Heritage Institute of Technology

DEPARTMENT OF CHEMICAL ENGINEERING

B. TECH. PROGRAMME IN

CHEMICAL ENGINEERING

July, 2021

CURRICULUM

1st Year 1st Semester (Semester 1)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	PHYS 1001	Physics I	3	1	0	4	4
02	MATH 1101	Mathematics - I	3	1	0	4	4
03	CSEN 1001	Programming for Problem Solving	3	0	0	3	3
	Total Theory						**11**
LABORATORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	PHYS 1051	Physics I Laboratory	0	0	3	3	1.5
02	MECH 1051	Workshop/Manufacturing Practices	1	0	4	5	3
03	CSEN 1051	Programming for Problem Solving Laboratory	0	0	4	4	2
	Total Practical						**6.5**
	Semester Total						**17.5**
HONOURS							
01	ECEN 1011	Basic Electronics	3	0	0	3	3
02	ECEN 1061	Basic Electronics Engineering Laboratory	0	0	2	2	1
	Honours Total						**4**

1st Year 2nd Semester (Semester 2)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	MATH 1201	Mathematics-II	3	1	0	4	4
02	CHEM 1001	Chemistry - I	3	1	0	4	4
03	ELEC 1001	Basic Electrical Engineering	3	1	0	4	4
04	HMTS 1202	Business English	2	0	0	2	2
	Total Theory						**14**
LABORATORY / SESSIONAL							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEM 1051	Chemistry Laboratory	0	0	3	3	1.5
02	HMTS 1252	Language Laboratory	0	0	2	2	1
03	MECH 1052	Engineering Drawing & Design	1	0	4	5	3
04	ELEC 1051	Basic Electrical Engineering Laboratory	0	0	2	2	1
	Total Practical						**6.5**
	Semester Total						**20.5**
HONOURS							
01	HMTS1011	Communication for Professionals	3	0	0	3	3
02	HMTS1061	Professional Communication Laboratory	0	0	2	2	1
	Honours Total						**4**

2nd Year 1st Semester (Semester 3)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 2101	Particle & Fluid Particle Processing	3	0	0	3	3
02	CHEN 2102	Chemical Engineering Fluid Mechanics	3	0	0	3	3
03	CHEN 2103	Basics of Material & Energy Balance	3	0	0	3	3
04	MECH 2106	Mechanics for Engineers	3	0	0	3	3
05	CHEN 2104	Thermodynamics - I	3	0	0	3	3
06	BIOT 2105	Biology	2	0	0	2	2
	Total Theory						**17**
LABORATORY / SESSIONAL							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 2151	Fluid Mechanics (ChE) Laboratory	0	0	3	3	1.5
02	CHEN 2152	Particle & Fluid Particle Processing Laboratory	0	0	2	2	1
03	CHEN 2153	Instrumental Methods of Analysis Laboratory	0	0	3	3	1.5
	Total Practical						**4**
	Semester Total						**21**
HONOURS							
01	PHYS2111	Physics II	3	1	0	4	4
	Honours Total						**4**

2nd Year 2nd Semester (Semester 4)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 2201	Heat Transfer	3	0	0	3	3
02	CHEN 2202	Transport Phenomena	3	0	0	3	3
03	CHEN 2203	Thermodynamics II	3	0	0	3	3
04	CHEM 2201	Chemistry II	3	0	0	3	3
05	CHEN 2204	Material Science	3	0	0	3	3
06	HMTS-2001	Human Values And Professional Ethics	3	0	0	3	3
07	EVSC 2016	Environmental Science	2	0	0	2	0
	Total Theory						**18**
LABORATORY / SESSIONAL							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 2251	Heat Transfer Laboratory	0	0	3	3	1.5
02	CHEN 2252	Programming Basics for Numerical Computation	0	0	3	3	1.5
03	CHEN 2253	Engineering Drawing Laboratory	0	0	2	2	1
	Total Practical						**4**
	Semester Total						**22**

3rd Year 1st Semester (Semester 5)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 3101	Chemical Process Technology	3	0	0	3	3
02	CHEN 3102	Chemical Reaction Engineering - I	3	0	0	3	3
03	CHEN 3103	Mass Transfer I	3	0	0	3	3
04	CHEN 3104	Numerical Methods in Chemical Engineering	3	0	0	3	3
05	CHEN 3131-3133	Professional Elective-I	3	0	0	3	3
06	CHEN 3141- 3143	Professional Elective-II	3	0	0	3	3
	Total Theory						**18**
LABORATORY / SESSIONAL							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 3151	Numerical Computation Laboratory	0	0	3	3	1.5
02	CHEN 3152	Chemical Reaction Engineering Laboratory	0	0	3	3	1.5
03	CHEN 3153	Energy Laboratory: Theory and Practice	0	0	2	2	1
	Total Practical						**4**
	Semester Total						**22**
HONOURS							
01	CHEN 3111	Chemical Reaction Engineering II	3	1	0	4	4
	Honours Total						**4**

Professional Elective- I	**CHEN 3131**	**CHEN 3132**
Subject name	Petrochemical Technology	Energy Engineering
Professional Elective –II	**CHEN 3141**	**CHEN 3142**
Subject name	Bioprocess Engineering	Industrial Safety and Hazards Analysis

3rd Year 2nd Semester (Semester 6)

THEORY							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 3201	Process Control and Instrumentation	3	0	0	3	3
02	CHEN 3202	Mass Transfer II	3	0	0	3	3
03	CHEN 3231-3233	Professional Elective-III	3	0	0	3	3
04		Open Elective I	3	0	0	3	3
05	HMTS 3201	Economics for Engineers	3	0	0	3	3
06	INCO 3016	Indian Constitution and Civil Society	2	0	0	2	0
	Total Theory						**15**
LABORATORY / SESSIONAL							
Sl. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 3251	Process Control Laboratory	0	0	2	2	1
02	CHEN 3252	Mass Transfer Laboratory	0	0	3	3	1.5
03	CHEN 3253	Process Equipment Design & Drawing Laboratory	0	0	3	3	1.5
04	CHEN 3293	Term Paper & Technical Seminar	0	0	4	4	2
	Total Practical						**6**
	Semester Total						**21**

Professional Elective – III	**CHEN 3231**	**CHEN 3232**	**CHEN 3233**
Subject name	Computational Fluid Dynamics	Novel Separation Processes	Nanotechnology

4th Year 1st Semester (Semester 7)

THEORY							
S. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 4131-4133	Professional Elective IV	3	0	0	3	3
02	HMTS 4101	Principles of Management	3	0	0	3	3
03		Open Elective-II	3	0	0	3	3
04		Open Elective-III	3	0	0	3	3
	Total Theory						**12**
LABORATORY / SESSIONAL							
S. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 4151	Design & Simulation Laboratory I	0	0	3	3	1.5
02	CHEN 4195	Project –I	0	0	0	7	3.5
03	CHEN 4191	Industrial Training					2
	Total Practical						**7**
	Semester Total						**19**
HONOURS							
01	CHEN4111	Industrial Process Control & Instrumentation	3	1	0	4	4
	Honours Total						**4**

Professional Elective – IV	**CHEN 4131**	**CHEN 4132**	**CHEN 4133**
Subject name	Modern Instrumental Methods of Analysis	Petroleum Refinery Engineering	Environmental Engineering

4th Year 2nd Semester (Semester 8)

THEORY							
S. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 4231-4233	Professional Elective V	3	0	0	3	3
02		Open Elective-IV	3	0	0	3	3
	Total Theory						**6**
LABORATORY / SESSIONAL							
S. No	**Code**	**Course Title**	**L**	**T**	**P**	**H**	**Credit**
01	CHEN 4295	Project –II	0	0	0	17	8.5
02	CHEN 4251	Design & Simulation Laboratory II	0	0	3	3	1.5
03	CHEN 4297	Grand Viva					1
	Total Practical						**11**
	Semester Total						**17**

Professional Elective – V	**CHEN 4231**	**CHEN 4232**
Subject name	Project Engineering	Process Integration

Open Electives to be offered by Chemical Engineering Department for Non-departmental Students		
Semester VI Open Elective I	Water and Liquid Waste Management (CHEN 3221)	Industrial Safety and Hazards (CHEN 3222)
Semester VII Open Elective II	Thin Film based Microstructure Fabrication (CHEN 4121)	Particle Characterization (CHEN 4122)
Semester VII Open Elective III	Industrial Total Quality Management (CHEN 4126)	Soft Methods in Microstructure Fabrication (CHEN 4127)
Semester VIII Open Elective IV	Fuel Cell Technology(CHEN 4221)	Introduction to Solar and Wind Technology(CHEN 4222)

Honours Courses for B. Tech Chemical Engineering Students			**Contact Hours / Week**			
Sem. No.	**Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1st	ECEN 1011	Basic Electronics	3	0	0	3
	ECEN 1061	Basic Electronics Engineering Laboratory	0	0	2	1
2nd	HMTS 1011	Communication For Professionals	3	0	0	3
	HMTS 1061	Professional Communication Laboratory	0	0	2	1
3rd	PHYS 2111	Physics II	3	1	0	4
5th	CHEN 3111	Chemical Reaction Engineering II	3	1	0	4
7th	CHEN 4111	Industrial Process Control & Instrumentation	3	1	0	4
Total Honors Credit						20

Division of Credits according to Categories	**AICTE Recommended**	**HIT CHE Credit**
Basic Sciences	27	24
Engineering Sciences	27	25
Humanities	12	12
Professional Core	55	55
Professional Elective	12	15
Open Elective	12	12
Seminar, Project, Internship etc.	12	17
Total	**157**	**160**

Division of Credits according to Categories from 3rd semester – 8th semester	**HIT CHE Credit**
Basic Sciences	5
Engineering Sciences	9
Humanities	9
Professional Core	55
Professional Elective	15
Open Elective	12
Seminar, Project, Internship etc.	17
Total	**122**

Swayam / MOOCs courses recommended to the students of CHE Dept.					
Code	**Name**	**Credit Points**	**Corresponding Online Course**	**Offered by**	**Platform**
ECEN1011	Basic Electronics	3	Fundamentals of Semiconductor Devices	IISc Bangalore	NPTEL
ECEN1061	Basic Electronics Lab	1			
HMTS1011	Communication for Professionals	3	Effective Business Communication **AND**	IIM Bangalore	Swayam
HMTS1061	Professional Communication Lab	1	Developing Soft Skills and Personality	IIT Kanpur	Swayam
CHEN3111	Chemical Reaction Engineering II	4	Chemical Reaction Engineering II	IIT Bombay	NPTEL
CHEN4111	Industrial Process Control and Instrumentation	4	Process Control and Instrumentation	IIT Kharagpur	NPTEL

Definition of Credit (as per AICTE):

- 1 Hour Lecture (L) per Week = 1Credit
- 1 Hour Tutorial (T) per Week = 1Credit
- 1 Hour Practical (P) per Week = 0.5Credits
- 2 Hours Practical (Lab) per Week = 1Credit

Range of Credits (as per AICTE): -

- A total of 160 credits will be necessary for a student to be eligible to get B. Tech. degree.
- A student will be eligible to get B Tech degree with Honours if he/she completes an additional 20 credits. These could be acquired through various Honours Courses offered by the respective departments.
- A part or all of the above additional credits may also be acquired through MOOCs. Any student completing any course through MOOCs will have to submit an appropriate certificate to earn the corresponding credit.
- For any additional information, the student may contact the concerned HODs.

PART II: DETAILED SYLLABUS

1st Year 1st Semester (Semester 2)

THEORY

Subject Name: Physics I					
Paper Code: PHYS1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

1. Interpret oscillations under different conditions, with the understanding of Resonance phenomena followed by calculation of Q factor.
2. Analyze the Quantum phenomenon like Black body radiation, Compton effect and origin of X-ray spectrum.
3. Understand the wave character of light through the phenomenon of interference, diffraction and polarization.
4. Study of various crystal structures and classification of different crystal planes.
5. Explain the working principle of LASER, and apply the knowledge in different lasing system and their engineering applications in holography
6. Understand the dual nature of matter, Heisenberg's uncertainty relation and it's various application.

Module I [12L]

Mechanics:

Elementary concepts of grad, divergence and curl. Potential energy function; F=-grad V, Equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, Curl of a force field; Central forces ; conservation of angular momentum; Energy equation and energy diagrams; elliptical, parabolic and hyperbolic orbit; Kepler Problem; Application : Satellite manoeuvres .

Non-inertial frames of reference; rotating coordinate system; five term acceleration formula-centripetal and coriolis accelerations; applications: Weather system, Foucault pendulum.

Module II [12L]

Optics:

Oscillatory Motion:

Damped harmonic motion – Over damped, critically damped and lightly damped oscillators; Forced oscillation and resonance. Electrical equivalent of mechanical oscillator, Wave equation, plane wave solution.

Optics:

Elementary features of polarization of light waves. Double refraction, Production and analysis of linearly, elliptic and Circularly polarized light, Polaroid and application of polarizations: Polarimeter.

Laser & Fiber Optics:

Characteristics of Lasers, Spontaneous and Stimulated Emission of Radiation, Meta-stable State, Population Inversion, Lasing Action, Einstein's Coefficients and Relation between them, Ruby Laser, Helium-Neon Laser, Semiconductor Diode Laser, Applications of Lasers.

