Thapar Institute of Engineering & Technology, Patiala

COURSES SCHEME

&

SYLLABUS

FOR

B.E.

MECHANICAL ENGINEERING

2019

Approved in 100th meeting of Senate held on March 09, 2020

SEMESTER-I

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UEC001	ELECTRONIC ENGINEERING	3	1	2	4.5
2	UHU003	PROFESSIONAL COMMUNICATION	2	0	2	3.0
3	UMA010	MATHEMATICS - I	3	1	0	3.5
4	UPH004	APPLIED PHYSICS	3	1	2	4.5
5	UTA015	ENGINEERING DRAWING	2	4	0	4.0
6	UTA003	COMPUTER PROGRAMMING	3	0	2	4.0
		TOTAL	**16**	**7**	**8**	**23.5**

SEMESTER-II

SR. NO.	COURSE NO.	TITLE	L	T	P	CR
1	UCB008	APPLIED CHEMISTRY	3	1	2	4.5
2	UEE001	ELECTRICAL ENGINEERING	3	1	2	4.5
3	UEN002	ENERGY AND ENVIRONMENT	3	0	0	3.0
4	UES009	MECHANICS	2	1	2*	2.5
5	UMA004	MATHEMATICS - II	3	1	0	3.5
6	UTA013	ENGINEERING DESIGN PROJECT – I (6 SELF EFFORT HOURS)	1	0	2	5.0
7	UTA018	OBJECT ORIENTED PROGRAMMING	3	0	2	4.0
		TOTAL	**18**	**4**	**8***	**27.0**

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

SEMESTER-III

S. No.	Course Number	Course Title	L	T	P	Cr
1.	UTA014	ENGINEERING DESIGN PROJECT-II (6 Self-Effort Hours) (Buggy)	1	0	4	6.0
2	UTA026	MANUFACTURING PROCESSES	2	0	2	3.0
3	UES017	SOLIDS AND STRUCTURES	3	1	2*	4.0
4	UME307	ENGINEERING FLUID MECHANICS	3	1	0	3.5
5	UME308	MECHANICS OF MACHINES	3	1	2*	4.0
6	UTA025	INNOVATION & ENTREPRENEURSHIP	1	0	2*	3.0
7	UMA035	OPTIMIZATION METHODS	3	0	2	4.0
		TOTAL	**16**	**3**	**11**	**27.5**

*** Alternate week**

SEMESTER-IV

S. No.	Course Number	Course Title	L	T	P	Cr
1.	UES012	ENGINEERING MATERIALS	3	1	2	4.5
2.	UMA011	NUMERICAL ANALYSIS	3	0	2	4.0
3.	UME404	MECHANICS OF DEFORMABLE BODIES	3	1	0	3.5
4.	UME410	MECHATRONIC SYSTEMS	3	0	2	4.0
5.	UME412	COMPUTER AIDED DESIGN & ANALYSIS	3	2	3	5.5
6.	UES004	THERMODYNAMICS	3	1	0	3.5
7.	UME515	INDUSTRIAL ENGINEERING	2	1	0	2.5
		TOTAL	**20**	**6**	**9**	**27.5**

First four semesters for integrated BE MBA (Mechanical) Program are common with BE (Mechanical) Program.

SEMESTER-V

S. No.	Course Number	Course Title	L	T	P	Cr
1.	UME408	MACHINE DESIGN-I	3	2	0	4.0
2.	UME718	APPLIED THERMODYNAMICS	3	1	2*	4.0
3.	UME509	MANUFACTURING TECHNOLOGY	3	0	2	4.0
4.	UME516	MECHANICAL ENGINEERING MATERIALS	3	1**	0	3.5
5.		ELECTIVE-I	2-3	1	0-2	3.5
6.	UME511	AUTOMOBILE ENGINEERING	3	0	2*	3.5
		TOTAL	**17-18**	**5**	**6-8**	**22.5**

*** Alternative week.**

**** Some of the tutorial classes will be used for demonstration in the lab.**

SEMESTER-VI

Sixth Semester						
S. No.	**Course Number**	**Course Title**	**L**	**T**	**P**	**Cr**
1.	UME699	PROJECT SEMESTER	**-**	**-**	**-**	**15**
OR Alternate Semester						
S. No.	**Course Number**	**Course Title**	**L**	**T**	**P**	**Cr**
1.	UME700	GROUP PROJECT	-	-	-	8
2.	UPE602	SUPPLY CHAIN MANAGEMENT	3	1	0	3.5
3	UPE601	FACILITY PLANNING	3	1	0	3.5
			6	**2**	**0**	**15.0**

OR

UME690 - Start-up Semester 15.0
This module shall be offered as an alternative to Internship for interested students. This semester will comprise of Hands-on Workshops on innovation & entrepreneurship and a project course. Students will be encouraged to extensively use Design Lab and Venture Lab.

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SEMESTER-VII

S. No.	Course Number	Course Title	L	T	P	Cr
1.	UME707	MACHINE DESIGN –II	2	2	0	3.0
2.	UME720	HEAT TRANSFER	3	1	2*	4.0
3.	UME719	REFRIGERATION AND AIR CONDITIONING	3	1	2*	4.0
4.	UME513	DYNAMICS & VIBRATIONS	3	1	2	4.5
5	UME793	CAPSTONE PROJECT (STARTS)	1*	-	2	--
6		ELECTIVE II	2-3	1	0-2	3.5
7		GENERIC ELECTIVE	3	0	0	3.0
			16-17	**6**	**6-8**	**22.0**

*** Alternate week.**

SEMESTER-VIII

S. No.	Course Number	Course Title	L	T	P	Cr
1	UHU005	HUMANITIES FOR ENGINEERS	2	0	2	3.0
2	UME723	FLUID MACHINES	3	1	2*	4.0
3		ELECTIVE III	2-3	1	0-2	3.5
4	UME793	CAPSTONE PROJECT (COMPLETION)	1*	-	2	8.0
			7-8	**2**	**5-7**	**18.5**

*** Alternate week.**

EL Activity

Semester	EL Activity**
I	Mountain bicycle
II	Engine and automobile gearbox
III	Chair testing machine
IV	2-axis and 3-axis CNC table
V	Heat exchanger

** These EL activities can be changed in subsequent years, if required.

PROFESSIONAL ELECTIVE BASKETS

Basket	Elective I (Semester 5)	Elective II (Semester 7)	Elective III Semester (8)
	Cr. 3.5	Cr. 3.5	Cr. 3.5
Design Basket	• Robotics Engineering (UME805) • Finite Element Methods (UME832) • Optimization in Engineering Design (UME521) • Fracture Mechanics (UME522)	• Tribology (UME721) • Machine Tool Design (UME844) • System Modelling and Simulation (UME722) • Conditioning Monitoring of Rotating Machines (UME737)	• Mechanics of Composite Materials (UME842) • Advanced Mechanical Vibrations (UME857) • Modern Automobile Engineering (UME841)
Manufacturing Basket	• Computer Aided Manufacturing (UPE705) • Industrial Automation and IoT (UME523) • Work Study and Ergonomics Engineering (UPE501) • Additive Manufacturing (UME524)	• Machining Science (UME735) • Metal Forming (UPE703) • Welding for Industry & Engineers (UME736) • Lean and Agile Manufacturing (UPE503)	• Non Traditional Machining Processes (UME855) • Operations Management (UME836) • Processing of Polymers and Composites (UPE831) • Total Quality Management (UME856)
Thermal Basket	• Power Plant and Process Utility Systems (UME852) • Renewable Energy Systems (UME839)	• Computational Fluid Dynamics (UME831)	• Solar Energy Engineering (UME853) • Advanced IC Engines (UME854)

GENERIC ELECTIVE						
S.No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1	UTD001	EMPLOYABILITY DEVELOPMENT SKILLS	2	2	0	3.0
2	UHU006	INTRODUCTORY COURSE IN FRENCH	3	0	0	3.0
3	UHU009	INTRODUCTION TO COGNITIVE SCIENCE	3	0	0	3.0
4	UHU008	INTRODUCTION TO CORPORATE FINANCE	3	0	0	3.0
5	UCS001	INTRODUCTION TO CYBER SECURITY	3	0	0	3.0
6	UPH063	NANOSCIENCE AND NANOMATERIALS	3	0	0	3.0
7	UEN004	TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT	3	0	0	3.0
8	UMA066	GRAPH THEORY AND APPLICATIONS	3	0	0	3.0
9	UMA067	ADVANCED NUMERICAL METHODS	3	0	0	3.0
10	UBT509	BIOLOGY FOR ENGINEERS	3	0	0	3.0

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SEMESTER-I

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UEC001: 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; Transistor as a switch, as an Amplifier and its frequency Response; Introduction to Field Effect Transistor and its characteristics, N and P channel MOS transistors; CMOS inverter, NAND and NOR gates; General CMOS Logic; TTL and CMOS logic families.

Operational Amplifier Circuits: The ideal operational amplifier; The inverting; non-inverting amplifiers; Op-Amp Characteristics; Applications 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; Karnaugh Maps.

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; IEEE Representation of Digital ICs.

Laboratory Work:

Familiarization with CRO, DSO and Electronic Components, Diodes characteristics - Input-Output and Switching, BJT and MOSFET Characteristics, Zener diode as voltage regulator, Rectifiers, Clippers and Clampers, adder circuit implementation, Multiplexer & its application, Latches/Flip-flops, up/down counters.

Course Learning Outcomes (CLO):

On completion of the Course, the student would be able to:

1. demonstrate the use of semiconductor diodes in various applications.
2. discuss and explain the working of transistors and operational Amplifiers, their configurations and applications.
3. recognize and apply the number systems and Boolean algebra.
4. reduce Boolean expressions and implement them with Logic Gates.
5. analyze, design and implement combinational and sequential circuits.

Text Books:

1. *Boylestad, R.L. and Nashelsky, L., Electronic Devices & Circuit Theory, Perason (2009).*
2. *M. M. Mano and M.D. Ciletti, Digital Design, Pearson, Prentice Hall, 2013.*

Reference Books:

1. *Milliman, J. and Halkias, C.C., Electronic Devices and Circuits, Tata McGraw Hill, 2007.*
2. *Donald D Givone, Digital Principles and Design, McGraw-Hill, 2003.*
3. *John F Wakerly, Digital Design: Principles and Practices, Pearson, (2000).*
4. *N Storey, Electronics: A Systems Approach, Pearson, Prentice Hall, (2009).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessional (May include Assignments/Projects/Tutorials/Quiz(es)/ 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 Communication skills.

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 and proposals.

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.

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

Laboratory work :

1. Needs-assessment of spoken and written communication and feedback.
2. Training for Group Discussions through simulations and role plays.
3. Technical report writing on survey based projects.
4. Project based team presentations.

Course Learning Outcomes (CLO):

On completion of the course, the students would be able to:

1. apply communication concepts for effective interpersonal communication.
2. select the most appropriate media of communication for a given situation.
3. speak assertively and effectively.
4. write objective organizational correspondence.
5. design effective resumes, reports and proposals .

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 New Delhi.(2011).*
3. *Mukherjee H.S.,Business Communication-Connecting at Work,Oxford University Press New Delhi, (2013).*

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Reference Books:

1. *Butterfield, Jeff.,Soft Skills for everyone,Cengage Learning New Delhi,(2013).*
2. *Robbins, S.P., & Hunsaker, P.L.,Training in Interpersonal Skills,Prentice Hall of India New Delhi,(2008).*
3. *DiSianza,J.J & Legge,N.J.,Business and Prfofessional Communication,Pearson Education India New Delhi,(2009).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (Group Discussions; professional presentations;poster presentatios ,public speaking;technical reports)	40

UMA010-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, calculus of several variables and complex analysis which would enable them to devise solutions for given situations they may encounter in their engineering profession.

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: : Double integral (Cartesian), Change of order of integration in double integral, Polar coordinates, graphing of polar curves, Change of variables (Cartesian to polar), Applications of double integrals to areas and volumes, evaluation of triple integral (Cartesian).
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 conditional convergence.
Series Expansions: Power series, Taylor series, Convergence of Taylor series, Error estimates, Term by term differentiation and integration.
Complex analysis: Introduction to complex numbers, geometrical interpretation, functions of complex variables, examples of elementary functions like exponential, trigonometric and hyperbolic functions, elementary calculus on the complex plane (limits, continuity, differentiability), Cauchy-Riemann equations, analytic functions, harmonic functions.

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

1) examine functions of several variables, define and compute partial derivatives, directional derivatives and their use in finding maxima and minima in some engineering problems.
2) evaluate multiple integrals in Cartesian and Polar coordinates, and their applications to engineering problems.
3) determine the convergence/divergence of infinite series, approximation of functions using power and Taylor's series expansion and error estimation.
4) represent complex numbers in Cartesian and Polar forms and test the analyticity of complex functions by using Cauchy-Riemann equations.

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), 6th ed.*
3. *Kasana, H.S., Complex Variables: Theory and Applications, Prentice Hall India, 2005 (2nd edition).*

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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).*
3. *Brown J.W and Chruchill R.V, Complex variables and applications, MacGraw Hill, (7^{th} edition)*

Evaluation Scheme:

Sr.No.	Evaluation Elements	Weightage (%)
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

Course 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 - skin depth.

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 various media.
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 diffraction grating.
5. Determination of specific rotation of cane sugar solution.
6. Study and proof of Malus' law in polarization.
7. Determination of beam divergence and beam intensity of a given laser.
8. Determination of displacement and conducting currents through a dielectric.
9. Determination of Planck's constant.

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

Course Learning Outcomes (CLO):

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On completion of the course, the students would 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.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

S.No	Assessment	Weightage (%)
1	MST	25
2	EST	35
3	Tut/Sessional	7
4	Lab + Project	25
5	Quiz	8
Total		**100**

UTA015: ENGINEERING DRAWING

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 projection system
3. Isometric Projections
4. Auxiliary Projections
5. Perspective Projections
6. Introduction to Mechanical Drawing
7. Sketching engineering objects
8. Sections, dimensions and tolerances

AutoCAD

1. Management of screen menus commands
2. Introduction to drawing entities
3. Co-ordinate systems: Cartesian, polar and relative coordinates
4. Drawing limits, units of measurement and scale
5. Layering: organizing and maintaining the integrity of drawings
6. Design of prototype drawings as templates.
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

Micro Projects /Assignments:

1. Completing the views - Identification and drawing of missing lines in the projection of objects
2. Missing views – using two views to draw the projection of the object in the third view, primarily restricting to Elevation, Plan and Profile views
3. 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 of the objects created in (1) and (2).

