

COURSE SCHEME
FOR
B.E. – CHEMICAL ENGINEERING
2019



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



BE (CHEMICAL ENGINEERING)**SEMESTER – I**

S.No.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UPH004	APPLIED PHYSICS	CF	3	1	2	4.5
2	UTA017	COMPUTER PROGRAMMING	CF	3	0	2	4.0
3	UEC001	ELECTRONIC ENGINEERING	CF	3	1	2	4.5
4	UTA015	ENGINEERING DRAWING	CF	2	0	4	4.0
5	UHU003	PROFESSIONAL COMMUNICATION	CF	2	0	2	3.0
6	UMA010	MATHEMATICS-I	CF	3	1	0	3.5
TOTAL				16	7	8	23.5

Note: EL activity in the semester-I will be carried out as per schedule.

SEMESTER – II

S.No .	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UCB008	APPLIED CHEMISTRY	CF	3	1	2	4.5
2	UTA018	OBJECT ORIENTED PROGRAMMING	CF	3	0	2	4.0
3	UEE001	ELECTRICAL ENGINEERING	CF	3	1	2	4.5
4	UEN002	ENERGY AND ENVIRONMENT	CF	3	0	0	3.0
5	UTA013	ENGINEERING DESIGN PROJECT-I (MANGONEL)	CF	1	0	2	2.0
6	UMA004	MATHEMATICS-II	CF	3	1	0	3.5
7	UES009	MECHANICS^	CF	2	1	0	2.5
TOTAL				18	4	8	24.0

[^] Only one lab session per semester.

Note: EL activity in the semester-II will be carried out as per schedule.

SEMESTER – III

S.No.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UTA014	ENGINEERING DESIGN PROJECT-II (BUGGY)	CF	1	0	4	3.0
2	UTA002	MANUFACTURING PROCESSES	CF	2	0	3	3.5
3	UMA035	OPTIMIZATION TECHNIQUES	CF	3	0	2	4.0
4	UCHXXX	CHEMICAL ENGINEERING THERMODYNAMICS-I	CP	3	1	0	3.5
5	UCH301	MATERIAL AND ENERGY BALANCES	CP	3	1	0	3.5
6	UCH502	MASS TRANSFER-I	CP	3	1	0	3.5
7		GENERIC ELECTIVE	GE	3	0	0	3.0
TOTAL				18	4	11	24.0

For IEP Program

UES011	THERMO-FLUIDS*	CF	3	1	2*	4.0
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* The lab sessions will be on every alternate week.

Note: EL activity in the semester-III will be carried out as per schedule.

SEMESTER – IV

S.NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UES012	ENGINEERING MATERIALS	CF	3	1	2	4.5
2	UMA007	NUMERICAL ANALYSIS	CF	3	0	2	4.0
3	UCHXXX	CHEMICAL ENGINEERING THERMODYNAMICS-II	CP	3	1	0	3.5
4	UCH302	PROCESS FLUID MECHANICS	CP	3	1	2	4.5
5	UCH402	HEAT TRANSFER	CP	3	1	2	4.5
6	UTA012	INNOVATION & ENTREPRENEURSHIP	CF	1	0	2*	3.0
TOTAL				19	4	10	24.0

* Alternate Week

NOTE: Students opted for ‘2+2’ UG program of Leeds University has to do following additional course in semester IV.

COURSE NO.	TITLE	CODE	L	T	P	CR
UESXXX	PHASE TRANSFORMATION OF MATERIALS	CF	3	0	0	3.0

Note: EL activity in the semester-IV will be carried out as per schedule.

SEMESTER-V

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH501	CHEMICAL REACTION ENGINEERING-I	CP	3	1	2	4.5
2	UCH401	FLUID AND PARTICLE MECHANICS	CP	3	1	2	4.5
3	UCH503	INDUSTRIAL POLLUTION ABATEMENT	CP	3	1	2	4.5
4	UCH506	PROCESS INSTRUMENTATION AND CONTROL	CP	3	1	2	4.5
5	UCH405	ENERGY RESOURCES	CP	3	1	2	4.5
TOTAL				15	5	10	22.5

Note: EL activity in the semester-V will be carried out as per schedule.

SEMESTER-VI

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH601	CHEMICAL REACTION ENGINEERING-II	CP	3	1	0	3.5
2	UCH602	MASS TRANSFER-II	CP	3	1	2	4.5
3	UCH603	TRANSPORT PHENOMENA	CP	3	1	0	3.5
4	UCH605	PROCESS UTILITY AND INDUSTRIAL SAFETY	CP	3	1	0	3.5
5	UCH802	PROCESS MODELING AND SIMULATION	CP	3	0	2	4.0
6	UCH507	CHEMICAL PROCESS INDUSTRIES	CP	3	0	0	3.0
7	UCH893	CAPSTONE PROJECT (STARTS) (4 SELF-EFFORT HOURS)	PR	1*	-	2	-
TOTAL				18	4	6	22.0

* Alternate Week

SEMESTER-VII

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH793	PROJECT SEMESTER [#]	PR		-		15
TOTAL							15

[#]TO BE CARRIED OUT IN INDUSTRY/RESEARCH INSTITUTION

OR

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH794	PROJECT	PR		-		8.0
2		ELECTIVE-I	PE	3	1	0	3.5
3		ELECTIVE-II	PE	3	1	0	3.5
TOTAL				6	2	0	15.0

OR

S. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UCH795	START- UP SEMESTER**	PR		-		15.0
		TOTAL					15.0

**BASED ON HANDS ON WORK ON INNOVATIONS AND ENTREPRENEURSHIP.

SEMESTER-VIII

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH604	BIOCHEMICAL ENGINEERING	CP	3	1	2	4.5
2	UHU005	HUMANITIES FOR ENGINEERS	CF	2	0	2	3.0
3	UCH801	PROCESS ENGINEERING AND PLANT DESIGN	CP	3	1	0	3.5
4	UCH893	CAPSTONE PROJECT (8 SELF-EFFORT HOURS)	PR	1*	0	2	8.0
5		ELECTIVE-III**	PE	3	0	0	3.0
6		ELECTIVE-IV**	PE	3	0	0	3.0
TOTAL				14	2	6	25.0

* Alternate Week

**SELECTION OF SUBJECT FROM EACH ELECTIVE AS PER ELECTIVE FOCUS AREA (ENERGY/MATERIALS/PETROLEUM)

LIST OF PROFESSIONAL ELECTIVES (PE)

ELECTIVE I

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH711	FLUIDIZATION ENGINEERING	PE	3	1	0	3.5
2	UCHXXX	ADVANCED SEPARATION PROCESSES	PE	3	1	0	3.5
3	UCH713	CORROSION ENGINEERING	PE	3	1	0	3.5

ELECTIVE II

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCH701	CATALYTIC PROCESSES	PE	3	1	0	3.5
2	UCH716	FOOD ENGINEERING AND SCIENCE	PE	3	1	0	3.5
3	UCH834	PROCESS INTEGRATION	PE	3	1	0	3.5

ELECTIVE-III

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCHXXX	BIOENERGY ENGINEERING	PE	3	0	0	3.0
2	UCHXXX	FUEL CELL TECHNOLOGY	PE	3	0	0	3.0
3	UCH840	POLYMER SCIENCE AND TECHNOLOGY	PE	3	0	0	3.0
4	UCHXXX	POLYMER BLENDS AND COMPOSITES	PE	3	0	0	3.0
5	UCHXXX	PETROLEUM DRILLING AND PRODUCTION ENGINEERING	PE	3	0	0	3.0
6	UCH850	PETROLEUM AND PETROCHEMICALS	PE	3	0	0	3.0

ELECTIVE – IV

S.NO.	COURSE NO.	COURSE NAME	CODE	L	T	P	CR
1	UCHXXX	MATERIALS AND DEVICES FOR ENERGY CONVERSION	PE	3	0	0	3.0
2	UCHXXX	ENERGY MANAGEMENT	PE	3	0	0	3.0
3	UCHXXX	POLYMER PROCESSING	PE	3	0	0	3.0
4	UCHXXX	STRUCTURAL MATERIALS	PE	3	0	0	3.0
5	UCHXXX	PETROLEUM RESERVOIR ENGINEERING AND FIELD	PE	3	0	0	3.0
6	UCHXXX	ENHANCED OIL RECOVERY TECHNIQUES	PE	3	0	0	3.0

GENERIC ELECTIVE (GE)

S. NO.	COURSE NO.	TITLE	CODE	L	T	P	CR
1	UHU007	EMPLOYABILITY DEVELOPMENT SKILL	GE	3	0	0	3.0
2.	UHU006	INTRODUCTORY COURSE IN FRENCH/GERMAN/SPANISH	GE	3	0	0	3.0
3.	UHU009	INTRODUCTION TO COGNITIVE SCIENCE	GE	3	0	0	3.0
4.	UHU008	INTRODUCTION TO CORPORATE FINANCE	GE	3	0	0	3.0
5.	UEN004	TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT	GE	3	0	0	3.0
6.	UBT509	BIOLOGY FOR ENGINEERS	GE	3	0	0	3.0
7.		ASTRONOMY AND ASTROPHYSICS	GE	3	0	0	3.0
8.		INTELLECTUAL PROPERTY RIGHTS	GE	3	0	0	3.0
9.		TOTAL QUALITY MANAGEMENT	GE	3	0	0	3.0
10.		INTRODUCTION TO INDIAN CONSTITUTION	GE	3	0	0	3.0
11.		ECONOMICS FOR DECISION MAKING	GE	3	0	0	3.0
12.		INTRODUCTION TO CYBER SECURITY	GE	3	0	0	3.0

13.		MOLECULAR MODELLING FOR ENGINEERS	GE	3	0	0	3.0
14		MASS COMMUNICATION	GE	2	0	2	3.0
15		YOGA AND SCIENCE	GE	2	0	2	3.0

List of EL Activities

Semester	EL Activity**
I	Hydro-distillation of biomass (rose pellets, raw turmeric, mint, etc.) to obtain essential oil. Production of edible oil from oil seeds (solvent extraction).
II	Production of liquid soap/detergent
III	Thermodynamics experiment to design experimental set-ups to study the P-V-T behaviour of air for: (i) Isobaric process (ii) Isothermal process (iii) Adiabatic Process
IV	Packed bed reactor design. Dissection of centrifugal pump. VLE data generation for acetone-water binary mixture.
V	Design and fabrication of double pipe /plate heat exchangers

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

SEMESTER WISE CREDITS FOR B.E. (CHEMICAL ENGINEERING)

SEMESTER	CREDITS
FIRST	23.5
SECOND	24.0
THIRD	24.0
FOURTH	24.0
FIFTH	22.5
SIXTH	22.0
SEVENTH	15.0
EIGHTH	25.0
TOTAL CREDITS	180

SEMESTER-I



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):

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) 6thed.*
2. *Griffiths, D.J., Introduction to Electrodynamics, Prentice Hall of India (1999) 3rded.*
3. *Jenkins, F.A. and White, H.E., Fundamentals of Optics, McGraw Hill (2001) 4thed.*

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) 1sted.*
3. *Pedrotti, Frank L., Pedrotti, Leno S., and Pedrotti, Leno M., Introduction to Optics, Pearson Prentice HallTM (2008) 3rded.*

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

UTA017: 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



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, Pearson (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

UTA015ENGINEERINGDRAWING

L	T	P	Cr
2	0	4	4.0

Course Objectives: This module is dedicated to graphics and includes two sections: manual drawing and AutoCAD. This course is aimed at making the student understand dimensioned projects, 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 tolerance and dimensions and geometric tolerances symbols and to create and edit drawings using drafting software AutoCAD.

Engineering Drawing***g***

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-ordinates systems: Cartesian, polar and relative coordinates
4. Drawing limits, unit 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 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 (wherever 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 tolerated 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 (formalwritten test)	25
2.	EST (formalwritten 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



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 McGraw 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).

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 Professional 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 presentations, public speaking; technical reports)	40

**JIJAPAR INSTITUTE
OF TECHNOLOGY**
JIJAPAR COLLEGE OF ENGINEERING

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 (CLO):

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

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, (7th edition)

Evaluation Scheme:

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





JAYPEE INSTITUTE
OF INFORMATION TECHNOLOGY
Delhi-NCR - 121016

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) 1sted.*
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, 1sted*
2. *Sivasankar, B., Engineering Chemistry, Tata McGraw-Hill Pub. Co. Ltd, New Delhi (2008).*
3. *Shulz, M.J. Engineering Chemistry, CengageLearnings (2007) 1sted.*

Evaluation Scheme:

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

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) 4thed.*
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) 4thed.*
2. *E Balagurusamy, Object Oriented Programming with C++ (2017) 7thed.*
3. *Stroustrup B., The C++ programming language, Pearson Education India (2013) 4thed.*

Evaluation scheme

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

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:

1. apply networks laws and theorems to solve electric circuits.
2. analyze transient and steady state response of DC circuits.
3. signify AC quantities through phasor and compute AC system behaviour during steady state.
4. explain and analyse the behaviour of transformer.
5. 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

UTA013ENGINEERINGDESIGNPROJECT-I

L	T	P	Cr
1	0	2	2.0

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 as all 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 lectures series includes subjects 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 working in groups throughout the semester to encourage team work, 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:

LecNo.	Topic	Contents
Lec1	Introduction	The Mangonel Project. History. Spreadsheet.
Lec2	PROJECTILE MOTION	no DRAG, Design spreadsheets simulator for it.
Lec3	PROJECTILE MOTION	with DRAG, Design spreadsheets simulator for it.
Lec4	STRUCTURES FAILURE	STATIC LOADS
Lec5	STRUCTURES FAILURE	DYNAMIC LOADS

Lec6	REDESIGNING THE MANGONEL	Design constraints and limitations of materials for redesigning the Mangonel for competition as a group.
Lec7	MANUFACTURING	Manufacturing and assembling the Mangonel.
Lec8	SIMULATION IN ENGINEERING DESIGN	Simulation and Analysis Tool in Engineering Design.
Lec9	ROLE OF MODELLING & PROTOTYPING	The Role of Modelling in Engineering Design.