Fiber optics - principle of operation, numerical aperture, acceptance angle, Single mode, graded indexed fiber.

Module III [12L]
Electrostatics:
Electrostatics in free space
Calculation of electric field and electrostatic potential for a charge distribution, Divergence and curl of electrostatic field, Laplace's and Poisson's equation for electrostatic potential. Boundary conditions of electric field and electrostatic potential. Method of images, energy of a charge distribution and its expression in terms of electric field.
Electrostatics in a linear dielectric medium
Electrostatic field and potential of a dipole, Bound charges due to electric polarization, Electric displacement, Boundary conditions on displacement, Solving simple electrostatic problem in presence of dielectric – point charge at the centre of a dielectric sphere, charge in front of dielectric slab, Dielectric slab and dielectric sphere in uniform electric field.

Module IV [12L]
Magnetostatics:
Biot-Savart law, divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; equation for vector potential and it's solutions for given current densities.
Magnetostatics in a linear magnetic medium:
Magnetization and associated bound currents; Auxiliary magnetic field $\vec{H}$; boundary conditions on $\vec{B}$ and $\vec{H}$.Solving for magnetic field due to simple magnet like a bar magnet; Magnetic susceptibility; ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.
Faraday's Law:
Differential form of Faraday's law expressing curl of electric field in terms of time derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi static approximation. Energy stored in a magnetic field.

Books of reference:

1. Optics, Eugene Hecht Pearson Education India Private Limited.
2. David J. Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited.
3. N.K. Bajaj, Waves and Oscillations.
4. David Halliday, Robert Resnick Jearl Walker, Principles of Physics, 10ed, Wiley.
5. Wayne M. Saslow, Electricity, Magnetism, and Light, Academic Press.
6. Narayan Rana, Pramod Joag, Classical mechanics, McGraw Hill Education.
7. R. Takwale, P Puranik, Introduction to Classical Mechanics, McGraw Hill Education.
8. Ghatak, Optics, McGraw Hill Education India Private Limited.
9. C.L. Arora, Refresher Course in B.Sc. Physics ,Vol1 and Vol2.

Subject Name: Mathematics I					
Paper Code: MATH 1101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

After successfully completing this course the students will be able to:

1. Apply the concept of rank of matrices to find the solution of a system of linear simultaneous equations.
2. Develop the concept of eigen values and eigenvectors.
3. Combine the concepts of gradient, curl, divergence, directional derivatives, line integrals, surface integrals and volume integrals.
4. Analyze the nature of sequence and infinite series.
5. Choose proper method for finding solution of a specific differential equation.
6. Describe the concept of differentiation and integration for functions of several variables with their applications in vector calculus.

Module I [10L]

Matrix:

Inverse and rank of a matrix; Elementary row and column operations over a matrix; System of linear equations and its consistency; Symmetric, skew symmetric and orthogonal matrices; Determinants; Eigen values and eigen vectors; Diagonalization of matrices; Cayley Hamilton theorem; Orthogonal transformation.

Module II [10L]

Vector Calculus:

Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function, Directional derivative, related problems on these topics.

Infinite Series:

Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test(statements and related problems on these tests), Raabe's test; Alternating series; Leibnitz's Test (statement, definition); Absolute convergence and Conditional convergence.

Module III [10L]

First order ordinary differential equations:

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Ordinary differential equations of higher orders:

General linear ODE of order two with constant coefficients, C.F. & P.I., D-operator methods, Method of variation of parameters, Cauchy-Euler equations.

Module IV [10L]
Calculus of functions of several variables:

Introduction to functions of several variables with examples, Knowledge of limit and continuity, Determination of partial derivatives of higher orders with examples, Homogeneous functions and Euler's theorem and related problems up to three variables.

Multiple Integration:

Concept of line integrals, Double and triple integrals. Green's Theorem, Stokes Theorem and Gauss Divergence Theorem.

Books of reference:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2000.
2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2006.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
5. K. F. Riley, M. P. Hobson, S. J. Bence. Mathematical Methods for Physics and Engineering, Cambridge University Press, 23-Mar-2006.
6. S. L. Ross, Differential Equations", Wiley India, 1984.
7. G.F. Simmons and S.G. Krantz, Differential Equations, McGraw Hill, 2007.
8. M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, Vector Analysis (Schaum's outline series), McGraw Hill Education.
9. S. S. Sastry, Engineering Mathematics, PHI.
10. M.C. Potter, J.L. Goldberg and E.F. Abonfadel (OUP), Advanced Engineering Mathematics, Indian Edition.
11. Seymour Lipschutz, Marc Lipson, Linear Algebra (Schaum's outline series), McGraw Hill Education.

Subject Name: Programming for Problem Solving					
Paper Code: CSEN 1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

On completion of this course, students are expected to be capable of solving problems using mathematics and generalize those solutions into flowcharts to form programs. This course is directed towards teaching the students, how to automate those solutions by implementing them in C programming language. It is expected that due to the use of C programming language, the students will learn the basics of how a high-level language works in tandem with memory. The students should be able to identify coding inefficiencies and errors in C code and turn those programs into efficient ones and remove programming bugs, primarily with manual inspection and later with the use of debuggers. After completion of this course students will be able to:

1. Understand and remember functions of the different parts of a computer.
2. Understand and remember how a high-level language (C programming language, in this course) works, different stages a program goes through.
3. Understand and remember syntax and semantics of a high-level language (C programming language, in this course).
4. Understand how code can be optimized in high-level languages.
5. Apply high-level language to automate the solution to a problem.
6. Apply high-level language to implement different solutions for the same problem and analyze why one solution is better than the other.

Learning Objectives:

Introduction to the concept of computer and computation and solving of problems using C as a programming language. Coverage of C will include basic concepts, arithmetic and logic, flow control, and data handling using arrays, structures, pointers and files.

Module I [10L]

Fundamentals of Computer:

History of Computers, Generations of Computers, Classification of Computers.

Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. Basic Concepts of Assembly language, High level language, Compiler and Assembler.

Binary & Allied number systems (decimal, octal and hexadecimal) with signed and unsigned numbers (using 1's and 2's complement) - their representation, conversion and arithmetic operations. Packed and unpacked BCD system, ASCII. IEEE-754 floating point representation (half- 16 bit, full- 32 bit, double- 64 bit).

Basic concepts of operating systems like MS WINDOWS, LINUX

How to write algorithms & draw flow charts.

Module II [10L]
Basic Concepts of C:
C Fundamentals:
The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements.
Operators & Expressions:
Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Standard input and output, formatted output -- printf, formatted input scanf.
Flow of Control:
Statement and blocks, if-else, switch-case, loops (while, for, do-while), break and continue, go to and labels.

Module III [10L]
Program Structures in C:
Basic of functions, function prototypes, functions returning values, functions not returning values. Storage classes - auto, external, static and register variables – comparison between them. Scope, longevity and visibility of variables.
C preprocessor (macro, header files), command line arguments.
Arrays and Pointers:
One dimensional arrays, pointers and functions – call by value and call by reference, array of arrays. Dynamic memory usage– using malloc(), calloc(), free(), realloc(). Array pointer duality. String and character arrays; C library string functions and their use.

Module IV [9L]
Data Handling in C:
User defined data types and files:
Basic of structures; structures and functions; arrays of structures.
Files – text files only, modes of operation. File related functions – fopen(), fclose(), fscanf(), fprintf(), fgets(), fputs(), fseek(), ftell().

Text Books:
1. Byron Gottfried, Schaum's outline of Programming with C.
2. Herbert Schildt, Teach Yourself C.
3. E Balagurusamy, Programming in ANSI C.

Books of reference:
1. Herbert Schildt, C: The Complete Reference.
2. D.M.Ritchie, B.W. Kernighan, The C Programming Language.

Subject Name: Basic Electronics					
Paper Code: ECEN 1011					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Categorize different semiconductor materials based on their energy bands and analyze the characteristics of those materials for different doping concentrations based on previous knowledge on semiconductors acquired.
2. Describe energy band of P-N Junction devices and solve problems related to P-N Junction Diode both from device and circuit perspectives.
3. Design different application specific circuits associated with diodes operating both in forward and reverse bias.
4. Analyze various biasing configurations of Bipolar Junction Transistor and categorize different biasing circuits based on stability.
5. Categorize different field-effect transistors based on their constructions, physics and working principles and solve problems associated with analog circuits based on operational amplifiers.
6. Design and implement various practical purpose electronic circuits and systems meant for both special purpose and general purpose and analyze their performance depending on the type of required output and subsequently the applied input.

Module I [10L]

Basic Semiconductor Physics:

Crystalline materials, Energy band theory, Conductors, Semiconductors and Insulators, Concept of Fermi Energy level, intrinsic and extrinsic semiconductors, drift and diffusion currents in semiconductor.

Diodes and Diode Circuits:

Formation of p-n junction, Energy Band diagram, forward & reverse biased configurations, V-I characteristics, load line, breakdown mechanisms, Zener Diode and its Application.

Rectifier circuits: half wave & full wave rectifiers: ripple factor, rectification efficiency.

Module II [8L]

Bipolar Junction Transistors (BJT):

PNP & NPN BJT structures, current components in BJT, CE, CB, CC configurations, V-I Characteristics of CB & CE modes, regions of operation, Base width modulation & Early effect, thermal runaway, Concept of Biasing: DC load line, Q-point, basics of BJT amplifier operation, current amplification factors, different biasing circuits: fixed bias, collector to base bias, voltage divider bias.

Module III [9L]

Field Effect Transistors (FET):

hannel Junction Field Effect Transistor (JFET) structure & V-I characteristics.

Metal Oxide Semiconductor Field Effect Transistor (MOSFET): enhancement & depletion type

MOSFETs (for both n & p channel devices), drain & transfer characteristics.

MOSFET as a digital switch, CMOS inverter, voltage transfer characteristic (VTC), NAND & NOR gate realization using CMOS logic.
Moore's Law, evolution of process node, state of integration (SSI, MSI, LSI, VLSI, ULSI), Classification of Integrated circuits (IC) and their applications.

Module IV [9L]
Feedback in amplifiers:
Concept of feedback, advantages of negative feedback (qualitative), Barkhausen criteria.
Operational Amplifier:
Ideal OPAMP characteristics, OPAMP circuits: inverting and non-inverting amplifiers, Adder, Subtractor, Integrator, Differentiator, Basic Comparator.
Special Semiconductor Devices:
Light Emitting Diode (LED), Silicon Controlled Rectifier (SCR), Photodiode: Operations, characteristics & applications.

Books of reference:

1. Boylestad & Nashelsky, Electronic Devices & Circuit Theory.
2. R.A Gayakwad, Op Amps and Linear IC's, PHI.
3. D. Chattopadhyay, P. C Rakshit, Electronics Fundamentals and Applications.
4. Adel S. Sedra, Kenneth Carless Smith, Microelectronics Engineering.
5. Millman & Halkias. Integrated Electronics.
6. Salivahanan, Electronics Devices &Circuits.
7. Albert Paul Malvino, Electronic Principle.

LABORATORY

Subject Name: Physics-I Lab					
Paper Code: PHYS 1051					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

1. To gain practical knowledge by applying the experimental methods to correlate with the Physicstheory.
2. To learn the usage of electrical and optical systems for various measurements.
3. Apply the analytical techniques and graphical analysis to the experimental data.
4. Understand measurement technology, usage of new instruments and real time applications in engineering studies.
5. To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

Minimum of six experiments taking at least one from each of the following four groups:

Group 1: Experiments in General Properties of matter

1. Determination of Young's modulus by Flexure Method.
2. Determination of bending moment and shear force of a rectangular beam of uniform cross-section.
3. Determination of modulus of rigidity of the material of a rod by static method.
4. Determination of rigidity modulus of the material of a wire by dynamic method.
5. Determination of coefficient of viscosity by Poiseulle's capillary flow method.

Group 2: Experiments in Optics

1. Determination of dispersive power of the material of a prism.
2. Determination of wavelength of light by Newton's ring method.
3. Determination of wavelength of light by Fresnel's biprism method.
4. Determination of the wavelength of a given laser source by diffraction method.

Group 3: Electricity & Magnetism experiments

1. Determination of dielectric constant of a given dielectric material.
2. Determination of resistance of ballistic galvanometer by half deflection method and study of variation of logarithmic decrement with series resistance.
3. Determination of the thermo-electric power at a certain temperature of the given thermocouple.
4. Determination of specific charge (e/m) of electron.

Group 4: Quantum Physics Experiments

1. Determination of Planck's constant.
2. Determination of Stefan's radiation constant.
3. Verification of Bohr's atomic orbital theory through Frank-Hertz experiment.
4. Determination of Rydberg constant by studying Hydrogen/ Helium spectrum.

5. Determination of Hall co-efficient of semiconductors.

6. Determination of band gap of semiconductors.
7. To study current-voltage characteristics, load response, areal characteristics and spectral response of photo voltaic solar cells.

Books of reference:

1. Optics – Eugene Hecht Pearson Education India Private Limited.
2. David J. Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited.
3. N.K. Bajaj, Waves and Oscillations.
4. David Halliday, Robert Resnick Jearl Walker, Principles of Physics, 10ed, Wiley.
5. Wayne M. Saslow, Electricity, Magnetism, and Light, Academic Press.
6. Narayan Rana, Pramod Joag, Classical mechanics, McGraw Hill Education.
7. R Takwale, P Puranik, Introduction to Classical Mechanics, McGraw Hill Education.
8. Ghatak, Optics, McGraw Hill Education India Private Limited.
9. C.L. Arora, Refresher Course in B.Sc. Physics , Vol1 and Vol 2.