4. Develop the lateral surface of different objects involving individual or a combination of solids like Prism, Cone, Pyramid, Cylinder, Sphere etc.
5. 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):

On completion of the Course, the student would be able to:

1. creatively comprehend geometrical details of common engineering objects
2. draw dimensioned orthographic and isometric projections of simple engineering objects
3. draw sectional views of simple engineering objects.
4. interpret the meaning and intent of toleranced dimensions and geometric tolerance symbolism
5. create and edit dimensioned drawings of simple engineering objects using AutoCAD
6. organize drawing objects using layers and setting up of templates in 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:

S.No.	Evaluation Elements	Weightage (%)
1.	MST (formal written test)	25
2.	EST (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

UTA003: COMPUTER PROGRAMMING

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.

Computers Fundamentals: Classification of Computers; Application of Computers; Basic organization of computer; Input and Output Devices; Binary Number System; Computer memory; Computer Software.

Algorithms and Programming Languages: Algorithm; Flowcharts; Pseudocode; Generation of Programming Languages.

C Language: Structure of C Program; Life Cycle of Program from Source code to Executable; Compiling and Executing C Code; Keywords; Identifiers; Primitive Data types in C; variables; constants; input/output statements in C; operators, type conversion and type casting. Conditional branching statements; iterative statements; nested loops; break and continue statements.

Functions: Declaration; Definition, Call and return; Call by value; Call by reference; showcase stack usage with help of debugger; Scope of variables; Storage classes; Recursive functions; Recursion vs Iteration.

Arrays, Strings and Pointers: One-dimensional; Two-dimensional and Multi-dimensional arrays; operations on array: traversal; insertion; deletion; merging and searching; Inter-function communication via arrays: passing a row; passing the entire array; matrices. Reading; writing and manipulating Strings; Understanding computer memory; accessing via pointers; pointers to arrays; dynamic allocation; drawback of pointers.

Linear and Non-Linear Data Structures: Linked lists; stacks and queues.

Laboratory work:

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

Course Learning Outcomes (CLO):

On completion of the Course, the student would be able to:

1. comprehend concepts related to computer hardware and software, draw flowcharts and write algorithm/pseudocode.
2. write, compile and debug programs in C language, use different data types, operators and console I/O function in a computer program.
3. design programs involving decision control statements, loop control statements, case control structures, arrays, strings, pointers, functions and implement the dynamics of memory by the use of pointers.
4. comprehend the concepts of linear and Non-Linear data structures by implementing linked lists, stacks and queues.

Text Books:

1. *Kernighan, B.W. and Ritchie, D.M., The C Programming language, (2012) 2nd ed.*
2. *Balagurusamy, E., Programming in Ansi C, TMH Publications (2019) 8th ed.*

Reference Books:

1. *Perry, G. and Miller, D., C Programming Absolute Beginner's Guide, Pearson (2013), 3rd ed.*
2. *Griffiths, D., and Griffiths, D., Head First C, O'Reilly (2012), 1st ed.*

Evaluation scheme:

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

SEMESTER-II

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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; Gibb's phase rule; one component and two component systems.

Water Treatment and Analysis: Hardness and alkalinity of water: units and determination; external and internal methods 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 and inorganic polymers.

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

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

Laboratory Work:

1. **Electrochemical measurements**: Experiments involving use of pH meter, conductivity meter, potentiometer.
2. **Acid and Bases**: Determination of mixture of bases.
3. **Spectroscopic techniques**: Colorimeter, UV-Vis spectrophotometer.
4. **Water and its treatment**: Determination of hardness, alkalinity, chloride, chromium, iron and copper in aqueous medium.

Course Learning Outcomes (CLO):

On completion of the Course, the student would be able to:

1. concepts of electrodes in electrochemical cells, migration of ions, liquid junction potential and conductometric titrations.
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 ion exchange.
4. concept of phase rule, fuel quality parameters and alternative fuels.

5. polymerization, molecular weight determination and applications as biodegradable and conducting polymers.
6. laboratory techniques like pH metry, potentiometry, colourimetry, conductometry and volumetry.

Text Books:

1. *Ramesh, S. and Vairam S. Engineering Chemistry, Wiley India (2012) 1st 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, 1st ed*
2. *Sivasankar, B., Engineering Chemistry, Tata McGraw-Hill Pub. Co. Ltd, New Delhi (2008).*
3. *Shulz, M.J. Engineering Chemistry, Cengage Learnings (2007) 1st ed.*

Evaluation Scheme:

S.No	Assessment	Weightage (%)
1	MST	25
2	EST	40
3	Sessionals	35

UEE001: ELECTRICAL ENGINEERING

L	T	P	Cr
3	1	2	4.5

Course Objective: To introduce concepts of DC and AC circuits and electromagnetism. To make the students understand the concepts and working of 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 supply systems.

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

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.

Course Learning Outcome (CLO):

On completion of the Course, the student would be able to:

- apply networks laws and theorems to solve electric circuits.
- analyze transient and steady state response of DC circuits.
- signify AC quantities through phasor and compute AC system behaviour during steady state.
- explain and analyse the behaviour of transformer.
- elucidate the principle and characteristics of DC motor and DC generator**.**

Text Books:

1. *Hughes, E., Smith, I.M., Hiley, J. and Brown, K., Electrical and Electronic Technology, PHI (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 India Private Limited *(2004)*

Evaluation Scheme:

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

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 and environment.

Introduction: Natural Resources & its types, Concept of sustainability and sustainable use of natural resources, Pollution based environmental issues and case studies

Conventions on Climate Change: Origin of Conference of Parties (COPs), United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC); Kyoto Protocol, instruments of protocol – CDM, JI and IET; Montreal Action Plan; Paris Agreement and post-Paris scenario.

Air Pollution: Origin, Sources and effects of air pollution; Primary and secondary meteorological parameters; Wind roses; Atmospheric Stability; Inversion; Plume behavior; Management of air pollution: Source reduction and Air Pollution Control Devices for particulates and gaseous pollutants in stationary and mobile sources.

Water Pollution: Origin, Sources of water pollution, Category of water pollutants, Physico-Chemical characteristics, Components of wastewater treatment systems, Advanced treatment technologies.

Solid waste management: Introduction to solid waste management, Sources, characteristics of municipal and industrial solid waste, Solid waste management methods: Incineration, composting, Biomethanation, landfill, E-waste management, Basal convention-.

Energy Resources: Classification of Energy Resources; Conventional energy resources-Coal, petroleum and natural gas, nuclear energy, hydroelectric power; Non-conventional energy resources-Biomass energy, Thermo-chemical conversion and biochemical conversion route; Generation of Biogas and biodiesel as fuels; Solar energy-active and passive solar energy absorption systems; Type of collectors; Thermal and photo conversion applications; Wind energy.

Facilitated through Online Platforms

Ecology and Environment: Concept of an ecosystem; structural and functional units of an ecosystem; Food Chain, Food Web, Trophic Structures and Pyramids; Energy flow; Ecological Succession; Types, Characteristics, Biodiversity, Biopiracy.

Human Population and the Environment: Population growth, variation among nations; Population explosion – Family Welfare Programmes; Environment and human health; Human Rights; Value Education; Women and Child Welfare; Role of Information Technology in Environment and Human Health, Environmental Ethics.

Course Learning Outcomes (CLOs):

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

1. Comprehend the interdisciplinary context with reference to the environmental issues and case studies
2. Assess the impact of anthropogenic activities on the various elements of environment and apply suitable techniques to mitigate their impact.
3. Conceptualise and explain the structural and functional features of ecological systems
4. Correlate environmental concerns with the conventional energy sources associated and assess the uses and limitations of non-conventional energy technologies

Recommended Books

1. *Moaveni, S., Energy, Environment and Sustainability, Cengage (2018)*
2. *Down to Earth, Environment Reader for Universities, CSE Publication (2018)*
3. *Chapman, J.L. and Reiss, M.J., Ecology - Principles and Application, Cambridge University Press (LPE) (1999).*
4. *Eastop, T.P. and Croft, D.R. Energy Efficiency for Engineers and Technologists, Longman and Harow (2006).*
5. *O'Callagan, P.W., Energy Management, McGraw Hill Book Co. Ltd. (1993).*
6. *Peavy H.S. and Rowe D.R. Environmental Engineering, McGraw Hill (2013).*

Evaluation Scheme:

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

UES009: MECHANICS

L	T	P	Cr
2	1	2*	2.5

(*:Two hours Lab Once In Semester)

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 behavior can be predicted.

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.
Shear Force and Bending Moment Diagrams: Types of load on beams; classification of beams; axial, shear force and bending moment diagrams: simply supported, overhung and cantilever beams subjected to any combination of point loads, uniformly distributed and varying load and moment.
Virtual Work: Principle of virtual work; calculation of virtual displacement and virtual work.

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):
On completion of the course, the students would be able to:

1. determine resultants in plane force systems
2. identify and quantify all forces associated with a static framework
3. draw Shear Force Diagram and Bending Moment Diagram in various kinds of beams subjected to different kinds of loads

Text Books:

1. *Shames, I. H. Engineering Mechanics: Dynamics, Pearson Education India (2006).*
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, (2006).*

Evaluation Scheme:

Approved in 100th meeting of Senate held on March 09, 2020

Sr. No.	Evaluation Elements	Weights (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quiz	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; Convolution theorem; 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):

On completion of the course, the students would 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).*

Recommended 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), 11th ed.*

Evaluation Scheme:

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

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UTA013: ENGINEERING DESIGN PROJECT-I

L	T	P	Cr
-	-	-	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.

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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 optimise 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):

On completion of the Course, the student would 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	
	Electronics Hardware and software Practical work in Laboratory	30
	Assessment of Mechanical contents in Lectures and Tutorials and Electronics contents in Lectures and Practical.	30 10
	Project (Assembly of the "Mangonel", innovative redesign with reflection, prototype competition, Final Presentation and viva-voce	30

UTA018: OBJECT ORIENTED PROGRAMMING

L	T	P	Cr
3	0	2	4.0

Course Objectives: To become familiar with object-oriented programming concepts and be able to apply these concepts in solving diverse range of applications.

Objects and Classes: Structure in C and C++, Class specification, Objects, Data hiding, Encapsulation and abstraction, namespaces, Array of objects, Passing objects as arguments, Returning object from a function, inline functions, Static data member and member function, 'const' member function.

Constructor and Destructor: Constructors, Parameterized Constructors, Constructor Overloading, Constructors in array of objects, Constructors with default arguments, Dynamic Initialization, Pointer to objects, this pointer, Dynamic memory allocation, Array of pointer to objects, Copy Constructor, Static objects, Friend function, and Friend classes.

Operator Overloading and Type Conversion: Syntax of operator overloading, Overloading Unary operator and Binary operator, overloading arithmetic operator, relational operator, Overloading Unary operator and Binary operator using friend function, Data conversion, Overloading some special operators like (), []

Inheritance: Derived Class declaration, Public, Private and Protected Inheritance, friend function and Inheritance, Overriding member function, Forms of inheritance, virtual base class, Abstract class, Constructor and Inheritance, Destructor and Inheritance, Advantage and disadvantage of Inheritance.

Polymorphism: Classification of Polymorphism, Compile time and Run time Polymorphism, Pointers to derived class object, Virtual functions, Pure virtual functions.

File handling: Formatted I/O, Hierarchy of file stream classes, Opening and closing a file, Working with multiple files, file modes, file pointers, Text vs Binary Files.

Templates: Need of template, Function templates, Function template with non-type parameter, Overloading function templates, Class templates, Class template with non-type parameter.

Exception Handling: Exception handling mechanism, Multiple Catch Blocks, Catch All exceptions, Throw an exception, Exception Specification.

Standard Template Library: Fundamental idea about string, iterators, hashes and other types, The String and Vector classes vs C-style pointers

Laboratory work:

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

Course Learning Outcomes (CLOs):

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

1. Understand the basic concept of Classes, objects and Object Orientation, with basic layout of an object oriented program.
2. Comprehend the concept of constructors and destructors.
3. Demonstrate the prime concepts *viz.* overloading, polymorphism, abstraction and Inheritance of an object oriented paradigm.
4. Grasp the File handling concepts and be able to use files.

5. Use template and Exception handling in an object oriented programming.

Text Books:

1. *Schildt H., C++: The Complete Reference, Tata Mcgraw Hill (2003) 4th ed.*
2. *Lippman B. S., Lajoie J., and Moo E. B., C++ Primer, Addison-Wesley Professional (2013) 5th ed.*

Reference books:

1. *Lafore R., Object-Oriented Programming in C++, Pearson Education (2002) 4th ed.*
2. *E Balagurusamy, Object Oriented Programming with C++ (2017) 7th ed.*
3. *Stroustrup B., The C++ programming language, Pearson Education India (2013) 4th ed.*

Evaluation scheme

Sr. No.	**Evaluation Elements**	**Weights (%)**
1.	MST	25
2.	EST	45
3.	Sessional (May include Assignments/ Quiz/Lab evaluations)	30

SEMESTER-III

Approved in 100th meeting of Senate held on March 09, 2020

UTA014: ENGINEERING DESIGN PROJECT-II (BUGGY LAB)

L	T	P	Cr
1	0	4	6.0

Course objective: The project will introduce students to the challenge of electronic systems design & integration. The project is an example of '*hardware and software co-design'* and the scale of the task is such that it will require teamwork as a co-ordinated effort.

Hardware overview of Arduino:

- Introduction to Arduino Board: Technical specifications, accessories and applications.
- Introduction to Eagle (PCB layout tool) software.

Sensors and selection criterion:

- Concepts of sensors, their technical specifications, selection criterion, working principle and applications such as IR sensors, ultrasonic sensors.

Active and passive components:

- Familiarization with hardware components, input and output devices, their technical specifications, selection criterion, working principle and applications such as-
  - Active and passive components: Transistor (MOSFET), diode (LED), LCD, potentiometer, capacitors, DC motor, Breadboard, general PCB etc.
  - Instruments: CRO, multimeter, Logic probe, solder iron, desolder iron
  - Serial communication: Concept of RS232 communication , Xbee
- Introduction of ATtiny microcontroller based PWM circuit programming.

Programming of Arduino:

- Introduction to Arduino: Setting up the programming environment and basic introduction to the Arduino micro-controller
- Programming Concepts: Understanding and Using Variables, If-Else Statement, Comparison Operators and Conditions, For Loop Iteration, Arrays, Switch Case Statement and Using a Keyboard for Data Collection, While Statement, Using Buttons, Reading Analog and Digital Pins, Serial Port Communication, Introduction programming of different type of sensors and communication modules, DC Motors controlling.

Basics of C#:

- Introduction: MS.NET Framework Introduction, Visual Studio Overview and Installation
- Programming Basics: Console programming, Variables and Expressions, Arithmetic Operators, Relational Operators, Logical Operators, Bitwise Operators, Assignment Operators, Expressions, Control Structures, Characters, Strings, String Input, serial port communication: Read and write data using serial port.
- Software code optimization, software version control

Laboratory Work:

Schematic circuit drawing and PCB layout design on CAD tools, implementing hardware module of IR sensor, Transmitter and Receiver circuit on PCB.