Breakup of lecture details to be taken up by ECED:

LecNo.	Topic	Contents
Lec1-5	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 spreadsheet to develop a simulator	T1
Dynamic of projectile launched by a Mangonel - No Drag	T2
Dynamic of projectile launched by a Mangonel - With Drag	T3
Design against failure under static actions	T4
Design against failure under dynamic actions	T5
Electronic hardware and Arduino controller	L1
Electronic hardware and Arduino controller	L2
Programming the Arduino Controller	L3
Programming the Arduino Controller	L4
Final project of sensors, electronic 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 design of the Mangonel and its testing by group	W3
Innovative design of the Mangonel and its testing by group	W4
Final intergroup 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 to be optimized;
2. perform tests 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 McRoberts, *Beginning Arduino, Technology in action publications.*
2. Alan G. Smith, *Introduction to Arduino: A piece of cake, CreateSpace 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 Assessment of Mechanical contents in Lectures and Tutorials and Electronics contents in Lectures and Practical. Project (Assembly of the "Mangonel", innovative redesign with reflection, prototype competition, Final Presentation and viva-voce)	30 30 10 30



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



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:

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



SEMESTER-III



UTA-014 Engineering Design Project-II (Buggy Lab)

L	T	P	Cr
1	0	4	3.0

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 (CLO): 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

UTA002 MANUFACTURING PROCESSES

L	T	P	Cr
2	0	3	3.5

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

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

Metal Casting:

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

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

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

Laboratory Work:

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

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

Assignments: Assignments for this course will include the topics: Manufacturing of micro-chips used in IT and electronics industry and use of touchscreens. 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 checks 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 a sound welded joint while welding different similar and dissimilar engineering materials.

Textbooks:

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

Reference Books:

1. *Martin, S.I., Chapman, W.A.J., Workshop Technology, Vol. I & II*, Viva Books (2006) 4th 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) 4th ed.

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))	35

UMA035OPTIMIZATION TECHNIQUES (all branches except for Mechanical)

L	T	P	Cr
3	0	2	4.0

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

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

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

Integer Programming: Branch and bound technique, Gomory's Cutting plane method.

Network Models: Construction of networks, Network computations, Free Floats, Critical path method (CPM), optimal scheduling (crashing). Initial basic feasible solutions of balanced and unbalanced transportation problems, optimal solutions, assignment problem.

Multiobjective Programming: Introduction to multiobjective linear programming, efficient solution, efficient frontier.

Nonlinear Programming:

Unconstrained Optimization: unimodal functions, Fibonacci search method, Steepest Descent method, Conjugate Gradient method

Constrained Optimization: Concept of convexity and concavity, Maxima and minima of functions of n-variables, Lagrange multipliers, Karush-Kuhn-Tucker conditions for constrained optimization

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

- 1) formulate the linear and nonlinear programming problems.
- 2) solve linear programming problems using Simplex method and its variants.
- 3) construct and optimize various network models.
- 4) solve multiobjective linear programming problems.
- 5) solve nonlinear programming problems.

Text Books:

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

Recommended Books:

- 1) Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004)
- 2) BazaraaMokhtar S., Jarvis John J. and ShiraliHanif D., Linear Programming and Network flows, John Wiley and Sons (1990)

- 3) Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons, (2010).
- 4) H.S. Kasana and K.D. Kumar, Introductory Operations research, Springer publication, (2004)
- 5) 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 include assignments/quizzes/projects)	25



UES011 THERMO-FLUIDS (Only for IEP students)

L	T	P	Cr
3	1	2*	4.0

Course Objective

To understand basic concepts of fluid flow and thermodynamics and their applications in solving engineering problems.

Fluid Mechanics

- **Introduction:** Definition of a fluid and its properties
- **Hydrostatics:** Measurement of pressure, thrust on submerged surfaces
- **Principles of Fluid Motion:** Description of fluid flow, continuity equation, Euler and Bernoulli equations, Pitot total head and static tubes, venturi-meter, orifice-meter, rotameter,momentum equation and its applications
- **Pipe Flow:** Fully developed flow, laminar pipe flow, turbulent pipe flow, major and minor losses,hydraulic gradient line (HGL) and total energy line (TEL)
- **Boundary Layer:** Boundary layer profile, displacement, momentum and energy thickness

Thermodynamics

- **Introduction:** Properties of matter, the state postulate, energy, processes and thermodynamic systems
- **Properties of Pure Substances:** Property tables, property diagrams, Mollier diagram, phase change, equations of state (ideal gas)
- **Energy:** Energy transfer by heat, work and mass
- **First Law of Thermodynamics:** Closed system, open system, steady-flow engineering devices
- **Second Law of Thermodynamics:** Statements of the second law, heat engines, refrigeration devices, reversible versus irreversible processes, the Carnot cycle, entropy and entropy change.

Laboratory/Project programme**List of Experiments**

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

*Lab to be conducted every alternate week.

Sample List of Micro-Projects

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

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

4. Develop a computer program for solving pipe flow network
5. To Determine the Co-efficient of Discharge through triangular notch and to calibrate given triangular notch
6. To study the performance and characteristics of centrifugal pump and to determine the efficiency of the pump
7. To study the performance and characteristics of reciprocating pump and to determine the efficiency of the pump
8. To determine the various coefficients of a sharp edge circular orifice, and to determine the time taken for emptying a tank through the orifice

Course Learning Outcomes (CLO):

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

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

Text Books:

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

Reference Books:

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

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	40
3	Sessional (may be tutorials/ quizzes/ assignments/lab/ project)	35

UCHXXX CHEMICAL ENGINEERING THERMODYNAMICS-I

L	T	P	Cr
3	1	0	3.5

Course Objective

To understand the laws of thermodynamics, availability, the concept of entropy change, entropy generation and thermodynamic cycles as applied to a variety of engineering systems.

Introduction and Basic Concepts: Role of thermodynamics in engineering and science, Applications of Thermodynamics, Concept of Continuum, Macroscopic approach, Thermodynamics system and properties, Various processes, Thermodynamic equilibrium, Ideal gas, Vander Waals equation of state, Compressibility chart, Process: Flow and non flow process, Cycle concept of work and heat, Specific heats, Zeroth law, Energy and its form, Pure substance, Thermodynamic diagrams, Triple point, Steam tables and their use.

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 function for open and closed system & second law efficiency.

Thermodynamic Cycles: Rankine cycle, Vapour compression refrigeration cycle, Air standard cycles: Otto, Diesel, Dual and Brayton cycles.

Non-Reacting Gas Mixtures: Properties of mixtures of gases and vapours, Adiabatic saturation, Properties of air.

Course Learning Outcomes (CLO):

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

1. Estimate properties of pure substance using steam tables, property diagrams and equation of states.
2. Analyze and solve problems involving closed system and open systems for both steady state and transient processes.
3. Analyze the second law of thermodynamics for various systems and to evaluate the performance of heat engines, refrigerators and heat pumps.
4. Analyze the performance of various power cycles and to identify methods for improving thermodynamic performance.
5. Analyze and solve problems involving non-reacting gas mixtures

Text Books

1. Rao, Y.V.C., *Thermodynamics*, Universities Press (2004).
2. Smith J. M. and Van Ness H. C., *Chemical Engineering Thermodynamics*, Tata

McGraw-Hill (2007).

3. Nag, P.K., *Engineering Thermodynamics*, Tata McGraw Hill (2008) 3rd ed.

Reference Books

1. Cengel, Y. A. and Boles, M., *Thermodynamics: An Engineering Approach*, Tata McGraw Hill (2008).
2. RathaKrishana , E., *Fundamentals of Engineering Thermodynamics*, Prentice Hall of India (2005) 2nd ed.
3. Sonntag, R.E., Borgnakke, C. and Van Wylen, G.J., *Fundamentals of Thermodynamics*, John Wiley (2007) 6th ed.
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	Sessional (may be tutorials/ quizzes/ assignments/ project)	25

UCH301 MATERIAL AND ENERGY BALANCES

L	T	P	Cr
3	1	0	3.5

Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes.

Introduction: Units and dimensions, Stoichiometry of chemical equations, Mole and weight fractions, Unit operations and unit processes with reference to material and energy balance calculations.

Behaviour of Gas and Liquid Mixtures: Gas laws, Raoult's law, Henry's law, Duhring's plot, Saturation, Partial saturation, Relative saturation, Real gases, Bubble point and dew point temperatures.

Material Balance Calculations: Law of conservation of mass, General material balance equation, Material balance calculations without chemical reactions, Material balance calculations with chemical reactions, Recycling, Bypass, Purge, Analysis of degrees of freedom.

Energy Balance Calculations: General energy balance equation, Internal energy, Enthalpy, Heat capacity of gases, liquids, and solids, Latent heats, Heats of formation, combustion, reaction and dissolution, Enthalpy-concentration chart, Fuel heating value, Theoretical flame temperature, Energy balance calculations in unit operations and systems with and without chemical reactions, Humidity and psychrometric chart, Energy balance calculations in humidification and adiabatic cooling.

Sample List of Micro-Projects

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

1. Complete material balances on a process flow sheet
2. Energy balances on a complete process flow sheet
3. Analyze the degrees of freedom for a complete process

Course Learning Outcomes (CLO)

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

1. perform material balance for problems without chemical reactions.
2. perform material balance for problems involving chemical reactions.
3. perform energy balance for problems without chemical reactions.
4. perform energy balance for problems involving chemical reactions.

Text Books:

1. *Himmelblau, D.M. and Riggs, J.B., Basic Principles and Calculations in Chemical Engineering, Prentice Hall of India (2003).*
2. *Bhatt, B.I. and Vora, S.M., Stoichiometry, Tata McGraw Hill (2004).*

Reference Books:

1. *Hougen, O.A., Watson, K.M. and Ragatz, R.A., Chemical Process Principles, Volume-I, C.B.S. Publications (2004).*
2. *Felder, R.M. and Rousseau, R.W., Elementary Principles of Chemical Processes, C.B.S. Publications (2000).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (may be tutorials/ quizzes/ assignments/ project)	25

SEMESTER-IV



UES012 – ENGINEERING MATERIALS

L	T	P	Cr
3	1	2	4.5

Course Objective: To provide basic understanding of engineering materials, their structure and the influence of structure on mechanical, chemical, electrical and magnetic properties.

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

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

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

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

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

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

Laboratory Work and Micro-Project:

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

1. To determine Curie temperature of a ferrite sample and to study temperature dependence of permeability in the vicinity of Curie temperature.
2. To study cooling curve of a binary alloy.
3. Determination of the elastic modulus and ultimate strength of a given fiber strand.
4. To determine the dielectric constant of a PCB laminate.
5. Detection of flaws using ultrasonic flaw detector (UFD).
6. To determine fiber and void fraction of a glass fiber reinforced composite specimen.
7. To investigate creep of a given wire at room temperature.

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

Course Outcomes: Student will be able to:

1. classify engineering materials based on its structure.
2. draw crystallographic planes and directions.
3. distinguish between elastic and plastic behavior of materials.
4. distinguish between isomorphous and eutectic phase diagram.
5. classify materials based on their electrical and magnetic properties.
6. propose a solution to prevent corrosion.

Text Books:

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

Reference Books:

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

Evaluation Scheme

Event	Weightage
Mid-Sem Test	25
Tut/Sessional	5
Lab + Project	25
Quiz	10
End-Sem Test	35
Total	100

UESXXX – PHASE TRANSFORMATION OF MATERIALS##

L	T	P	Cr
3	0	0	3.0

(## Students opted for ‘2+2’ UG program of Leeds University has to do this additional course along with UES012 in semester IV)

Objectives: To provide students with

- a sound understanding of fundamental principles that govern kinetics and mechanisms of phase transformation
- the knowledge to be able to select an appropriate processing route to obtain materials of desired properties.

Introduction to phase transformation: Atomic movement in phase transformation; Types of phase transformation - transformation with change in composition, transformation with change in structure, transformation with change in order; Homogeneous and heterogeneous transformations.

Diffusion in Solids: Laws of diffusion; Temperature dependence of diffusion coefficient; Determination of activation energy.

Thermodynamics of transformations: Concepts of free energy for elemental crystals and solid solutions; Order of transformations; First order transformations with and without composition change.

Nucleation kinetics: Homogenous and heterogeneous nucleation; Different models for homogeneous nucleation with composition change; Heterogeneous nucleation (Nucleation on grain boundaries, dislocations, inclusions, corners, etc.);

Growth kinetics: Interface controlled growth (Growth rate at a constant temperature, Growth rate as a function of temperature); Diffusion controlled growth (Growth rate, Growth of spherical particles, plane front growth); Transformation kinetics for Interface controlled and diffusion controlled growth;

Particle coarsening: Driving force and kinetics of coarsening.

Phase transformation in solids: Pearlitic transformation and martensitic transformation

Course learning outcomes:

The students will be able to

1. distinguish between first order and second order transformations
2. apply laws of diffusion to modify the surface properties
3. understand nucleation kinetics
4. understand the interface - controlled and diffusion - controlled growth kinetics

5. understand the microstructure development in materials during pearlitic and martensitic transformation

Reference books:

1. V. Raghavan, “Solid State Phase Transformations”, PHI learning Private Limited, New Delhi (2015).
2. M. Soustelle, “Phase Transformations” (Volume 5 of Chemical Engineering Series: Chemical Thermodynamics Set), John Wiley & Sons, Inc. NJ, USA (2016).
3. M. Hillert, “Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis”, Cambridge University Press (2003).

Scheme of Evaluation:

Mid-Semester Test	30
End-Semester Test	45
Quiz	10
Assignment/Tutorial/Sessional Test	15
Total	100

UMA007: NUMERICAL ANALYSIS
(For all branches except ELE and EIC)

L	T	P	Cr	3
0	2	4.0		

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

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

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

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

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

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

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

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

Course learning outcomes (CLOs): Upon completion of this course, the student will be able to:

1. understand the errors, source of error and its effect on any numerical computations and also analysis the efficiency of any numerical algorithms.
2. learn how to obtain numerical solution of nonlinear equations using bisection, secant, Newton, and fixed-point iteration methods.
3. solve system of linear equations numerically using direct and iterative methods.
4. understand how to approximate the functions using interpolating polynomials.
5. learn how to solve definite integrals and initial value problems numerically.

Text Books:

1. Gerald F. C. and Wheatley O. P., Applied Numerical Analysis, Pearson, (2003) 7thEdition, 2. Jain K. M., Iyengar K. R. S. and Jain K. R., Numerical Methods for Scientific and Engineering Computation, New Age International Publishers (2012), 6thedition.

2. Steven C. Chapra, Numerical Methods for Engineers, McGraw-Hill Higher Education; 7th edition (1 March 2014)

Reference Books:

3. Mathew H. J., Numerical Methods for Mathematics, Science and Engineering, Prentice Hall, (1992) 2nd edition.
4. Burden L. R. and Faires D. J. Numerical Analysis, Brooks Cole (2011), 9th edition.
5. Atkinson K. and Han H., Elementary Numerical Analysis, John Wiley & Sons (2004), 3rd edition.

Evaluation Scheme:

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

UCHXXXCHEMICAL ENGINEERING THERMODYNAMICS-II

L	T	P	Cr
3	1	0	3.5

Course Objective:

To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Introduction: Laws of thermodynamics and their applications to real processes, Heat capacities, Heat effects during: Phase change, formation, combustion and mixing, Enthalpy-concentration diagram, Thermodynamic analysis of flowing fluids.

