Cr
3  0  0  3.0
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Course Objectives: This course provides an introduction to the study of intelligence, mind and brain from an interdisciplinary perspective, It encompasses the contemporary views of how the mind works, the nature of reason, and how thought processes are reflected in the language we use, Central to the course is the modern computational theory of mind and it specifies the underlying mechanisms through which the brain processes language, thinks thoughts, and develops consciousness,

Overview of Cognitive Science: Newell's big question, Constituent disciplines, Interdisciplinary approach, Unity and diversity of cognitive science,

Philosophy: Philosophy of Mind, Cartesian dualism Nativism vs, empiricism, Mind-body problem, Functionalism, Turing Test, Modularity of mind, Consciousness, Phineas Gage, Physicalism.

Psychology: Behaviorism vs, cognitive psychology, The cognitive revolution in psychology, Hardware/software distinction , Perception and psychophysics, Visual cognition, Temporal dynamics of visual perception, Pattern recognition, David Marr's computational theory of vision, Learning and memory, Theories of learning, Multiple memory systems, Working Memory and Executive Control, Memory span, Dissociations of short- and long-term memory, Baddeley's working memory model.

Linguistics: Components of a grammar, Chomsky, Phrases and constituents, Productivity, Generative grammars, Compositional syntax, Productivity by recursion, Surface- and deep structures, Referential theory of meaning, Compositional semantics, Semantics, Language acquisition, Language and thought.

Neuroscience: Brain anatomy, Hierarchical functional organization, Decorticate animals, Neuroimaging, Neurophysiology, Neuron doctrine, Ion channels, Action potentials, Synaptic transmission, Synaptic plasticity, Biological basis of learning, Brain damage, Amnesia, Aphasia, Agnosia, Parallel Distributed Processing(PDP), Computational cognitive neuroscience, The appeal of the PDP approach, Biological Basis of Learning, Cajal's synaptic plasticity hypothesis, Long-term potentiation (LTP) and depotentiation (LTD), NMDA receptors and their role in LTP, Synaptic consolidation, Vertical integration, The Problem of representation, Shannon's information theory.

Artificial Intelligence: Turing machines, Physical symbol systems, Symbols and Search Connectionism, Machine Learning,**,** Weak versus strong AI, Subfields, applications, and recent trends in AI, Turing Test revisited, SHRDLU, Heuristic search, General Problem Solver (GPS), Means-ends analysis.

Cognitive architectures: Tripartite architecture, Integration, ACT-R Architecture Modularity.

Course Learning Outcomes (CLOs):

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

1. identify cognitive science as an interdisciplinary paradigm of study of cross-cutting areas such as Philosophy, Psychology, Neuroscience, Linguistics, Anthropology, and Artificial Intelligence.
2. explain various processes of the mind such as memory and attention, as well as representational and modelling techniques that are used to build computational models of mental processes;
3. acquire basic knowledge of neural networks, linguistic formalism, computing theory, and the brain.
4. apply basic Artificial Intelligence techniques to solve simple problems.

Recommended Books

1. *Bermúdez, J.L., Cognitive Science: An Introduction to the Science of the Mind (2nd Ed,), Cambridge, UK: Cambridge (2014).*
2. *Friedenberg ,J,D, and Silverman,G, Cognitive Science: An Introduction To The Study Of Mind, Sage Publications:, London* (2014)
3. *Thagard, P., Mind: An introduction to Cognitive Science, MIT Press, (2005)*
4. *Thagard, P., (1998) Mind Readings: Introductory Selections on Cognitive Science, MIT Press, Cambridge, Mass,*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UHU008 INTRODUCTION TO CORPORATE FINANCE

	L	T	P	Cr
	3	0	0	3.0

Course Objective:
This course aims to provide the students with the fundamental concepts, principles and approaches of corporate finance, enable the students to apply relevant principles and approaches in solving problems of corporate finance and help the students improve their overall capacities.