Subject Name: Workshop/Manufacturing Practices					
Paper Code: MECH 1051					
Contact	**L**	**T**	**P**	**Total**	**Credit Points**
Hours Per Week	**1**	**0**	**4**	**5**	**3**

Course Outcomes:

1. Upon completion of this course
2. The students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.
3. The students will be able to fabricate components with their own hands.
4. They will also get practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
5. By assembling different components, they will be able to produce small devices of their interest.
6. The students will be able to describe different components and processes of machine tools.
7. The students will be able to apply the knowledge of welding technology and they can perform arc and gas welding to join the material.

(i) Lectures & videos: (13 hours)
Detailed contents

1. Introduction on Workshop and Safety Precautions. **(1 lecture)**
2. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods **(3lectures)**
3. CNC machining, Additive manufacturing **(1lecture)**
4. Fitting operations & power tools **(1lecture)**
5. Electrical & Electronics **(1lecture)**
6. Carpentry **(1lecture)**
7. Plastic moulding, glass cutting **(1lecture)**
8. Metal casting **(1lecture)**
9. Welding (arc welding & gas welding),brazing **(2lecture)**
10. Viva-voce **(1 lecture)**

(ii) Workshop Practice :(52 hours)[L : 0; T:0 ; P : 4 (2credits)]

1. Machine shop **(12 hours)**
2. Fitting shop **(8hours)**
3. Carpentry **(4hours)**
4. Electrical & Electronics **(4hours)**
5. Welding shop **(Arc welding 4 hrs + gas welding4 hrs)** **(8hours)**
6. Casting **(4hours)**

7. Smithy **(4hours)**

8. Plastic moulding & Glass Cutting **(4hours)**

9. Sheetmetal Shop **(4hours)**

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Books of reference:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., Elements of Workshop Technology, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. And Steven S. Schmid, Manufacturing Engineering and Technology, 4th edition, Pearson Education India Edition, 2002.
3. Gowri P. Hariharan and A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2008.
4. Roy A. Lindberg, Processes and Materials of Manufacture, 4th edition, Prentice Hall India, 1998.
5. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGrawHill House, 2017.

Subject Name: Programming for Problem Solving Lab					
Paper Code: CSEN 1051					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**4**	**4**	**2**

Course Outcomes:

After completion of this course the students should be able:

1. To write simple programs relating to arithmetic and logical problems.
2. To be able to interpret, understand and debug syntax errors reported by the compiler.
3. To implement conditional branching, iteration (loops) and recursion.
4. To decompose a problem into modules (functions) and amalgamating the modules to generate a complete program.
5. To use arrays, pointers and structures effectively in writing programs.
6. To be able to create, read from and write into simple text files.

Software to be used: GNU C Compiler (GCC) with LINUX
NB: Cygwin (Windows based) may be used in place of LINUX

Topic 1: LINUX commands and LINUX based editors
Topic 2: Basic Problem Solving
Topic 3: Control Statements (if, if-else, if-elseif-else, switch-case)
Topic 4: Loops - Part I (for, while, do-while)
Topic 5: Loops - Part II
Topic 6: One Dimensional Array
Topic 7: Array of Arrays
Topic 8: Character Arrays/ Strings
Topic 9: Basics of C Functions
Topic 10: Recursive Functions
Topic 11: Pointers
Topic 12: Structures
Topic 13: File Handling

Text Books:

1. Byron Gottfried, Schaum's outline of Programming with C.
2. Herbert Schildt, Teach Yourself C.
3. E Balagurusamy, Programming in ANSI C.

Subject Name: Basic Electronics Engineering Lab					
Paper Code: ECEN 1061					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**2**	**2**	**1**

Course Outcomes:

1. The students will correlate theory with diode behavior.
2. They will design and check rectifier operation with regulation etc.
3. Students will design different modes with BJT and FET and check the operations.
4. They will design and study adder, integrator etc. with OP-AMPs.

List of Experiments (from)

1. Familiarization with passive and active electronic components such as Resistors, Inductors, Capacitors, Diodes, Transistors (BJT) and electronic equipment like DC power supplies, multi-meters etc.
2. Familiarization with measuring and testing equipment like CRO, Signal generators etc.
3. Study of I-V characteristics of Junction diodes.
4. Study of I-V characteristics of Zener diodes.
5. Study of Half and Full wave rectifiers with Regulation and Ripple factors.
6. Study of I-V characteristics of BJTs Effect Transistors.
7. Determination of input-offset voltage, input bias current in CB mode
8. Study of I-V characteristics of BJTs in CE mode
9. Study of I-V characteristics of Field
10. and Slew rate of OPAMPs.
11. Determination of Common-mode Rejection ratio, Bandwidth and Off-set null of OPAMPs.
12. Study of OPAMP circuits: Inverting and Non-inverting amplifiers, Adders, Integrators and Differentiators.

1st Year 2nd Semester (Semester 2)

THEORY

Subject Name: Mathematics- II					
Paper Code: MATH 1201					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**1**	**0**	**4**	**4**

Course Outcomes:

After successfully completing this course the students will be able to:

1. Demonstrate the knowledge of probabilistic approaches to solve wide range of engineering problem.
2. Recognize probability distribution for discrete and continuous variables to quantify physical and engineering phenomenon.
3. Develop numerical techniques to obtain approximate solutions to mathematical problems where analytical solutions are not possible to evaluate.
4. Analyze certain physical problems that can be transformed in terms of graphs and trees and solving problems involving searching, sorting and such other algorithms.
5. Apply techniques of Laplace Transform and its inverse in various advanced engineering problems.
6. Interpret differential equations and reduce them to mere algebraic equations using Laplace Transform to solve easily.

Module I [10L]

Basic Probability:

Random experiment, Sample space and events, Classical and Axiomatic definition of probability, Addition and Multiplication law of probability, Conditional probability, Bayes' Theorem, Random variables, General discussion on discrete and continuous distributions, Expectation and Variance, Examples of special distribution: Binomial and Normal Distribution.

Module II [10L]

Basic Numerical Methods:

Solution of non-linear algebraic and transcendental equations: Bisection Method, Newton-Raphson Method, Regula-Falsi Method. Solution of linear system of equations: Gauss Elimination Method, Gauss-Seidel Method, LU Factorization Method, Matrix Inversion Method. Solution of Ordinary differential equations: Euler's Method, Modified Euler's Method, Runge-Kutta Method of 4th order.

Module III [10L]

Basic Graph Theory:

Graph, Digraph, Weighted graph, Connected and disconnected graphs, Complement of a graph, Regular graph, Complete graph, Sub-graph, Walk, Path, Circuit, Euler Graph, Cut sets and cut vertices, Matrix representation of a graph, Adjacency and incidence matrices of a graph, Graph isomorphism, Bipartite graph, Dijkstra's Algorithm for shortest path problem. Definition and properties of a Tree, Binary tree and its properties, Spanning tree of a graph, Minimal spanning tree, Determination of spanning trees using BFS and DFS algorithms, Determination of minimal spanning tree using Kruskal's and Prim's algorithms.

Module IV [10L]

Laplace Transformation:

Basic ideas of improper integrals, working knowledge of Beta and Gamma functions (convergence to be assumed) and their interrelations. Introduction to integral transformation, Functions of exponential order, Definition and existence of Laplace Transform(LT) (statement of initial and final value theorem only), LT of elementary functions, Properties of Laplace Transformations , Evaluation of sine , cosine and exponential integrals using LT, LT of periodic and step functions, Definition and properties of inverse LT, Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of linear ODEs with constant coefficients (initial value problem) using LT

Books of reference:

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley Publications.
2. S. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier.
3. S.S. Sastry, Introductory methods of Numerical Analysis, PHI learning.
4. D. B. West, Introduction to Graph Theory, Prentice-Hall of India.
5. B.S. Grewal, Engineering Mathematics, S. Chand &Co.

Subject Name: Chemistry 1					
Paper Code: CHEM 1001					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**1**	**0**	**4**	**4**

Course Outcomes:

The subject code CHEM1001 corresponds to chemistry theory classes for the first year B. Tech students, which is offered as Engineering Chemistry and is common for all branches of engineering subjects. The course provides basic knowledge of theory based subjects like quantum mechanics, thermodynamics, reaction dynamics, electrochemistry, structure and reactivity of molecules. The course outcomes of the subject tare

1. Knowledge of understanding the operating principles and reaction involved in batteries and fuel cells and their application in automobiles as well as other sectors to reduce environmental pollution.
2. An ability to analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces for engineering applications.
3. Have knowledge of synthesizing nano materials and their applications in industry, carbon nano tube technology is used in every industry now-a-days.
4. Understanding of bulk properties and processes using thermodynamic considerations.
5. Elementary knowledge of IR, UV, NMR and X-ray spectroscopy is usable in structure elucidation and characterisation of various molecules.
6. Knowledge of electronic effect and stereochemistry for understanding mechanism of the major chemical reactions involved in synthesis of various drug molecules.

Module 1 [10L]

Atomic structure and Wave Mechanics:

Brief outline of the atomic structure, Duel character of electron, De Broglies's equation, the Heisenberg uncertainty principle, brief introduction of quantum mechanics, the Schrodinger wave equation, Hermitian operator, solution of the Schrodinger equation for particle in a one dimensional box, interpretation of the wave function Ψ, concept of atomic orbital.

Thermodynamics:

Carnot cycle, 2nd law of thermodynamics, entropy, Clausius inequality, free energy and work function, Clausius Clapeyron Equation, Chemical Potential, Activity and Activity coefficient. Gibbs Duhem Relation.

Spectroscopic Techniques & Application:

Electromagnetic spectrum: EMR interaction with matter - absorption and emission of radiation.
Principle and application of UV- visible and IR spectroscopy
Principles of NMR Spectroscopy and X-ray diffraction technique.

Module II [10L]

Chemical Bonding:

Covalent bond, VSEPR Theory, hybridization, molecular geometries, Dipole moment, Intermolecular forces, V.B. and M.O. Theory and its application in Homo and Heteronuclear

diatomic molecules, Band theory of solids, Pi-molecular orbitals of ethylene and butadiene.

Periodicity:
Effective nuclear charge, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electro-negativity, inert pair effect.
Ionic Equilibria:
Acid Base Equilibria, Salt Hydrolysis and Henderson Equation, Buffer solutions, pH indicator, Common ion Effect, Solubility product, Fractional Precipitation .

Module III [10L]
Conductance:
Conductance of electrolytic solutions, Strong and Weak electrolytes, effect of temperature and concentration. Kohlrausch's law of independent migration of ions, transport numbers and hydration of ions. Application of conductance Acid-base and precipitation titration.
Electrochemical Cell:
Thermodynamic derivation of Nernst equation, Electrode potential and its application to predict redox reaction; Standard Hydrogen Electrode, Reference electrode, cell configuration, half cell reactions, evaluation of thermodynamic functions; Reversible and Irreversible cells; Electrochemical corrosion.
Electrochemical Energy Conversion: Primary & Secondary batteries, Fuel Cells.
Reaction dynamics:
Rate Laws, Order & Molecularity; zero, first and second order kinetics. Pseudo-unimolecular reaction, Arrhenius equation.
Mechanism and theories of reaction rates (Transition state theory, Collison theory).
Catalysis: Homogeneous catalysis (Definition, example, mechanism, kinetics).

Module IV [10L]
Stereochemistry:
Representations of 3-dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis.
Structure and reactivity of Organic molecule:
Inductive effect, resonance, hyper conjugation, electromeric effect, carbocation, carbanion, free radicals, aromaticity.
Organic reactions and synthesis of drug molecule:
Introduction to reaction mechanisms involving substitution, addition, elimination and oxidation-reduction reactions. Synthesis of commonly used drug molecules.

Text Books:

1. P.W. Atkins, Atkins' Physical Chemistry, 10thEdition.
2. I. L. Finar, Organic Chemistry, Vol-1, 6thEdition.
3. Jain & Jain, Engineering Chemistry, 16thEdition.
4. A. K. Das, Fundamental Concepts of Inorganic Chemistry, 2ndEdition.
5. Gourkrishna Dasmohapatra, Engineering Chemistry -I, 3rdEdition.

Books of reference:

1. R. P. Sarkar, General & Inorganic Chemistry.
2. P. C. Rakshit, Physical Chemistry, 7th Edition.
3. Morrison & Boyd, Organic Chemistry, 7th Edition.
4. C.N. Banwell, Fundamentals of Molecular Spectroscopy, 4th Edition.
5. G. W. Castellan, Physical Chemistry, 3rd Edition.
6. Subrata Sen Gupta, Basic Stereo chemistry of Organic Molecules, 1st Edition.

Subject Name: Basic Electrical Engineering					
Paper Code: ELEC 1001					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**1**	**0**	**4**	**4**

Course Outcomes:

After attending the course, the students will be able to

1. Analyse DC electrical circuits using KCL, KVL and network theorems like Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.
2. Analyse DC Machines; Starters and speed control of DC motors.
3. Analyse magnetic circuits.
4. Analyse single and three phase AC circuits.
5. Analyse the operation of single phase transformers.
6. Analyse the operation of three phase induction motors.