Bronze Challenge: Single buggy around track twice in clockwise direction, under full supervisory control. Able to detect an obstacle. Parks safely. Able to communicate state of the track and buggy at each gantry stop to the console.

Silver Challenge: Two buggies, both one loop around, track in opposite directions under full supervisory, control. Able to detect an obstacle. Both park safely. Able to communicate state of the track and buggy at each gantry stop with console.

Gold Challenge: Same as silver but user must be able to enter the number of loops around the track beforehand to make the code generalized.

Course learning outcome (CLOs):

The student will be able to:

1. Recognize issues to be addressed in a combined hardware and software system design.
2. Draw the schematic diagram of an electronic circuit and design its PCB layout using CAD Tools.
3. Apply hands-on experience in electronic circuit implementation and its testing.
4. Demonstrate programming skills by integrating coding, optimization and debugging for different challenges.
5. Develop group working, including task sub-division and integration of individual contributions from the team.

Text Books:

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

Reference Books:

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

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	Evaluation-1 (ECE lab)	20
2.	Evaluation-2 (CSE lab)	20
3.	Quiz	10
4.	Evaluation-3 (ECE+CSE lab)	50

UTA026 MANUFACTURING PROCESSES

L	T	P	Cr
2	0	2	3.0

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, 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):

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

- develop simple CNC code, and use it to produce components while working in groups.
- analyse various machining processes and calculate relevant quantities such as velocities, forces.
- recognise cutting tool wear and identify possible causes and solutions.
- understand the basic principle of bulk and sheet metal forming operations for analysis of forces.
- analyse various shearing operations for tooling design.

- apply the knowledge of metal casting for different requirements.
- analyse and understand the requirements to achieve sound welded joint while welding different similar and dissimilar engineering materials.

Text books:

1. *Degarmo, E. P., Kohser, Ronald A. and Black, J. T., Materials and Processes in Manufacturing, Prentice Hall of India (2008) 8thed.*
2. *Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, Dorling Kingsley (2006) 4thed.*

Reference Books:

1. *Martin, S.I., Chapman, W.A.J. , Workshop Technology, Vol.1 & II, Viva Books (2006) 4 th ed.*
2. *Zimmer, E.W. and Groover, M.P., CAD/CAM - Computer Aided Designing and Manufacturing, Dorling Kingsley (2008).*
3. *Pandey, P.C. and Shan, H. S., Modern Machining Processes, Tata McGraw Hill (2008).*
4. *Mishra, P. K., Non-Conventional Machining, Narosa Publications (2006).*
5. *Campbell, J.S., Principles of Manufacturing, Materials and Processes, Tata McGraw Hill Company (1999).*
6. *Lindberg, Roy A., Processes and Materials of Manufacture, Prentice Hall of India (2008) 4 thed.*

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

UES017: SOLID AND STRUCTURES

L	T	P	Cr
3	1	2*	4.0

Course Objectives: This subject aims to develop an understanding of the stresses and strainsthat 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, overhung and cantilever beams subjected to any combination of point loads, uniformly distributed and varying load and moment, equation of condition, load function equation, qualitative analysis for two-dimensional frames.

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

Experimental project assignment: Students in groups of 4/5 will do projects:

1. Calculation of tensile strength using UTM
2. Buckling of struts
3. 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.
4. Torsion: Study the behavior of circular shafts under torsion and analysis of failure and indirect evaluation of the modulus of rigidity.

Micro Project:

Model Bridge Experiment: This will involve construction of a model bridge using steel wire and wood.

Course Learning Outcomes (CLOs):

After completion of this course, the students 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

UME307 : Engineering Fluid Mechanics

L	T	P	Cr
3	1	0	3.5

Course Objectives: Students will be exposed to the basic fundamentals of transport phenomena in relation to mass, momentum and energy conservation.

Fluid Statics: Definition of a fluid and its properties, Pascal law, force on submerged surfaces.
Fluid Kinematics: Stream and potential function, description of fluid flow, continuity equation, Euler and Bernoulli equations. Buckingham's Pi theorem, similarity relation, non-dimensionalized equations of motion.
Fluid Dynamics:
Governing Equations of Fluid Dynamics: Reynolds transport theorem, conservation of mass (Continuity equation), and momentum (Navier-Stokes equations), exact solution of Navier-Stokes equations.
Potential flow: Kelvin's theorem, source, sink, vortex and doublet, development of complex potentials by super position, singularities – plane flow past bodies.
Boundary Layer Approximation: Boundary layer profile, displacement, momentum and energy thickness.
Internal Flows: Entrance region and fully developed flow, laminar and turbulent flows in pipes and ducts.
External Flows: Drag and lift, friction and pressure drag, drag coefficients of common geometries, laminar, turbulent and separated flows over flat plates, cylinders in cross flow, tube arrays.
Turbulent Flow: Mechanism of turbulence, derivation of governing equations for turbulent flow, k-ε model of turbulence, universal velocity distribution law and friction factor.
Flow and Pressure Measurement Devices: Through flipped classroom mode.

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

1. analyze and solve the problems of fluid interaction with solid surfaces in static condition.
2. derive and solve the description of fluid kinematics problems and determination of dimensionless groups using Buckingham's Pi method..
3. derive and solve(simplified cases) the governing equations for fluid flow (Navier-Stokes equation).
4. analyze and solve the internal and external flows problems.

Text Books

1. Cengel, Y. A. and CIMBALA, J.M., *Fluid Mechanics*, Tata McGraw Hill Publishing Company Limited, New Delhi(2006).
2. *White, F. M., Viscous Fluid Flow, McGraw Hill, New York (2006).*
3. Douglas J. F., Gasiorek, J. M. and J. A. Swaffield, Fluid Mechanics, Addison-Wesley Longman Inc., Edinburgh, U.K (1995).
4. Panton, R.L., Incompressible Fluid Flow, John Wiley & Sons, New Jersey (2005).

Reference Books

1 Bird, R. Byron, Warren E. Stewart, and Edwin N. Lightfoot. Transport Phenomena. New York, NY: John Wiley & Sons, 2nd ed. 2001.

Evaluation Scheme:

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

UME308 MECHANICS OF MACHINES

L	T	P	Cr
3	1	2*	4.0

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 (CLOs):

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

UTA025 INNOVATION AND ENTREPRENEURSHIP

L	T	P	Cr
1	0	2*	3.0

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, Business Pitching.

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 (CLOs):

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

1. Explain the fundamentals behind the entrepreneurial personality and their intentions
2. Discover/create and evaluate opportunities
3. Identify various stakeholders for the idea and develop value proposition for the same.
4. Describe various Business Models and design a business model canvas.
5. Analyse and select suitable finance and revenue models for start-up venture.

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. *Osterwalder, Alex and Pigneur, Yves (2010) Business Model Generation.*
4. *T. H. Byers, R. C. Dorf, A. Nelson, Technology Ventures: From Idea to Enterprise, McGraw Hill (2013)*

Reference Books:

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

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	20
2	EST	40
3	Sessionals(Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	40

UMA035 OPTIMIZATION METHODS

L	T	P	Cr
3	0	2	4.0

Course Objective: The course aims at integrating the mathematical backgrounds for provide the best solution in linear programming problems and network problems or solutions in deterministic situation. In addition to this, the course introduces decision analysis, queuing theory and Monte Carlo simulation techniques for optimization problems.

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 solution of balanced and unbalanced transportation problems, optimal solutions, Assignment Problem

Goal programming: Introduction to Goal programming, Standard form of linear Goal programming problem, Solution of linear Goal Programming problem by graphical method.

Network Models: Construction of Networks, network computations, free floats, critical path method, optimal scheduling

Decision Analysis: Decision analysis with minimax (maximin) criteria**,** Dominance property**,** Two person zero-sum game, Game with mixed strategies, Graphical method

Queuing Theory: Pure birth and death model, Classification of Queuing models, M/M/1 model, Introduction to cost models in queuing

Monte Carlo simulations: Mid-square algorithm for random number generation, Introduction to simulation of queuing system

Laboratory Work: Lab experiments will be set in consonance with materials covered in the theory using **Matlab**.

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

1) formulate and solve linear programming problems using Simplex method and its variants.
2) solve linear goal programming problem graphically.
3) construct and optimize various network models
4) to study two-person zero sum game and its solutions.
5) classify and modeling of queuing system.

Text Books:

1) *Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons, (2010).*
2) *Chandra, S., Jayadeva, Mehra, A., Numerical Optimization and Applications, Narosa Publishing House, (2013).*
3) *Taha H.A., Operations Research-An Introduction, PHI (2007).*

Approved in 100th meeting of Senate held on March 09, 2020

Recommended Books:

1) *Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004)*
2) *Bazaarra Mokhtar S., Jarvis John J. and ShiraliHanif D., Linear Programming and Network flows, John Wiley and Sons (1990)*
3) *H.S. Kasana and K.D. Kumar, Introductory Operations research, Springer publication, (2004)*
4) *Ravindran, D. T. Phillips and James J. Solberg: Operations Research- Principles and Practice, John Wiley & Sons, Second edn. (2005).*

Evaluation Scheme:

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

SEMESTER-IV

Approved in 100th meeting of Senate held on March 09, 2020

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, Yielding and yield strength, Tensile strength, Stiffness, Ductility, Brittleness, Resilience, Toughness, True stress - true strain relationship, Hardness, Shrinkage, 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, 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.

Diffusion and Corrosion: Diffusion in solids, Corrosion: their type, cause and protection against corrosion.

Materials Selection: Overview of properties of engineering materials, Material selection in design based on properties covering timber, aluminium, glass, polymers and ceramics.

Laboratory Work:

1. Determination of the elastic modulus and ultimate strength of a given fiber strand.
2. To measure grain size and study the effect of grain size on hardness of the given metallic specimens.
3. To determine fiber and void fraction of a glass fiber reinforced composite specimen.
4. To study cooling curve of a binary alloy.
5. Detection of flaws using ultrasonic flaw detector (UFD).
6. To determine the dielectric constant of a PCB laminate.
7. To estimate the Hall coefficient, carrier concentration and mobility in a semiconductor crystal.
8. To estimate the band-gap energy of a semiconductor using four probe technique.

Micro Project:

The micro-project will be assigned to the group(s) of students at the beginning of the semester. Based on the interest and branch of the student, he will carry out one of the followings:

1. Design experiments to determine various mechanical properties like strength, ductility, elastic modulus, etc. of a given specimen(s) and correlate them.
2. Design an experiment to classify the given specimens based on their electrical properties.
3. Identify the most suitable material from the given specimens for solar cell application.
4. Identify the suitability of given samples in marine, acidic and alkaline environment.
5. Design a virtual experiment to analyse / predict physical properties of a given material/composite.

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.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional	40

UMA011: NUMERICAL ANALYSIS

L	T	P	Cr
3	0	2	4.0

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: 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), 11th ed.*

Evaluation Scheme:

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

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, Mohr Circle in 3D, differential equations of equilibrium in Cartesian and cylindrical coordinates,

Three-dimensional strain analysis: rectangular strain components, (Flipped learning component: principal strains and strain invariant), compatibility conditions.

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

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

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 introduction to Unsymmetrical Bending, Bending of Curved Flexural Members, Stress distribution in Thick Cylinders, (Flipped learning component: Thin cylinder) and Rotating Discs and Helical Springs.

Introduction to finite element methods: Introduction to the standard finite element procedures such as assembly of stiffness matrix and formation of system equations. Apply these procedures to solve one-dimensional problems such as deformation analysis of springs, and stress analysis of bar elements. FEA modelling of these problems on any available finite element software and comparison with hand calculations.

Assignment:

Students in groups will work on the problem formulation and perform failure analysis of different mechanical and structural components, such as model beams, pressure vessel, explosion of a pipeline, automobile suspension, crane hookes, tail pipe support etc. Use suitable FEA/CAE tools for solving and displaying results. This assignment also includes technical report writing and viva voce .

Course Learning Outcomes (CLOs):

The students will be able to:

1. calculate the state of stress at the critical point of the object.
2. establish 3D stress-strain relationship for isotropic materials.
3. conduct the failure analysis under static loading in ductile and brittle materials using different theories of failures.
4. calculate deflection at any point on a solid structure using Castigliano's theorems.
5. determine the distribution of circumferential and radial stress along the thickness of thick cylinders.

~~6.~~ model and analyze real structures or engineering systems through projects/assignments

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 (%)
	MST	30
	EST	45
	Sessionals	25
	Minor Project/Assignment/Tutorials/Quizes	20
	Flipped learning component	5

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.

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 (Flip Learning Component): 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 or SRV-02 workstation in MATLAB/Simulink/Labview environment.

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: Assignments/Lab Work/Project/Quizzes/Class Test etc. Flip Learning Component	 20 10

UME412 COMPUTER-AIDED DESIGN AND ANALYSIS

(Project based)

L	T	P	Cr
3	2	3	5.5

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'. 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. The projects should be preferably based on experiential learning activities done. CAE analysis will be used to evaluate and redesign the system to optimize it for conditions of use. 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 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: 50% pass marks. Tests and projects on software will be open book examination.

UES004 THERMODYNAMICS

L	T	P	Cr
3	1	0	3.5

Prerequisite(s): None

Course Objectives

This course introduces basic concepts of thermodynamics and their applications in solving engineering problems. This course also introduces the concept of Rankine cycle, reheat and regeneration.

Basic Concepts: Thermodynamics system & properties, Various processes, Thermodynamic equilibrium, Process: Flow and non flow process, Cycle concept of work and heat, Specific heats, Energy and its form

First Law of Thermodynamics: Concept of internal energy & enthalpy, Energy equation as applied to a close and open system, PMMI, Transient flow processes.

Second Law of Thermodynamics & its Corollaries: Kelvin Plank and Clausius statements, Reversible and Irreversible processes, Carnot cycle, Clausius theorem and concept of entropy, Principle of increase of entropy, PMM2, Thermodynamic temperature scale, Second law analysis of control volume, Availability, Irreversibility, Availability for open and closed system & second law efficiency.

Properties of pure substance, Thermodynamic diagrams, Triple point, Steam tables and their use, Moiller Diagram.

Thermodynamic Relations: Maxwell & T-ds equations.

Vapor Power Cycles: Rankine cycle and modified Rankine cycle, reheat, regenerative and binary cycles.

Course Learning Outcomes (CLO's):

The students will be able to

1. analyze and solve problems related to closed systems and steady-flow devices by applying the conservation of energy principle
2. analyze the second law of thermodynamics for various systems and to evaluate the performance of heat engines, refrigerators and heat pumps
3. estimate vapor-liquid properties and solve basic problems using steam tables, Mollier diagrams and equation of state
4. apply the first and second laws of thermodynamics for the complete thermal analysis of vapor power cycle.
5.