Introduction to corporate finance: Finance and corporate finance. Forms of business organizations, basic types of financial management decisions, the goal of financial management, the agency problem; the role of the financial manager; basic types of financial management decisions.

Financial statements analysis: Balance sheet, income statement, cash flow, fund flow financial statement analysis Computing and interpreting financial ratios; conducting trend analysis and Du Pont analysis.

The time value of money: Time value of money, future value and compounding, present value and discounting, uneven cash flow and annuity, discounted cash flow valuation.

Risk and return: Introduction to systematic and unsystematic risks, computation of risk and return, security market line, capital asset pricing model.

Long-term financial planning & Financial Decisions: Various sources of long term financing, the elements and role of financial planning, financial planning model, percentage of sales approach, external financing needed. Cost of capital, financial leverage, operating leverage. Capital structure, theories of capital structure net income, net operating income & M&M proposition I and II.

Short-term financial planning and management: Working capital, operating cycle, cash cycle, cash budget, short-term financial policy, cash management, inventory management, credit management.

Capital budgeting : Concepts and procedures of capital budgeting, investment criteria (net present value, payback, discounted payback, average accounting return, internal rate of return, profitability index), incremental cash flows, scenario analysis, sensitivity analysis, break-even analysis,

Dividend policy: Dividend, dividend policy, Various models of dividend policy (Residual approach, Walter model, Gordon Model, M&M, Determinants of dividend policy.

Security valuation: Bond features, bond valuation, bond yields, bond risks, stock features, common stock valuation, and dividend discount & dividend growth models. Common stock yields, preferred stock valuation.

Course Learning Outcomes (CLO):
1.   Ability to evaluate critically corporate financial management practices with the aim of proposing and implementing improvements.

2. Apply the methods and procedures of financial management, with particular reference to investment evaluation corporate evaluation and risk management.

3. Applying the knowledge to estimate a company's cost of capital; determine whether a company is creating or destroying value.

4. Applying the various theories of corporate finance to design a company's optimal mix of debt and equity financing; and compensate shareholders in the most convenient way.

5. Apply the methods and procedures to value stocks and bonds; assess the risk and return of assets.

Recommended Books:

1. *Brealey, R. A., Myers. S.C., Allen, F., Principles of Corporate Finance (9th edition), The McGraw-Hill, London, (2006).*

2. *Ehrhardt, M.C., Brigham, E.F., Financial Management: Theory and Practice (10th edition) South Western-Cengage, New York (2011)*

3. *Van Horne, J.C., Wachowicz, J.M., Kuhlemeyer, G.A., 2005, Fundamentals of Financial Management, Pearson, Vancouver (2010)*

4. *Pandey, I. M., Financial management, Vikas Publishing House Pvt. Ltd., Noida (2011)*

5. *Elton, E.J. and Gruber, M.J., Modern Portfolio Theory and Investment Analysis, (7th Edition), John Wiley and Sons, New York (2007)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UMA062 GRAPH THEORY AND APPLICATIONS

	L	T	P	Cr
	3	0	0	3.0

Course Objective:

The objective of the course is to introduce students with the fundamental concepts in graph Theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the computer, electrical and other engineering,

Introduction: Graph, Finite and infinite graph, incidence and degree, Isolated vertex, Pendent vertex and null graph, Isomorphism, Sub graph, Walks, Paths and circuits, Euler circuit and path, Hamilton path and circuit, Euler formula, Homeomorphic graph, Bipartite graph, Edge connectivity, Computer representation of graph, Digraph.

Tree and Fundamental Circuits: Tree, Distance and center in a tree, Binary tree, Spanning tree, Finding all spanning tree of a graph, Minimum spanning tree.

Graph and Tree Algorithms: Shortest path algorithms, Shortest path between all pairs of vertices, Depth first search and breadth first of a graph, Huffman coding, Cuts set and cut vertices, Warshall's algorithm, topological sorting.