Module-I [11L]

DC Network Theorem:

Kirchhoff's laws, Nodal analysis, Mesh analysis, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Star-Delta conversion.

Electromagnetism:

Review of magnetic flux, Force on current carrying conductors, Magnetic circuit analysis, Self and Mutual inductance, B-H loop, Hysteresis and Eddy current loss, Lifting power of magnet.

Module II [10L]

AC single phase system:

Generation of alternating emf, Average value, RMS value, Form factor, Peak factor, representation of an alternating quantity by a phasor, phasor diagram, AC series, parallel and series-parallel circuits, Active power, Reactive power, Apparent power, power factor, Resonance in RLC series and parallel circuit.

Module III [11L]

Three phase system:

Generation of three-phase AC power, Balanced three phase system, delta and star connection, relationship between line and phase quantities, phasor diagrams, power measurement by two wattmeter method.

DC Machines:

Construction, EMF equation, Principle of operation of DC generator, Open circuit characteristics, External characteristics, Principle of operation of DC motor, speed-torque characteristics of shunt and series machine, starting of DC motor, speed control of DC motor.

Module IV [10L]

Transformer:

Construction, EMF equation, no load and on load operation and their phasor diagrams, Equivalent circuit, Regulation, losses of a transformer, Open and Short circuit tests, Efficiency, Introduction to three phase transformer.

Three-phase induction motor:

Concept of rotating magnetic field, Principle of operation, Construction, Equivalent circuit and phasor diagram, torque-speed/slip characteristics.

Text Books:

1. D.P Kothari & I.J Nagrath, Basic Electrical engineering, TMH, Second Edition.
2. V.N Mittle & Arvind Mittal, Basic Electrical Engineering, TMH, Second Edition.
3. Hughes, Basic Electrical Engineering.
4. Surinder Pal Bali, Electrical Technology, Pearson Publication, Vol-I, Vol-II,
5. B.L. Theraja, A.K. Theraj, A Text Book of Electrical Technology, S. Chand & Company, Vol. I & II.

Books of reference:

1. Vincent Del Toro, Electrical Engineering Fundamentals, Prentice-Hall.
2. H. Cotton, Advance Electrical Technology, Reem Publication.
3. R.A. Natarajan, P.R. Babu, Basic Electrical Engineering, Sictech Publishers.
4. N.K. Mondal, Dhanpat Rai, Basic Electrical Engineering.
5. Nath & Chakraborti, Basic Electrical Engineering.
6. Rajendra Prasad, Fundamental of Electrical Engineering, PHI, Edition2005.

Subject Name: Business English					
Paper Code: HMTS 1202					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**2**	**0**	**0**	**2**	**2**

Course Outcomes:
The learner will

1. Acquire competence in using English language to communicate.
2. Be aware of the four essential skills of language usage-listening, speaking, reading and writing.
3. Be adept at using various modes of written communication at work.
4. Attain the skills to face formal interview sessions.
5. Write reports according to various specifications.
6. Acquire the skill to express with brevity and clarity.

Module I
Grammar (Identifying Common Errors in Writing)

- Subject-verb agreement.
- Noun-pronoun agreement.
- Misplaced Modifiers.
- Articles.
- Prepositions.
- Redundancies.

Module II
Basic Writing Strategies
Sentence Structures

- Use of phrases and clauses in sentences.
- Creating coherence.
- Organizing principles – accuracy, clarity, brevity.
- Techniques for writing precisely.
- Different styles of writing: descriptive, narrative, expository.
- Importance of proper punctuation.

Module III
Business Communication- Scope & Importance.
Writing Formal Business Letters:
Form and Structure-Parts of a Business letter, Business Letter Formats, Style and Tone, Writing strategies.
Organizational Communication:
Agenda & minutes of a meeting, Notice, Memo, Circular Organizing e-mail messages, E-mail etiquette.
Job Application Letter:
Responding to Advertisements and Forced Applications, Qualities of well-written Application

Letters: The You-Attitude, Length, Knowledge of Job Requirement, Reader-Benefit Information,

Organization, Style, Mechanics – Letter Plan: Opening Section, Middle Section, Closing Section

Resume and CV:

Difference, Content of the Resume – Formulating Career Plans: Self Analysis, Career Analysis, Job Analysis, Matching Personal Needs with Job Profile – Planning your Resume – Structuring the Resume: Chronological Resume, The Functional Resume, Combination of Chronological and Functional Resume, Content of the Resume: Heading, Career Goal or Objectives, Education, Work Experience, Summary of Job Skills/Key Qualifications, Activities, Honors and Achievements, Personal Profile, Special Interests, References.

Module IV

Writing skills

- Comprehension: Identifying the central idea, inferring the lexical and contextual meaning, comprehension passage –practice.
- Paragraph Writing: Structure of a paragraph, Construction of a paragraph, Features of a paragraph, Writing techniques/developing a paragraph.
- Précis: The Art of Condensation-some working principles and strategies. Practice sessions of writing précis of given passages.
- Essay Writing: Characteristic features of an Essay, Stages in Essay writing, Components comprising an Essay, Types of Essays-Argumentative Essay, Analytical Essay, Descriptive Essays, Expository Essays, Reflective Esseays.

Books of reference:

1. Armand Matterlart and Michele Matterlart, Theories of Communication: A Short Introduction, Sage Publications Ltd.
2. Chan, Janis Fisher and Diane Lutovich, Professional Writing Skills, San Anselmo, CA: Advanced Communication Designs.
3. Hauppauge, Geffner, Andrew P. Business English, New York: Barron's Educational Series.
4. Kalia, S. & Agarwal, S. Business Communication, Wiley India Pvt. Ltd., New Delhi, 2015.
5. Mukherjee, H.S., Business Communication- Connecting at work, Oxford University Press.2nd Edition.2015.
6. Raman, M. and Sharma, S., Technical Communication: Principles and Practice, 2nd Ed., 2011.

Subject Name: Communication for Professionals					
Paper Code: HMTS 1011					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

Students will be able to

1. Write business letters and reports.
2. Communicate in an official and formal environment.
3. Effectively use the various channels of communication at workplace.
4. Use language as a tool to build bridges and develop interpersonal relations in multi-cultural environment.
5. Learn to articulate opinions and views with clarity.
6. Use various techniques of communication for multiple requirements of globalized workplaces.

Module I

Introduction to Linguistics:

- Introduction to Linguistics.
- Phonetics- Vowel and Consonant Sounds (Identification &Articulation).
- Word- stress, stress in connected speech.
- Intonation (Falling and Rising Tone).
- Voice Modulation.
- Accent Training.
- Vocabulary Building.
- The concept of Word Formation.
- Root words from foreign languages and their use in English.
- Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
- Synonyms, Antonyms and standard abbreviations.

Module II

Communication Skills:

- Definition, nature & attributes of Communication.
- Process of Communication.
- Models or Theories of Communication.
- Types of Communication.
- Levels or Channels of Communication.
- Barriers to Communication.

Module III

Professional Writing Skills:

- Letter Writing: Importance, Types, Process, Form and Structure, Style and Tone.
- Proposal Writing: Purpose, Types of Proposals, Structure of Formal Proposals.

- Report Writing: Importance and Purpose, Types of Reports, Report Formats, Structure of Formal Reports, Writing Strategies.

Module IV

Communication skills at Workplace:

- Communication and its role in the workplace.
- Benefits of effective communication in the workplace.
- Common obstacles to effective communication.
- Approaches and Communication techniques for multiple needs at workplace: persuading, convincing, responding, resolving conflict, delivering bad news, making positive connections.
- Identify common audiences and design techniques for communicating with each audience.

Books of reference:

1 Kumar, S. & Lata, P. Communication Skills, OUP, New Delhi,2011.
2 Rizvi, Ashraf, M. Effective Technical Communication, Mc Graw Hill Education (India) Pvt. Ltd.Chennai, 2018.
3 Raman, M. and Sharma, S., Technical Communication: Principles and Practice, 2nd Ed., 2011.

LABORATORY

Subject Name: Chemistry I Lab					
Paper Code: CHEM 1051					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**3**	**3**	**1.5**

Course Outcomes:

The subject code CHEM1051 corresponds to chemistry laboratory classes for the first year B. Tech students. This course enhances the students' experience regarding handling of various chemicals along with various laboratory equipments. Hands on experiments increase the depth of knowledge that is taught in the theory classes as well as it increases research aptitude in students because they can see the direct application of theoretical knowledge in practical field. The course outcomes of the subject are

1. Knowledge to estimate the hardness of water which is required to determine the usability of water used inindustries.
2. Estimation of ions like Fe^{2+}, Cu^{2+} and Cl^- present in water sample to know the composition of industrial water.
3. Study of reaction dynamics to control the speed and yield of various manufactured goods produced in polymer, metallurgical and pharmaceutical industries.
4. Handling physico-chemical instruments like viscometer, stalag mometer, pH-meter, potentiometer and conductometer.
5. Understanding the miscibility of solutes in various solvents required in paint, emulsion, biochemical and material industries.
6. Knowledge of sampling water can be employed for water treatment to prepare pollution free water.

List of Experiments:

1. Estimation of iron using $KMnO_4$: selfindicator.
2. Iodometric estimation of Cu^{2+}.
3. Determination of Viscosity.
4. Determination of surface tension.
5. Adsorption of acetic acid by charcoal.
6. Potentiometric determination of redox potentials.
7. Determination of total hardness and amount of calcium and magnesium separately in a given water sample.
8. Determination of the rate constant for acid catalyzed hydrolysis of ethyl acetate.
9. Heterogeneous equilibrium (determination of partition coefficient of acetic acid in n-butanol and water mixture).
10. Conductometric titration for the determination of strength of a given HCl solution against a standard NaOH solution.
11. pH-metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
12. Determination of chloride ion in a given water sample by Argentometric method (using chromate indicator solution).

Books of reference:

1. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis.
2. S. C. Das., Advanced Practical Chemistry.
3. P. S. Sindhu, Practicals in Physical Chemistry.

Subject Name: Language lab					
Paper Code: HMTS 1252					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**2**	**2**	**1**

Course Outcomes:

The learner will

1. Acquire the techniques to become an effective listener.
2. Acquire the skill to become an effortless speaker.
3. Organize and present information for specific audience.
4. Communicate to make a positive impact in professional and personal environment.
5. Engage in research and prepare authentic, formal, official documents.
6. Acquire reading skills for specific purpose.

Module I

Listening Skills

- Principles of Listening: Characteristics, Stages.
- Types of Listening: Passive listening, Marginal or superficial listening, Projective Listening, Sensitive or Empathetic Listening, Active or Attentive listening.
- Guidelines for Effective Listening.
- Barriers to Effective Listening.
- Listening Comprehension.

Module II

- Interviewing
  Types of Interviews, Format for Job Interviews: One-to-one and Panel Interviews, Telephonic Interviews, Interview through video conferencing.
- Interview Preparation Techniques, Frequently Asked Questions, Answering Strategies, Dress Code, Etiquette, Questions for the Interviewer, Simulated Interviews.

Module III

- Public Speaking: The Speech Process: The Message, The Audience, The Speech Style, Encoding, Feedback.
- Characteristics of a good speech : content and delivery, structure of a speech
- Modes of delivery in public speaking: Impromptu, Extemporaneous, Prepared or Memorized, Manuscript.
- Conversation: Types of conversation: formal and informal, Strategies for effective conversation, Improving fluency.
- Situational conversation practice: Greetings and making introductions, Asking for information and giving instructions, agreeing and disagreeing.
- Conversational skills in the business scenario: One-to-one and Group communication, Gender and Culture Sensitivity, Etiquette, Sample Business Conversation, Telephonic Conversation.

Module IV

Presentation Skills

- Speaking from a Manuscript, Speaking from Memory, Impromptu Delivery, Extemporaneous Delivery, Analyzing the Audience, Nonverbal Dimensions of Presentation.
- Organizing the Presentation: The Message Statement, Organizing the Presentation: Organizing the Speech to Inform, The Conclusion, Supporting Your Ideas – Visual Aids: Designing and Presenting Visual Aids, Selecting the Right Medium.
- Project Team/Group Presentations.

Books of reference:

1. Carter, R. And Nunan, D. (Eds), The Cambridge guide to Teaching English to Speakers of Other Languages, CUP, 2001.
2. Edward P. Bailey, Writing and Speaking At Work: A Practical Guide for Business Communication, Prentice Hall, 3rd Ed., 2004.
3. Munter, M., Guide to Managerial Communication: Effective Business Writing and Speaking, Prentice Hall, 5th Ed., 1999.
4. Sen, S, Mahendra, A. & Patnaik, P, Communication and Language Skills, Cambridge University Press, 2015.
5. Locker, Kitty O. Business and Administrative Communication McGraw-Hill/Irwin.
6. Chaney, L. and Martin, J., Intercultural Business Communication. Prentice Hall.

Subject Name: Engineering Drawing & Design					
Paper Code: MECH 1052					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**1**	**0**	**4**	**5**	**3**

Course Outcomes:

After going through the course, the students will be able

1. To understand the meaning of engineering drawing.
2. To have acquaintance with the various standards (like lines, dimensions, scale etc.) and symbols followed in engineering drawing.
3. To represent a 3-D object into 2-D drawing with the help of orthographic and isometric projections.
4. To read and understand projection drawings.
5. To draw the section view and true shape of a surface when a regular object is cut by a section plane.
6. To use engineering drawing software (CAD).