Thermodynamic Properties of Fluids and Equations of State: Relationships among thermodynamic properties, Behavior of gases in multi-component systems, Thermodynamic properties of gases and their mixtures, Thermodynamic diagrams, Equations of state and generalized property correlations for gases.

Vapour-Liquid Equilibria and Solution Thermodynamics: Criteria for equilibrium, Fugacity of gases and liquids, Composition of phases in equilibrium, Generalized correlations for the fugacity coefficients, Models for the excess Gibbs energy, Effect of pressure and temperature on phase behavior, Chemical reaction equilibria.

Refrigeration and Liquefaction: Refrigeration cycle, Vapor compression cycle, Eco-friendly refrigerants, Absorption and adsorption refrigeration, Liquefaction processes.

Course Learning Outcomes (CLO)

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

1. apply fundamental concepts of thermodynamics to engineering applications.
2. estimate thermodynamic properties of substances in gas and liquid states.
3. estimate thermodynamic parameters for solutions, vapor-liquid equilibria and chemical reaction equilibria.
4. determine efficiency of thermodynamic cycles.

Text Books:

1. *Smith J. M. and Van Ness H. C., Chemical Engineering Thermodynamics, Tata McGraw-Hill (2007).*
2. *Rao, Y. V. C., Chemical Engineering Thermodynamics, University Press (1997).*

Reference Books:

1. *Weber, H. C. and Meissner, H. P., Thermodynamics for Chemical Engineers, John Wiley, (1970).*
2. *Hougen, O.A., Watson, K.M. and Ragatz, R.A., Chemical Processes Principles (Thermodynamics), Part 2, C.B.S. Publications (2006).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (may be tutorials/quizzes/ assignments etc.)	25





UCH302PROCESS FLUID MECHANICS

L	T	P	Cr
3	1	2	4.5

Course Objective:

To introduce the principles of fluid mechanics and illustrate their applications in the pipe networking, fluid machinery and various flow measuring devices.

Introduction: Definition of a fluid and its properties; Classification of fluids

Hydrostatics: Measurement of pressure; Manometers; Thrust on submerged surfaces

Fluid flow phenomena: Description of fluid flow; Velocity and acceleration of a fluid particle; Continuity equation; Circulation, potential function and stream function; Energy equation: Euler and Bernoulli equations; Navier-Stokes equation; Flow measuring devices: Pitot tube, Orifice meter, Venturimeter, Rotameter; Momentum equation and its applications.

Flow through Pipe: Fully developed flow; Laminar pipe flow: Hagen-Poiseuille law; Introduction to turbulent pipe flow; Major and minor energy losses, Pipe networks: Pipes in series and parallel, Concept of equivalent pipe.

Pumps and Compressors: Types, Working principles, Basic equations, NPSH, Cavitation, Priming.

Flow of Compressible Fluids: Basic equations; Adiabatic, isothermal and isentropic flows.

Dimensional analysis: Methods of dimensional analysis

Laboratory work:

Verification of Bernoulli's theorem, Calibration of venturimeter, Calibration of orifice meter, Rheology of non-newtonian fluids, Determination of friction factor for pipes of different materials, Determination of hydraulic coefficients of an orifice, Verification of momentum equation, Determination of loss coefficients for various types of pipe fittings, Calibration of rotameter, Visualization of laminar and turbulent flow.

Course Learning Outcomes (CLO)

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

1. capability to analyze and solve problems of fluid based engineering systems including pressures and forces on submerged surfaces
2. analyze fluid flow problems with the application of the mass, momentum and energy equations
3. evaluate practical problems associated with pipe flow systems
4. analyze and solve the problems related to compressible fluids, and fluid machinery.

Text Books

1. McCabe, W., Smith, J. and Harriot, P., *Unit Operations of Chemical Engineering*, McGraw-Hill (2005) 7th ed.

Reference Books

1. Fox, R.W., McDonald, A.T, and Pritchard, P.J., *Introduction to Fluid Mechanics*, John Wiley (2008) 6th ed.
2. Wilkes, J.O., *Fluid Mechanics for Chemical Engineers with Microfluidics and CFD*, Prentice Hall of India (2005) 2nd ed.
3. Denn, M., *Process Fluid Mechanics*, Prentice Hall (1979).
4. Cengel Y., Cimbala J., *Fluid Mechanics: Fundamentals and Applications*, McGraw-Hill (2005) 4th ed.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	25
5.	EST	45
6.	Sessional (may include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

JIAPAR INSTITUTE
of Technology & Research
Deemed to be University

UCH502 MASS TRANSFER-I

L	T	P	Cr
3	1	0	3.5

Course Objective: To impart the knowledge of mass transfer operations and equipment.

Introduction: Overview of separation processes.

Diffusion: Steady state molecular diffusion in gases and liquids, Fick's first Law of diffusion, Fick's second Law of diffusion, Correlation for diffusivity in gases and liquids for binary and multi-component systems, Diffusivity measurement and prediction, Diffusion in solids, Types of solid diffusion.

Mass Transfer Coefficients: Concept of mass transfer coefficients, Mass transfer coefficients in laminar flow and turbulent flow, Mass, heat and momentum transfer analogy etc. Simultaneous heat and mass transfer.

Interphase Mass Transfer: Equilibrium curve, Diffusion between phases, Overall mass transfer coefficient, Two film theory in mass transfer, Steady state concurrent and counter current Process, Stages and Multistage cascade, Kremser equation for dilute gas mixtures.

Mass transfer equipment: Gas dispersed: bubble column, Mechanically agitated vessels, Mechanical agitation of single phase liquid, Mechanical agitation of gas liquid contact, Venturi scrubber, Wetted Wall tower, Spray tower, Tray tower, Packed tower, Classification of packing materials, Cooling tower.

Gas Absorption: Equilibrium solubility of gases in liquids, isothermal and adiabatic gas-liquid contact, Choice of solvents, Material balance in absorber, Counter-current multistage operations, Continuous contact equipment, Design of absorption towers, Gas absorption with chemical reaction. Packed towers and column internals, Types of packing, general pressure drop correlation, Column diameter and height.

Crystallization: Solid liquid phase equilibrium, Nucleation and crystal growth, Batch crystallization, crystallization equipment.

Drying: Drying Equilibria, The drying rate curve, calculations of the drying time from drying rate data, Classification of the drying equipment, Dryer selection, and Different type of dryer.

Pressure vessels design: Design pressure, Design temperature, Design stress, Factor of safety, Design wall thickness, Corrosion allowance, Weld joint efficiency factor, thin & thick wall cylindrical and spherical vessels, Tall vessels, Storage vessels.

Course Learning Outcomes (CLO):

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

1. solve problems related to diffusion and interphase mass transfer and mass transfer equipments
2. perform design calculation related to absorption and humidification.

3. solve problems related to drying and crystallization
4. Design different types of pressure vessels

Text Books:

1. Treybal, R.E., Mass Transfer Operations, McGraw Hill (1980) 3rd Ed.
2. McCabe, W.L., and Smith, J.C., Unit Operations of Chemical Engineering, McGraw Hill, 3 rd Ed. (1993).
3. Bhattacharyya, B.C., Introduction to Chemical Equipment Design, Mechanical Aspects, CBS Publishers and Distributors (2009).

Reference Books:

1. Sherwood, T.K, Pigford, R.L., and Wilkes, C.R, Mass Transfer, McGraw Hill (1975).
2. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India (1993) 4th Ed.
3. Seader, H., Henley, J. E., Separation Process Principles, Wiley India (2007) 2nd Ed.
4. Skelland, A.H.P., Diffusional Mass Transfer, John Wiley & Sons (1985)
5. Mahajani, V.V. and Umarji, S.B., Joshi's Process Equipment Design, 4th edition, Macmillan Publishers India Limited, New Delhi (2010).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May include tutorials/ assignments/ quiz's etc.)	25

UCH402 HEAT TRANSFER

L	T	P	Cr
3	1	2	4.5

Course Objective:

To understand the fundamentals of heat transfer and their applications in various heat transfer equipment design of process industries.

Introduction: Introduction, Applications, Relation between heat transfer and thermodynamics, Transport properties, Heat transfer coefficients.

Heat Transfer mechanisms: Fourier's law, Thermal conductivity, Heat conduction equations and applications, Newton's law of cooling, Boundary layer theory, Heat transfer in laminar and turbulent flows inside tubes, Heat transfer analogies, Natural convection, Boiling & Condensation, Stefan - Boltzmann law, Radiation equations, Emissivity, Absorption, Black and gray body, Thermal radiation between two surfaces and its applications.

Heat Transfer Equipment Design: Cross flow and counter flow arrangements, Process design calculations for heat transfer equipment, Fouling in heat transfer equipment, Classification of heat exchangers, LMTD and ϵ -NTU methods, Design of plate type & shell and tube heat exchangers, Estimation of heat transfer coefficients and pressure drop by Kerns' and Bell's methods, Double pipe, shell and tube, Design codes, Evaporators, Classification, Single and multiple effect evaporators, Enthalpy balance, Performance of evaporators, Capacity and economy, Methods of feeding, Fundamentals of Condenser design.

Laboratory Work:

Thermal conductivity of a metal rod, Thermal conductivity of insulating power, Emissivity measurement, Parallel flow/counter flow heat exchanger, Heat transfer through composite wall, Drop wise & film wise condensation, Heat transfer through a pin-fin, Heat transfer in natural convection, Heat transfer in forced convection, Critical heat flux, Stefen-Boltzman's law of radiation, Heat flow through lagged pipe, Shell and tube heat exchanger.

Course Learning Outcomes (CLO)

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

1. solve conduction, convection and radiation problems
2. design and analyse the performance of heat exchangers
3. design and analyse the performance of evaporators & condensers

Text Books:

1. McCabe, W.L., Smith J.C., and Harriott, P., *Unit Operations of Chemical Engineering*, McGraw-Hill (2005).
2. Holman, J.P., *Heat Transfer*, Tata McGraw-Hill Education (2008).

3. Sinnott Ray and Towler Gavin, Coulson and Richardson's Chemical Engineering series Chemical Engineering Design Volume 6, 5th edition (2013).

Reference Books:

1. Kern, D.Q., *Process Heat Transfer*, Tata McGraw-Hill (2008).
2. Frank, P.I. and David, P.D., *Fundamentals of Heat and Mass Transfer*, John Wiley & Sons (2007).
3. Cengel, Y.A., *Heat and Mass Transfer*, Tata McGraw-Hill Publishing Company Limited (2007).
4. Alan, S.F., Leonard, A.W. and Curtis, W.C., *Principles of Unit Operations*, Wiley India (P) Ltd., (2008).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (may include lab/tutorials/ assignments/ quizzes)	40



UTA012: 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 analyzing 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 behavioral; 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 analyzing business models; Business model canvas, Introduction to lean startups, Business Pitching.

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

Course learning outcomes (CLO):

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. S. Carter and D. Jones-Evans, *Enterprise and small business- Principal Practice and Policy*, Pearson Education (2006)

Reference Books:

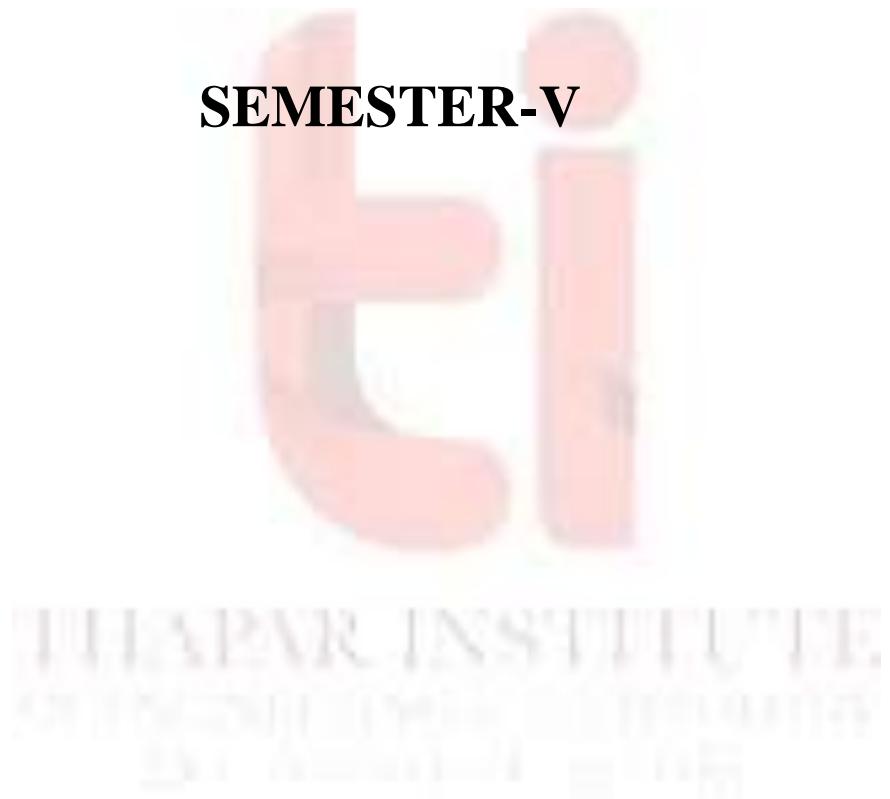
1. T. H. Byers, R. C. Dorf, A. Nelson, *Technology Ventures: From Idea to Enterprise*, McGraw Hill (2013)
2. Osterwalder, Alex and Pigneur, Yves (2010) *Business Model Generation*.
3. Kachru, Upendra, *India Land of a Billion Entrepreneurs*, Pearson
4. Bagchi, Subroto, (2008), *Go Kiss the World: Life Lessons For the Young Professional*, Portfolio Penguin

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

Evaluation scheme:

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

SEMESTER-V



UCH501 CHEMICAL REACTION ENGINEERING-I

L	T	P	Cr
3	1	2	4.5

Course Objective:

To understand the kinetics of single and multiple reactions and the effect of temperature on reaction systems.

Introduction: Overview of chemical reaction engineering, Classification of reactions, Variables affecting rate, Definition of reaction rate, single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Reaction pathways, Effects of temperature, pressure, Heat and mass transfer on rate, Arrhenius law, Activation energy, Reversible and irreversible reactions, Reaction equilibrium.

Kinetics: Constant volume and variable volume batch, CSTR and PFR reactor data, Analysis of total pressure data obtained from a constant-volume batch reactor, Integral and differential methods of analysis of data, Autocatalytic reactions, Reversible reactions, and Bio-chemical reactions.

Homogeneous Single Reactions: Performance equations for ideal batch, Plug flow, Back-mix flow and semi batch reactors for isothermal condition, Size comparison of single reactors, Multiple-reactor systems, Recycle reactor, Autocatalytic reactions, Optimum recycle operations.

Multiple Reactions: Parallel reactions of different orders, Yield and selectivity, Product distribution and design for single and multiple-reactors, Series reactions: first-order reactions and zero-order reactions, Mixed series parallel complex reactions, Choice of reactors for simple and complex reactions.