Text Books

1. *Sonntag, R.E., Borgnakke, C. and Van Wylen, G.J., Fundamentals of Thermodynamics, John Wiley (2007) 6th ed.*
2. *Nag, P.K., Engineering Thermodynamics, Tata McGraw Hill (2008) 3rd ed.*

Reference Books

1. *Rao, Y.V.C., Thermodynamics, Universities Press (2004).*
2. *Ratha Krishana , E., Fundamentals of Engineering Thermodynamics, Prentice Hall of India (2005) 2nd ed.*
3. *Cengel, Y. A. and Boles, M., Thermodynamics: An Engineeing Approach, Tata McGraw Hill (2008).*
4. *Rogers, G. and Mayhew, Y., Engineering Thermodynamics, Pearson Education (2007) 4th ed.*

Evaluation Scheme:

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

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 for efficient utilization of firm's resources.

Introduction: Introduction to industrial engineering, need of industrial engineering, evolution of this field, significance of system's approach in applying industrial engineering in the industry.
Productivity Management: Productivity vs production, partial productivity, total factor productivity, total productivity, measurement and improvement, use of deflator/inflator in productivity calculations, break even analysis.
Plant Location & Layout: Factors affecting plant location, selection of plant site, quantitative techniques of plant location decision, principles of layout design, 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: Production system, types of production systems, demand forecasting and its various techniques, aggregate planning, master production scheduling, materials requirements planning, type of inventories, inventory costs, economic order quantity (under deterministic conditions), economic run length.
Work Study and Ergonomics: Method study and work measurement, principles of motion economy, principle of work sampling, MOST etc., role of ergonomics in industry, introduction to anthropometry, posture analysis, and effect of physical environment on performance.

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

i. obtain productivity indices to evaluate effectiveness of resource utilization.
ii. analyze line balancing issues in a product layout for improving cycle times.
iii. apply quality engineering tools for process control and improvement.
iv. develop a production schedule using information/data from different functional areas.
v. determine the time standards using work study principles/human factors in engineering.

Text Books:

1. *Monks, J. G., Production/Operations Management, McGraw Hill (2012).*
2. *Shankar, R., Industrial Engineering and Management, Galgotia Publications (2016).*

Reference Books:

1. Grant, E.L., Statistical Quality Control, McGraw Hill (2014).
2. Sanders, M. and McCormick, E., Human factors in Engineering, McGraw Hill (1993).
3. Montegomery, D.C., Introduction to Statistical Quality Control, Wiley (2010).

Approved in 100th meeting of Senate held on March 09, 2020

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (May include tutorial assignments/quizzes)	25

SEMESTER-V

Approved in 100th meeting of Senate held on March 09, 2020

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.

Course Content: The detailed design of mechanical systems/subsystems based on realistic examples will be followed. Following topics will be covered to understand the design philosophy and to perform the design calculations and failure analysis of various machine elements.

1. Introduction to design of systems and machine elements, design approaches, national and international standards, standard sizes of parts for all the components.
2. Selection of materials.
3. Fits and tolerance, Design for manufacturing
4. Types of loadings, Stresses in machine elements, Stress concentration under static and fluctuating loading, Factor of safety, Modes of failure and theories of failure.
5. Design of Belt Drive and Pulley
6. Design of Coupling
7. Design of Shaft and keys
8. Selection of Rolling contact bearings
9. Design of Spurand Helical Gears
10. Design of threaded fasteners and power screw

NB: *Prescribed design data book will be allowed in MST and EST. ASTM or equivalent standard will be followed in the design of machine elements.*

Micro Project/ Design Assignment:

In the micro-project, the students will work in groups to redesign angle cutter/ power tool or other mechanical systems. Project activity may 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 modeling, drafting and analysis, preparation of final technical report. Use suitable CAD/CAE tools.

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. select the suitable materials and manufacturing considerations.
2. calculate stresses involved with static/ fatigue loading

3. represent machine elements with a free body diagram and solve for unknown reactions
4. conduct a failure analysis for the design/sizing of mechanical components
5. design and analyze a real engineering system through projects/assignments

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).*
5. *Design Data: Data Book Of Engineers By PSG College -Kalaikathir Achchagam – Coimbatore (2012).*
6. *Mahadevan, K. Balaveera Reddy K., Design Data Handbook for Mechanical Engineers in Si and Metric Units,CBS Publishers & Distributors (2018).*

Evaluation Scheme:

Sr. No.	**Evaluation Elements**	**Weightage (%)**
1	MST	30
2	EST	40
3	Sessional (may include the following) Quiz, Assignments/Micro Projects, Technical Report	30

UME718 APPLIED THERMODYNAMICS

L	T	P	Cr
3	1	2*	4.0

Course Objectives

This course introduces various thermodynamic cycles used for analysis of heat engines and gas turbines. This course also introduces fundamental thermodynamic operating principles, phenomena of I.C. engines and performance parameters of I.C. engines.

Thermodynamic Air Standard Cycles: Introduction, Assumptions, Carnot cycle, Stirling cycle, Ericsson cycle, Otto cycle, Diesel cycle and Dual cycle. Comparison of Otto, Diesel and Dual cycles.

Brayton cycle: Open and closed cycles, Effect of pressure ratio, Brayton cycle with inter-cooling and reheating, Brayton cycle with regeneration, Applications of Brayton cycle, Comparison between Otto and Brayton cycles

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 system, Combustion in C.I.Engine, delay period, knocking, engine variables effects, fuel requirements, rating, combustion chambers; Fuel supply system, Engine cooling and lubrication, Performance of engines: Variable and constant speed tests as per ISI standards. Performance curves, heat balance, Exhaust and emission control.

Steam generators and condensers: Introduction to steam generator, mountings and accessories, condensers, Overview of steam power plant, boiler trial -energy balance sheet.

Laboratory Work: Assembly of Petrol and Diesel engine components, Identification of components and their working principles, Study of performance of Petrol and Diesel engines (Kirloskar Diesel engine, Ruston Diesel engine, Krimo oil engine, VCR engine, Dual fuel engine)

Micro Project: Students in group of 4/5 will carry out micro project on alternative fuels to be used in I.C. engines (Petrol, Diesel and Dual fuel engines)

(10% weightage of total marks shall be given to this micro project)

Course Learning Outcomes (CLOs):

1. Derive and analyze Otto cycle, Diesel cycle and Dual cycle air standard efficiencies.
2. Derive and analyze simple Brayton cycle.
3. Determine and analyze the performance parameters of I.C. engines in an engine test rig.
4. To prepare heat balance sheet of the boiler.

Text Books

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

Reference Books

1 *Heywoold, J. B., I.C .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).*

Evaluation Scheme:

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

UME509 : MANUFACTURING TECHNOLOGY

L	T	P	Cr
3	0	2	4.0

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. They will study different casting processes used in industries. The students will understand the principle of different modern welding process and know the utilization of heat during welding. The students will study bulk metal forming 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: casting defects; investment casting; die casting; centrifugal casting, Shell moulding; cupola, charge estimating, Theory of solidification, Gating & Riser Design, Steel smelting, Extraction process of metals.
Welding: heat flow during welding, principles and application of TIG and MIG welding, Resistance welding, Submerged Arc Welding, Friction Stir Welding, welding defects.
Metal Cutting: Principles of orthogonal and oblique cutting, shear angle relationships, Machinability, Milling, milling cutters and milling machines. Grinding, grinding wheel selection, surface grinding.
Metal Forming: Hot and cold working, forging machines, forging design considerations, forging defects; High energy rate forming processes, Rolling Process.
Manufacturing of plastics & composites: Plastic Manufacturing: Materials, Additives, Extrusion; Injection Moulding, Extrusion Blow Moulding, 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. Identify suitable casting technique for a particular application based on the differentiation in process salient features.
2. Design the gating and riser system for the casting process and calculate the charge constituents in liquid metal.
3. Evaluate the heat flow and select suitable welding technique for different applications.
4. Estimate the forces, power and energy requirements during forging and rolling processes.

5. Recognize the manufacturing processes for processing of plastics & ceramics.

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 (%)
	MST	25
	EST	40
	Sessional (Lab Assignments/Quizzes/Project)	35

UME516 MECHANICAL ENGINEERING MATERIALS

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 mechanical 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. Also, it provides an overview to other mechanical engineering materials like polymer matrix composites and metal matrix composites.

Alloy Systems: Basic terms in industrial metallurgy (phases, components, degrees of freedom, equilibrium etc.) and their significance, Isomorphous and eutectic alloy systems, 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, effect of microstructure on hardness, strength, impact strength, creep resistance, fatigue strength, machinability of steels; 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, 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, strain hardening, precipitation hardening mechanisms for alloys, especially steels and aluminium.

Polymers, Polymer Matrix Composites, Metal Matrix Composites; Coatings for hard-facing.

Course Learning Outcomes (CLOs):

The students will be able to:

- describe the microstructures and phases that exist in alloys in general, and steels/eutectic series alloys in particular.
- analyze how microstructures are affected by alloy composition and heat treatment processes.
- analyze the isothermal-reversible (invariant) reactions of hypoeutectoid, eutectoid, and hypereutectoid steels.
- obtain and interpret information from the TTT curves and CCT diagrams of different alloys.
- select and analyze suitable surface heat treatment for a given alloy composition.

Text Books:

1. *Higgins, R. A., Engineering Metallurgy-Applied Physical Metallurgy, Elsevier (2012).*
2. *Avner, S.E., Introduction to Physical Metallurgy, McGraw Hill (2007).*

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:

S. No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessional (May include tutorial assignments/quizzes)	25

UME511 : AUTOMOBILE ENGINEERING

L	T	P	CR
3	0	2*	3.5

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 and layouts, frame and frameless construction, design requirements of different chassis types, vehicle dimensions, components of an automobile, power requirements, power and torque correlation, vehicle performance parameters, gear ratio for maximum acceleration, stability of vehicles.

Clutch and Transmission: Clutch fundamentals, different type of manual clutches, automatic clutch, fluid coupling, torque convertor, requirements for manual and automatic transmission, their type and constructional detail, sliding mesh gearbox, constant mesh gearbox, synchromesh gearbox, gear ratios of planetary gear system, planetary gear selection mechanism, gear change mechanism, Simpson transmission, hydraulic gear change mechanism for automatic transmission, Constantly Variable Transmission System (CVT) construction and operation, Dual Clutch Transmission (DCT) construction and operation mechanism.

Drive Line: Introduction to driveline components, speed variations of Universal Joint, constant velocity (CV) joints, types of propeller shafts and support bearings, differential gear ratio, 4X4 drive, differential locks, limited slip differentials (LSD), types of axles and hubs.

Wheel and Tyres: Types of tyres and their requirements, tyre construction, tubed and tubeless tyres, radial tyres , tyre design specifications and coding, tread pattern, speed ratings, tyre wear, disc pressed wheels, static and dynamic balancing of wheels, alloy wheels, split rims.

Braking System: Introduction to braking system and their types, brake fade, stopping distance, hydraulic braking system, brake line layouts and safety features, solid disc and ventilated disc brakes, vacuum booster brakes, self-energizing brakes, antilock braking system (ABS).

Suspension and Steering: Steering mechanisms and steering system including power steering, caster, camber, camber roll, steering axis inclination, toe-in , toe-out, rack and pinion steering, recirculating ball screw (RBS) steering , suspension principle, coil spring and leaf spring suspension, rigid axle suspension and independent suspension, types of dampers,

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, electric and 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.

Research Assignments:

- investigate different problems related to the design and functioning of engine performance 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
- 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, Oxford University Press, UK (2014).*

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:

Approved in 100th meeting of Senate held on March 09, 2020

S.No.	Evaluation Elements	Weightage (%)
	MST	25
	EST	45
	Sessionals (May include Assignments/Projects/Quizzes/Lab Evaluations)	30

SEMESTER-VI

Approved in 100th meeting of Senate held on March 09, 2020

UME699: Project Semester

L	T	P	Cr
-	-	-	**15.0**

Course Objectives: To provide work experience in an Industry/ Company/ Research Organisation. To sharpen the technical skills of students by exposing them to Industrial environment, along with adoption of value based Industrial culture, while being engaged in industrial problem solving.

Scope of work:

- Every student is expected to spend 5-6 months in an Industry/ Company/ Research Organization, during sixth semester.
- Translate engineering theory into practice in a professional engineering environment.
- It includes a practical training in a professional engineering culture (a company, top educational institution, research institute etc.). The type of industry must be NOT below the Medium Scale category in his / her domain of the degree programme.
- It must be based around significant engineering work and is principally assessed on that basis
- The technical activity should be related to both the student's engineering studies and the host organization's activities.
- It should involve tasks and methods that are more appropriately completed in a professional engineering environment and should, where possible, make use of human and technology resources provided by the organization.
- Consolidates the student's prior learning and provides a context for later research studies.
- The student remains a full time registered student at TIET during the project semester.
- this activity is therefore wholly distinct from any other industrial interactions.
- The student must submit the "Training Completion Certificate" issued by the industry / company / Research Organization as well as a technical report, within the stipulated time to be eligible for making a presentation before the committee constituted by the department.
- The committee will then assess the student based on the report submitted and the presentation made.
- The committee must recommend redoing the course, if it collectively concludes, based on the assessment made from the report and presentations submitted by the student, that either the level of training received or the skill and / or knowledge gained is NOT satisfactory.

Goal Report and Final Reports

- The *goals report* (upto 5 pages) should
  - describe the engineering problem/ opportunity being addressed
  - define the project objectives
  - set out the methodology
  - identify tasks to be completed and
  - present a plan for the completion of the project semester.

- **The *midway report* (10 pages) should describe**
  - Work done and the results (or other outcomes) achieved to date

- Major challenges and innovations along with the remaining tasks to be completed by the end of the project.

- **The *FINAL report* will outline achievements while on project semester and incorporate the description of all the work conducted and how this work meets the learning objectives of the project semester. The final report (approx 80 pages) should:**
  - Introduce the project setting and identify objectives
  - Describe the background to the project (eg. Prior work)
  - Describe the methodology and work done on the project, highlighting the areas of greatest challenge and innovation; this description should demonstrate how the learning outcomes are achieved
  - Present conclusions, findings and recommendations for further work
  - Include the Reflective diary as an appendix

Course Learning Outcomes (CLOs):

The students will be able to:

1. collect the relevant information to identify the problems and formulate the 'Problem definition'.
2. analyze the problem with appropriate model to formulate solution using established research methods and review of literature.
3. design or formulate the solution as per problem definition for solving the problem as per need or requirements.
4. prepare a project report in specified format and grammar using proper citations and deliver the verbal presentation with the associated questionnaires.
5. involve in assigned job by adopting new work environments in context of technology developments.