Lecture Plan [13 L]

1. Importance and principles of engineering drawing (1 L)
2. Concepts of Conic sections and Scale (1 L)
3. Introduction to concept of projection (Projections of points, lines and surfaces) (4 L)
4. Definitions of different solids and their projections (1 L)
5. Section of solids and sectional view (1 L)
6. Isometric projection (2 L)
7. Introduction to CAD (2 L)
8. Viva Voce (1 L)

Module I

Introduction to Engineering Drawing covering:

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lines, lettering & dimensioning, Conic section like Ellipse (General method only); Involute; Scales – Plain, Diagonal.

Module II

Orthographic Projections covering:

Principles of Orthographic Projections - Conventions - Projections of Points and lines inclined to both planes; Projections on Auxiliary Planes. Projection of lamina.

Module III

Projections of Regular Solids covering:

Those inclined to both the Planes- Auxiliary Views.

Module IV

Sections and Sectional Views of Right Angular Solids covering:

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids**.**

Module V
Isometric Projections covering:
Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions.

Module VI
Overview of Computer Graphics covering:
listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids.

Module VII
Customisation & CAD Drawing:
consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.

Module VIII
Annotations, layering & other functions covering:
applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation.

Module IX
Demonstration of a simple team design project that illustrates:
Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame.

Books of reference:

1. Bhatt, N.D., Panchal V.M. & Ingle P.R., Elementary Engineering Drawing, Charotan Publishing House, 2014.
2. Narayana, K.L. and Kannaaiah P Engineering Graphics, TMH.
3. Lakshminarayanan, V. and Vaish Wanar, R.s Engineering Graphics, Jain Brothers.
4. Shah, M.B. & Rana B.C., Engineering Drawing and Computer Graphics, Pearson Edication, 2008.
5. Agarwal B. & Agarwal C. M., Engineering graphics, TMH Publications, 2012.

Subject Name: Basic Electrical Engineering Lab					
Paper Code: ELEC 1051					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**2**	**2**	**1**

Course Outcomes:

The students are expected to

1. Get an exposure to common electrical apparatus and their ratings.
2. Make electrical connections by wires of appropriate ratings.
3. Understand the application of common electrical measuring instruments.
4. Understand the basic characteristics of different electrical machines.

List of Experiments:

1. Characteristics of Fluorescent lamps.
2. Characteristics of Tungsten and Carbon filament lamps.
3. Verification of the Venin's & Norton's theorem.
4. Verification of Superposition theorem.
5. Verification of Maximum Power Transfer theorem.
6. Calibration of ammeter and voltmeter.
7. Open circuit and Short circuit test of a single phase Transformer.
8. Study of R-L-C Series / Parallel circuit.
9. Starting and reversing of speed of a D.C. shunt Motor.
10. Speed control of DC shunt motor.
11. No load characteristics of D.C shunt Generators.
12. Measurement of power in a three phase circuit by two wattmeter method.

Subject Name: Professional Communication Lab					
Paper Code: HMTS 1061					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**2**	**2**	**1**

Course Outcomes:

Students will be skilled in the following areas

1. Communicate in an official and formal environment.
2. Effectively communicate in a group and engage in relevant discussion.
3. Engage in research and prepare presentations on selected topics.
4. Understand the dynamics of multicultural circumstances at workplace and act accordingly.
5. Organize content in an attempt to prepare official documents.
6. Appreciate the use of language to create beautiful expressions

Module I

Techniques for Effective Speaking.
Voice Modulation: Developing correct tone.
Using correct stress patterns: word stress, primary stress, secondary stress.
Rhythm in connected speech.

Module II

Effective Speaking and Social awareness
The Art of Speaking

- Encoding Meaning Using Nonverbal Symbols.
- How to Improve Body Language.
- Eye Communication, Facial Expression, Dress and Appearance.
- Posture and Movement, Gesture, Paralanguage.
- Encoding meaning using Verbal symbols: How words work and how to use words.
- Volume, Pace, Pitch and Pause.
- Cross-Cultural Communication: Multiple aspects/dimensions of culture.
- Challenges of cross-cultural communication.
- Improving cross-cultural communication skills at workplace.

Module III

Group Discussion: Nature and purpose

- Group Discussion: Nature and purpose.
- Characteristics of a successful Group Discussion.
- Group discussion Strategies: Getting the GD started, contributing systematically, moving the discussion along, promoting optimal participation, Handling conflict, Effecting closure.

Module IV

Professional Presentation Skills

Nature and Importance of Presentation skills.

Planning the Presentation: Define the purpose, analyze the Audience, Analyze the occasion and choose a suitable title.
Preparing the Presentation: The central idea, main ideas, collecting support material, plan visual aids, design the slides.
Organizing the Presentation: Introduction-Getting audience attention, introduce the subject, establish credibility, preview the main ideas, Body-develop the main idea, present information sequentially and logically, Conclusion-summaries, re-emphasize, focus on the purpose, provide closure.
Improving Delivery: Choosing Delivery methods, handling stage fright
Post-Presentation discussion: Handling Questions-opportunities and challenges.

Books of reference:

1. Carter, R. And Nunan, D. (Eds), The Cambridge guide to Teaching English to Speakers of Other Languages, CUP, 2001.
2. Edward P. Bailey, Writing and Speaking At Work: A Practical Guide for Business Communication, Prentice Hall, 3rd Ed., 2004.
3. Munter, M., Guide to Managerial Communication: Effective Business Writing and Speaking, Prentice Hall, 5th Ed., 1999.
4. R. Anand, Job Readiness For IT & ITES- A Placement and Career Companion, McGraw Hill Education.2015.
5. Malhotra, A., Campus Placements, McGraw Hill Education.2015.

2nd Year 1st Semester (Semester3)

THEORY

Subject Name: Particle and Fluid Particle Processing					
Paper Code: CHEN 2101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:

1. Calculate average particle diameters for a mixture of solid particles and select different screens according to specifications.
2. Select the type of crusher/grinder for a particular comminution operation and calculate the energy consumption.
3. Calculate drag force and terminal settling velocity for single particles.
4. Select the type of classifier required for a given operation and given a particular thickening operation, design the thickener required.
5. Calculate power consumption for an agitation operation and scale up the agitator as per the problem given.
6. Analyze filtration data and select filtration equipment based on requirements.

Module I [10L]
Characterization of particulate solids:
particle size, shape and particle size distribution; concepts of mass-mean diameter, volume-surface-mean diameter, arithmetic-mean diameter and volume- mean diameter, specific surface area of a mixture of solid particles, measurement of specific surface area of a mixture of particles.
Screen analysis:
concept of mesh number, types of standard screens, differential and cumulative analysis, concept of cut diameter and screen efficiency; industrial screening equipment eg. stationary screens, vibratory screens, grizzlies and trammels.
Handling and storage of solids:
Operation and performance criteria of screw, belt, pipe, apron and flight conveyors, bucket elevators. Operation of pneumatic and hydraulic conveyors. Storage of solids in bins, silos and hoppers.

Module II [10L]
Comminution (size reduction) of solids:
Different forces for comminution, laws of comminution - Rittinger's law, Kick's law, Bond's law and their validity limits, crushing efficiency and power consumption.
Primary crushing equipment: Blake jaw crusher, gyratory crusher, Taggart's law.
Secondary crushers:
Smooth and toothed roll crushers, concepts of nipping and angle of nip.
Grinders:
Operation of ball mill, critical speed of ball mil, operation of rod mill and hammer mill,

applicability of these mills for different sizes of feed, vertical roller mill and attrition mill, concepts of dry and wet grinding.

Ultrafine grinders:
Colloid mill and fluid-energy mill, Close-circuit and Open-circuit size reduction.
Size enlargement:
Nucleation and growth of particles, Extrusion of solids.

Module III [10L]
Flow of particles in fluids:
Concepts of drag, boundary layer separation, skin and form drag, drag correlations.
Gravitational settling of particles:
Concepts of terminal settling velocity, Stokes's law and Newton's law regimes of settling, free and hindered settling, Richardson-Zaki equation, use of gravitational settling for solid-fluid separation, settling tank and its design principles, spitzkasten, elutriator and rake classifier, clarification and thickening, operation of Lamelar clarifiers, Hirate thickeners, design of continuous thickener using Kynch theory.
Flow through packed bed:
Ergun and Kozeny Carman equation, Darcy's law and permeability, Blaine's apparatus.
Agitation and Mixing:
Agitation equipment, different types of agitators, flow patterns in agitation, calculation of power consumption in agitated vessels, scale up of agitated vessels using concepts of geometric, kinematic and dynamic similarity, Mixing effectiveness and mixing index, solid-solid mixing equipment.
Froth flotation:
Theory, operation, flotation agents.

Module IV [10L]
Solid-liquid filtration:
Cake and clarifying filters, constant pressure and constant rate filtration, compressible and incompressible filter cakes, pressure drop through filter cake; Operation of plate and frame filter press, cake washing and filtration cycle; continuous filtration, operation of a rotary drum vacuum filter, filter aids and filter media; Centrifugal filtration.
Solid-gas filtration:
Bag filters and electrostatic filters - design principles.
Centrifugal separation:
Design and operation of cyclone separators and hydrocyclones.
Introduction to nanoparticles:
Properties, characterization, synthesis methods and applications.

Text Books:

1. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
2. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.

Books of reference:

1. Kulkarni A.P. & Hiremath R.S., Mechanical Operations – Unit Operations of Chemical Engineering (Volume 1), Everest Publishing House.
2. Gavhane K.A. Unit Operations-I, Fluid Flow & Mechanical Operation, Nirali Prakashan, 2019.

Subject Name: Chemical Engineering Fluid Mechanics					
Paper Code: CHEN 2102					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to equip students with fundamental concept of fluid mechanics so that the students can develop understanding related to fluid statics as well as dynamics of fluid flow. The students will be capable to apply concepts of mass, momentum and energy conservation to various fluid flow encountered in industrial and other sectors. After completion of the course students will be able to:

1. Analyze the continuum concept of fluid and to categorize Newtonian and non-Newtonian fluids.
2. Determine force on submerged bodies and analyze working principle of manometric devices.
3. Apply continuity equation, momentum balance equation, Bernoulli's equation to solve engineering problems on fluid flow.
4. Categorize different flow measuring devices as well as fluid moving devices used in various engineering applications.
5. Determine terminal velocity and settling regime in case of motion of particles through fluids.
6. Estimate pressure drop in a packed bed and apply knowledge of fluidization in industrial applications.

Module I [10L]

Fundamental Concepts: Introduction to Fluid mechanics:

Definition of Fluid, Continuum concept of fluid, concept of Knudsen number. Shear stress field, Rheological properties of fluids.

Fluid Statics:

Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices– manometer, U-tube, inclined tube, force on submerged bodies (straight, inclined), centre of pressure.

Fluid kinematics:

Eulerian and Lagrangian approach, Streamline, pathline, timeline, streak line.

Fluid dynamics:

Velocity field, mass, volumetric flow rate, dimensionality of flow; stress field; Reynolds number —its significance, laminar, transition and turbulent flows, steady, unsteady and uniform, non-uniform flows.

Boundary layers:

Flow in boundary layers, transition length for laminar and turbulent flow, boundary layer separation.

Module II [10L]

Basic laws for a system; relation of system derivatives to the control volume ; conservation of

mass; continuity equation.

Momentum balance equation:
Derivation of Equation of motion, Introduction to Navier - Stokes equation in rectangular, cylindrical coordinates and its applications, Couette flow, Introduction to rotational and irrotational flow.
Mechanical Energy equation:
Introduction to Bernoulli's equation, Euler's Equation, kinetic energy correction factor, momentum correction factor, pump work in Bernoulli's equation.
Internal incompressible viscous flow:
Velocity distribution of fluid flowing in a closed conduit – local, average, maximum velocity. Turbulent flow- universal velocity distribution laws, Reynolds stress, Prandtl's mixing length.
Head loss in different flow condition:
Hagen Poiseuille equation, Fanning's equation, friction factor, Moody's diagram, effect of roughness, friction from changes in velocity or direction.

Module III [10L]
Flow measurement:
Introduction; Orifice meter; Venturimeter;
Concept of area meters:
rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flow meter.
Open channel flow:
Introduction, Flow classification, importance of Froude number, Chezy formula, Manning roughness correction, flow measurement by weirs.
Fluid moving machines:
Introduction;
Basic classification of pumps:
Non-Mechanical Pumps— acid egg, steam jet ejector, air lift pump,
Mechanical pump: Centrifugal pumps - cavitation, NPSH, basic characteristics curves for centrifugal pumps, positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; parallel operation of Centrifugal pumps; system resistance curves; fan, blower and compressor.
Valves and fittings:
Pipe fittings and valves, schedule no, equivalent diameter.

Module IV [10L]
Flow past immersed bodies:
Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body.
Flow through beds of solids:
Concept of sphericity; Ergun equation, modified friction factor.
Motion of particles through fluids:
Terminal velocity, criteria for settling regime.
Fluidization:
Introduction; different types of fluidization; minimum fluidization velocity; governing equation; advantages and disadvantage, industrial applications.