Temperature Effects for Single and Multiple Reactions: Thermal stability of reactors and optimal temperature progression for first order reversible reactions, Adiabatic and heat regulated reactions, Design of non-isothermal reactors, Effect of temperature on product distribution for series and parallel reactions.

Laboratory work: Experiments on batch reactors, Semi-batch reactors, Continuous stirred tank reactors, Tubular reactors, RTD, Fluid-solid reactions.

Course Learning Outcomes (CLO):

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

1. develop rate laws for homogeneous reactions.
2. analyze batch reactor data by integral and differential methods.
3. design ideal reactors for homogeneous single and multiple reactions.
4. select the appropriate type reactor/scheme.

5. demonstrate the temperature effect on reaction rate and design non-isothermal reactors..

Text Books:

1. *Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India (2003).*
2. *Levenspiel, O., Chemical Reaction Engineering, John Wiley & Sons (1998).*

Reference Books:

1. *Smith, J.M., Chemical Engineering Kinetics, McGraw Hill, New York (1990).*
2. *Denbigh, K.G., and Turner, J.C.R., Chemical Reactor Theory - An Introduction, Cambridge University Press, UK (1984).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/tutorials/ assignments/ quiz's etc)	40

UCH401 FLUID AND PARTICLE MECHANICS

L	T	P	Cr
3	1	2	4.5

Course Objective:

To understand basic principles of fluid and particle mechanics including construction and working of the equipments.

Particle Characterization and Handling: Determination of mean particle size, Particle shape and size distribution, Screen analysis, Storage of solids, conveying systems

Size Reduction: Principles of crushing and grinding; Laws of size reduction, Industrial size reduction equipment.

Fluid-Solid Separations: Free and hindered settling, Clarification and thickening, Froth flotation, Centrifugal separation, Theory of filtration and filtration equipment

Packed and Fluidized Bed: Friction in flow through packed beds, Mechanism of fluidization, Determination of minimum fluidization velocity, Determination of velocity range for the operation of a fluidized bed, Applications of fluidized Bed

Agitation and Mixing of Liquids and Solids: Types of impellers, Power consumption, mixing times, Scale up, mixing of solids and power index.

Laboratory Work:

Screen analysis, Power requirement in mixing, Plate and frame filter press, Leaf filter, Elutriation, Pressure drop in fluidized bed and packed bed, Sedimentation, Centrifugal pump characteristics, Size reduction, Cyclone separator.

Course Learning Outcomes (CLO)

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

1. solve and analyze problems of size reduction and solid-solid separation methods.
2. analyze and design of equipment handling fluid-particle systems.
3. analyze and solve problems related to flow through beds of solids.
4. analyze mixing process, and solid storage in hoppers/bins.

Text Books:

1. McCabe, W.L., Smith, J.C., and Harriot, P., *Unit Operations of Chemical Engineering*, McGraw-Hill (2005).

2. Richardson, J.F., Harker, J.H. and Backhurst, J.R., Coulson and Richardsons Chemical Engineering, Vol. 2, Butterworth-Heinemann (2007).

Reference Books:

1. Foust, A.S, Wenzel, L.A, Clump, C.W., Maus, L. and Anderson, L.B., Principles of Unit Operations, John Wiley (2008).
2. Perry, R.H, and Green, D.W., Perry's Chemical Engineers' Handbook, McGraw Hill (2007).
3. Narayanan, C.M. and Bhattacharya, B.C., Mechanical Operations for Chemical Engineers Incorporating Computer Aided Analysis, Khanna Publishers (2005).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May include may be lab/tutorials/ assignments/ quiz's etc.)	40



UCH503 INDUSTRIAL POLLUTION ABATEMENT

L	T	P	Cr
3	1	2	4.5

Course Objective:

To understand the important issues and their abatement principles of industrial pollution.

Introduction: Industrial pollution, Different types of wastes generated in an industry, Different water pollutants, Air pollutants and solid wastes from industry.

Water Pollution: Identification, quantification and analysis of wastewater, Classification of different treatment methods into physico-chemical and biochemical techniques, Physico-chemical methods, General concept of primary treatment, Liquid-solid separation, Design of a settling tank, Neutralization and flocculation, Disinfection, Biological methods, Concept of aerobic digestion, Design of activated sludge process, Concept of anaerobic digestion, Biogas plant layout, Different unit operations and unit processes involved in conversion of polluted water to potable standards.

Air Pollution: Classification of air pollutants, Nature and characteristics of gaseous and particulate pollutants, Analysis of different air pollutants, Description of stack monitoring kit and high volume sampler, Atmospheric dispersion of air pollutants, Gaussian model for prediction of concentration of pollutant down wind direction, Plume and its behavior, Operating principles and simple design calculations of particulate control devices, Brief concepts of control of gaseous emissions by absorption, adsorption, chemical transformation and combustion.

Solid Wastes: Analysis and quantification of hazardous and non-hazardous wastes, Treatment and disposal of solid wastes, Land filling, Leachate treatment, Incineration.

Laboratory work: Characterization of wastewater (pH, BOD, COD, Nitrate, Phosphate, Solids, Turbidity, Alkalinity, Hardness, Dissolved oxygen and fluoride), Ambient air quality measurement by high volume sampler (Particulate, SO_x, NO_x), Gas analysis with Orsat apparatus, Determination of sludge volume index.

Course Learning Outcomes (CLO):

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

1. quantify and analyze the pollution load.
2. analyze/design of suitable treatment for wastewater
3. model the atmospheric dispersion of air pollutants.
4. Selection and design of air pollution control devices.
5. analyze the characteristics of solid waste and its handling & management.

Text Books:

1. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. *Environmental Engineering*, McGraw Hill International (1985).
2. Metcalf & Eddy, *Wastewater Engineering*, Tata McGraw-Hill Education Private Limited (2009).

Reference Books:

1. Masters, G.M., *Introduction to Environmental Engineering and Science*, Prentice Hall off India, (2008).
2. Rao, C.S., *Environmental Pollution Control Engineering*, Wiley Eastern (2010).
3. De Nevers, N., *Air Pollution Control Engineering*, McGraw-Hill (2000).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/assignments/quiz's etc)	40

UCH506 PROCESS INSTRUMENTATION AND CONTROL

L	T	P	Cr
3	1	2	4.5

Course Objective:

To analyze the system behavior for the design of various control schemes, and to gain knowledge of different process instruments.

Introduction: General Principles of process control, Time domain, Laplace domain and frequency domain dynamics and control.

Linear Open-loop Systems: Laplace domain analysis of first and second orders systems, Linearization, Response to step, pulse, impulse and ramp inputs, Physical examples of first and second order systems such as thermocouple, level tank, U-tube manometer, etc., Interacting and non-interacting systems, Distributed and lumped parameter systems, Dead time.

Linear Closed-loop Systems: Controllers and final control elements, Different types of control valves and their characteristics, Development of block diagram, Transient response of simple control systems, Stability in Laplace domain.

Frequency Response: Frequency domain analysis, Control system design by frequency response, Bode stability criterion, Different methods of tuning of controllers.

Process Applications: Introduction to advanced control techniques as feed forward, feedback, cascade, ratio, etc., Application to equipment such as distillation-columns, reactors, etc.

Instrumentation: Classification of measuring instruments, Elements of measuring instruments, Instruments for the measurement of temperature, pressure, flow, liquid level, and moisture content, Instruments and sensors for online measurements.

Laboratory Work: Dynamics of first order and second order systems, Valve characteristics, Interacting and non-interacting systems, Flow, level and temperature measurement and their control using proportional, proportional-integral and proportional-integral-derivative control action, Manual and closed loop controls, Positive and negative feedback control, Tuning of controller, Step, pulse, impulse and frequency response.

Course Learning Outcomes (CLO):

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

1. set up a model, analyse and solve the first and second order system for its dynamic behaviour
2. evaluate the process stability in Laplace domain
3. design control system using frequency response analysis
4. identify advanced control techniques for chemical process.

Text Books:

1. Coughanowr, D.R. and LeBlanc, S.E., *Process Systems Analysis and Control*, McGraw Hill (2009).
2. Eckman, D.P., *Industrial Instrumentation*, John Wiley & Sons (2004).

Reference Books:

1. Stephanopoulos, G., *Chemical Process Control: An Introduction to Theory and Practice*, Prentice Hall of India (1984).
2. Harriott, P., *Process Control*, Tata McGraw Hill (1972).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/ tutorials/ assignments/ quiz's etc)	40

UCH405 ENERGY RESOURCES

L	T	P	Cr
3	1	2	4.5

Course Objective:

To study various types of conventional and non-conventional energy resources including solid, liquid and gaseous fuels.

Energy Scenario: Indian and global, Present and future energy demands, Energy crisis, Classification of various energy sources, Renewable and non-renewable energy sources, Pattern of energy consumption.

Solid Fuels: Coal: Origin, formation, analysis, classification, washing and carbonization, Treatment of coal gas, Recovery of chemicals from coal tar, Coal gasification, Liquid fuel synthesis from coal, Carbonization of coal, Briquetting of fines.

Liquid and Gaseous Fuels: Crude petroleum, Physical processing of crude petroleum, Fuels from petroleum, Storage and handling of liquid fuels, Natural and liquefied petroleum gases, Gas hydrates, Gasification of liquid fuels, Carbureted water gas.

Fuel Characterization: Viscosity, Viscosity index, Flash point, Cloud point, Pour point, Fire point, Smoke point and Char value, Carbon residue, Octane number, Cetane number, Aniline point and Performance number, Acid value, ASTM distillation, Calorific value, Proximate and ultimate analysis.

Alternate Energy Sources: Solar energy: Radiation measurement, applications and types of collectors and storage, Wind power, Geothermal energy, Tidal energy, Nuclear power, Fuel cells, Biogas, Biomass.

Laboratory Work:

Experiments on proximate and ultimate analysis of fuels, Orsat analysis, Surface tension, Cloud & pour point, Flash point, Viscosity, Melting point, Reid vapor pressure, ASTM distillation, Saponification value.

Course Learning Outcomes (CLO):

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

1. analyze the energy scenario of the world.
2. carry out a comparative analysis of different types of coal, including their treatment, liquefaction and gasification.

3. compare the liquid and gaseous fuels sourced from petroleum including their characterization.
4. analyze the potential of alternate energy sources and their scope and limitations.
5. solve energy related problems related to combustion and non-combustion.

Text Books:

1. *Rao, S. and Parulekar, B.B., Energy Technology-Non-conventional, Renewable and Conventional, Khanna Publishers (2000).*
2. *Gupta, O.P., Elements of Fuel, Furnaces and Refractories, Khanna Publishers (1996).*
3. *Rai, G.D., Non-Conventional Energy Sources, Khanna Publishers (2001).*

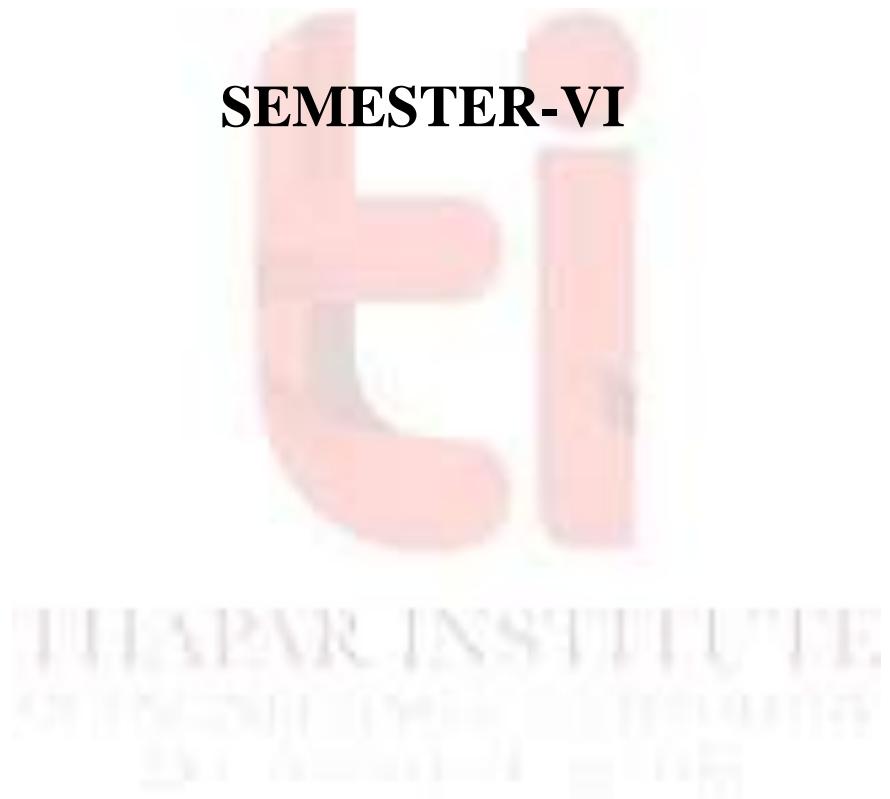
Reference Books:

1. *Brame J.S.S. and King J.G., Edward Arnold "Fuel Solid, Liquid and Gases" Edward Arnold (1967).*
2. *Sukhatme S.P, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw- Hill (1996).*
3. *I.S. Code 770, Classification of Coal.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab, tutorials/ assignments/ quiz's etc)	40

SEMESTER-VI



UCH601 CHEMICAL REACTION ENGINEERING II

L	T	P	Cr
3	1	0	3.5

Course Objective:

To understand the effect of non-ideal flow on reactor performance and to design reactors for heterogeneous reaction systems.

Non-ideal Flow: Residence time distribution (RTD) of fluids in vessels, RTD models - dispersion, tanks-in-series and multi-parameter models, Conversion calculations using RTD data for first order reactions.

Non-catalytic Heterogeneous Reactions: Fluid-solid reaction models, Fluid-Solid reaction kinetics, Determination of rate controlling step, Prediction of mean conversion in flow reactors, Fluid-solid contacting schemes, Reactor design.

Solid-catalyzed Reactions: Interaction of physical and chemical rate processes, Kinetics of catalytic reactions and application to reactor design for isothermal and adiabatic operations, Design of packed bed and fluidized bed reactors, Introduction to slurry and trickle-bed reactors.

Fluid-fluid Reactions: Introduction to fluid-fluid reaction systems, Rate equations, Reactor design with and without mass transfer considerations.

Laboratory work: Experiments on Batch reactor, Semi-batch reactor, Continuous stirred tank reactor, Tubular reactor, RTD studies, Fluid-solid reaction.

Course Learning Outcomes (CLO):

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

1. predict the conversion in a non-ideal reactor using tracer information.
2. design reactors for fluid-solid reactions.
3. design reactors for catalytic reactions.
4. design towers for gas–liquid reactions with and without mass transfer considerations.