Planar and Dual Graph: Planner graph, Kuratowski's theorem, Representation of planar graph, five-color theorem, Geometric dual.

Coloring of Graphs: Chromatic number, Vertex coloring, Edge coloring, Chromatic partitioning, Chromatic polynomial, covering.

Application of Graphs and Trees: Konigsberg bridge problem, Utilities problem, Electrical network problem, Seating problem, Chinese postman problem, Shortest path problem, Job sequence problem, Travelling salesman problem, Ranking the participant in a tournament, Graph in switching and coding theory, Time table and exam scheduling, Applications of tree and graph in computer science.

Course Learning Outcomes (CLO):

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

1) understand the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices.
2) understand the properties of trees and able to find a minimal spanning tree for a given weighted graph.
3) understand Eulerian and Hamiltonian graphs.
4) apply shortest path algorithm to solve Chinese Postman Problem .
5) apply the knowledge of graphs to solve the real life problem.

Recommended Books

1. *Deo, N., Graph Theory with Application to Engineering with Computer Science, PHI, New Delhi (2007)*
2. *West, D. B., Introduction to Graph Theory, Pearson Education, London (2008)*

3. *Bondy, J. A. and Murty, U.S.R., Graph Theory with Applications, North Holland Publication, London (2000)*
4. *Rosen, K. H., Discrete Mathematics and its Applications, Tata-McGraw Hill, New Delhi (2007)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UMA061 ADVANCED NUMERICAL METHODS

	L	T	P	Cr
	3	0	0	3.0

Course Objective:

The main objective of this course is to motivate the students to understand and learn various advanced numerical techniques to solve mathematical problems governing various engineering and physical problems.

Non-Linear Equations: Methods for multiple roots, Muller's, Iteration and Newton-Raphson method for non-linear system of equations and Newton-Raphson method for complex roots.

Polynomial Equations: Descartes' rule of sign, Birge-vieta, Giraffe's methods.

System of Linear Equations: Cholesky and Partition methods, SOR method with optimal relaxation parameters.

Eigen-Values and Eigen-Vectors: Similarity transformations, Gerschgorin's bound(s) on eigenvalues, Given's and Rutishauser methods.

Interpolation and Approximation: Cubic and B – Spline and bivariate interpolation, Least squares approximations, Gram-Schmidt orthogonalisation process and approximation by orthogonal polynomial, Legendre and Chebyshev polynomials and approximation.

Differentiation and Integration: Differentiation and integration using cubic splines, Romberg integration and multiple integrals.

Ordinary differential Equations: Milne's, Adams-Moulton and Adam's Bashforth methods with their convergence and stability, Shooting and finite difference methods for second order boundary value problems.

Course Learning Outcomes (CLO):

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

1) find multiple roots of equation and apply Newton -Raphson's method to obtain complex roots as well solution of system of non - linear equations.
2) learn how to obtain numerical solution of polynomial equations using Birge - Vitae and Giraffe's methods.
3) apply Cholesky, Partition and SOR methods to solve system of linear equations.
4) understand how to approximate the functions using Spline, B- Spline, least square .approximations
5) learn how to solve definite integrals by using cubic spline, Romberg and initial value problems and boundary value problems numerically.

Recommended Books

1) Gerald, C.F. and Wheatley, P.O., Applied Numerical Analysis, Pearson Education (2008) 7ᵗʰ ed.
2) Gupta, S.R., Elements of Numerical Analysis, MacMillan India (2009).