Introduction to compressible flow:

Concept of speed of sound, Mach number, subsonic, sonic, supersonic flow.

Text books:

1. Pritchard P.J., Fox and McDonald's Introduction to Fluid Mechanics, , John Wiley & Sons Inc., 8th edition,2011.
2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Books of reference:

1. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.
2. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.
3. Karassik I.J., Messina J. P., Cooper P. & Heald C. C. Pump Handbook, McGraw Hill, 4th Edition.
4. Singh S. Fluid Mechanics, Khanna Book Publishing, 1st Edition, 2016.
5. Som S.K., Biswas G. & Chakraborty S. Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 3rd Edition, 2017.

Subject Name: Basics of Material and Energy Balance					
Paper Code: CHEN 2103					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of the course will to be served as a basis for all further chemical engineering courses that are part of the curriculum. After completion of the course students will be able to:

1. Apply knowledge base to identify dimensionless numbers given a system of correlated variables.
2. Generate ability to handle elementary flow-sheeting given a specific process.
3. Identify skills to develop equations for energy and mass balance given a specific process.
4. Illustrate material and energy balance calculations without and with chemical reactions.
5. Identify recycle, bypass and purge points in a chemical process and perform calculations with them.
6. Describe equations of state and properties of gases and liquids, including phase transition.

Module I [10L]
Introductory concepts of units, physical quantities in chemical engineering, dimensionless numbers, dimensionless groups, "basis" of calculations.
Material Balance:
Introduction, solving material balance problems without chemical reaction for industrially relevant unit operations like Evaporation, Drying, Distillation, Crystallization, Absorption, Extraction.

Module II [10L]
Material Balance:
With chemical reaction, Concept of stoichiometry and mole balance, examples, including combustion, Material Balances with recycle, bypass and purge – examples.

Module III [10L]
Gases,
Vapours and Liquids:
Equations of state, Vapour pressure, Clausius-Clapeyron equation, Cox chart, Duhring's plot, Raoult's law.
Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use.
Linear regression analysis of linear and nonlinear data, log and semilog plotting for nonlinear data.

Module IV [10L]
Energy balance:
Open and closed system, heat capacity, calculation of enthalpy changes, adiabatic and isothermal process, non-adiabatic and non-isothermal process.
Energy balances with chemical reaction:

Heat of reaction, Heat of combustion, calorific value of fuel, adiabatic flame temperature.

Text Books:

1. Felder R. M. & Rousseau R. W. Elementary Principles of Chemical Processes, John Wiley & Sons, 3rd edition, 2000.
2. Himmelblau D. M. & Riggs J. B. Basic Principles and Calculations in Chemical Engineering, Pearson India Education Services, 8th edition, 2015.

Books of reference:

1. Bhatt B. I. & Vora S.M. Stoichiometry, Tata McGraw Hill Publishing Company Ltd, 4thedition, 2004.
2. Hougen O. A., Watson K. M. & Ragatz R. A. Chemical Process Principles, Part-I Material & Energy Balances, , CBS Publishers & Distributors, 2nd edition,2004.
3. Venkataramani V., Anantharaman N., Begum K.M. & Sheriffa M. Process Calculations, Prentice Hall of India, 2nd Edition,2011.
4. Sikdar D. C. Chemical Process Calculations, Prentice Hall of India, 2013.
5. Narayanan K.V. & Lakshmikutty B. Stoichiometry and Process Calculations, PHI, 2010.

Subject Name: Mechanics for Engineers					
Paper Code: MECH 2106					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

After going through the course, the students will be able to

1. Understand basic concepts of vector algebra as applied to engineering mechanics.
2. Draw free body diagram of a system under equilibrium.
3. Understand friction phenomenon and calculate friction loss.
4. Understand and quantify elastic behavior of deformable bodies.
5. Know how to calculate the CG location required for design of structures.
6. Apply the principles of work-energy for analysis of dynamic systems.

Module I [10L]

Importance of Mechanics in Engineering; Definition of Mechanics; Concepts of particles & rigid bodies;

Vector and scalar quantities; vector algebra –definition and notation; Types of vectors – equal , equivalent , free , bound , sliding ; Addition , subtraction of vectors ; Parallelogram law , triangle law , vector polygon ; scalar multiplication of vectors ; Resolution of vectors in Cartesian co–ordinate system ; unit vector, unit co–ordinate vectors $(\hat{i}, \hat{j}, \hat{k})$; Direction cosines ; Addition/ subtraction of vectors in components form.

dot product , cross product and the application ; important vector quantities (position vector , displacement vector, velocity vector, acceleration vector, force vector);

Force, moment of a force about a point and about an axis, moment of a couple ; representation of force and moments in items of$\hat{i}, \hat{j}, \hat{k}$Principle of transmissibility of force (sliding vector); Varignon's theorem for a system of concurrent forces with proof; Resolution of a force by its equivalent force-couple system; resultant of forces.

Module II [10L]

Type of forces – collinear, concurrent, parallel, concentrated, distributed; active and reactive forces, different types of reaction forces; free body concept and diagram; concept and equilibrium of forces in two dimensions; equations of equilibrium; equilibrium of three concurrent forces -- lami's theorem. Concept of friction: laws of coulomb's friction; angle of friction, angle of repose, coefficient of friction -- static and kinetic.

Module III [10L]

Distributed force system; centre of gravity; centre of mass & centroid; centroid of an arc; centroid of plane areas – triangle, circular sector, quadrilateral and composite area consisting of above figures.

Concept of simple stress and strain ; normal stress , shear stress , normal strain, shear strain; hooke's law; poisson's ratio; stress- strain diagram of ductile and brittle material; proportional

limit, elastics limit, yield point , ultimate stress, breaking point,; modulus of elasticity. Factor of safety for design calculations.

Module IV [10L]
Introduction to dynamics: kinematics & kinetics; newton's laws of motion; law of gravitation and acceleration due to gravity; rectilinear motion of particles with uniform & non – uniform acceleration.
Plane curvilinear motion of particles: Rectangular components (projectile motion).
Principle of work & energy; principle of conservation of energy.

Text/ Books of reference:

1. Meriam J. L. & Kreige L.G. Engineering mechanics:- Statics and Dynamics, Wiley India,1998
2. Shames I.H. & Rao G.K.M. Engineering mechanics: - Statics and Dynamics, PHI, 4thEdition, 2005.
3. Timoshenko S., Young D.H., Sukumar P. & Rao J.V. Engineering mechanics, TMH, 2013.
4. Nag D. & Chanda A. Fundamentals of Engineering Mechanics, Chhaya Prakashani, 2018.

Subject Name: Thermodynamics – I					
Paper Code: CHEN 2104					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of this course is to elaborate principles and application of first and second law of thermodynamics, and phase equilibrium. After completion of the course students will be able to:

1. Apply mass and energy balances to closed and open systems.
2. Evaluate the properties of non-ideal gases.
3. Solve problems involving liquefaction, refrigeration and different power cycles.
4. Evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.
5. Calculate thermodynamic efficiency of a process.
6. Quantify the deviation from ideal behaviour of a system.

Module I [10L]
Basic concept of thermodynamics:
Definition and classification of thermodynamic systems, Temperature, Pressure, Work, Energy, Heat.
Energy conservation & first law of thermodynamics; State functions; Thermodynamic Properties; Equilibrium; Phase Rule; Reversible and Irreversible process.
Energy balance for open & closed system:
Energy relation for steady flow process; Application of Steady Flow Energy Equation (SFEE) in Turbine, Compressor, Pump, Heat Exchangers, Condenser, Boilers; Isenthalpic process and Joule-Thompson Coefficient.

Module II [10L]
Thermodynamic properties of pure substance,
P-V-T behavior of pure substance:
Diagram and P-V diagram, Critical Properties (Pc, Tc & Vc) of pure substance.
Equation of State:
Ideal gas equation of state; Virial equation of state; Virial equation of state at low to moderate pressure;
Cubic equation of state:
Two parameter cubic equation of state (Van-der-waals equation of state, Redlich-Kwong equation of state), Compressibility factor; Cubic equation in reduced form; Laws of corresponding state; Compressibility factor chart; Definition of Acentric factor and its application.

Module III [10L]
Limitations of first law of thermodynamics; Statements of the second law; Concept of Heat engines and Heat pump; Carnot Cycle; Carnot's theorem; Concept of Entropy; Calculation of entropy change; Mathematical statement of the second law; Entropy balance for open systems;

Calculation of ideal work, Lost work; Clausius inequality.

Thermodynamic energy properties; Fundamental property relation; Maxwell relation.

Heat effects:

latent heat, sensible heat, standard heats of formation, reaction and combustion; Hess's law of constant heat summation; Effect of temperature on heat of reaction.

Module IV [10L]

Temperature-Entropy diagram; Mollier diagram; Steam table.

Ideal Power cycle; Ideal Rankine cycle; Practical Rankine cycle; Reheat cycle; Internal combustion engine: Otto cycle; Diesel cycle.

Ideal Refrigeration cycle; Vapour Compression cycle; Absorption refrigeration cycle; Thermodynamic criteria of selecting refrigerant.

Gas Liquefaction process:

Linde and Claude liquefaction process.

Text Book:

1. Smith J.M., Van Ness H.C. & Abbott M.M., Introduction to Chemical Engineering Thermodynamics, McGraw-Hill International Edition, 7th edition, 2005.

Books of reference:

1. Nag P.K., Engineering Thermodynamics, McGraw-Hill Education (India) Private Limited, 5th edition, 2013.
2. Rao Y.V.C., Chemical Engineering Thermodynamics, University Press (India) Private limited, 1st edition, 2004.

Subject Name: Biology					
Paper Code: BIOT 2105					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**2**	**0**	**0**	**2**	**2**

Course Outcomes:

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

1. Understand the basic structure and function of cells and cellular organelles.
2. Understand the fundamental concepts of DNA, RNA and central dogma of cells.
3. Characterize the different types of proteins, lipids and carbohydrates.
4. Analyze the mechanism of inheritance of characters through generations.
5. Understand and implement the working principles of enzymes and their applications in biological systems and industry.
6. Design and evaluate different environmental engineering projects with respect to background knowledge about bio-resources, bio-safety and bio-remediation.

Module I

Basic Cell Biology:

Prokaryotic and Eukaryotic cells, Cell theory; Cell structure and function, Cell organelles, Structure and function of DNA and RNA, Central Dogma; Genetic code and protein synthesis.

Module II

Biochemistry and Cellular Aspects of Life:

Biochemistry of carbohydrates, proteins and lipids; Fermentation; Cell cycle; Basics of Mendelian Genetics.

Module III

Enzymes and Industrial Applications:

Enzymes – significance, co-factors and co-enzymes, classification of enzymes; models for enzyme action; Restriction enzymes; industrial applications of enzymes.

Module IV

Biodiversity and Bioengineering Innovations:

Basic concepts of environmental bio-safety, bio-resources, biodiversity, bio-prospecting, bioremediation, biosensors; recent advances in engineering designs inspired by examples in biology.

Text Books:

1. Wiley Editorial, Biology for Engineers: As per Latest AICTE Curriculum, Wiley-India, 2018.
2. ThyagaRajan S., Selvamurugan N., Rajesh M. P., Nazeer R. A., Thilagaraj R.W.,Barathi S. & Jaganathan M. K. Biology for Engineers, Tata McGraw-Hill, 2012.

Books of reference:

1. Berg J.M., Tymoczko J.L. & Stryer L. Biochemistry, W.H. Freeman and Co. Ltd., 6th Ed., 2006.
2. Weaver R. Molecular Biology, McGraw-Hill, 5th Edition, 2012.
3. Cooper J. Biosensors A Practical Approach, Bellwether Books**,** 2004.
4. Alexander M. Biodegradation and Bioremediation, Academic Press, 1994.
5. Murphy K. Janeway's Immunobiology, Garland Science, 8th edition, 2011.

Subject Name: Physics -II					
Paper Code: PHYS 2111					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcomes:

1. To understand the concept of mechanics of Quantum Particles and hence their strange behavior which ultimately imparting the knowledge of nano – science and its applications in nanotechnology.
2. To understand magnetic properties and magnetic behaviour of materials which will enrich the industrial use of different materials for various purposes.
3. To understand the physics behind the superconducting properties of materials and their industrial and medical usefulness.
4. Understand the physics behind X-ray diffraction in crystalline structure of a material, and the different imperfection in it.
5. To understand the basic difference between the atomic structure of an isolated atom and atoms in solids differ and accordingly assures the electrical and thermal properties of solids.
6. To study the energy band formation in solids and the behavior of electron and hole in the bands.

Module I [12 L]
Quantum
Mechanics:
Group velocity and Phase Velocity, Heisenberg's Uncertainty Relation and its application, Wave function and its physical interpretation, Postulates of Quantum Mechanics, Schrodinger time dependent and time independent equation , Operator formalism, commutation ,expectation value.
Application of Quantum Mechanics:
Concept of free state and bound state, finite and infinite potential , step potential, Rectangular barrier potential, Square well, One dimensional potential well of finite and infinite depth. Quantum confinement.