Evaluation Scheme:

S.	Evaluation Elements	Weightage
1.	Goal Report	5
2.	Mid Way Report	15
3.	Evaluation for Industry Mentor	20
4.	Final Evaluation- Presentation and Report, Daily diary	60

UME700: Group Project

L	T	P	Cr
-	-	-	**8.0**

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

UPE602 SUPPLY CHAIN MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course objectives: This course educates students about the concepts of and the role supply chain management by developing an understanding about markets, logistics, drivers of supply chain and matching supply and demand through planning, forecasting and replenishment.. The course further develops basic knowledge about competitive performance, network design, planning for inventories in supply chain and opportunities for growth. The course culminates with the introduction of concepts regarding synchronization and risk management in the supply chain.

Introduction: Understanding the Supply Chain, Process view, Decision phases and importance of supply chain, Supply chain management and logistics, Supply chain and the value chain, Competitive advantage, Supply chain and competitive performance, Changing competitive environment, Supply Chain drivers and obstacle

Matching supply and demand The lead-time gap, Improving the visibility of demand, supply chain fulcrum, Forecast for capacity, execute against demand, Demand management and aggregate planning, Collaborative planning, Forecasting and replenishment.

Creating the responsive supply chain Product 'push' versus demand 'pull' The Japanese philosophy, Foundations of agility, Route map to responsiveness.

Strategic lead-time management: Time-based competition, Lead-time concepts, Logistics pipeline management.

Planning and managing inventories in a supply chain: Managing economies of scale in supply chain cycle inventory, Managing uncertainty in supply chain, Determining optimal level of product availability.

Transportation, Network Design and Information Technology in a supply chain: Transportation, Facility design network design in a supply chain, Extended enterprise and the virtual supply chain,Role of information and information technology in the supply chain, Laying the foundations for synchronization, 'Quick response' logistics, Production strategies for quick response, Logistics systems dynamics.

Managing risk in the supply chain: Vulnerability in supply chains, Understanding the supply chain risk profile, Managing supply chain risk.

Research Assignment:

- Use a case study related to assessing cost imperatives of reverse logistics in a battery manufacturing unit
- An assessment of supply chain drivers

Course Learning Outcomes (CLOs):

The student will be able to:

1. explore opportunities for cost reduction through Supply Chain efficiency,
2. assess demand versus supply and use it for aggregate planning
3. optimize product availability to improve revenue streams
4. assess performance of a supply chain – up stream as well as down stream

5. assess vulnerability in supply chains

Text Books:

1. *Chopra, S. and Meindl, PSupply Chain Management, , Prentice Hall, .(2010) 4th Edition*
2. *Christopher, M. Logistics & Supply Chain Management, , FT Prentice Hall, (2011) 4th Edition,*

Reference Books:

1. *Michael H. Hugos, M. H, Essentials of Supply Chain Management, John Wiley.(2011) 3rd Edition*
2. *Simchi-Levi, D.,Kaminsky, P., Simchi-Levi, E Designing and Managing the Supply Chain McGraw Hill Higher Education.(2011)*
1. *3. John T. Mentzer, J. T. Supply Chain Management, illustrated edition, SAGE Publications. (2001),*

Evaluation Scheme:

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

UPE601 FACILITIES PLANNING

L	T	P
3	1	0

Course Objectives: This course introduces the concept of facility planning, its need and importance in the industry, factors affecting facility location decision, plant design, concept of line balancing, and material handling systems.

Facilities Planning: Need for facilities planning, Importance of plant layout in plant design, classifications of production process structures, types of layout, Characteristic features, suitability and applications of different types of layout.

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

Planning Design And Presentation: Principles of plant layout design, Procedure for plant layout design, evaluate alternative layouts, installation of layout, Quantitative techniques for developing alternative layouts, Design of process and product layouts, line balancing techniques.

Material Handling: Principles of material handling, classification of material handling systems, characteristic features of key material handling equipment, concept of unit load, introduction, guidance methods, applications.

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 facility planning. 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 finding out suitable location for a facility, designing/ re-designing of an existing layout

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

1. Classify the characteristic features and production structures of different layouts.
2. Analyse an existing facility in context to its location and design.
3. Develop a new plant layout or to improve an existing layout.
4. Design/ re-design proposed a new material handling system.

Text Books:

1. *Tompkins, J. A., White, J. A., Bozer, Y.A. and Tanchoco, J.M.A., Facilities Planning, John Wiley (2003) 3rd ed.*
2. *Facilities Planning and Materials Handling, Sheth, V., Marcel Decker, 1995*

Reference Books*:*

1. *Muther, R., Practical Plant Layout, McGraw Hill Book Company (1995).*
2. *Agrawal G. K., Plant layout and Material Handling, Khanna Publishers (2003).*

Evaluation Scheme:

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

UME690 Startup Semester: Jan-June 2019

Course Objective:

This course provides the students with competence building workshop and need based skill trainings that enable them to develop their prototype/working model/software application, which is supported by a Business Plan.

Workshop / Session	**Schedule** (Tentative)	**Assignment/Reflective Exercise after the session**	**Remarks**
Introductory session	**7th Jan**	Daily Dairy Networking and Mentorship TEIT/Chd/Delhi NCR/other	**Dr. MD Singh**
Refresher course for the students (Revisiting the earlier leanings) or (Revision/Review of 'Entrepreneurship & Innovation') and **Pitching of Projects**	17-18th Jan 2019	Summary: Business Development Process Relating theoretical framework with their business idea Industry dynamics, SCQA Framework	**Dr. MD Singh**
Business Model Value creation, Value delivery and Value capture	6th Feb 2019	Asking students to talk to work in a team of three and talk to an entrepreneur on the topics discussed in the class and submit the key points	Mr. K Dass
Segmentation-Targeting-Positioning, Creativity, Innovation &Technology management	22nd Feb 2019	Asking students to talk to work in a team of three and talk to an entrepreneur on the topics discussed in the class and submit the key points	Mr. Puneet Jindal
Tools for an Entrepreneur to Implementing a business strategy	23rd Feb 2019	What technology / innovation issues have you faced so far and how you handled them?	Mr. Sanjay Saini
Design thinking: Fundamental Creative Technological Design	19 April 2019	How design thinking applies to the project/startup idea	Dr. Karminder Ghumman
Financial management Funding, Cash Flow, etc.	19 April 2019		Dr. Sonia
Need Based Workshop on Technical Skills	Any one day (9-13 April)		The Grooves/ TIET/ LMTSOM

Legal and regulatory aspects of Forms of Business Organization	**Submission between 24th to 28th April 2019**	A small write up on a select form of organization describing how you can establish that type of organization after going through self-learning material?	Self study. Submit the report
Business Plan: Developing a draft of Business Plan **Presentation of Business Plan**	**8th May 2019**	Students will learn how to submit a professional business plan to Government agencies or Investors.	Mr. Koustav Das
Presenting Business Model Canvas	**8th May 2019**	Students will learn how to develop or re-align their Business Model.	Dr. Karun Verma
Entrepreneurial Marketing: Guerilla, Buzz Marketing, Digital &Viral Marketing			To be announced
Presentation of Prototype/Working model/useful app/software	First week of June 2019	Students will submit their final version of Business model Canvas (A2 Poster), balance sheet (if available) and Prototype/Working model or software.	
Final presentation	As per department schedule	Students have to submit all their reports, daily dairy, BMC	

Course learning outcome (CLO):

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

1. Develop a prototype/working model/software application.
2. Carry out design calculations/simulations and implementations in the area of project.
3. Demonstrate an ability to develop a business plan.
4. Comprehend the fundamentals of business pitching

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Reference Books:

1. *Agarwal, Varun (2012). How I Braved Anu Aunty and Co-Founded A Million Dollar Company, Rupa Publications India Pvt. Ltd.*
2. *Bagchi, Subroto, (2012). MBA At 16: A Teenager's Guide to Business, Penguin Books*
3. *Abrams, R. (2006). Six-week Start-up, Prentice-Hall of India.*
4. *Verstraete, T. and Laffitte, E.J. (2011). A Business Model of Entrepreneurship, Edward Elgar Publishing.*
5. *Ries, Eric(2011), The lean Start-up: How constant innovation creates radically successful businesses, Penguin Books Limited.*
6. *Prasad, Rohit (2013), Start-up sutra: what the angels won't tell you about business and life, Hachette India.*

Approved in 100th meeting of Senate held on March 09, 2020

Need based Skill Training to be made available
Daily diary should be maintain by students and should be signed by mentor on weekly basis

SEMESTER-VII

Approved in 100th meeting of Senate held on March 09, 2020

UME707 : MACHINE DESIGN-II

L	T	P	CR
2	2	0	3.0

Course objectives: The objective for this course is to impart the knowledge required to apply the design procedure to the mechanical system design. The course is also intended to provide the experiential learning experience towards the design of commonly used mechanical systems.

Contents:
The focus of this course will be on the design of mechanical systems/subsystems based on the practical examples, such as the design of transmission and braking system of an automobile, power tool, and power operated machine tools etc. Students will be given exposure to the real-world mechanical systems from the mechanical engineering laboratories, and/or workshop and/or experiential learning center to understand the design philosophy and the design concept of the existing mechanical system/subsystem. The design principles of standalone machine elements viz. bearings, gears, springs, shafts and spindles, braking and clutch mechanisms etc. will be employed towards the design of an integrated system comprising two or more of these elements. The different tasks of the experiential learning activities may include hands-on experiences on disassembly and assembly of available mechanical systems e.g. engine and gear box, dimensioning, material recognition, design calculations, failure analysis, in addition to the consideration of manufacturing aspects such as fits, tolerances, surface finish, etc.

Flipped Learning Component: Review of the various aspects of machine element design covered in the basic module of machine design course, such as material selection, theories of failure, factor of safety, fits and tolerance, design under static and fluctuating loads etc.

NB: *Prescribed design data book will be allowed in MST and EST. ASTM or equivalent standard will be followed in the design of machine elements.*

Design Assignment:
The design assignment will be based on the ongoing experiential learning activities and/or on the similar mechanical systems available in the mechanical engineering laboratory or workshop to understand the design approach of an integrated system comprising two or more of the machine elements. This assignment will essentially include hands-on experience in disassembly and assembly of available mechanical systems, the details on material selection, force analysis, designing of components on the basis of stress analysis, use of CAD/CAE tools and generation of production drawings. The re-design of the existing mechanical system will be a desirable component of this assignment. 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 identification of the manufacturing methods.
2. design and analyze failure of gears for different loading conditions.
3. select bearings for a given load carrying capacity.

4. apply different theories for designing friction clutch and brakes.
5. design and analyze the real engineering system through design assignment.
6. assemble, disassemble and generate the detail drawings of the existing or new mechanical system/subsystem.

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)*

5 *Design Data: Data Book Of Engineers By PSG College - Kalaikathir Achchagam – Coimbatore (2012)*

6 *Mahadevan, K. Balaveera Reddy K., Design Data Handbook for Mechanical Engineers in Si and Metric Units, CBS Publishers & Distributors (2018)*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessional Flipped Learning Component/Tutorials /Assignment/Quiz	30

UME720 : Heat Transfer

L	T	P	Cr
3	1	2*	4.0

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

Introduction to basic modes of heat transfer: Physical origins and rate equations relevant to conduction, convection and radiation.

Introduction to conduction: Conduction rate equation, thermal properties of matter, heat diffusion equation in three dimensions (Cartesian, cylindrical and spherical coordinates), Boundary and Initial Conditions.

Steady-State Conduction: Temperature distribution for the plane wall and radial systems (cylinder and sphere) with and without heat generation, composite walls, critical insulation thickness, unsteady heat conduction, heat transfer from extended surfaces - efficiency and effectiveness.

Transient Conduction: Lumped capacitance method and its validity, general lumped capacitance analysis, spatial effects, plane wall with convection, radial systems with convection, semi-infinite solid.

Free and Forced Convection: Dimensional analysis, governing equations, Reynolds analogy, energy equation for thermal boundary layer over a flat plate, empirical correlations for plates, pipes and spheres.

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

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

Thermal Radiation: Mechanism of radiation, electromagnetic spectrum. concept of black body, Planck's law, Stefan Boltzmann law, Wien's displacement law, gray body, spectral directional emissivity, absorptivity, and transmissivity, Kirchhoff law. View factor and view factor algebra. Enclosure Analysis: radiosity irradiation method for gray diffuse enclosures, radiation shields, concept of re-radiating surface.

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 and convention heat transfer to solve heat transfer problems.

2. calibrate equipment, acquire, tabulate and analyze useful data in the laboratory, checks for repeatability and reproducibility.
3. evaluate the thermal performance of heat exchangers and analyze and recognize their requirements of heat transfer optimization and pressure drop minimization.
4. assess and evaluate the thermal performance of systems for radiation heat transfer and its applications.

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 Books:

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

Evaluation Scheme:

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

UME719 REFRIGERATION AND AIR CONDITIONING

L	T	P	Cr
3	1	2*	4.0

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: Reciprocating Compressors and multistaging, expansion devices, condensers, evaporators, 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	25
2	EST	45
3	Sessionals (May include Assignments/Projects/Quizzes/Lab Evaluations)	30

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:

- Natural frequencies of physical systems
- Modal analysis of realistic systems
- Suspension systems of vehicles
- Vibration isolation of machines
- Gyroscopic effect in aero planes and ships

Micro Project: Group project for this course may include one of the following topics:

- Determine the natural frequencies of physical systems like, suspension system, bridge etc. (both using analytical and numerical approach)
- Calculate the mode shapes and perform modal analysis analytically and validate the results obtained using commercial packages.

- Determination of damping value experimentally using logarithmic decrement method and validate theoretically.
- 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

UME793 CAPSTONE PROJECT

L	T	P	Cr
1*	0	2	--
1*	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, powerpoint/ 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 powerpoint / 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.

Approved in 100th meeting of Senate held on March 09, 2020

Course Learning Outcomes (CLOs):

The students will be able to:

CLOs for CAPSTONE by project	**CLOs for CAPSTONE by research**
1. Design a mechanical system implementing an integrated system design approach applying knowledge accrued in various professional courses	1. Develop an integrated mechanical system or product or process with novelty implementing applying knowledge accrued in various professional courses
2. Work in a design team lead by a team leader and demonstrate team work	2. Demonstrate ability to systemically identity scope of development or improvement of new product or process through critical review of literature/technologies available
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.	3. Develop a product or process using standard engineering practices, including analysis and optimization of design 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	4. Create design of experiments, carry out test work or use of appropriate computational tools following relevant standards and conventions
5. Read production drawings for mechanical components and systems and plan a production based on it	5. Demonstrate ability to carry out data analysis, develop model, test hypothesis
6. Use suitable manufacturing and fabrication processes for manufacturing a prototype	6. Generate new knowledge of process or product development through analysis of results and critical evaluation w.r.t other existing technologies
7. Assemble a mechanical system after manufacturing its components and analyze its working	7. Communicate the results and inferences effectively to scientific and industry communities

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

Approved in 100th meeting of Senate held on March 09, 2020

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.