1) *Atkinson, K.E., An introduction to Numerical Analysis, John Wiley (2004) 2nd ed.*
2) *S.D. Conte, S.D. and Carl D. Boor, Elementary Numerical Analysis: An Algorithmic Approach, Tata McGraw Hill (2005).*
3) *Jain M. K., Iyengar. S.R.K. and Jain, R.K. Numerical Methods for Scientific and Engineering Computation, New Age International (2008) 5th ed.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UHU006 INTRODUCTORY COURSE IN FRENCH

L T P Cr
3 0 0 3.0

Course Objectives:

The objectives of the course is to introduce to the students:

1. The basics of French language to the students. It assumes that the students have minimal or no prior knowledge of the language.
2. To help them acquire skills in writing and speaking in French, comprehending written and spoken French.
3. The students are trained in order to introduce themselves and others, to carry out short conversation, to ask for simple information, to understand and write short and simple messages, to interact in a basic way.
4. The main focus of the students will be on real life language use, integration of French and francophone culture, & basic phrases aimed at the satisfaction of needs of concrete type.
5. During class time the students are expected to engage in group & pair work.

Communicative skills: Greetings and Its Usage, Asking for and giving personal information, How to ask and answer questions, How to talk over the phone, Exchange simple information on preference, feelings etc. Invite, accept, or refuse invitation, Fix an appointment, Describe the weather, Ask for/give explanations, Describe a person, an object, an event, a place.

Grammar : Pronouns: Pronom sujets (Je/ Tu/Il/Elle/Nous/Vous/Ils/Elles), Nouns: Genders, Articles: Definite article and Indefinite articles, Verbs: Regular verbs (-er, -ir ending) Irregular verbs (-re ending), Auxiliary verbs (avoir, être, aller). Adjective: Description, Adjective possessive, Simple Negation, Tense: Present, Future, Questions, Singular & plural.

Vocabulary: Countries and Nationalities, Professions, Numbers (ordinal, cardinal), Colours, Food and drinks, Days of the week, Months, Family, Places.

Phonetics: The course develops the ability, to pronounce words, say sentences, questions and give orders using the right accent and intonation. To express surprise, doubt, fear, and all positive or negative feelings using the right intonation. To distinguish voiced and unvoiced consonants. To distinguish between vowel sounds.

Course Learning Outcomes (CLO):

Upon the completion of the course:

1. The students begin to communicate in simple everyday situations acquiring basic grammatical structure and vocabulary.
2. The course develops oral and reading comprehension skills as well as speaking and writing.
3. Students can demonstrate understanding of simple information in a variety of authentic materials such as posters, advertisement, signs etc.
4. Discuss different professions, courses and areas of specialisation.

5. Write simple messages, letters, composition and dialogues. Complete simple forms and documents.

6. Express feelings, preferences, wishes and opinions and display basic awareness of francophone studies.

7. Units on pronunciation and spelling expose students to the different sounds in the French language and how they are transcribed.

Recommended Books :

1. *Alter ego-1 : Méthode de français by Annie Berthet, Catherine Hugot, Véronique M. Kizirion, Beatrix Sampsonis, Monique Waendendries, Editions Hachette français langue étrangère.*

2. *Connexions-1 : Méthode de français by Régine Mérieux, Yves Loiseau, Editions Didier*

3. *Version Originale-1: Méthode de français by Monique Denyer, Agustin Garmendia.*

4. *Marie-Laure Lions-Olivieri, Editions Maison des Langues, Paris 2009*

5. *Latitudes-1 : Méthode de français by Régine Mérieux, Yves Loiseau, Editions Didier*

6. *Campus-1 : Méthode de français by Jacky Girardet, Jacques Pécheur, Editions CLE International.*

7. *Echo-1 : Méthode de français by J. Girardet, J. Pécheur, Editions CLE International.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UBT509 BIOLOGY FOR ENGINEERS

L T P Cr
3 0 0 3.0

Course Objective: To learn about living world and basic functioning of biological systems. The course encompasses understanding of origin of life, its evolution and some of its central characteristics. It also aims to familiarize engineering students to some of the intricate biological phenomena and mechanisms.

Characteristics of life: Living versus non-living organisms, origin of life, theory of evolution, diversity of life, classification of life into animals, plants, fungi, protists, archea and bacteria. Phylogenetics and its relationship with evolution.