Text Books:

1. *Levenspiel, O., Chemical Reaction Engineering, John Wiley & Sons (2010).*
2. *Smith, J.M., Chemical Engineering Kinetics, McGraw Hill (1990).*

Reference Books:

1. *Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India (2009).*
2. *Denbigh, K.G., and Turner, J.C.R., Chemical Reactor Theory - An Introduction, Cambridge University Press (1984).*
3. *Nauman, E.B., Chemical Reactor Design, John Wiley & Sons (1987).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/ tutorials/ assignments/ quiz's etc)	40



UCH602 MASS TRANSFER-II

L	T	P	Cr
3	1	2	4.5

Course Objective: To impart the knowledge of separation processes like distillation, adsorption, and extraction.

Distillation: Vapor-liquid equilibria, Flash distillation, Differential distillation, Continuous Rectification- Binary system, Steam distillation, Multistage tray tower- McCabe-Thiele method, Ponchon-Savarit method, types of plate contractors, Distillation in a packed tower, Principles of azeotropic and extractive distillation, Bubble point and dew point calculation of multi-component system, Introduction to multi-component distillation.

Liquid-Liquid Extraction: Equilibrium relationship for partially miscible and immiscible systems, Selectivity and choice of solvent, Stage wise contact, Single stage and multistage extraction, Determination of number of equilibrium stages by graphical methods.

Adsorption: Adsorption equilibria, Batch and continuous adsorption, Selection of adsorbent, specific surface area of an adsorbent, Break-through curve.

Solid-Liquid Extraction: Classification of solid liquid extraction systems, Solid liquid contacting equipment.

Mass transfer Equipment Design: Process design calculations for multi-component distillation, Fenske-Underwood-Gilliland Method, Selection of key components, Fenske equation for minimum equilibrium stage, Gilliland correlations for actual reflux ratio and theoretical stages, Minimum reflux ratio by Underwood method, Feed stage locationtypes of plate contractors, tray layout and hydraulic design, Packed towers-column internals, Types of packing, General pressure drop correlation, Column diameter and height.

Laboratory work: Study of vapour liquid equilibria, Cross current leaching, HETP in a packed distillation column operating under total reflux, Liquid in air diffusion, Liquid-liquid extraction apparatus, Absorption in packed bed apparatus, Wetted wall column, Solid in air diffusion apparatus, Batch drying unit, Batch distillation apparatus, Batch crystallizer, Water cooling tower, Steam distillation apparatus.

Course Learning Outcomes (CLO):

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

1. use the phase equilibrium concepts in mass transfer related problems.
2. solve problems related to adsorption.

3. solve problems related to liquid-liquid and solid-liquid extraction.
4. design different types of mass transfer equipment.

Text Books:

1. Treybal, R.E., Mass Transfer Operations, McGraw Hill (1980).
2. McCabe, W.L., and Smith, J.C., Unit Operations of Chemical Engineering, McGraw Hill (1993).
3. Sinnott Ray and Towler Gavin, Coulson and Richardson's Chemical Engineering series Chemical Engineering Design Volume 6, 5th edition (2013).

Reference Books:

1. Sieder J.D., Ernest J.Henley. Separation Process Principles (2011).
2. Skelland, A.H.P., Diffusional Mass Transfer, John Wiley & Sons (1985).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/ tutorials/ assignments/ quiz's etc)	40

UCH603 TRANSPORT PHENOMENA

L	T	P	Cr
3	1	0	3.5

Course Objective:

To impart knowledge about individual and simultaneous momentum, heat and mass transfer, model development along with appropriate boundary conditions.

Introduction: Viscosity and generalization of Newton's law of viscosity, Thermal conductivity and mechanism of energy transport, Diffusivity and mechanism of mass transport, Basic concept and review of classical momentum, heat and mass transfer problems.

Momentum Transport: Shell momentum balance, velocity distribution in laminar incompressible flow, The equations of change for isothermal flow: Equations of continuity, motion, conservation of mechanical energy in fluids, Application of Navier-Stokes equation, , Stream function, Potential flow, Boundary layer theory, Velocity and pressure distributions with more than one independent variables, Unsteady flow.

Turbulent flow: Velocity distribution in turbulent flow, fluctuations and time smoothed equations for velocity, Time smoothed of equation of change for incompressible fluids, Reynolds stress, Empirical relations.

Energy Transport: Shell energy balance, temperature distribution in solids and laminar flow, Equations of change for non-isothermal flow - Equations of energy, Energy equation in curvilinear coordinates, set-up of steady state heat transfer problems, Temperature distributions with more than one independent variables, Unsteady heat transfer.

Mass Transfer: Shell mass balance and concentration distribution in solids and laminar flow, Equations of change for multi-component systems: Equations of continuity for a binary mixture, Equation of continuity in curvilinear coordinates, Multi-component equations of change in terms of the flows, Multi component fluxes in terms of the transport properties, Use of equations of change to setup diffusion problems, Unsteady mass transfer.

Simulations momentum, heat and mass transfer: Simultaneous momentum, heat and mass transfer in laminar and turbulent flow regimes, Temperature and concentration distribution in turbulent flow, time smoothed equations of change for incompressible non-isothermal flow, Concentration fluctuation and time smoothed concentration, time smoothed equation of continuity.

Course Learning Outcomes (CLO):

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

1. analyze heat, mass, and momentum transport in a process.
2. formulate problems along with appropriate boundary conditions.
3. develop steady and transient solution for problems involving heat, mass, and momentum transport.

Text Book:

1. Bird, R. B., Stewart, W. E., Lightfoot, E. N., *Transport Phenomena*, Wiley (2002).

Reference Books:

1. Geankolis, C. J., *Transport Processes and Unit Operations*, Prentice-Hall (1993).
2. Deen, W. D., *Analysis of Transport Phenomena*, Oxford University Press (1998).
3. Griskey, R. G., *Transport Phenomena and Unit Operations: A Combined Approach*, Jon Wiley (2002).
4. Batchelor, G. K., *An Introduction to Fluid Dynamics*, Cambridge University Press (1967).
5. Salterry, J. C., *Momentum Energy and Mass Transfer in Continua* Robert e. Kridger (1981).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May includes tutorials/ assignments/ quiz's etc)	25



UCH605 PROCESS UTILITY AND INDUSTRIAL SAFETY

L	T	P	Cr
3	1	0	3.5

Course Objective:

To gain knowledge about different process utilities used in the chemical process industry and issues related to hazards & safety.

Water: Water resources, Storage and characterization, Conditioning.

Steam: Boilers, Steam Handling and distribution, Steam nozzles, Condensate utilization, Steam traps, Flash tank analysis, Safety valves, Pressure reduction valves, Desuperheaters.

Air: Air compressors, Vacuum pumps, Air receivers, Distribution systems, Different types of ejectors, Air dryers.

Hazards and Safety: Classifications and assessment of various types of hazards, Risk assessment methods, General principles of industrial safety, Hazards due to fire, explosions, toxicity and radiations, Industrial hygiene, Maximum allowable concentration and threshold limit value, Protective and preventive measures in hazards control, Introduction to industrial safety regulations.

Case studies of hazardous incidents in industries using HAZOP.

Course Learning Outcomes (CLO):

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

1. calculate the requirements of water and air and their applications as utilities.
2. calculate the steam requirement and its applications as utility.
3. evaluate and apply the various risk assessment methods in industries.
4. do the hazard analysis for different industries using HAZOP.

Text Books:

1. *Vasandhani, V. P., and Kumar, D. S, Heat Engineering, Metropolitan Book Co. Pvt. Ltd. (2009).*
2. *Crowl, D.A. and Louvar, J.F., Chemical Process Safety-Fundamentals with Applications, Prentice Hall, (2002).*

Reference Books:

1. *Lees, F.P., Prevention in Process Industries. Butterworth's (1996).*
2. *Peavy, H. S., and Rowe, D. R, Environmental Engineering, McGraw Hill (1985).*
3. *Banerjee, S., Industrial Hazards and Plant Safety, Taylor & Francis 2003).*
4. *Sanders, R. E. Chemical Process Safety-Learning from Case Histories, Oxford (2005).*
5. *Perry, R.H., and Green, D. W, Chemical Engineer's Handbook, McGraw Hill (1997).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May includes tutorials/ assignments/ quiz's etc)	25



UCH802 PROCESS MODELING AND SIMULATION

L	T	P	Cr
3	0	2	4.0

Course Objective:

To study the modeling & simulation techniques of chemical processes and to gain skills in using process simulators.

Introduction: Use and scope of mathematical modeling, Principles of model formulation, Role and importance of steady-state and dynamic simulation, Classification of models, Model building, Modeling difficulties, Degree-of-freedom analysis, Selection of design variables, Review of numerical techniques, Model simulation.

Fundamental Laws: Equations of continuity, energy, momentum, and state, Transport properties, Equilibrium and chemical kinetics, Review of thermodynamic correlations for the estimation of physical properties like phase equilibria, bubble and dew points.

Modeling of Specific Systems: Constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Stability analysis, Gas phase pressurized CSTR, Two phase CSTR, Non-isothermal PFR, Batch and semi-batch reactors, Heat conduction in a bar, Laminar flow of Newtonian liquid in a pipe, Gravity flow tank, Single component vaporizer, Multi-component flash drum, Absorption column, Ideal binary distillation column and non-ideal multi-component distillation column, Batch distillation with holdup etc.

Simulation: Simulation of the models, Sequential modular approach, Equation oriented approach, Partitioning and tearing, Introduction and use of process simulation software (Aspen Plus/ Aspen Hysys) for flow sheet simulation.

Laboratory:

Writing and solving models for simple chemical processes, use of process simulator for solving models for mixer, pump, compressor, heat exchanger, reactor, absorption/distillation column and steady state flow sheet simulation.

Course Learning Outcomes (CLO):

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

1. analyze physical and chemical phenomena involved in various process.
2. develop mathematical models for various chemical processes.
3. use various simulation approaches.
4. Simulate a process using process simulators (ASPEN Plus/ ASPEN Hysys).

Text Books:

1. *Luyben W.L., Process Modeling, Simulation, and Control for Chemical Engineering, McGraw-Hill (1998).*
2. *Babu, B.V., Process Plant Simulation, Oxford University Press (2004).*

Reference Books:

1. *Denn, M. M., Process Modeling, Longman Sc & Tech. (1987).*

2. Himmelblau, D.M and Bischoff, K.B., *Process Analysis and Simulation: Deterministic Systems*, John Wiley (1968).
3. Holland, C. D., *Fundamentals and Modeling of Separation Processes: Absorption, Distillation, Evaporation and Extraction*, Englewood Cliffs, Prentice-Hall (1974).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	40
3	Sessional (may includes tutorials/ assignments/ quiz's etc)	35



UCH507 CHEMICAL PROCESS INDUSTRIES

L	T	P	Cr
3	0	0	3.0

Course Objective:

To study process technologies of various organic and inorganic process industries.

Introduction: Production trends, Material and energy balances, Symbols and flow sheets, Waste generation and recycling, Engineering problems, Materials of construction, Environmental and energy conservation measures.

Pulp and Paper: Cellulose derivatives: Pulp, paper and boards, Types of raw material for pulping, Various pulping methods, Recovery of chemicals from black liquor, Manufacture of paper, Quality improvement of paper.

Sugar and Starch: Raw and refined sugar, Byproducts of sugar industries, Starch and starch derivatives.

Oils and Fats: Types of oil, Different fatty acids, Extraction of oil from seeds, Oil purification, Hydrogenation of oil.

Soaps and Detergents: Types of soaps, Soap manufacture, recovery and purification.

Chlor-alkali Industries: Brine electrolysis, Manufacture of caustic soda and chlorine in mercury cells, Diaphragm cells, Membrane cells, Hydrochloric acid.

Nitrogen Industries: Ammonia, Nitric acid, Ammonium sulphate, Ammonium nitrate, Urea, Calcium ammonium nitrate.

Phosphorus Industries: Phosphorus, Phosphoric acid, Phosphatic fertilizers.

Mixed Fertilizers: SSP, TSP, NPK, KAP, DAP, Nitrophosphate, Bio fertilizers.

Sulphur Industries: Sulphur dioxide, Sulphuric acid, Oleum.

Ceramic Industries: Portland cement, Lime, Gypsum.

Course Learning Outcomes (CLO)

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

1. understand the processes involved in manufacturing of various inorganic and organic chemicals.
2. prepare the process flow diagrams.
3. analyze important process parameters and engineering problems during production.

Text Books:

4. Dryden, C.E., *Outlines of Chemical Technology* (Edited and Revised by M. GopalRao and Sittig. M), East West Press Pvt. Ltd, New Delhi (1997).
5. Austin, G.T., *Shreve's Chemical Process Industries*, McGraw Hill (1984).

Reference Books:

6. Faith, W.L., Keyes, D.B. and Clark, R.L., *Industrial Chemicals*, Wiley (1980).
7. Kirk and Othmer, *Encyclopaedia of Chemical Technology*, Wiley (2004).
8. Groggins, P.H., *Unit Processes in Organic Synthesis*, Tata McGraw-Hill (2003).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional (May includes seminar assignments/ quiz's etc.)	20



SEMESTER-VII
(Project Semester)



SEMESTER-VIII



UCH604 BIOCHEMICAL ENGINEERING

L	T	P	Cr
3	1	2	4.5

Course Objective:

To apply the chemical engineering principles in biological systems.

Introduction to Biochemical Engineering: Comparative study of chemical and biochemical processes, Basic concepts of microbiology.

Sterilization: Sterilization of air and medium; sterilization of fermentor, thermal death kinetics of microorganisms.

Biochemical Kinetics: Enzyme Kinetics with one or two substrates, modulation and regulation of enzyme activity, enzyme reactions in heterogeneous systems, Immobilized enzyme technology, Industrial application of enzymes.

Microbial Fermentation Kinetics: Fermentation and its classification, Growth-cycle phases (for batch cultivation), Continuous culture, Biomass production in cell culture, Mathematical modeling of batch growth, Product synthesis kinetics, Overall kinetics and thermal death kinetics of cells and spores, Analysis of multiple interacting microbial population.

Bioreactors: Classification and characterization of different bioreactors e.g. batch and continuous, mechanically and non-mechanically agitated, CST type, tower, continuous, rotating, anaerobic etc., Design and analysis of Bioreactors - CSTR and Air Lift Reactor, Scale up considerations of bioprocesses.

Transport Phenomenon in Bioprocess Systems: Agitation and aeration-gas-liquid mass transfer, oxygen transfer rates, determination of k_{La} , Heat balance and heat transfer correlations – sterilization etc.

Commercial production of bioproducts: Concept of primary and secondary metabolites, Production processes for yeast biomass, antibiotics, alcoholic beverages and other products.