Laboratory work:

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

UME723 FLUID MACHINES

Approved in 100th meeting of Senate held on March 09, 2020

L	T	P	Cr
3	1	2*	4

Course Objectives; Students will be exposed to the fundamentals of momentum equation, working principles of the hydropower plant and its components, centrifugal pumps, design parameters of the centrifugal and reciprocating pumps. Course provides basic introduction of subsonic and supersonic flows through nozzles of gases and vapour, the students will have exposure to steam turbine types and their designs, governing, gas turbine cycles and their thermal refinements, jet propulsion. Students will be introduced to centrifugal and axial flow compressors, performance and design characteristics of compressors.

Principles of fluid machines: Impulse momentum equation, Impact of jets.
Hydraulic Turbines: Classification, head losses, efficiencies, hydropower plant, various elements, impulse and reaction turbines, components, selection of design parameters, size calculations, work, efficiency, Similarity relations and unit quantities, specific speed, cavitation.
Hydraulic Pumps: classification, selection, installation, centrifugal pumps, head, vane shape, pressure rise, velocity vector diagrams, work, efficiency, design parameters, multistaging, operation in series and parallel, submersible pumps, NPSH, specific speed.
Reciprocating Pumps: indicator diagram, work, efficiency, effect of acceleration and friction, air vessels.
Compressible Flow: Stagnation Properties, Speed of sound and Mach Number, one dimensional isentropic flow, isentropic flow through nozzles, shock waves, air and steam flow through nozzles, supersaturated 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, losses, partial admission factor, overall efficiency, governing.
Compressors and blowers: Centrifugal and axial flow type; characteristic curves of compressors.
Gas Turbines: Brayton cycles and its modifications, jet propulsion, turbo jet, ram jet, turbo- prop.

Course Learning Outcomes (CLOs):
The students will be able to:
1. Derive and apply thermodynamic and fluid terminology to fluid machines.
2. Determine the parameters affecting performance pumps and turbine.
3. Draw the velocity triangles in turbo machinery stages operating at design and off-design conditions.
4. Determine methods to analyze flow behavior depending upon nature of working fluid and geometric configuration of fluid machinery.

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	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	30

ELECTIVES

Approved in 100th meeting of Senate held on March 09, 2020

UME521 OPTIMIZATION IN ENGINEERING DESIGN

L	T	P	Cr
3	1	0	3.5

Objectives: The main objective of this course is to provide the detailed classification of optimization techniques available in order to address wide range of optimization problems. The course will also highlight different solution strategies and performance criterion for applied optimization problems. Through this course, the students will learn how to formulate an engineering optimization problem. The course will also introduce the basics of evolutionary optimization techniques as compared to classical optimization techniques.

Introduction to Optimization: Statement of an Optimization Problem, Classification of Optimization Problems, Optimization Techniques, Solution of Optimization Problems Using MATLAB.

One-dimensional Optimization Methods: Optimality Criteria – necessary and sufficient conditions, Bracketing methods, Region-elimination methods, Point estimation method, Gradient based methods, Sensitivity analysis.

Multi-dimensional Optimization Methods: Optimality Criteria, Unidirectional search, Direct search methods, Gradient-based methods. Conjugate-direction methods, Quasi-Newton methods.

Constrained Optimization Methods: Constrained Optimization Criteria, Penalty Methods, Method of Multipliers, Direct search methods, Linearization methods, Feasible Direction method, Generalized Reduced Gradient Method.

Structured Problems and Algorithms: Integer Programming, Quadratic Programming.

Specialized Optimization Techniques: Introduction to Multi-Objective optimization; Global Optimization: Criteria, Ant Colony Optimization, Particle swarm Optimization, Introduction to Genetic algorithm

Engineering Case Studies: Optimal Location of Coal-Blending Plants, Optimal Design of a Compressed Air Energy Storage System

Course Learning Outcomes:

The students will be able to

- solve one-dimensional and multi-dimensional engineering optimization problems.
- formulate as well as analyze unconstraint and constraint optimization problems.
- analyze the progress of any engineering process in terms of achieving local optimum and global optimum.
- solve special design problems with discrete solutions using Integer programming.

Recommended Books:

1. Deb, K., Optimization for Engineering Design Algorithms and Examples, Prentice Hall of India Pvt. Ltd., (2005), Eighth Print.
2. Deb, K., Multi-objective Optimization using Evolutionary Algorithms, John Wiley and Sons, (2009), First Edition.
3. Rao, S.S., Engineering Optimization Theory and Practice, John Wiley and Sons, (2009), Fourth Edition.
4. Ravindran, A., Ragsdell, K.M., Reklaitis, G.V., Engineering Optimization: Methods and Applications, John Wiley and Sons, (2006), Second Edition.
5. Belegundu, A.D., Chandrupatla, T.R., Optimization Concepts and Applications in Engineering, Cambridge University Press, (2011), Second Edition.
6. Dasgupta, B., Applied Mathematical Methods, Pearson Education India, (2006), First Edition.

Evaluation Scheme

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Sr. No.	Component	Weightage (%)
1	MST (2 hrs.)	35
2	EST	45
3	Sessional	20

UME522: FRACTURE MECHANICS

L	T	P	Cr
3	1	0	3.5

Course objective: The aim of this course is to develop an understanding of the mechanics of fracture of engineering materials and structures under static and dynamic loading. This understanding is essential for the assessment of integrity and durability of structures and structural components in the presence of structural defects, so as to ensure reliability and safety.

Introduction: Introduction to the realm of fracture and back ground history of development of fracture mechanics; Discrepancy between theoretical and real strength of materials, conventional failure criteria based on stress concentration and characteristic brittle failures, Griffith's work.

Linear Elastic Fracture Mechanics (LEFM) Based Design Concepts: Crack deformation modes and basic concepts, crack tip stresses and deformation, stress intensity factor (SIF) and its criticality in different modes, superposition of SIFs, LEFM design concept applications; Concept of energy release rate, equivalence of energy release rate and SIF.

Fracture Toughness: Fracture toughness and its laboratory determination procedure, test specimen size requirement etc.; Effect of temperature and loading rate on fracture toughness; Fatigue and fatigue crack propagation laws, fatigue life calculations under constant and variable amplitude loading, mixed-mode fatigue crack propagation.

Strain Energy Density Failure Criterion: Introduction, volume strain energy density, basic hypothesis and application of energy density based failure criteria for two and three dimensional linear elastic crack problems.

Elastic Plastic Fracture Mechanics Based Design Criteria: Design criteria for non-brittle materials; plastic zone corrections, crack opening displacement (COD), J-contour integral and crack growth resistance (R-curve) concepts.

Research Assignment:

Each team of 4-5 students will submit a case study on a fracture mechanics problem. Students are expected to enhance their knowledge, problem solving skills and understanding of the subject matter through completing the research assignment. The assignments are marked, with the mark contributing to the final grade for the subject.

Course Learning Outcomes: The students will be able to

- Predict material failure for any combination of applied stresses.
- Estimate failure conditions of a structure.
- Determine the stress intensity factor for simple components of simple geometry.
- Predict the likelihood of failure of a structure containing a defect/flaw.

Recommended Books:

1. *Gdoutos, E.E., "Fracture Mechanics: An Introduction", 2nd Ed., Springer. 2005.*
2. *Broek, D., "Elementary Engineering Fracture Mechanics", 3rd Ed., Springer. 1982.*
3. *Kumar, P., "Elements of Fracture Mechanics", Wheeler Publishing. 1999.*
4. *Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3rd Ed., CRC Press. 2005.*
5. *Shukla, A., "Practical Fracture Mechanics in Design", 2nd Ed., CRC Press. 1989.*

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6. *Bazant, Z. P. and Cedoliin, L., "Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories", World Scientific Publishers. 2010.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessionals (Assignments/Projects/Tutorials/Quizes)	25

UME832: FINITE ELEMENT METHODS

L	T	P	Cr
3	1	0	3.5

Course Objective: 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).*

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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 RoboAnalyser.
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. *Craig, J.J., Introduction to Robotics: Mechanics and Control, prentice Hall (2004).*
2. *Schilling, R.J., Fundamentals of Robotics Analysis and Control, Prentice Hall of India (2006).*
3. *Saha, S.K., Introduction to Robotics, McGraw Hill, Second Edition (2014).*

Reference Books:

1. *Deb, S.R. and Deb, S., Robotics Technology and Flexible Automation, McGraw Hill (2004).*
2. *Niku, S.B., Introduction to Robotics: Analysis, system, application, Dorling kingsley (2006).*
3. *Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., Robotics: Control, Sensing, Vision, and Intelligence, McGraw Hill (1987).*
4. *Ghoshal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press (2006).*
5. *Pratihar, D. K., Fundamental of Robotics, Alpha Science (2016).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
	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 and tribo-pairs. This course also introduces the concept of contacts of solid surfaces, lubricants, Fluid film lubrication, analysis of friction and wear in bearings and other tribological applications.

Introduction: Introduction to Tribology, Interdisciplinary approach, Tribological considerations in the design of machine elements.
Contact of Solid Surfaces: Geometrical properties of surfaces, surface characterization techniques, contact of engineering surfaces- Herzian and non- Hertzian contacts.
Friction: Adhesion and friction, Causes of friction, laws of sliding and rolling friction, friction instability, theories of friction, friction measurement.
Wear: Wear mechanisms, laws of wear, Measurement of wear, Wear reduction methods.
Fluid Film Lubrication: Introduction, Equations of continuity and motion, Reynold equation, lubrication regimes, Stribeck curve, Hydrostatic and hydrodynamic lubrication, Petroff equation.
Lubricants (Flipped learning component): Functions of lubricants, solid lubricants, mineral and synthetic liquid lubricants, electrorheological, magnetorheological and micropolar lubricants, lubricant additives.
Tribology of Bearings: Bearing types and selection, Sliding bearings- idealized bearings, infinitely long and short journal bearings, Design and analysis of ~~finite~~ hydrostatic and hydrodynamic thrust and journal bearing. Tribological considerations in air, magnetic and hybrid bearings.
Miscellaneous tribological applications: Gear metal forming, brakes of automobile, cutting tools, machine tools, IC engines, tribology in micro/nano devices and biological systems, etc.

Research Assignment: Research assignment will constitute collection of data from industry/internet and interpret the latest research on the new topics in tribology. This also includes technical report writing and seminar presentation.

Course Learning Outcomes (CLOs):
The students will be able to:
1. understand the theories of friction and wear.
2. calculate the topographical or contact parameters of the solid surfaces.
3. understand and perform the basic calculations for fluid film lubrication problems.
4. calculate the load carrying capacity and performance parameters of ~~hydrostatic~~ sliding bearings.
5. address the prevailing tribological issues in the miscellaneous tribosystems, such as braking systems, gears, IC engines, machining, etc.
6. analyze and present the latest research on the various topics of tribology (through research assignment).

Text Books:

1 Bhushan, B., Introduction to tribology, John Wiley and Sons, UK (2013).

2 *Arnell R. D., Davies P. B., Halling J. and Whomes T. L. , Tribology: Principles and Design Applications, First edition, Springer-verlag (1991).*
3 *Hirani, H., Fundamentals of Engineering Tribology with Applications, Cambridge University Press (2016).*

Reference Books:

1 *Majumdar B.C., Introduction to Tribology of Bearings, S. Chand Publishing, New Delhi (2010).*
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).*
5 *Hutchings I.M., Tribology: Friction and wear of engineering materials, Edward Arnold, London, (1992).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals	25
	Assignments +Flipped learning component	15
	Tutorial/Quiz	10

UME722: SYSTEM MODELLING AND SIMULATION

L	T	P	Cr
3	1	0	3.5

Course Objective: 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.

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).*

Evaluation Scheme:

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

UPE501 WORK STUDY AND ERGONOMICS ENGINEERING

Approved in 100th meeting of Senate held on March 09, 2020

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

UPE 705 COMPUTER AIDED MANUFACTURING

L	T	P	Cr
2	1	2	3.5

Course Objectives: To introduce the students to the standard terminologies, conventions, processes, design and operational characteristics of key hardware components, programming techniques and applications of modern multi-axis computer numerical control (CNC) machining centers. To expose the students to automatic computer assisted CNC tool path programming and virtual simulation of toolpath data for CNC milling and turning centres using modern professional software.

Introduction: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 centres, types and functions of CNC systems, advantages of CNC technology compared to conventional manufacturing, types and functions DNC (direct numeric control), advantages of combined CNC/DNC systems.
CNC part programming: Work holding and tool setting procedures for CNC turning and milling centres, tool zero pre-setting, tool length and radius compensation, manual part programming including use of standard canned cycles for CNC turning and milling centres, introduction to automatic part programming using standard CAM software.
Computer numerical control elements: introduction to sensors, drives and feedback devices used in CNC systems, control loop circuit elements in point to point (PTP) and contouring system, interpolation schemes for linear and circular interpolations, types and functions adaptive control systems.
Introduction to advanced CNC machining systems: Advantages of3-1/2-1/2 axis, 4-axis and 5-axis CNC machining systems, types of 5-axis machining centres, advanced CNC controllers and their special features for multi-axis machining, fundamentals of automatic toolpath planning for multi-axis CNC machining systems,
Automated manufacturing support systems: introduction to group technology, introduction to automated quality control in manufacturing, automated material transfer, handling, storage and identification systems: AGVs, ASRS, carousel, and RFID technologies.

Laboratory Work
Exercises in tool pre-setting, workpiece referencing and manual part programming for machining of simple parts on CNC turning and milling centres, use of CAM software for simulation of turning and millingtoolpath data for simple parts, automatic cutter location data generation from CAD models and post-processing for machining on CNC machines using standard CAD-CAM software, and use of CMM for automatic quality control.

Students in a group of 5/6 will carry out project on generation of CNC part program for machining of a part shape in milling or turning centre using standard canned cycles. Each student group will submit a report on the procedure followed for executing the given assignment along with the part machined on specified CNC machining centre.

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

1. create aplan for ~~automatic~~ machining of a given part on a multi-axis CNC machining centerincluding selection of machining parameters, cutting tools, process sequence and controller settings for tool presets.

2. create and validate a CNC part program data using manual data input (MDI) / commercial CAM package for machining of component using a CNC machining centre.
3. Analyse and apply the appropriate automated manufacturing support system.