Introduction to biological systems: Cell as basic unit of life, cellular organelles and their functions, important biomacromolecules (carbohydrates, lipids, proteins and nucleic acids) and their properties.

Cell membrane: Membrane structure, selective permeability, transport across cell membrane, active and passive transport, membrane proteins, type of transport proteins, channels and pumps, examples of membrane transport in cell physiology.

Classical and molecular genetics: Heredity and laws of genetics, genetic material and genetic information, Structure and properties of DNA, central dogma, replication of genetic information, universal codon system, encoding of genetic information via transcription and translation.

Course Learning Outcomes (CLOs):

After completion of this course the students will be able to:

1. Describe living-systems and differentiate them from non-living systems
2. Explain the theory of evolution and apply it non-living world
3. Apply properties of nucleic acids in molecular recognition based diagnostics
4. Familiarized with various transport mechanisms across cell membranes
5. Explain how genetic information is stored, replicated and encoded in living organisms.

Recommended Books:

1. *Nelson, D.L., Cox, M.M., Lehninger: Principles of Biochemistry, WH Freeman (2008) 5th ed.*
2. *Dhami, P.S., Srivastava, H.N. Chopra, G., A Textbook of Biology, Pradeep Publications (2008).*
3. *Das, H.K., Textbook of Biotechnology, John Wiley & Sons (2004) 3rd Edition.*
4. *Gardner, E.J., Simmons, M., Peter, S.D., Principles of Genetics, John Wiley & Sons (2008)*
5. *Albert, B., Essential Cell Biology, Taylor & Francis, London (2009)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UCS001 INTRODUCTION TO CYBER SECURITY

L   T   P   Cr
3   0   0   3.0

Course Objectives: In this course, the student will learn about the essential building blocks and basic concepts around cyber security such as Confidentiality, Integrity, Availability, Authentication, Authorization, Vulnerability, Threat and Risk and so on.

Introduction: Introduction to Computer Security, Threats, Harm, Vulnerabilities, Controls, Authentication, Access Control, and Cryptography, Authentication, Access Control, Cryptography

Programs and Programming: Unintentional (Non-malicious) Programming Oversights, Malicious Code—Malware, Countermeasures

Web Security: User Side, Browser Attacks, Web Attacks Targeting Users, Obtaining User or Website Data, Email Attacks

Operating Systems Security: Security in Operating Systems, Security in the Design of Operating Systems, Rootkit

Network Security: Network Concepts, Threats to Network Communications, Wireless Network Security, Denial of Service, Distributed Denial-of-Service Strategic Defenses: Security Countermeasures, Cryptography in Network Security, Firewalls, Intrusion Detection and Prevention Systems, Network Management

Cloud Computing and Security: Cloud Computing Concepts, Moving to the Cloud, Cloud Security Tools and Techniques, Cloud Identity Management, Securing IaaS

Privacy: Privacy Concepts, Privacy Principles and Policies, Authentication and Privacy, Data Mining, Privacy on the Web, Email Security, Privacy Impacts of Emerging Technologies, Where the Field Is Headed

Management and Incidents: Security Planning, Business Continuity Planning, Handling Incidents, Risk Analysis, Dealing with Disaster

Legal Issues and Ethics: Protecting Programs and Data, Information and the Law, Rights of Employees and Employers, Redress for Software Failures, Computer Crime, Ethical Issues in Computer Security, Incident Analysis with Ethics

Emerging Topics: The Internet of Things, Economics, Computerized Elections, Cyber Warfare.

Course Learning Outcomes (CLO):

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

1. Understand the broad set of technical, social & political aspects of Cyber Security and security management methods to maintain security protection
2. Appreciate the vulnerabilities and threats posed by criminals, terrorist and nation states to national infrastructure
3. Understand the nature of secure software development and operating systems
4. Recognize the role security management plays in cyber security defense and legal and social issues at play in developing solutions.