Laboratory work:

Sterilization in steam autoclave, Estimation of reducing sugars (Glucose) by di-Nitro Salicylic Acid (DNS) method in a sample broth; Estimation of dimensionless mixing time in a batch reactor Understanding of dissolved oxygen (DO) measurement system of a bioreactor and its calibration, Estimation of volumetric oxygen transfer coefficient in a fermenter by dynamic gassing out technique; Understanding the functioning of bioreactor and to carry out blank sterilization of the reactor Operation of pH control system of a bioreactor and evaluation of response of the controller to different control settings; Enzyme assay; Enzyme kinetic studies; Demonstration & Examination of different organisms; Determination of microbial cell biomass using spectrophotometer;

Microbial growth kinetic study; Immobilization of enzymes, Immobilization of microbial cells.

Course Learning Outcomes (CLO):

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

1. calculate the kinetic parameters of enzymatic reactions.
2. calculate and analyze the kinetic parameters for microbial growth.
3. analyze bioprocess design and operation.
4. select suitable bioreactor.

Text Books:

1. Shuler M., Kargi F., *Bioprocess Engineering: Basic Concepts*, PHI (2012).
2. Bailey, J.E. and Ollis, D.F, *Biochemical Engineering Fundamentals*, McGraw Hill, New York (1986)

Reference Books:

1. Doran, P.M *Bioprocess Engineering Principles*, Academic Press (2012)
2. Aiba, S., Humphrey, A.E and Millis, N.F., *Biochemical Engineering*, Academic Press (1973)
3. Weith, John W.F., *Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression*, Wiley and Sons Inc. (1994).
4. Stanbury P. F., Whittaker, A. and Hall, S. J., *Principles of Fermentation Technology*, Butterworth-Heinemann (2007).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessional (May includes lab/tutorials/ assignments/ quiz's etc)	40

UHU005: Humanities for Engineers

L	T	P	Cr
2	0	2	3

Course Objectives (COs): The objective of this course is to introduce values and ethical principles, that will serve as a guide to behavior on a personal level and in professional life. The course is designed to help the students to theorize about how leaders and managers should behave to motivate and manage employees; to help conceptualize conflict management strategies that managers can use to resolve organizational conflict effectively. It also provides background of demand and elasticity of demand to help in devising pricing strategy; to make strategic decisions using game theory and to apply techniques of project evaluation.

Detailed Content:***Unit 1: Human Values and Ethics***

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

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

Kohlberg's Theory of Moral Development

Professional Ethics: Profession: Attributes and Ethos, Whistle-blowing.

Unit 2: Organizational Behavior

Introduction to the Field of Organizational Behaviour

Individual Behaviour, Personality, and Values

Perceiving Ourselves and Others in Organizations

Workplace Emotions, Attitudes, and Stress

Foundations of Employee Motivation and Leadership

Performance Appraisal

Conflict and Negotiation in the Workplace

Unit 3: Economics

Demand, Supply & Elasticity – Introduction to Economics, Demand & its Determinants, Elasticity and its types

Production & Cost Analysis – Short run & Long Run Production Functions, Short run & Long run cost functions, Economies & Diseconomies of Scale

Competitive Analysis & Profit Maximization – Perfect competition, Monopoly, Monopolistic & Oligopoly Markets

Strategy & Game Theory – Pure Strategy & Mixed Strategy Games, Dominance, Nash Equilibrium, & Prisoner's Dilemma

Capital Budgeting– Capital Projects, Net Present Value (NPV) & IRR techniques.

Practical:

1. Practical application of these concepts by means of Discussions, Role-plays and Presentations,
2. Analysis of Case Studies on ethics in business and whistle-blowing, leadership, managerial decision-making.
3. Survey Analysis
4. Capital Budgeting assignment

Course learning Outcomes (CLOs)

The student after completing the course will be able to:

1. comprehend ethical principles and values and apply them as a guide to behavior in personal and professional life.
2. apply tools and techniques to manage and motivate employees.
3. analyse and apply conflict management strategies that managers can use to resolve organizational conflict effectively.
4. devise pricing strategy for decision-making.
5. apply techniques for project evaluation.

Text Books

1. A. N. Tripathi, Human Values, New Age International (P) Ltd. (2009).
2. Robbins, S. P/ Judge, T. A/ Sanghi, S Organizational Behavior Pearson, New Delhi, (2009).
3. Petersen, H.C., Lewis, W.C. and Jain, S.K., Managerial Economics, Pearson (2006).

Reference Books

1. McKenna E. F. Business psychology and organisational behaviour. Psychology Press, New York (2006).
2. Furnham A. The Psychology of Behaviour at Work: The Individual in the organization. Psychology Press, UK (2003).
3. Salvatore, D and Srivastava, R., Managerial Economics, Oxford University Press (2010).
4. Pindyck, R and Rubinfeld, D., Microeconomics, Pearson (2017).

Evaluation Scheme:

Mid Semester Exam	25
End Semester Exam	45
Sessional	30



UCH801 PROCESS ENGINEERING AND PLANT DESIGN

L	T	P	Cr
3	1	0	3.5

Course Objective:

To provide comprehensive knowledge of various process parameters and economics involved in the development of process and plant design.

Basic Concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.

Flow-sheetSynthesis: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound.

Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.

Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

Course Learning Outcomes (CLO):

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

1. apply various algorithms to synthesize a process flow sheet.
2. calculate different costs involved in a process plant.
3. calculate interest and time value of investments.
4. measure profitability on investments.
5. perform breakeven analysis and optimum design of a process.

Text Books:

1. Peters, M.A. and Timmerhaus, K.D., *Plant Design and Economics for Chemical Engineers*, McGraw Hill (2003).

Reference Books:

1. Anil Kumar, *Chemical Process Synthesis and Engineering Design*, Tata McGraw Hill (1982).
2. Ulrich, G.D., *A Guide to Chemical Engineering Process Design and Economics*, John Wiley & Sons (1984).

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional (May includes assignments/quiz's etc.)	20



UCH893 CAPSTONE PROJECT

L	T	P	Cr
1*	0	2	8.0

Course Objective:

A design project based course to implement integrated approach to the process and plant design of chemical process system/plant using chemical engineering courses studied in the previous semesters.

Scope of work:

Capstone project is focused on an integrated approach to the design of chemical process/plant using concepts of chemical engineering courses studied in the previous semesters. Chemical process/plantsystems are to be designed satisfying requirements like reliability, optimized design, installation, maintenance, economic, environmental, social, ethical, health,safety and sustainability considerations.

In this course, students are separated in groups. Each student group shall develop a process/system design project related to chemical process/plant involving need analysis, problem definition, analysis, synthesis and optimization. Software like ANSYS, HYSYS, FLUENT and ASPEN etc. along with a spread sheet may be used for the design modeling, synthesis, optimization and analysis. The course concludes with a report submission by the group, final showcase using poster/presentation along with comprehensive viva by a committee.

Course Learning Outcomes (CLO):

The students will be able to:

1. design a chemical process/plant system implementing an integrated approach applying knowledge accrued in various professional courses.
2. work in a team and demonstrate their role in the team work.
3. design, analyze and optimize the design of a chemical process/plant considering various requirements like reliability, optimized design, manufacturing, assembly, installation, maintenance, cost and use of design standards and industry standards.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	Faculty mentor	30
2	Final report	30
3	Presentation/Viva	40

ELECTIVE-I

UCH711 FLUIDIZATION ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objective:

To study the fluidization phenomena, fluidized bed regimes and models.

Introduction: Fluidization phenomenon, Liquid-like behaviour of a fluidized bed

Industrial Applications: Physical operations, Synthesis reaction, Cracking of hydrocarbons, Combustion, Incineration, and gasification.

Fluidization and Mapping of Regimes: Distributors, Gas jets in fluidized beds, Pressure drop in fixed beds, Geldart classification of particles, Gas fluidization with and without entrainment, Mapping of fluidization regimes.

Fluidized Beds: Dense beds, Bubbling fluidized beds, Entrainment from fluidized beds, High velocity fluidization, Solids mixing, segregation, and staging, Gas dispersion and interchange in bubbling beds, Heat and mass transfer, Industrial applications.

Fluidized Bed Models: CSTR model, Two region model, Kunii-Levenspiel model.

Course Learning Outcomes (CLO):

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

1. understand the fluidization phenomena and operational regimes.
2. design various types of gas distributors for fluidized beds and determine effectiveness of gas mixing at the bottom region.
3. analyze fluidized bed behavior with respect to the gas velocity.
4. develop and solve mathematical models of the fluidized bed.

Text Books:

1. *Kunii, D., Levenspiel, O. and Robert, E., Fluidization Engineering, Butterworth-Heinemann (1991).*
2. *Coulson, J.M., and Richardson, J.F., Chemical Engineering, Vol. 2, Asian Books Private Limited (2002).*

Reference Books:

1. *Yates, J.G., Fundamentals of Fluidized Bed Chemical Processes, Butterworth-Heinemann (Butterworth's Monographs in Chemical Engineering) (1983).*
2. *Yang, W. and Amin, N.D., Fluidization engineering: fundamentals and applications, American Institute of Chemical Engineers (1988)*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May includes tutorials/assignments/quiz's etc)	25



UCHXXX ADVANCED SEPARATION PROCESSES

L	T	P	Cr
3	1	0	3.5

Course Objective:

To understand the underlying principles and modelling and design concepts of novel separation techniques and their applications.

Introduction: Fundamentals of separation processes and basic concepts.

Adsorptive Separation: Definition, Types of adsorption, Adsorbent types, Preparation and properties, Types of adsorption isotherms and their importance, Mathematical modeling under different conditions, Cases such as thermal swing, pressure swing, and moving bed adsorption, Desorption.

Membrane Separation: Synthesis and characterization of membranes, Transport processes in membrane, Modeling of reverse osmosis (RO), Ultrafiltration (UF) and gaseous separations, Supported liquid membrane and immobilization, Facilitated transport, Design, Operation, Maintenance and industrial applications of different membrane separation processes such as RO, UF, Nano-filtration (NF), Pervaporation through non-porous membranes, External field induced membrane separation processes for colloidal particles, Fundamentals of various colloid separation, Derivation of profile of electric field strength, Coupling with membrane separation and electrophoresis, electrodialysis.

Liquid Membranes: Fundamentals and modeling, Micellar enhanced separation processes, Cloud point extraction, Centrifugal Separation processes and their calculations, Ion exchange and chromatographic separation processes.

Surfactant Based Separation Processes: Concept, Modeling and design aspects and applications.

Supercritical Fluid Extraction: Concept, Modeling and design aspects and applications.

Biofiltration: Concept, Modeling and design aspects and applications.

Course Learning Outcomes (CLO):

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

- develop models and the solutions for adsorptive separation processes.
- characterize the membrane.
- use the concepts of membrane separation techniques for industrial separations.
- solve problems involving separation based on liquid membrane.
- exposure to other new separation techniques - surfactant based, supercritical fluid extraction and bio-filtration.

Text Books:

1. *D. M. Ruthven, Principles of Adsorption and Adsorption Processes, John Wiley (1984).*
2. *M. Mulder, Basic Principles of membrane Technology, Springer (1996).*
3. *M. A. McHugh and V.J. Krukonis, Supercritical Fluid Extraction, Butterworth (1985).*

Reference Books:

1. *S. Sourirajan and T. Matsuura, Reverse Osmosis and Ultra-Filtration Process Principles, NRC Canada (1985).*
2. *C.J. King, Separation Processes, Tata McGraw Hill (1981).*
3. *D. M. Ruthven, S. Farooq and K. S. Knaebel, Pressure Swing Adsorption, Wiley-VCH (1994).*
4. *W. S. Ho and K. K. Sirkar, Membrane Handbook, Kluwer (2001).*
5. *R W Rousseau, Handbook of Separation Process Technology, John Wiley & Sons (2009).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May includes tutorials/assignments/ quiz's etc)	25



UCH713 CORROSION ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course Objective:

To provide an understanding of the corrosion principles and engineering methods used to minimize and prevent the corrosion.

Basic concepts: Definition and importance, Electrochemical nature and forms of corrosion, Corrosion rate and its determination.

Electrochemical thermodynamics and kinetics: Electrode potentials, Potential-pH (Pourbaix) diagrams, Reference electrodes and experimental measurements, Faraday's laws, Instrumentation and experimental procedure.

Galvanic and concentration cell corrosion: Basic concepts, Experimental measurements, and determination of rates of galvanic corrosion, Concentration cells.

Corrosion measurement through polarization techniques: Tafel extrapolation plots, Polarization resistance method, Commercial corrosion probes, Other methods of determining polarization curves.

Passivity: Basic concepts of passivity, Properties of passive films, Experimental measurement, Applications of Potentiostatic Anodic Polarization, Anodic protection.

Pitting and crevice corrosion: Mechanisms of pitting and crevice corrosion, Secondary forms of crevice corrosion, Localized pitting, Metallurgical features and corrosion: Intergranular corrosion, Weldment corrosion, De-alloying and dezincification.

Environmental induced cracking: Stress corrosion cracking, Corrosion fatigue cracking, Hydrogen induced cracking, Methods of prevention and testing, Erosion, Fretting and Wear.

Environmental factors and corrosion: Corrosion in water and aqueous solutions, Corrosion in sulphur bearing solutions, Microbiologically induced corrosion, Corrosion in acidic and alkaline process streams.

Atmospheric and elevated temperature corrosion: Atmospheric corrosion and its prevention, Oxidation at elevated temperatures, Alloying, Oxidizing environments.

Prevention and control of corrosion: Cathodic protection, Coatings and inhibitors, Material selection and design.

Course Learning Outcomes (CLO):

The students will be able to:

1. solve problems involving various types of corrosion.

2. select corrosion resistant materials for a given application.
3. select technique for corrosion prevention.

Text Books:

1. *Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd ed. (seventh reprint)*
2. *Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall (1996).*

Reference Books:

1. *Pierre R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill (2008).*
2. *Pierre R. Roberge, Handbook of corrosion engineering, McGraw-Hill (2012). 2nd ed.*
3. *Sastri, V.S., Ghali, E. and Elboujdaini, M., Corrosion prevention and protection: Practical solutions, John Wiley and Sons (2007).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (may include tutorial/ assignments/quiz's etc.)	25

ELECTIVE-II**UCH701 CATALYTIC PROCESSES**

L	T	P	Cr
3	1	0	3.5

Course Objective:

To gain the knowledge of catalyst characteristics, mechanism of catalytic reactions, and design of catalytic reactors.

Introduction: Catalysis and catalysts – homogeneous & heterogeneous, Classification of catalytic reactions and catalysts, Commercial chemical catalysts, Steps in catalytic reactions.

Preparation and Properties of Catalysts: Methods of catalyst preparation, Physical properties of catalyst – surface area, pore volume, pore size distribution, solid density, particle density, bulk density, void volume, Catalyst promoters & inhibitors, Catalyst accelerators & poisons.