Recommended 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. *Smith Peter, CNC programming handbook, 2nd edition, 2003, Industrial Press Inc.*
4. *Groover, M. P. and Zimmers, E. W., CAD/CAM:Computer Aided Design & Manufacturing, 2006, Pearson Education India*
5. *Hood-Daniel P., and Kelly J.F., Build Your Own CNC Machine, 2009, Springer-Verlag New York*
6. *Manuals of CAD/CAM Software Package on CAM Module and CNC Machines.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessional (Including assignments/ Minor Projects/ Quizes etc.)	35

UME523 – INDUSTRIAL AUTOMATION & IoT

L	T	P	Cr
3	1	0	3.5

Course objective: This course focus on understanding the smart manufacturing technologies, critical processes and new enabling technologies in industrial automation for reshaping engineering and manufacturing practices. Also, it focusses on understanding various components of state of art automation technologies encountered in modern manufacturing industries through new trends in automation & industrial IoT. This course introduces to the practical methods of automatic control of machines, processes and systems. All major parts of a modern industrial control system are to described and their principles explained.

Prerequisite(s): Basic electrical/electronic, fluid mechanics courses.

Factory Automation and Integration: Introduction to Automation technologies, applications around us and in mechanical industries. Types of systems - mechanical, electrical, electronics.

Hydraulics & Pneumatic Systems and Components: Elements of hydraulics/pneumatics, fluid power control elements and standard graphical symbols for them, hydraulic & pneumatic cylinders, hydraulic pumps, hydraulic & pneumatic valves for pressure, flow & direction control, safety valves.

Circuit Design Approach for Hydraulics & Pneumatic Systems: Design and operation of logic control circuits approach for real time examples; sequence operation of two/more than two cylinders as per the design requirements to automate the various systems in modern industries/equipments. Hydraulic and pneumatic safety and their applications to clamping, traversing and releasing operations. Hydraulic system analysis.

Design and Operation of Electro-Pneumatic Control Circuits: Elements of electro-pneumatic, advantages over hydraulics & pneumatic control, solenoid valves, factory automation sensors, electrical sensors, process automation sensors and their interfaces. Electro-pneumatic control circuits design using relay logic approach and examples, sequence control of a lifting device, terminal allocation, sequence operation of more than two cylinders/actuators, and motors, electro-pneumatic & electro hydraulic systems, relays, relay logic circuits, feedback control systems.

Industrial Control Systems: Programmable Logic Controllers (PLC) based control system, programming languages & instruction set, ladder logic, functional blocks, structured text, and applications. Human Machine Interface (HMI) & Supervisory Control and Data Acquisition System (SCADA); motion controller, Smart sensors, Actuators and controllers, RFID technology and its application; Machine vision and control applications.

Industrial Internet of Things (IIoT): Overview of IIoT components, Various architectures of IOT and IIOT, Advantages & disadvantages. Real life examples in manufacturing industries. Key terms – IoT platform, Interfaces, Role of IIOT in manufacturing processes, Industrial cyber safety and security. Use of IIoT in plant for different practices, Challenges & benefits in implementing IIoT.

Research Assignments: Students in a group will carry out research assignments on design and implementation of various automatic modular systems which can be useful in contemporary automation industries. The methodologies will be followed as first design and simulation of automated systems using Festo Fluid SIM, SIROS, PLC software and then implementation by using pneumatic controls, electro-pneumatic controls, PLC, motion controls and using IIoT methodologies.

Course learning outcome (CLOs): The students will be able to

1. design and simulate a system or process after identifying the various hydraulic as well as pneumatic control valves to meet the desired needs within realistic constraints and the same can be applied to automate the different processes in contemporary manufacturing systems.
2. design pneumatic, electro-pneumatic logic circuits and PLC ladder logics for various process control applications in industry.
3. use the different automation approaches and skills to solve the complex industrial problems necessary for contemporary engineering practice.
4. develop the automation application using IIoT techniques as per their relative importance.

Text Books:

1. *Groover, M. P., Automation, Production System & Computer Integrated Manufacturing, Pearson Education Asia (2009).*
2. *Esposito, A., Fluid Power with Applications, Sixth Edition, Pearson Education (2009).*
3. *Majumdar, S. R., Pneumatic Systems, McGraw Hill (2005).*
4. *Minoli, D., Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, Wiley (2013).*

Reference Books:

1. *Nakra, B. C., Theory and Applications of Automatic Controls, Revised 2nd Edition, New Age International Publishers (2014).*
2. *Morriss, S. B., Automated Manufacturing Systems, McGraw Hill (2006).*
3. *Auslander, D. M. and Kempf, C. J., Mechatronics: Mechanical System Interfacing, Prentice Hall Inc., New Jersey (1996).*
4. *John W. Webb & Ronald A. Reis, Programmable Logic Controllers – Principles and Applications, Fifth Edition, Pearson Education (2008).*
5. *John R. Hackworth & Frederick D. Hackworth Jr, Programmable Logic Controllers – Programming Methods and Applications, Pearson (2011).*
6. *Workbook of Pneumatic, Electropneumatics and PLC by published by FESTO.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessional (Assignments/Projects/Tutorials/Quizes)	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, machine tool control systems.

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 re-circulating power screw assemblies.

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

Approved in 100th meeting of Senate held on March 09, 2020

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, Slab Method

Metal Forming Processes (Flip Learning Component): 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

UME856: TOTAL QUALITY MANAGMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course provides students with the knowledge required to assess and improve product quality through process control procedures and quality improvement techniques. The course also provides required knowledge for line/angular measurements.

Quality Management: Meaning and significance of 'Quality', Fitness levels of quality: characteristic features and limitations of each type, Essential components of Quality, Product Features, Freedom from Deficiencies, Characteristics and attributes under each for products and services, Phases or elements of building quality in a product: Quality of design, Quality of conformance, Quality of performance, History of quality, Evolution of the concepts of quality, Big Q Vs Small Q: changing scope of quality activities, Ishikawa's seven quality tools, Quality circles, TQM meaning and TQM culture.

Quality System Economics: Different obvious quality costs; Hidden quality costs, Economic models of quality costs: Conventional and modern models, cost curves: Different zones and actions to be taken for each zone.

Quality Control and Improvement: Causes of variation: special and chance causes; sporadic and chronic problems, Juran's Quality Trilogy, Different Zones and their functions; Quality Planning activities, Crosby's and Deming's quality viewpoint, Variable Vs Attribute Data; Different distributions, their significance and applications; Control charts for variables, underlying principle, advantages, limitations and applications of: X-bar & R charts, X-bar & S charts, X & MR charts. Control charts for attributes, underlying principle, advantages, limitations and applications of: p, np, c and u charts.

Process Capability Analysis: Need and significance, Process capability for variable data, Process capability indices, Interpreting the indices, Six Sigma Process Quality.

Tools and Techniques for Quality Management: Quality functions development (QFD), Failure mode and effect analysis (FMEA), Seven new management tools, Poka yoke, Total preventive maintenance (TPM), Implementing TQM: an integrated system's approach.

Metrology: Introduction to metrology, methods of measurement, measurement standards, calibration, linear metrology, measurement of surface finish, measurement of flatness and cylindricity, use of comparators, screw thread metrology.

Course Learning Outcomes (CLOs):

The students will be able to:

- analyze various obvious and hidden quality costs of a firm for quality system economics.
- apply various quality control tools for troubleshooting to reduce sporadic quality problems.
- conduct process capability analysis
- perform line and angular measurements using appropriate metrological instruments.

Text Books:

1. *Juran and Gryna, Quality Planning & Analysis, McGraw Hill (2001).*
2. *Grant, E. L., Statistical Quality Control, McGraw Hill (2008).*
3. *Beckwith Marangoni and Lienhard., Mechanical Measurements, Pearson Education (2006).*

Reference Books:

1. *Feignbaum, Total Quality Control, McGraw Hill (1991).*

2. *Engineering Metrology and Measurements, N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.*

Evaluation Scheme:

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

UME857 ADVANCED MECHANICAL VIBRATIONS

L	T	P	Cr
3	1	0	3.5

Course Objectives: Introduction to Advanced Mechanical Vibrations starts with a review of single and double degree of freedom systems. After that, multiple degrees of freedom systems are introduced to explain the vibrations of string and beam. These vibration systems provide to apply or use them into practical problems.

Introduction: Review of free and forced vibrations with and without damping.
Isolation: Vibration isolation and transmissibility; Un-damped vibration absorbers.
Multi degree of freedom system: Generalized coordinates and coordinate coupling; Orthogonality of modes, Free and forced vibration of multi-degree of freedom systems with and without viscous damping; Lagrange's equation; Holzer's method. Solution of Eigen value problem, transfer matrix and modal analysis.
Stability criterion: Self excited vibrations; Criterion of stability; Effect of friction on stability.
Nonlinear vibration: Free vibrations with non-linear spring force or nonlinear damping; Phase plane; Energy curves; Lienard's graphical construction; Method of isoclines.
Vibration of continuous system: Vibrations of strings; Free and forced longitudinal vibrations of prismatic bars; Ritz and Galerkin methods.
Random vibration: Mathematical descriptions of stochastic processes; Stationary and ergodicity; Gaussian random process, correlation functions and power spectral density.

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

1. Ability to define, formulate and solve advanced problems of mechanical vibrations
2. Being able to provide information about determining Natural Frequencies and Mode shapes
3. Being able to provide information about determining forced response

Text Books:

1. Rao, S.S., "Mechanical Vibrations", 4th Ed., Pearson Education., 2007
2. Meirovitch, L., "Fundamental of Vibrations", Mc-Graw Hill., 2001
3. Inman, D.J., "Vibration and Control", John Willey & Sons., 2002
4. Tamadonni, S. and Kelly, G.S., "Mechanical Vibrations", Mc-Graw Hill., 1998
5. Rao, J. S., "Vibration Condition Monitoring of Machines", Tata Mc-Graw Hill., 2006

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
	MST	30
	EST	45
	Sessional (May include Assignments/Quizzes/Tutorial Evaluations)	25

UME737 : CONDITION MONITORING OF ROTATING MACHINERY

L	T	P	Cr
3	1	0	3.5

Course Objectives: To utilize signal processing and data analysis tools with a focus on monitoring, assessing, predicting and diagnosing the condition of rotating machinery equipment. Students will follow a systematic process to conduct signal processing and data analysis. Students will be divided into groups to conduct term-project in applying this process for rotating machinery applications.

Introduction: Introduction of rotating machineries components and related fault symptoms e.g. Unbalance, Misalignment, Shaft cracks, Bearing faults, gear faults, Maintenance Principles and Condition Monitoring

Introduction of MATLAB

Measurement Signals: Vibrations analysis, Acoustic emissions, Motor current signals, Different data mmeasuring sensors e.g. Accelerometers, Eddy current probes, etc.

Data Acquisition Principles: Nyquist Theorem, Sampling frequency and number of samples, Windowing, Aliasing, Signal Conditioning and Filtering.

Time domain analysis: Statistical Parameters (Mean, median, RMS, Kurtosis, Crest Factor etc.), Gaussian distributions and their analysis, Time Synchronous Averaging, Case study including, auto-correlation, cross correlation.

Frequency domain analysis: Fourier Analysis, Fourier Transform, Fast Fourier Transform, Hilbert Transform, Envelope Analysis, Cepstrum Analysis

Time frequency domain analysis: Discrete Wavelet Transform, Continuous Wavelet Transform, Empirical Mode Decomposition , Hilbert Huang Transform

Introduction to basic Machine Learning algorithms: Artificial Neural Networks, Self-Organising Maps, Support vector Machines.

Case Studies

Research Assignment: Students will be divided into groups to finish course projects. The course projects will consist of actual fault data from rotating machinery related topics. The course projects requires students to use analytical tools learned from this course to deal with real problems and which is also not limited to only use what you learned here. Innovative solutions and ideas are encouraged by bonus points. Students will have a final group presentation, where each group will demonstrate their understanding and use of the data analytics tools learned as applied to one real application.

Course Learning Outcomes (CLOs):

The students will be able to:

1. evaluate data sources and data quality in the context of rotating machinery faults
2. work in groups to demonstrate proficiency at use of analytical tools and justify the use of methods selected
3. use data and analytical tools to make predictive diagnosis regarding data from actual faults from rotating machinery equipment.

Text Books:

1 Randall, Robert Bond. Vibration-based condition monitoring: industrial, aerospace and automotive applications. John Wiley & Sons, 2011.

2 Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessionals (Assignments/ Presentation, Technical Report)	25

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. simulateengineering 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:

1. *Muralidhar, K. and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa (2008) 2nd ed.*
2. *Jaluria, Y. and Torrance, K. E., Computational Heat Transfer, Taylor & Francis (2003).*
3. *Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Taylor & Francis (2007).*

Approved in 100th meeting of Senate held on March 09, 2020

Evaluation Scheme:

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

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 superheater 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.

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

UME735: MACHINING SCIENCE

L T P Cr

2 **1** **2** **3.5**

Course objective: The objective of this course is to expose the students about the design aspects and modeling of process parameters involved in various machining operations. 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: Determination of strain rate, velocity relationships, Estimation of cutting forces and power using various theories as Lee and Shaffer, (Flip learning) Palmer and Oxley, Ernst Merchant etc, Power and energy relationships, friction and thermal aspects of machining.

Machining with Multi-Point Cutting Tools: Analysis of chip cross-section, forces and power requirement in various types of milling, drilling and grinding operations.

Cutting Tool Wear and Tool Life: Wear Mechanism, wear criterion, Tool life, factors affecting tool life, Taylor's tool life equation,-Universal machinability index, Estimation of tool life, Factors affecting dimensional accuracy and material removal rate in machining, calculation of economic cutting speed for maximum production and minimum cost, (Flip learning) Gilberts model for economic tool life, Determination of optimal cutting speed, High efficiency zone

Non-conventional Machining Methods: Process capabilities, tool design, Mechanics of processes, applications, limitations of various non-conventional machining methods.

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, Non conventional machining, Abrasive shot blasting process

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 and non-conventional machining processes. Students will be required to go through the topics and recent developments 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. analyze the thermal and frictional aspects of machining parameters used in manufacturing industries
3. design the conditions for the maximum tool life and factors influencing surface quality, dimensional accuracy and material removal rate in machining

4. develop mathematical models to predict material removal rate surface quality for different process parameters in different non-conventional machining methods

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	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizzes)	30

UME841 MODERN AUTOMOBILE ENGINEERING

L T P Cr
3 1 0 3.5

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

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

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

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

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

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

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

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

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

Course Learning Outcomes (CLO):

The students will be able to:

1. understand the function of electronic systems in modern automobiles.
2. evaluate the use of modern electronics technology to improve the performance, safety, comfort and related issues.

3. synthesize and specify the addition of new features in existing electronic automotive subsystems for enhanced functionality.