Recommended Books:

1. *Pfleeger, C.P., Security in Computing, Prentice Hall, 5th edition (2010)*
2. *Schneier, B., Applied Cryptography, Second Edition, John Wiley & Sons (1996)*
3. *Rhodes-Ousley, M., Information Security: The Complete Reference, Second Edition, Information Security Management: Concepts and Practice. New York, McGraw-Hill, (2013).*
4. *Whitman, M.E. and Herbert J. M., Roadmap to Information Security for IT and Infosec Managers, Course Technology, Boston, MA (2011).*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55

UTD007 EMPLOYABILITY DEVELOPMENT SKILLS

L	T	P	Cr
0	3	3	3.0

Course Objectives:
This course aims to sensitize students with the gamut of skills which facilitate them to enhance their employability quotient and do well in the professional space. These skills are imperative for students to establish a stronger connect with the environment in which they operate. An understanding of these skills will enable students to manage the placement challenges more effectively.

Emotional Intelligence: Understanding Emotional Intelligence (EI); Daniel Goleman's EI Model: Self Awareness, Self-Regulation, Internal Motivation, Empathy, Social Skills; Application of EI during Group Discussions & Personal Interview; Application of EI in personal life, student life and at the workplace

Team Dynamics & Leadership: Understanding the challenges of working within a team format in today's complex organizational environments; Stages of team formation; Appreciating forces that influence the direction of a team's behaviour and performance; Cross-functional teams; Conflict in Teams- leveraging differences to create opportunity Leadership in the team setting & energizing team efforts; Situational leadership; Application of team dynamics & collaboration in Group Discussions; Application of team dynamics at the workplace

Complex Problem Solving: Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions; Understanding a working model for complex problem solving - framing the problem, diagnosing the problem, identifying solutions & executing the solutions; Appreciation of complex problem solving at the workplace through case studies

Lateral Thinking: Understanding lateral thinking & appreciating the difference between vertical & lateral thinking, and between convergent & divergent thinking; Understanding brain storming & mind-maps; Solving of problems by an indirect and creative approach, typically through viewing the problem in a new and unusual light; Application of lateral thinking during Group Discussions & Personal Interviews; Application of lateral thinking at the workplace

Persuasion: Role of persuasion in communication; Application of ethos-pathos-logos; Using persuasive strategies to connect with individuals & teams to create competitive advantage

Quantitative Reasoning: Thinking critically and applying basic mathematics skills to interpret data, draw conclusions, and solve problems; developing proficiency in numerical reasoning; Application of quantitative reasoning in aptitude tests

Verbal Reasoning: Understanding and reasoning using concepts framed in words; Critical verbal reasoning; Reading Comprehension; Application of verbal reasoning in aptitude tests

Group Discussion (GD): Illustrating the do's and don'ts in Group Discussions; Specific thrust on types of GD topics; GD evaluation parameters; Understanding the challenge in a case discussion; SPACER model

Personal Interview (PI): Interview do's and don'ts; PI evaluation parameters; The art of introduction; Managing bouncer questions; Leading the panel in a PI

Course Learning Outcomes (CLOs):

The students will be able to

1. appreciate the various skills required for professional & personal success.
2. bridge the gap between current and expected performance benchmarks.
3. competently manage the challenges related to campus placements and perform to their utmost potential.

Recommended Books:

1. *Harvard Business Essentials; Creating Teams with an Edge; Harvard Business School Press (2004)*
2. *Edward de B., Six Thinking Hats; Penguin Life (2016)*
3. *Daniel, G., Working with Emotional Intelligence; Bantam Books (2000)*
4. *Aggarwal, R.S., Quantitative Aptitude for Competitive Examinations; S Chand (2017)*
5. *Agarwal, A., An expert guide to problem solving: with practical examples; CreateSpace Independent Publishing Platform (2016)*
6. *William, D., The Logical Thinking process; American Society for Quality (2007)*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	45
2	EST	55