Adsorption and Catalytic Reactions: Adsorption isotherms, Surface reaction, Single site and dual site mechanism, Desorption, Catalyst deactivation, Pore structure and surface area estimation and their significance.

External Transport Processes: Fluid particle mass and heat transfer, Mass transfer-limited reactions in packed beds, Non-isothermal behavior of packed-bed reactors, Staged packed-bed reactors for approaching optimum temperature progression, Stable operating conditions in reactors and hot spot formation, Effect of external transport processes on selectivity under non-isothermal conditions.

Diffusion and Reaction in Porous Catalysts: Intra-pellet mass transfer and diffusion in cylindrical and spherical porous catalyst particles, Thiele modulus, Diffusion controlled and surface reaction controlled kinetics, Effectiveness factor for catalysts, Effects of heat transfer – temperature gradients across fluid-solid film and across catalyst pellet, Fluidized bed reactors, Three phase reactors – slurry and trickle bed reactors.

Generalized Design: Design of catalytic reactors under adiabatic and non-adiabatic conditions, Design of industrial fixed-bed, fluidized-bed and slurry reactors.

Course Learning Outcomes (CLO):

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

1. develop various catalytic reaction mechanisms.
2. characterize a catalyst.
3. assess the effects of external heat and mass transfer effects in heterogeneous catalysis.
4. calculate the effectiveness of a porous catalyst.

5. design different types of reactors for catalytic reactions.

Text Books:

1. *Smith, J.M., Chemical Engineering Kinetics, McGraw-Hill (1981).*
2. *Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice-Hall India (2009).*

Reference Books:

1. *Denbigh, K.G., and Turner, J.C.R., Chemical Reactor Theory: An Introduction, Cambridge University Press (1984).*
2. *Carberry, J.J., Chemical and Catalytic Reaction Engineering, McGraw-Hill, (2001).*
3. *Levenspiel, O., Chemical Reaction Engineering, John Wiley (2006).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May includes tutorials/assignments/quiz's etc)	25



UCH716 FOOD ENGINEERING AND SCIENCE

L	T	P	Cr
3	1	0	3.5

Course Objective: To impart knowledge to the students about food process engineering, preservation, packaging, related hazards and safety.

Introduction: General aspects of food industry, Composition of foods, quality and nutritive aspects, Characteristic features of processed and natural food, Mass and energy balance in food processing operation.

Food Rheology: Characteristics of non-Newtonian fluids, Time-independent and time-dependent non-Newtonian fluids, linear viscoelastic fluids.

Thermal Processing: Canning/retort processing – process design and equipments. Equipment design aspects of pasteurizer, sterilizers, evaporators and concentrators, Dryers and their design parameters – tray dryer, spray dryer, fluidized bed dryer.

Food Preservation: Microbial Survivor Curves, thermal death of microorganisms and D, Z and F value calculation, Spoilage probability, Food preservation by dehydration, irradiation, Food preservation by adding preservatives.

Food Production, Packaging and Storage: Process design aspects for liquid foods such as milk and juices. Concentration with thermal and membranes processes, Food packaging & product shelf life, Modified atmosphere and controlled atmosphere storage, Aseptic packaging, Freezing and Thawing calculations

Food laws: Legislation, safety and quality control.

Course Outcome

The students will be able to:

1. calculate rheological properties of foods.
2. identify and evaluate various design parameters for equipment involved in thermal processing of food.
3. quantify thermal death of micro-organism and calculate spoilage probability
4. evaluate effect of food processing and packaging /storage on food quality
5. analyze food related hazards and HACCP method.

Text Books:

1. Potter Norman N., Hotchkiss Joseph, Food science, CBS (2005).
2. Toledo Romeo, Fundamentals of Food Process Engineering, CBS (2007).

Reference Books:

1. Potty V.H. and Mulky, M.J., Food Processing, Oxford and IBH (1993).
2. Heldman D.R. and Singh R.P., Food Process Engineering, Chapman and Hall (1984)
3. Frazier, Food Microbiology, Tata McGraw Hill, (2007).

Evaluation Scheme:

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



UCH834 PROCESS INTEGRATION

L	T	P	Cr
3	1	0	3.5

Course Objective:

To understand the energy and mass targets in design of processes.

Introduction: Process integration, Role of thermodynamics in process design, Concept of pinch technology and its application.

Heat exchanger networks: Heat exchanger networks analysis, Simple design for maximum energy recovery, Loop Breaking & Path Relaxation, Targeting of energy, area, number of units and cost, Trading off energy against capital.

Network Integration: Super targeting, maximum energy recovery (MER), Network for multiple utilities and multiple pinches, Grand Composite curve (GCC).

Mass integration: Distillation sequences.

Heat and Power Integration: Columns, Evaporators, Dryers, and reactors.

Case studies: Waste and waste water minimization, Flue gas emission targeting.

Course Learning Outcomes (CLO):

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

1. understand the fundamentals of process integration.
2. perform pinch analysis.
3. analyze and design heat exchanger networks.
4. minimize the water consumption and waste generation.

Text Books:

1. Linnhoff, D.W., *User Guide on Process Integration for the Efficient Use of Energy*, Institution of Chemical Engineers (1994).
2. Smith, R., *Chemical Process Design and Integration*, John Wiley & Sons(2005).

Reference Books:

1. Shenoy, V. U., *Heat Exchanger network synthesis*, Gulf Publishing (1995).
2. Kumar, A., *Chemical Process Synthesis and Engineering Design*, Tata McGraw Hill (1977).

Evaluation Scheme:

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

ELECTIVE-III(Elective Focus Energy/Materials/Petroleum)**UCHXXX BIOENERGY ENGINEERING**

L	T	P	Cr
3	0	0	3.0

Course Objective:

To understand the fundamentals of energy conversion mechanisms in biomass and biogas.

Sources of bioenergy and classification. Chemical composition and properties of biomass. Energy plantations. Size reduction, Briquetting, Drying, Storage and handling of biomass.

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment.

Thermochemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

Thermochemical Principles: Effect of pressure, temperature, steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass.

Combustion of woody biomass and rice husk. Cogeneration using bagasse.

Course Learning Outcomes (CLO):

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

1. identify the sources of bioenergy and their classification.
2. identify and understand the various processes for bioenergy production.
3. identify the thermochemical principles involved in gasification of biomass.

Text Books:

1. Chakraverthy A., "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing Co, 1989.
2. Mital K.M., "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.
3. Nijaguna, B.T., Biogas Technology, New Age International publishers (P) Ltd., 2002

Reference Books:

1. VenkataRamana P and Srinivas S.N., "Biomass Energy Systems", Tata Energy Research Institute, 1996.
2. Rezaiyan, J. and Cheremisinoff, N. P., "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005
3. Khandelwal. K. C. and Mahdi S. S, "Bio-Gas Technology", Tata McGraw-Hill Pub. Co.Ltd, 1986.
4. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003 [chapter 10]

Evaluation Scheme

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessional (may include assignments/quizzes etc.)	20

UCHXXX FUEL CELL TECHNOLOGY

L	T	P	Cr
3	0	0	3.0

Course Objective:

To understand the fundamentals of fuel cell system design and applications.

Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

Fuel cell reaction kinetics: Electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro-catalyses - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

Fuel cell characterization: In-situ and ex-situ characterization techniques, i-V curve, frequency response analyses.

Fuel cell modelling and system integration: 1D model - analytical solution and CFD models.

Course Learning Outcomes (CLO):

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

1. solve the energy conservation equations and estimate the fuel cell efficiency.
2. solve the electrochemical kinetics of fuel cell.
3. identify the techniques for fuel cell characterization.
4. develop the analytical & CFD models of fuel cells.

Text Books:

1. *Fuel Cell System*, edited by Leo J.M.J. Blomen and Michael N. Mugerwa, New York, Plenum Press, 1993.
2. *Basu, S., Fuel Cell Science and Technology*, Springer, New York, 2007.

Reference Books:

1. *Fuel Cell Handbook*, by A. J. Appleby and F. R. Foulkes, Van Nostrand, 1989.
2. *O'Hayre, R.P., S. Cha, W. Colella, F.B. Prinz, Fuel Cell Fundamentals*, Wiley, New York, 2006.
3. *Bard, A. J., L. R., Faulkner, Electrochemical Methods*, Wiley, New York, 2004.
4. *Liu, H., Principles of fuel cells*, Taylor & Francis, New York, 2006.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessional (may include assignments/quizzes etc.)	20

UCH840 POLYMER SCIENCE AND TECHNOLOGY

L	T	P	Cr
3	0	0	3.0

Course Objective:

To provide fundamental and applied knowledge of polymers and their synthesis, manufacture, processing and characterization.

Introduction: Basic concepts of polymer science, Classification of polymers, Average molecular weight and Molecular weight distribution.

Polymerization: Mechanism and kinetics of: Free radical addition polymerization, Ionic addition polymerization, Coordination polymerization, Step growth polymerization.

Structure and Properties: Thermal transitions, Crystallinity, Molecular weight characterization, Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared (FTIR) techniques.

Plastic Technology: Introduction, Rheology, Mixing and Compounding, Extrusion, Compression molding, Transfer molding, Injection molding, Blow molding, Calendering, Coating, Casting, Thermoforming.

Fiber Technology: General principles, Spinning, Fiber treatment, Properties.

Elastomer Technology: Natural and synthetic elastomers, Processing, Properties.

Manufacture: Brief description of manufacture, properties and uses of Polyethylene, Polypropylene, Polyvinylchloride, Polystyrene, Nylon, Polyethylene terephthalate.

Polymer Blends: Types, Compatibility, Thermal and Mechanical Properties.

Polymer Composites: Types, Properties, Preparation, Fibre-reinforced composites, In-situ composites.

Polymer Nanocomposites: Basic concepts, Processing, Characterization.

Course Learning Outcomes (CLO):

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

1. Identify the synthesis technique for different polymers.
2. Differentiate various polymers on the basis of their thermal transitions and molecular weight.
3. Analyze the various polymer processing techniques.
4. Carry out a comparative analysis of the properties and applications of polymer blends, composites and nanocomposites.

Text Books:

1. Billmeyer, F.W. Jr., *Text Book of Polymer Science*, Wiley & Sons (2005).
2. Kumar, A., Gupta, R. K., *Fundamentals of Polymers*, McGraw Hill (1998).

Reference Books:

1. Tadmor, Z; Gogos, C.G., *Principles of Polymer Processing*, Wiley Interscience (2006).
2. Williams, D. J., *Polymer Science and Engineering*, Prentice Hall of India (1971)

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional (may include assignments/quizzes etc.)	20



UCHXXX POLYMER BLENDS AND COMPOSITES

L	T	P	Cr
3	0	0	3.0

Course objective: To study the properties and manufacturing methods of thermoset and thermoplastic blends and composites.

Introduction: Blends; Composites; Material property envelope; Different types of reinforcements; Fibres; Matrices; Interface; Compatibilizers; Polymer processing.

Fibre Architecture Reinforcement geometry and scale; Fibre volume fraction and voids; Packing arrangement; Orientation of reinforcement.

Reinforcement Processes: Load sharing; Elastic stress transfer (Cox shear-lag theory); Stress transfer by slip; Effect of aspect ratio; Deformation in long fibre composites (axial and transverse).

Interfacial Effects: Enhancing the compatibility between fibre and matrix interface; Measuring interfacial properties.

Elastic Deformation of Laminates: Axial and transverse stiffness of unidirectional laminae; Off-axis loading and interaction effects; Multi-ply laminates.

Mechanical Properties: Inelastic processes; Predicting the strength of composites; Structure-processing-property correlations, Toughness.

Manufacturing: Manufacturing methods for thermoset and thermoplastic matrix composites.

Course learning outcomes (CLO)

Students will be able to:

1. correlate fibre architecture and reinforcement properties.
2. identify compatibilizers for polymer blends for improving interfacial properties.
3. calculate the elastic and inelastic properties of laminates and composites.
4. select manufacturing methods for thermoset and thermoplastic matrix composites.

Text Book

1. D. Hull, T.W. Clyne, "An Introduction to Composite Materials", Cambridge University Press.

Reference Books

1. M.R. Piggott, "Load Bearing Fibre Composites", Pergamon

- . 2. T.A. Osswald, "Polymer processing fundamentals", Hanser

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include assignments/quizzes etc.)	20



UCHXXX PETROLEUM DRILLING AND PRODUCTION ENGINEERING

L	T	P	Cr
3	0	0	3.0

Course Objective: To impart knowledge of oil well drilling and its production.

Section A: OIL & GAS WELL DRILLING

Well planning: Drilling planning approaches, Evaluation of pore & fracture pressure, Casing seat selection.

Rotary Drilling Method: Rig parts, selection and general layout. Advancements in Rig Equipment: Top drive & Bottom drive systems.

Drilling Operations & Practices: Hoisting, Circulation, Rotation, power plants and Power transmission.

Drilling Fluids: Types, function, properties, equipments & Design.

Cementing: Methods, Tools & Techniques, cementing calculations, Special Cement System.

Wire Lines: Types & Classification, service life evaluation & precautions in handling.

Drill Bits: Types and Application, selection, design & performance.

Drill String & Casing String: Parts, function & operations. Selection/ Design.

Drilling Problems, their control & Remedies: Pipe sticking, Sloughing Shales, Lost Circulation, Blow Outs.

Oil Well Fishing: Fish classification, tools and techniques.

Fundamental of directional drilling

Section B: OIL & GAS PRODUCTION

Well equipment: Well head assembly, Christmas tree, valves, hangers, flow control devices, packers, tubular and flow lines, safety & control systems.

Well completion: Systems, types and applications.

Well perforation & Well activation

Processing in oil fields: GGS/CTF - layout, sequential treatment, separation, storage and transportation of petroleum. Demulsification & desalting.

Introduction to well servicing and stimulation system: objectives and applications.

Course Learning Outcomes (CLO):

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

1. Explain the basic procedures and role of all fundamental systems used in petroleum drilling.
2. Develop awareness of the multiple aspects of drilling operations and the challenge of analysing and synthesizing the numerous technical issues encountered during

drilling.

3. Explain basic concepts and methods of oil & gas production and technologies for its recovery.
4. Analyse the key issues in the design and optimisation of petroleum production systems.

Text Books:

1. *Drilling Engineering: A Complete Well Planning Approach* by Neal J. Adams, Penn Well Publishing Company, Tulsa, Oklahoma, 1985.

Reference Books:

1. *Petroleum Engineering: Drilling and well completion* by Carl Gatlin, Englewood Cliffs NJ, Prentice Hall Inc., 1960.
2. *Applied Drilling Engineering* by Bourgoyn A. D., Chenevert M. E., Millhemp K. K., Young Jr. F.S., Society of Petroleum Engineers, 1991.