Text Books:

1. *Hiller, V. A. W., Fundamentals of Motor Vehicle Technology, Oxford University Press, UK (2014).*
2. *Hollembeak, B., Today's Technician: Advanced Automotive Electronic Systems, Cengage Learning, New Delhi (2010).*

Reference Books:

1. Heisler, H., Advanced Vehicle Technology, SAE International.
2. Pike , J. A., Automotive Safety, SAE International.
3. Duffy, J.E., Modern Automotive Technology, SAE International.

Evaluation Scheme:

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

UME836 OPERATIONS MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective of this course is to develop understanding of the strategic role of operations management in creating and enhancing a firm's competitive advantages. This will help to apply key concepts and issues of operations management in both manufacturing and service organizations by enabling the students to apply analytical skills and problem-solving tools for the analysis of the operations problems like forecast demand, material requirement planning, inventory etc.

General: Operations Management: meaning and scope; significance of operations management in increasing productivity of firms; soft variety and hard variety; categories of production systems and layouts.

Forecasting Analysis: Need and benefits, various qualitative and quantitative models, error analysis in quantitative forecasting.

Production Planning: Aggregate production planning, pure and mixed aggregate planning strategies; Master production scheduling; material requirements planning and manufacturing resource planning (MRP I and MRP II); Supply Chain Management.

Inventory Management and Control: Need and types inventory, methods of handling inventory uncertainties, methods of inventory control systems, perpetual (fixed order-quantity) system, periodic (fixed order-interval) system, economic run length

Course Learning Outcomes (CLOs):

The student will be able to:

1. analyze the fundamental theory of operations and production management
2. analyze forecasting problems or issues faced by service and manufacturing industries
3. solve problems on materials requirement planning, aggregate production planning
4. analyze inventory management problems

Text Books

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

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

Reference Books

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

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

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (may include Assignments/Projects/Quizes/Seminar presentation)	25

UME855 NON TRADITIONAL MACHINING PROCESSES

L	T	P	Cr
2	1	2	3.5

Course Objectives: To understand several non- traditional machining processes in micro and precision manufacturing field. To cultivate the ability to develop and implement new improved manufacturing processes resulting in creation and distribution of value in engineering applications. To impart knowledge about the significance of controlling process parameters for the optimal performance for newly developed engineering materials.

Introduction - Classification - process economy - Mechanical machining – Types - Ultrasonic machining (USM) - Abrasive Jet Machining (AJM) - Abrasive Flow Machining (AFM) - Water Jet Machining (WJM) - Operating principle - Process parameters – Design aspects, Applications - Limitations.

Laser materials processing - Laser types - Processes - Laser beam machining (LBM) – Laser cutting (LC) – Laser drilling (LD) - Laser marking and engraving (LM) – (Flip Learning component) Laser micromachining (LMM) - Laser engineered net shaping (LENS) - Applications – Limitations

Electro chemical machining - Chemical material removal - Types - Electro chemical machining (ECM) - Electro chemical drilling (ECD) - Electro chemical grinding (ECG) - Electro chemical honing (ECH) - Shaped tube electrolytic machining - Operating principle - Process parameters - Applications - Limitations.

Thermo electrical machining - Types – Electrical discharge machining (EDM) - Electrical discharge wire cutting (EDWC) - Electron beam machining (EBM) - (Flip Learning component) Ion Beam Machining (IBM) -Plasma Arc Machining (PAM) - Operating principle - Process parameters - Applications – Limitations

Laboratory Work

Experimental work pertaining to determination of effects of various process parameters on material removal rate, quality of machined surface, microstructure, optimization of process parameters in various Non- traditional machining processes.

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 involved in various Non-traditional machining processes. Students will be required to go through the topics and recent developments 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 (CLO):

The students will be able to:

1. understand the contribution of non-traditional machining process in micro and precision manufacturing field.
2. summarize the merits and demerits of the non-traditional machining processes

3. analyze the processes and evaluate the role of each process parameter during machining of various advanced materials.
4. understand requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials.

Recommended Books:

1. *Abdel, H. and El-Hofy, G. "Advanced Machining Processes", McGraw-Hill, 2005.*
2. *Jain, V.K., Advanced Machining processes, Allied Publishers Private Limited (2004).*
3. *Mishra, P.K., Non Conventional Machining, Narosa Publications (2006).*
4. *Groover, M.P. "Fundamentals of modern manufacturing processes - Materials, Processes and Systems", 3rd Edition, John Wiley and Sons Inc., 2007.*

Evaluation Scheme:

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

UME524: ADDITIVE MANUFACTURING

L	T	P	Cr
2	1	2	3.5

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

Introduction: Classification of manufacturing processes, Introduction to additive manufacturing (AM), Basic Principles of AM, Steps in AM, Advantages of AM.
Classifications of Different AM Techniques: Based on raw material, Based on layering technique and energy sources.
Design of CAD Models for AM: Transformations, Design of Curves, Surface Modeling, Solid modeling for AM.
Process Technology in AM*:* 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 AM: STL file generation, Defects in STL files and repairing algorithms, other Interface formats.
Research Areas in AM: 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 additive manufacturing

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 AM 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 Additive manufacturing.
5. The students will be doing a project realizing the application of AM technology for product development.

Course learning outcome (CLO): On completion of this course the student will be able to

1. Implement the concepts of transformation and solid modeling in developing a solid model.
2. Identify suitable process and process parameters required for fabricating a part through additive manufacturing.
3. Examine & detect the errors in .stl files and implement a suitable repair algorithm.
4. Implement suitable shrinkage compensation and identify appropriate orientation of parts for 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 (%)
11	MST	25
2	EST	45
3	Sessional (Assignments/Quizzes/Presentations)	30

UPE503 LEAN AND AGILE MANUFACTURING

L	T	P	CR
2	1	2	3.5

Course objective: This course introduces the concept of manufacturing in the present day context. Students will get exposed to the complexity of manufacturing systems, manufacture of a large variety of products in small lots, dynamically changing product mix, short lead times and product life cycles and ever increasing pressures to contain costs. The course will also introduce strategies adopted by manufacturing industry, lean and agile manufacturing, high degree of automation and synchronization of various technical and supply chain operations in the industry. Industry 4.0 and its essentials will also be introduced in the course. The course will also introduce some tools and techniques which are essential to move towards lean and agile manufacturing. These are Just-in-time, Total Productive Maintenance, 5S, Single Minute Exchange of Die (SMED) and Fool proofing.

Introduction: Manufacturing: Types of manufacturing systems: continuous and intermittent manufacturing; mass production, batch production and job shop production. Basic process of manufacturing large variety of products in a productive system. Set up changeovers- need and strategy to reduce or eliminate changeovers.

Manufacturing management: Brief coverage of layout design, material handling, product design, process design, capacity planning, aggregate planning, master production scheduling, material requirements planning and production control.

Need of lean and agile manufacturing; Business and manufacturing scenario, uncertainty & volatility of demand, shortening product life cycles and rapid product introductions leading to complexity of manufacturing systems, manufacture of large variety of products in small lots. Lead time gap and manufacturing strategies to make up for this gap, demand penetration point & supply chain fulcrum- role of inventory and capacity in meeting demand, concept of postponement and mass customization.

Lean Manufacturing: Concept and objectives, contrast between traditional and lean manufacturing, five interdependent principles of lean manufacturing- value definition, value stream analysis, just-in-time, flow and perfection; 7 different types of waste and their mitigation, lean manufacturing techniques- SMED, TPM, 5S, Fool-proofing, Just in time.

Agile Manufacturing: Concept of agile manufacturing, difference between lean and agile manufacturing, four Rs of supply chain- responsiveness, reliability, resilience and relationship, set up time and lot sizing, level production, Leagile manufacturing.

Industry 4.0: Six design principles of industry 4.0- Interoperability (internet of things and internet of services), virtualization, decentralisation, real time capability, service orientation and modularity. Building blocks of industry 4.0- autonomous robots, simulation, horizontal & vertical system integration, industrial internet of things, cyber security, additive manufacturing, augmented reality, big data analysis.

Course Learning Outcomes (CLOs):

The students will be able to:

1. Apply the procedure of manufacturing management to prepare aggregate plans and schedules for manufacturing systems
2. Evaluate the set up changeover procedures, identify areas of improvement and improve them
3. Apply the concept, principles and techniques of lean manufacturing to reduce waste and improve productivity of manufacturing systems
4. Evaluate agility in manufacturing systems, identify areas of improvement and develop action plans
5. Apply the concept, structure and essentials of Industry 4.0 to improve processes and their integration

Text Books:

1. *Monks, J.G. Operations Management, Second Edition, McGraw-Hills, (1996)*
2. *Christopher, M. Logistics and Supply Chain Management, FT Prentice Hall, (2011).*

Evaluation Scheme:

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

UPE831 PROCESSING OF POLYMERS AND COMPOSITES

L	T	P	Cr
3	1	0	3.5

Course objective: To impart knowledge of the basic nature of different polymers and manufacturing processes associated thereof. Tailoring properties in composites as required for specific applications.To introduce attendants to the principles of the processing and concept of the deformation behaviour of plastics. To provide an outline account for all major processing routes, thermoplastics, as well as thermoset and rubbers.

Properties and processing of polymers: Structure and mechanical properties of plastics: thermoplastics and thermosets, their properties and applications, processing the polymers considering crosslinking and curing, influence of time, temperature, and mass, shelf life and pot life, stoichiometric considerations. additives in polymers: dispersion aids, UV stabilizers, antioxidants and antiozonents, processing/flow modifiers, different fillers.
Extrusion using single and twin screw extruders, injection moulding, thermoforming, compression moulding, transfer moulding, general behavior of polymer melts, machining of polymers, processing of rubbers, testing of polymers, Recycling of plastics.
Properties and processing of composites: Classification of composite materials, properties of composites, processing methods of polymeric matrix composites: Hand lay-up, autoclaving, filament winding, pultrusion, compression molding, pre-pegging, sheet molding compounds etc.,
Secondary processing of composite materials, need of secondary operations, different type of secondary operations, machining, drilling, joining of composites. welding of polymers using thermal, ultrasonic and laser bonding, destructive and non-destructive inspection and evaluation, characterization of composites using microscopy : Scanning electron microscopy and transmission electron microscopy, review of simulation technologies for composite design, manufacturing and performance, applications of polymer composites in automotive, marine and aerospace

Research Assignment: Students in a group of 4/5 will do term projects with help of critically reviewing some technical research papers on the recent technology developments and industrial applications as well as challenges for processing of polymers and composites.

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

1. analyze the behavior of polymers, their properties to select suitability for engineering applications.
2. know the behavior during processing of polymers.
3. gain knowledge on the properties and industrial applications of the polymers.
4. gain practical knowledge of the structure-property relationships to improve properties of polymers and the manufacturing the products with alternative technology.
5. derive and calculate stress, strain and modulus for a given problem of unidirectional composite.

Text Books:

1. *Strong, A.B., Plastic Materials and Processing, Prentice Hall, New Delhi (1999)*
2. *Middleman, S., Fundamentals of Polymer Processing, Houghton Mifflin Company, UK(1997)*

Reference Books:

1. *Chawala, K.K., Composite materials, Springer-Verlag, New York (1987)*
2. *Tadmor, Z. and Gogos, C.G., Principles of Polymer Processing, John Wiley, US (2006).*

Evaluation Scheme:

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

UME834: ADVANVED 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 carburetor

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 Books:

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

UME736 WELDING FOR INDUSTRY & ENGINEERS

L	T	P	Cr
2	0	2	3

Course objective: To introduce the fundamental concepts of various welding and allied processes. After completing this course the students will understand the science behind the joining processes and its associated applications.

Principles of arc welding: Principles of arc welding, basic physics of arc and flame
Welding and Allied Processes: Arc welding power sources, power source characteristic, Manual metal arc welding, GTAW, GMAW and SAW processes and their recent variants, Gas welding and Gas cutting. Plasma arc welding processes and their applications, Resistance welding, Brazing, Soldering and their applications.
Heat flow in welding: Heat source, Analysis of heat flow in welding, effect of welding parameters, characteristics and metallurgical changes in fusion welding,
Radiant energy welding processes: Electron beam welding, (EBW) - laser beam welding (LBW) - applications of EBW and LBW,
Weld Design and Defects: Joint design, welding symbols and Joint evaluation through destructive and non destructive testing methods, welding defects and discontinuities, their causes and remedies.
Advances in welding: Recent advances and applications in welding for sustainable manufacturing like hot wire laser, Hybrid welding processes etc.

Laboratory Work: Joint preparation through various welding processes like Gas Metal Arc Welding, Gas Tungsten Arc Welding, Submerged Arc welding, Shielded Metal Arc Welding, Defect analysis through various destructive and non-destructive testing, lap joint preprations by Resistance Spot Welding.

Micro Project:
Each team of 4-5 students will submit a small project made by using welding techniques. The project will constitute design and fabrication of some working item. Finally, each team has to submit a detailed report.

Course Learning Outcomes:
The students will be able to

- Analyze and understand the fundamental of arc physics.
- Select and use of suitable welding process and the power source for given application.
- Estimate and analyze the heat flow during welding, and calculation of the cooling rate.
- Select, application and understanding of the radiant energy welding processes.
- Design of the weld joint for given condition and identification of the welding defects and discontinuities.
- Analyze and understand the role of advanced welding techniques towards industry and societal impact.

Text Books:

1. R.S., Parmar, Welding Engineering and Technology, Khanna Publishers, 2002

2. Sindo Kou, Welding Metallurgy, Wiley-Interscience, John Wiley & Sons
3. Nadkari, S. V., Modern Arc Welding Technology, Oxford & India Book House Pvt. Ltd. (2005)

Reference Books:

1. ASM Handbook – welding, brazing and soldering, vol 6,
2. Howard B Cary, Modern welding technology, 6th Ed., Prentice Hall USA, 2004

Evaluation Scheme:

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

GENERIC ELECTIVES

Approved in 100th meeting of Senate held on March 09, 2020

UPH063 NANOSCIENCE AND NANOMATERIALS

L	T	P	Cr
3	0	0	3.0

Course Objective:

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 outcomes:

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

Approved in 100th meeting of Senate held on March 09, 2020

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

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UHU009 INTRODUCTION TO COGNITIVE SCIENCE

L	T	P	Cr
3	0	0	3.0

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.

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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

UMA066 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 (CLOs):
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

UMA067 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:
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.*

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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 (CLOs):

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. Explain the characteristic features of living-systems and differentiate them from non-living systems
2. Broaden the application of engineering knowledge of their branch by applying concepts of living systems.
3. Demonstrate familiarity with special properties of biological macromolecules
4. Upgrade their understanding about biological systems by drawing parallel with thermodynamics system and develop interface between an engineering specialization and living systems.
5. Design engineering products inspired by living creatures.
6. Plan application of computational tools in bioinformatics.

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 (CLOs):
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

UTD001 EMPLOYABILITY DEVELOPMENT SKILLS

L	T	P	Cr
2	2	0	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