Module II [12 L]
Magnetic Properties of Solids:
Magnetic Properties of Atoms: Para- and Dia-Magnetism, Basic Definitions of types of Magnetism, Hund's Rules, Coupling of Electrons in Atoms to an External Field, Free Spin (Curie or Langevin) Paramagnetism, Larmor Diamagnetism, Spontaneous Order: Antiferro-, Ferri-, and Ferro-Magnetism Macroscopic Effects in Ferromagnets: Domains, Hysteresis in Ferromagnets,
Super Conductivity:
Introduction (experimental survey). General properties of super conductivity. Effect of magnetic field. Meissner effect. Explanation in view of wave mechanical property. Hard and soft superconductors. Thermal properties of superconductor. London equations and penetration depth.

Module III [12 L]

Crystal Physics:

Review of Symmetries in solid, two dimensional and three dimensional Bravias lattices, Millers indices; X-ray Diffraction: Brags law, Laue's equation. Reciprocal lattice, Concept of Brillion Zone, Ewald construction, Structure factor, Imperfections due to point defects, Energy of formation of vacancy, number of vacancies at any temperature, equilibrium concentration of of Schottky and Frenkel defects in ionic crystal , Colour center, Exciton.

Module IV [12 L]

Physics of Solids:

Bonding energy of ionic crystal, Vibrations of monoatomic linear lattice, One dimensional diatomic lattice, Concept of phonons, Inelastic scattering of photons and phonons, Einstein and Debye theory of specific heat.

Band Theory of Solids:

Fermi Dirac distribution and its application in metal and semiconductor. Bloch theorem. Kronig-Penny model (qualitative treatment). Origin of energy band formation in solids. Classification of materials into conductors, Semi conductors & Insulators. Concept of effective mass of an electron and hole.

Text/ Books of reference:

1. Ghoshal S.N. Atomic Physics (Volume 1), S Chand & Company, 2010.
2. Ashcroft N.W. & Mermin N. Solid State Physics, Brooks/Cole, 1976.
3. Kittel C. Introduction to Solid State Physics, Wiley, 2019.
4. Dekker A.J. Solid State Physics, Macmillan, 1969.

LABORATORY

Subject Name: Fluid Mechanics (ChE) Laboratory					
Paper Code: CHEN 2151					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**3**	**3**	**1.5**

Course Outcomes:

The objective of this course is to impart working knowledge and develop skills of the students in fluid mechanics through bridging between the theoretical concepts and working practices for attaining the competency in practical applications or for working in the industry and conducting research & development activities. After completion of the course students will be able to:

1. Predict the energy losses, economic factors and maintenance aspects in the design, installation and operations of fluid flow systems for efficient transportation of mass & energy by studying the flow characteristics namely, turbulent, laminar and transition flow of different fluids.
2. Identify the requirements of various types of devices for quantitative measurement of fluid flow in open channel (rivers,/dams etc) and in closed channel(pipe flow etc) efficiently and economically.
3. Analyze the pump characteristics relating to best efficiency of the pump, power consumption, head developed by the pump for a given flowrate.
4. Design and install pumping system to demonstrate occurrence of cavitation in the system and also to take a practical measure to avoid cavitation during fluid flow and ultimately develop skills and expertise in designing the most efficient fluid transportation system including pump & the piping.
5. Construct and design packed bed and fluidized bed chemical reactors for various types of chemical processes and unit operations with a given pressure drop and various flow rates of the fluid or vice-versa.
6. Describe the concept of packed bed or fluidized bed operations practically for physical processes such as coating granular metal surfaces with various other desirable materials by normal fluidisation technique and separation of oil from water by reverse fluidisation techniqueetc.

Experiments to be performed:

1. Determination of coefficient of discharge at various Reynolds number during fully developed fluid flow through orificemeter.
2. Determination of coefficient of discharge at various Reynolds number during fully developed fluid flow through venturimeter.
3. Determination of loss coefficient of pitot tube and construction of fully developed velocity profile through pipe in laminar and turbulent flow regime.
4. Measurement of open channel flow and determination of coefficient of discharge V-notch and rectangular notch.
5. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
6. Determination of characteristic curve of a centrifugal pump.
7. Experiments on Reynolds apparatus for determination of flow regime and

construction of fanning's friction factor vs Reynolds number plot.

8. Determination of pressure drop and bed height profile with varying modified Reynolds number during flow through a fluidized bed & determination of incipient fluidization.
9. Calibration of rotameter.
10. Assembling of pipe line and fitting according to a given layout.

Text Books:

1. P Pritchard P.J. Fox and McDonald's Introduction to Fluid Mechanics, John Wiley & Sons Inc., 8th edition,2011.
2. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Harker J.H., Backhurst J.R. & Richardson J.F. Coulson and Richardson's Chemical Engineering (Volume 2), Butterworth-Heinemann, 5th edition, 2002.

Books of reference:

1. Jain A.K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, 1998.
2. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, John Wiley & Sons, 2nd Edition, 2010.

Subject Name: Particle & Fluid-Particle Processing Laboratory					
Paper Code: CHEN 2152					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

The objective of this course is to provide a hands-on idea on the mechanical devices that are essential in handling the material and it's processing in different chemical engineering related downstream applications. After completion of this course students will be able to:

1. Identify mechanical instruments required for particles processing before downstream applications.
2. Describe the working principle of the mechanical instruments required for particles processing.
3. Solve the experimental problems related to particles' processing applications.
4. Generate real life data from the experiments.
5. Analyze the outcome of the experiment on the basis of theoretical knowledge they had acquired.
6. Conclude on the troubleshooting required after analyzing the experimental outcomes.

Experiments to be performed:

1. Sieve Analysis: To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions.
2. Overall Screen Effectiveness: To find out screen efficiency through a suitable material balance with respect to a single screen.
3. Jaw Crusher: To find out the reduction ratio and capacity and to verify Rittinger's law.
4. Ball Mill: To determine the reduction ratio, capacity and the critical speed of the ball mill.
5. Rod Mill: To determine the reduction ratio and capacity and compare the reduction ratio for the same feed sample to that in a ball mill.
6. Hammer Mill: To find out the reduction ratio and capacity.
7. Batch sedimentation: To determine the settling and sedimentation characteristics of given slurry.
8. Filtration: To determine the specific cake resistance and filter medium resistance in the given plate and frame filtration.
9. Elutriator: To study the sorting of a given mixture in an elutriator.
10. Cyclone Separator: Demonstration of the operation of a cyclone separator and determination of its overall collection efficiency.

Text Books:

1. McCabe W.L., Smith J.C. & Harriot P. Unit Operations in Chemical Engineering, McGraw-Hill, 7th Edition, 2004.
2. Harker J.H., Backhurst J.R. & Richardson J.F. Chemical Engineering - Volume 2,

Butterworth-Heinemann, 5th Edition, 2002.

Books of reference:

1. Badger W.L., Banchero J.T. & Bancheo J.T. Introduction to Chemical Engineering, McGraw Hill, 1955.
2. Narayanan C.M. & Bhattacharya B.C. Mechanical Operations for Chemical Engineers, Khanna Publications, 2014.

Subject Name: Instrumental Methods of Analysis Laboratory					
Paper Code: CHEN 2152					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

1. Given a sample of turbid water, students will be able to plot calibration curve (NTU vs. concentration) from samples of known turbidity and determine the turbidity of the unknown sample using Nephelo Turbidimeter.
2. Given a sample of pure protein, students will be able to plot calibration curve (Absorbance vs. concentration) using a spectrophotometer by Folin's Method.
3. Given a sample of ferric ion solution, students will be able to plot calibration curve (Absorbance vs. concentration) from samples of known Fe^{3+} concentration and determine the Fe^{3+} concentration of the unknown sample using a Colorimeter.
4. Given a sample of water, students will be able to determine he dissolved Oxygen concentration using a DO meter.
5. Given a sample of ethanol-water mixture, students will be able to plot calibration curve (RI vs. concentration) from samples of known ethanol concentration and determine the Ethanol concentration of the unknown sample using Abbe Refractometer
6. Given a sample of dextrose-water solution, students will be able to plot calibration curve (Specific Rotation vs. concentration) from samples of known dextrose concentration and determine the dextrose concentration of the unknown sample using a Polarimeter.

Experiments to be performed:

1. Determination of Turbidity of Water using Nephelo Turbidimeter.
2. Construction of standard curve (Absorbance vs. concentration) of a pure protein by Folin's Method using Spectrophotometer.
3. Determination of Fe^{3+} in a solution by Colorimeter Method.
4. Determination of Dissolved Oxygen in water by DO Meter.
5. Estimation of Ethanol concentration in a mixture of Ethanol & Water by Abbe Refractometer.
6. Determination of concentration of any optically active substance in presence of nonactive species by a Polarimeter.
7. Determination of TDS of water sample by Conductivity Meter.
8. Demonstration of analysis of gas mixtures by Gas Chromatography.

Text/ Book of reference:

1. Dash D.C. Analytical Chemistry, PHI, 2nd Edition,2017

2nd Year 2nd Semester (Semester4)

THEORY

Subject Name: Heat Transfer					
Paper Code: CHEN 2201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of this course is to understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries. After completion of the course students will be able to:

1. Describe basic knowledge of the heat transfer.
2. Justify the practical importance and relevance of energy transfer and its conservation in chemical industry.
3. Categorize the technological methods related to heat transfer in process plant.
4. Identify a detailed overview of heat transfer equipment and problems associated at preliminary stage of design.
5. Construct a bridge between theoretical and practical concept used in industry.
6. Analyze basic heat transfer processes and identify modes.

Module I [10L]
Introduction to basic modes of heat transfer and their application in chemical process,
Heat transfer by conduction:
Fourier law, thermal conductivity, thermal resistance; general heat conduction equation, thermal diffusivity; steady state heat conduction with heat generation for plane wall, cylindrical body and spherical body;
Conduction-convection system:
Critical insulation thickness of curved surface, steady state heat conduction through fin, fin efficiency, unsteady state heat conduction in solid with large thermal conductivity, significance of Biot no and Fourier no, transient heat conduction in solid.

Module II [10L]
Convective heat transfer without phase change:
Newton-Rikhman law, local and average heat transfer coefficient, Reynold-Colburn analogy, concept of individual heat transfer coefficient and overall heat transfer coefficient, LMTD, empirical correlation for heat transfer coefficient in forced convection; elementary concept of thermal boundary layer, temperature distribution in laminar flow, analysis of free convection and correlation of free convection, Grash of number.

Module III [10L]
Heat transfer with phase change:
Film-wise and drop-wise condensation, laminar film condensation on vertical plate, Nusselt equation; analysis of heat transfer during boiling, different boiling regimes during pool boiling. Characteristics of radiation, properties of radiating surface,
Black body radiation:
Plank's distribution law,

Total emissive power:

Stefan-Boltzman law, use of radiation function table; Wien's displacement law; Kirchoff's law; emissivity of black body, gray body and real body;

Radiation between surfaces:

View factor, Electrical network approach for radiation heat exchange, radiation shields and their application, radiation heat exchange for three radiating surfaces; radiation heat transfer through absorbing emitting medium.

Module IV [10L]

Heat exchangers and their classification,

Performance analysis of heat exchanger:

Fouling factor, LMTD correction factor, effectiveness and NTU of heat exchangers, sizing and rating problems of heat exchangers, construction details of shell and tube heat exchanger, Shell and Tube heat exchanger design, elementary note on heat exchanger network.

Evaporators and their classification, capacity and steam economy, Boiling Point Elevation (BPE), material and energy balance of single effect evaporator, classification of multiple effect evaporator, design of single effect and multiple effect evaporator.

Text Books:

1. Kern D. Q. Process Heat Transfer, Tata McGraw-Hill, 1997.
2. Dutta B. K. Heat Transfer Principles and Application, PHI Learning Pvt. Ltd., 2015.
3. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Books of reference:

1. Ozisik M. N. Heat Transfer: A Basic Approach, McGraw-Hill International Edition, Singapore, 1984.
2. Sikdar D.C. Process Heat Transfer & Chemical Equipment Design, Khanna Publishing House, 1st Edition, 2018.

Subject Name: Transport Phenomena					
Paper Code: CHEN 2202					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to provide an idea about the unified approach on the analysis of momentum, mass and energy transport process across the boundary of the system. The students will learn:

1. The students will be able to identify the inherent analogy between different property transport processes.
2. The students will be able to describe the concept of momentum transport for different flow geometry.
3. The students will be able to describe the concept of mass transport for different flow geometry.
4. The students will be able to describe the concept of energy transport for different flow geometry.
5. The students will be able to solve the flow problems relating all three different transport processes.
6. The students will be able to describe the concept of boundary layer and analyze the flow problem based on the comparative survey on the boundary layer thickness.

Module I [10L]

Understanding of unified approach in transport phenomena for momentum, mass and energy transport; Fundamental variables and units used in describing a transport process; Concept of closed and open system; Concept of non-dimensional form of the basic transport equation and dimensionless number; Concept of diffusion and convection mechanism; Idea on tensor and vector approach in describing a transport process; Understanding of thermodynamic equilibrium and transport process; Concept of different steady state condition (steady state and quasi-steady state condition) and its importance in analyzing transport process; Role of intermolecular forces (and potential) in quantification of system intrinsic properties for transport process.