Evaluation Scheme:

S.No.	Evaluation elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional(May include assignments/quizzes etc.)	20

UCH850PETROLEUM AND PETROCHEMICALS

L	T	P	Cr
3	0	0	3.0

Course Objective:

To impart knowledge of petroleum refining, hydrocarbon processing, and derived petrochemicals.

Introduction: World petroleum resources, Petroleum industries in India, Chemistry and composition of crude oil, Transportation and pretreatment of crude oil, New trends in refinery.

Classification and Characterization: Classification of petroleum, Characterization of petroleum fractions.

Crude oil distillation: Impurities in crude oil, Desalting of crude oil, Atmospheric distillation and vacuum distillation units.

Conversion Processes: Thermal conversion processes, Conventional vis-breaking and soaker visbreaking process, Coking processes, Catalytic conversion processes, Fluid catalytic cracking, Catalytic reforming, Hydrocracking, Catalytic alkylation, Catalytic isomerization and catalytic polymerization.

Finishing Processes: Sulphur conversion processes, Sweetening processes, Solvent extraction process, Hydrotreating process.

Lube oil manufacturing Processes: Solvent extraction of lube oil fractions, Manufacture of petroleum wax, Hydrofinishing process.

Petrochemicals: Primary petrochemicals such as ethylene, propylene, butadiene, benzene, toluene, xylene and their derived polymers.

Course Learning Outcomes (CLO):

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

1. select the appropriate characterization parameters.
2. specify the properties of petroleum products.
3. attain knowledge of various separation & conversion processes involved in petroleum refining.
4. attain knowledge of manufacturing of various petrochemical products.

Text Books:

1. BhaskaraRao, B.K. *Modern Petroleum Refining Processes*. Oxford & IBH Publishing

- Company Pvt. Ltd. New Delhi, (2007) 3rd Ed.*
2. *Prasad, R. Petroleum Refining Technology, Khanna Publishers, (2011) 1st Ed.*
 3. *Mall, I.D. Petrochemical Process Technology, Mecmillan Publishers, (2006) 1st Ed.*

Reference Books:

1. *Nelson, W. L. Petroleum Refinery Engineering, Tata McGraw Hill Publishing Company Limited, (1958) 4th Ed.*
2. *Garry,J.H. Petroleum Refining Technology and Economics, Marcel Dekker Inc., (2001) 4th Ed.*
3. *Wells G. M.Handbook of petrochemicals and processes, Ashgate Publishing Ltd, (1999) 2nd Ed.*
4. *Spitz P. H. Petrochemicals: The rise of an industry, John Wiley & Sons, (1999).*
5. *Sarkar, G.N. Advanced Petroleum Refining, Khanna Publishers, (2000).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional (May includes seminar/assignments/quiz's etc)	20

ELECTIVE-IV (Elective Focus Energy/Materials/Petroleum)

UCHXXX MATERIALS AND DEVICES FOR ENERGY CONVERSION

L	T	P	Cr
3	0	0	3.0

Course Objective:

To understand the fundamentals and scope of available materials and device fabrication techniques in energy applications.

Physics of semiconductor devices: Basics of solar cells High efficiency solar cells, PERL Si solar cell, III-V high efficiency solar cells, GaAs solar cells, tandem and multi-junction solar cells, solar PV concentrator cells and systems, III-V, II-VI thin-film solar cells (GaAs, Cu(In,Ga)Se₂, CdTe) Nano-, micro- and poly-crystalline Si for solar cells, mono-micro silicon composite structure, crystalline silicon deposition techniques, material and solar cell characterization, advanced solar cell concepts and technologies (Porous Si layer transfer, Metal induced crystallization, etc.). Amorphous silicon thin-film (and/or flexible) technologies, multi-junction (tandem) solar cells, stacked solar cells. Conjugated polymers, organic/plastic/flexible solar cells, polymer composites for solar cells, device fabrication and characterization.

Characterization of Solar Cells: Spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization.

Device fabrication technologies: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), etc.

Materials and devices for energy storage: Batteries, CNTs for hydrogen storage, CNT-polymer composites, ultra-capacitors etc. Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells.

Course Learning Outcomes (CLO):

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

1. learn the fundamentals of semiconductor devices
2. identify the parameters for characterization of solar cells
3. learn the various device fabrication techniques.
4. identify the various materials and devices for energy storage.

Text Books:

1. *Semi-conductors for solar cells*, H. J. Moller, Artech House Inc, MA, USA, 1993.
2. *Solid State electronic devices*, Ben G. Streetman, Prentice-Hall of India Pvt. Ltd., New Delhi 1995.
3. *Carbon nanotubes and related structures: New material for twenty-first century*, P. J. F. Harris, Cambridge University Press, 1999.

Reference Books:

1. *Solar cells: Operating principles, technology and system applications*, by Martin A. Green, Prentice-Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. *Thin-film crystalline silicon solar cells: Physics and technology*, R. Brendel, Wiley-VCH, Weinheim, 2003.
3. *Clean electricity from photovoltaics*, M. D. Archer, R. Hill, Imperial college press, 2001.
4. *Organic photovoltaics: Concepts and realization*, C. Barbec, V. Dyakonov, J. Parisi, N. S. Sariciftci, Springer-Verlag 2003.
5. *Fuel cell and their applications*, K. Kordesch, G. Simader, VCH, Weinheim, Germany, 1996.
6. *Battery technology handbook*, edited by H.A. Kiehne, Marcel Dekker, New York, 1989

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessional (may include assignments/quizzes etc.)	20

UCHXXX ENERGY MANAGEMENT

L	T	P	Cr
3	0	0	3.0

Course Objective:

To introduce the energy management principles related to process industries.

Introduction: Importance of energy management. Energy auditing: methodology, analysis of past trends plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments. Energy economics - discount rate, payback period, internal rate of return, life cycle costing.

Steam Systems: Boiler-efficiency testing, excess air control, Steam distribution & use-steam traps, condensate recovery, flash steam utilisation. Thermal Insulation.

Electrical Systems: Demand control, power factor correction, load scheduling/shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control. Lighting- lighting levels, efficient options, fixtures, daylighting, timers, Energy efficient windows.

Mechanical systems: Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems.

Waste heat recovery: Recuperators, heat wheels, heat pipes, heat pumps.

Cogeneration: Concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. Heat exchanger networking- concept of pinch, target setting, problem table approach, composite curves. Demand side management. Financing energy conservation

Course Learning Outcomes (CLO):

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

1. identify the components involved in energy auditing.
2. explain the energy conservation techniques.
3. evaluate the performance of electrical systems, lighting and pumps.
4. evaluate the performance of industrial boilers, furnaces, cogeneration options.

Text Books:

1. *NagabhushanRaju, K., Industrial Energy Conservation Techniques: Concepts, Applications and Case Studies, Atlantic Publishers & Distributors (2007).*

2. *Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.*

Reference Books:

1. *The Efficient Use of Energy, Ed: I.G.C. Dryden, Butterworths, London, 1982*
2. *L.C. Witte, P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, 1988.*
3. *W.C. Turner, Energy Management Handbook, Ed: Wiley, New York, 1982.*
4. *Technology Menu for Efficient energy use- Motor drive systems, Prepared by National Productivity Council and Centre for Environmental Studies- Princeton Univ, 1993.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessional (may include assignments/quizzes)	20



UCHXXX POLYMER PROCESSING

L	T	P	Cr
3	0	0	3.0

Course objective:

To study processing methods for elastomers, thermoplastics, adhesives, fibres and coatings, and to select appropriate processing methods for an engineering application.

Introduction: Polymer classification; Molecular weight distributions; Thermal transitions; Mechanical properties; Polymer solubility; Interfacial Properties; Properties of thermoplastics; Rubber elasticity; Crosslinking; Additives.

Polymer Rheology: Principles of rheology; Rheometry; Constitutive equations; Flow modeling; Dynamic mechanical properties; Viscoelasticity.

Polymer Processing Operations: Rubber compounding; Unit operations in polymer processing; Extrusion and injection molding; Mixing and Compounding; Compression molding, Transfer molding, Blow molding, Calendering, Coating, Casting, Thermoforming. Secondary shaping operations; Polymer blends and composites.

Processing Operation Calculations: Calculations in Extrusion and Injection molding.

Course learning outcomes (CLO)

Students will be able to:

1. Choose appropriate polymer processing operations depending on the material and final product requirements.
2. Identify methods for rheological measurements and analyze the results.
3. Relate properties required and the processing techniques used; such as injection molding, single screw extrusion, twin screw compounding, mixing, thermoforming, blown film, etc.
4. Solve simple flow problems and perform simple calculations in extrusion and injection molding.

Text Book

1. *J.R. Fried, "Polymer Science and Technology", 3rd Ed. Prentice Hall, 2014*

Reference Books

1. *S.L. Rosen, "Fundamental principles of polymeric materials", Wiley*
2. *T.A. Osswald, "Polymer processing fundamentals", Hanser*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include assignments/quizzes etc.)	20

UCHXXX STRUCTURAL MATERIALS

L	T	P	Cr
3	0	0	3.0

Course Objective:

To give the necessary background to understand the design of suitable microstructures to give desired properties across the full range of materials classes.

Introduction: Stress-strain relationships in linear elastic and non-linear elastic solids; plastic deformation of metals; strengthening mechanisms; micro-mechanisms of plastic deformation and fracture; creep: characteristics of the creep curve, creep mechanisms.

Mechanical Behaviour: Plastic deformation of polymers; fracture: fracture of brittle materials; brittle-ductile transition; fracture of semi-brittle materials-crack-tip plasticity; fatigue: characteristics of fatigue crack nucleation and growth; the Paris Law and lifetime predictions; rupture life predictions.

Ceramics

Structural ceramics: general considerations; oxide ceramics; silicon carbide.

Composites

Composites: elastic behaviour; strength; toughening.

Polymers

Polymers: structural overview; structural transitions: factors affecting the glass transition temperature in amorphous polymers; crystalline polymers; liquid crystal polymers.

Course Learning Outcomes:

The students will be able to:

1. Apply a quantitative treatment to the properties of materials, and their origin.
2. Perform simple calculations to predict the lifetime of a component subjected to fatigue or creep using data obtained from standard tests.
3. Apply knowledge gained of the processing-microstructure-property relationship to the design of alloys, ceramics, polymers and composites for structural applications.

Text Book:

1. W.D. Callister, *Materials Science and Engineering*; John Wiley & Sons, Singapore, 2002.

Reference Book:

1. V. Raghavan, *Introduction to Materials Science and Engineering*; PHI, Delhi, 2005.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessional (May include assignments/quizzes etc.)	20



UCHXXX PETROLEUM RESERVOIR ENGINEERING AND FIELD DEVELOPMENT

L	T	P	Cr
3	0	0	3.0

Course Objective:

To impart the in-depth knowledge of petroleum reservoir engineering and field development.

Characteristics of crude oil and natural gas, classification of crude and its physico-chemical properties.

Petrophysical properties of reservoir rocks: porosity, permeability, fluid saturation. Fluid flow through porous media.

Reservoir Fluids: Gas, condensate and oil reservoirs, Reservoir fluid properties. Reservoir fluid sampling and PVT studies.

Thermodynamics of fluid system: Phase behavior of single & multiphase systems,

Reserve Estimation: Material Balance, Volumetric Methods, Reservoir simulation method, Decline curve analysis.

Reservoir energies & drives: Basic drive mechanism, Water influx; Well performance: productivity index, IPR. Water and gas coning, Open flow potential for gas wells.

Applications of horizontal wells, ERD & multi-laterals.

Oil & Gas field development: Oil and gas field development: Principles of oil and gas field development; rational development plan; well spacing and patterns, Reservoir drives and drive mechanism, Economics of field development.

Course Learning Outcomes (CLO):

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

1. Analyze the petro-physical properties of reservoir rocks and reservoir fluids.
2. Estimate and analyze the thermodynamics of fluid system, reserve estimation and reservoir energies and drives.
3. Analyze the principles of the development for the oil and gas field.

Text Books:

1. *Fundamentals of Reservoir Engineering* by L.P. Dake, Elsevier, NY, 2010.
2. *Basics of Reservoir Engineering* by R. Cosse, Editions Technip, Paris, 1993.

Reference Books:

1. *Reservoir Engineering Handbook* by TarekAhme, 3rdEdn, Gulf Professional Publishing, Elsevier, NY, 2006.
2. *Reservoir Engineering manual* by Frank W Cole, Gulf Publishing Company, Houston, Texas, 1983.
3. *Applied Reservoir Engineering (Vol I & II)* by C R Smith, G W Tracy, R L Farrar, OGCI and PetroSkills Publications, Tulsa, Oklahoma, 2008.

Evaluation Scheme:

S.No.	Evaluation elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional(May include Assignments/Quizzes)	20



UCHXXX ENHANCED OIL RECOVERY TECHNIQUES

L	T	P	Cr
3	0	0	3.0

Course Objective: To impart the knowledge and in-depth understanding of enhanced oil recovery techniques.

Introduction: Historical background and review of primary and secondary recovery, injection rate and pressures in secondary recovery. Flood Patterns and Coverage.

Microscopic displacement of fluids in a reservoir: Capillary forces, viscous forces, phase trapping, mobilization of trapped phases.

Macroscopic displacement of fluids in a reservoir: Areal sweep efficiency, vertical sweep efficiency, displacement efficiency, mobility ratio, well spacing.

Flow of immiscible fluids through porous media. Continuity equation, equation of motion, solution methods Water flooding, Fractional flow equation, Frontal advance theory. Recovery efficiency, permeability heterogeneity.

Water flooding performance calculations: Frontal advance method, viscous fingering method, Stiles method, Dykstra-Parsons Method, Water for water flooding.

Chemical Flooding: Polymer flooding and mobility control processes, Micellar/ polymer flooding, phase behavior of micro-emulsions, phase behavior and IFT, wettability alterations, Alkali flooding.

Miscible Displacement Processes: Mechanism of miscible displacement, phase behavior related to miscibility, high pressure gas injection, enriched gas injection, LPG flooding, Carbon dioxide flooding, alcohol flooding.

Thermal Recovery Processes: mechanism of thermal flooding, hot water flooding, cyclic steam injection, estimation of oil recovery from steam drive, in-situ combustion, air requirement for in-situ combustion.

Microbial oil recovery, EOR Project Evaluation.

Course Learning Outcomes (CLO):

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

1. Learn the macroscopic displacement of fluids in a reservoir.
2. Estimate the water flooding performance and chemical flooding.
3. Learn and understand the miscible displacement and thermal recovery processes.

Text Book:

1. *Fundamentals of Enhanced Oil Recovery* by HK Van Poolen.

Reference Books:

1. *Enhanced oil recovery* by Don W. Green, G. Paul Willhite.
2. *Enhanced Oil Recovery*.-Larry W. Lake.

Evaluation Scheme:

S.No.	Evaluation elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessional(May include Assignments/Quizzes)	20