Module II [10L]

Description of Newtonian and Non-Newtonian fluid; Newton's law of motion; Concept of momentum diffusivity; Basic idea on Lennard-Jones potential (from collision theory) to understand viscosity of gas with low density; Pressure and temperature dependence of viscosity; Tensor form for momentum transport; Shell momentum balance and boundary condition; Equation of Continuity in rectangular (Cartesian) coordinate system; Development of Navier-Stokes equation in rectangular (Cartesian) coordinate system; Concept of Euler's equation of motion; Concept of laminar and turbulent flow; Velocity profile prediction for (a) falling film (b) flow in a circular tube (c) flow through annulus (d) flow of two adjacent immiscible fluids; Coutte flow; Creeping flow and Drag force; Boundary Layer over a flat plate; Determination of boundary layer thickness and average flow velocity determination.

Module III [10L]

Fourier law of heat conduction; Temperature and pressure dependence of thermal conductivity; Shell energy balance and boundary condition; Development of convection-diffusion energy equation; Concept of thermal diffusivity; Heat conduction through laminar flow when (a) heat conduction with an electrical heat source (b) heat conduction with a nuclear heat source (c) heat conduction with a viscous heat source (d) heat conduction with a viscous heat source (e) heat conduction through composite wall (f) heat conduction in cooling fin; Unsteady heat conduction for semi-infinite and finite slab – Solution for temperature profile using similarity solution; Concept of thermal boundary layer; Relation establishment between thermal and momentum boundary layer thickness using Von-Karman integral method; Forced convective heating of a fluid flowing through a circular tube at laminar condition; Laminar free convection of fluid flowing between two parallel plates at two different temperatures.

Module IV [10L]

Fick's law of diffusion; Temperature and pressure dependence of diffusivity; Shell energy balance and boundary condition; Development of convection-diffusion equation for mass transport; Equation of continuity for a multi-component mixture in rectangular (Cartesian) coordinate system; Evaluation of concentration profile for diffusion (a) through a stagnant gas film (b) with heterogeneous chemical reaction (c) with homogeneous chemical reaction (d) during gas absorption in a falling liquid film (e) during solid dissolution in a falling liquid film; Unsteady heat conduction for semi-infinite and finite slab – Solution for concentration profile using similarity solution; Concept of thermal boundary layer; Relation establishment between thermal and momentum boundary layer thickness using Von-Karman integral method; Concept of analogy between momentum, heat and mass transport; Derivation of Reynolds analogy; Coulburn Analogy and its benefits over Reynolds analogy.

Text Book:

1. Bird R.B., Stewart W.E. & Lightfoot E.N. Transport Phenomena, Wiley, 2nd Edition, 2006.

Books of reference:

1. Brodkey R.S. & Herskey H.C. Transport Phenomena, McGraw- Hill, 1988.
2. Geankoplis C.J. Transport Processes and Unit Operations, Prentice Hall of India, 3rdEdition, 1993.
3. Roy S.C. & Guha C. Introduction to Transport Phenomenon, Dhanpat Rai & Co., 2014.

Subject Name: Thermodynamics II					
Paper Code: CHEN 2203					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
To introduce the concepts of fugacity, activity coefficient, vapour -liquid equilibrium, reaction equilibrium, and introduction to molecular thermodynamics. After completion of the course students will be able to:

1. Ability to understand the basic knowledge that allows the students to solve problems relating fugacity of pure components as well as in mixture.
2. Ability to utilize the concept of chemical potential as criterion of phase equilibrium.
3. Ability to use concept of partial molar properties in solution thermodynamics.
4. Ability to understand the basic knowledge that allows the students to solve problems on equilibrium of different phases involving no chemical reaction.
5. Ability to understand the basic knowledge that allows the students to solve problems on chemical reaction equilibrium.
6. Ability to differentiate the basic thermodynamics approach to irreversible and reversible processes in chemical engineering practice.

Module I [10L]
Review of first and second law of thermodynamics:
First law for closed and open systems (steady and unsteady), entropy and second law, principle of maximum entropy.
Thermodynamic property of pure substances and mixture:
Residual properties, fugacity and fugacity coefficient/in solution, relation between fugacity coefficient and compressibility factor , chemical potential, chemical potential as criterion of phase equilibrium, free energy and chemical potential, excess properties, numerical problems.

Module II [10L]
Solution thermodynamics:
Concept of partial molar properties, Gibbs- Duhem equation, fundamental excess property relation, evaluation of partial properties, property change on mixing,
Vapour –liquid equilibrium:
Phase rule, simple models for VLE, VLE by modified Raoult's law, VLE from K- value correlations, Numerical problems.

Module III [10L]
Application of Solution thermodynamics:
Liquid phase properties from VLE data,
Non-ideal VLE:
Models for excess Gibbs free energy, UNIFAC and UNIQUAC models, property changes of mixing, heat effect of mixing processes, liquid- liquids equilibrium, solid liquid equilibrium, vapour-liquid-liquid equilibrium, solid-vapour equilibrium, numerical problems.

Module IV [10L]

Chemical reaction equilibrium:

Reaction coordinate, equilibrium criterion, equilibrium constant, effect of temperature on equilibrium constant, evaluation of equilibrium constant, equilibrium conversion of single reaction, multi reaction equilibria, numerical problems.

Introduction to molecular thermodynamic:

Postulates; microcanonical, canonical and grand canonical ensembles; non-interacting examples. Partition function, second virial coefficients from potential functions, internal energy of ideal gases- microscopic view, thermodynamic and statistical mechanics.

Text Book:

1. Smith J.M., Van Ness H.C. & Abbott M.M. Introduction to Chemical Engineering Thermodynamics, McGraw-Hill International Edition, 7th. Edition, 2005.

Books of reference:

1. Sandler S. Chemical, Biochemical and Engineering Thermodynamics, Wiley, 5th. Edition, 2017.
2. Kyle B.G. Chemical Process Thermodynamics, Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 2000.
3. Narayanan K.V. A Text Book Chemical Engineering Thermodynamics, PHI Learning Pvt. Ltd, 2013.
4. Rao Y.V.C. Chemical Engineering Thermodynamics, University Press (India) Ltd. Reprint, 2004.

Subject Name: Chemistry II					
Paper Code: CHEM 2201					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Students will have a firm knowledge in the advances of inorganic, organic and physical chemistry. They will get an understanding of the theoretical principles underlying molecular structure, bonding and properties.
2. Knowledge of understanding the quantum mechanics makes students to learn illustrative case studies that organize molecular modeling for designing of reactors and derivation of thermo-chemical functions.
3. Ability to identify and formulate different types of complexes can be of further use in dye and pigment industry. Organometallic chemistry will provide clear idea on transition metal catalysis which has wide industrial and biological applications.
4. Understanding of the role of transition metal in living cell will be introduced through the knowledge of bioinorganic chemistry has tremendous scope in future research.
5. Knowledge in the fundamental concepts of structure and reactivity of alicyclic and acyclic organic molecules has important applications in pharmaceuticals industries and natural product synthesis.
6. Studies on adsorption isotherms can develop the concept of heterogeneous catalysis widely applied in oil refinery and petroleum industry.

Module I [9L]

Introduction to Quantum Theory for Chemical Systems:

Schrodinger equation, applications to Hydrogen atom, atomic orbitals, many electron atoms.

Kinetic Theory of Gases:

Maxwell distribution law, kinetic energy distribution, equipartition principle.

Colloids:

Introduction, classification of colloids, size and shape, preparation of sols, origin of charge in colloidal particles, stability of colloids, kinetic, optical & electrical properties, electrokinetic phenomena, electrical double layer, applications of colloids.

Module II [9L]

Basic Idea of Coordination Chemistry:

IUPAC nomenclature of coordination complexes (up to two metal centres), idea of coordination number and isomerism in coordination compounds.

Properties of Coordination Compounds:

Effective atomic number, elementary crystal field theory: splitting of d^nconfigurations in octahedral, and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. spectrochemical series. Jahn-Teller distortion, magnetism and colour: orbital and spin magnetic moments, d-d transitions, charge transfer spectra.

Organometallic Chemistry:
Definition and classification of organometallic compounds on the basis of bond type, 18-electron Rule, applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. Zeise's salt: Preparation, structure, evidences of synergic effect.

Module III [9L]
Acyclic System:
Conformation of alkanes, halogeno-alkanes, stability, intra-molecular hydrogen bonding, optical activity, racemic mixture and their resolution.
Alicyclic Compounds:
Concept of I-strain, ring-size and ease of cyclisation, characteristics of chair conformation, conformation of cyclohexane, mono and di substituted cyclohexane, considering steric and stereoelectronic requirements reactivity of cyclohexane towards elimination, nucleophilic substitution, rearrangements.
Strategies for Synthesis of Organic Compounds:
(a) Substitution at sp^3 centre: mechanisms, relative rates & stereochemical features, role of crown ethers and phase transfer catalysts, (b) Elimination reactions: formation of alkenes and alkynes.

Module IV [9L]
Bio-inorganic Chemistry:
(a) Elements of life, essential trace and ultra trace elements in biological systems, role of metal ions in biological systems. (b) Toxic effects of metal ions and detoxification by chelation therapy (BAL, Unithiol, D-penicillamine, triethylene tetramene, ferrichrome, desferrioxamine B, EDTA), (c) Active site structure and basic function of O_2 uptake proteins-haemoglobin and myoglobin and electron transportproteins-Ferredoxins.
Adsorption:
Introduction, Gibb's adsorption equation, Surface Excess, adsorption isotherms-Langmuir, BET adsorption equations, surface Films, Langmuir Balance, two dimensional equation of state.
Synthesis and applications of industrially important materials:
(a) Phenol formaldehyde resins (Bakelite, Novalac), (b) Conducting Polymers, (polyacetylene, polyaniline), (c) Pharmaceuticals (Ibuprofen, anticancer drug), (c) Battery industry materials (Li ion batteries).

Text Books:

1. Castellan G.W. Physical Chemistry, Narosa, 2004.
2. Finar I.L. Organic Chemistry, Vol I & II, Pearson Education, 6th Edition, 2002.
3. Morrison R.T., Boyd R.N. & Bhattacharjee S.K. Organic Chemistry, PHI/Pearson Education, 7th Edition, 2010.
4. Rakshit P. C. Physical Chemistry, Sarat Book House, 7th Edition, 2014.
5. Nasipuri D. Stereochemistry of Organic Compounds, New age international (P) limited, 3rd Edition, 2018.
6. Gupta S.S. Basic Stereochemistry of Organic Molecules, Oxford Higher Education,

1st Edition, 2014.

7. Huheey J. E., Keiter E. A. & Keiter R. L. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 4th Edition,1997.
8. Cotton F.A., Wilkinson G. & Gaus P.L. Basic Inorganic Chemistry, Wiley, 3rd Edition, 1994.

Books of reference:

1. Atkins P. W. Physical Chemistry, Oxford, 9th Edition,2009.
2. Kapoor K. L. A Text book of Physical Chemistry, Macmillan, 1999.
3. Sykes P. A guide Book to Mechanism in Organic Chemistry, Pearson Education, 6thEdition, 2003.
4. Loudon G.M. Organic Chemistry, Oxford University Press, 4th Edition, 2008.
5. Sarkar R. General Inorganic Chemistry (Vol-II), New Central Book Agency, 3rd edition 2011.

Subject Name: Material Science					
Paper Code: CHEN 2204					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to impart basic knowledge and provide strong foundation to the learners on the processing, structural aspects, properties and functional applications of traditional and advance materials of the modern day. After completion of this course students will be able to:

1. Construct materials into numerous valuable products / devices.
2. Design research and development works for futuristic smart materials.
3. Solve industrial problems and inspire for achieving success in higher studies and employment in industries.
4. Identify different metal extraction processes from their ores.
5. Describe solid phase behavior from phase equilibrium study.
6. Construct ideas on the crystalline and optoelectronic properties of material.

Module I [10L]

Structure of materials:

Various types of bonds; Crystalline Structure of Solids- concepts of unit cell and space lattice, packing factor; Classification of materials, Selection of materials.

Mechanism of plastic deformation, slip and twinning,

Structural imperfections:

Elementary concepts of point, line, surface & volume imperfections; Influence of dislocations/Line imperfections on the mechanical properties of materials**;** Strain hardening and recrystallization; Elementary aspects of creep, fatigue fracture.

Module II [10L]

X-ray diffraction for determining crystal structure;

Mechanical properties:

Strength, hardness, toughness, ductility, brittleness of Engineering Materials**;** Elastic, Anelastic and visco-elastic behaviour of materials; Electrical, Electronic, Magnetic, Optical & Optoelectronic properties of material; Inorganic & organic amorphous materials and their structural & property characteristics; Optical fibers.

Phase Diagrams:

Solidification and structure of metals, Grain boundaries; Phase equilibrium and phase diagrams of binary alloys; Phase diagram of ternary systems; Iron-Carbon diagram;

Heat Treatment:

Introduction and purposes of heat treatment; T-T-T diagram; Corrosion-Concepts and forms of corrosion; Corrosion Mechanism and prevention; Protective materials and coating.

Module III [10L]

Basic principles of metal extraction:

Pyrometallurgy: Smelting, calcinations, roasting— oxidizing, predominance area diagrams, multiple hearth, flash and fluo-solid, sintering, smelting, slag and its classification.

Iron making in Blast furnace,

Steelmaking process flow diagram:

Steel making (oxygen blown converter –LD) – Secondary steel making / refining (ladle processing, vacuum degassing, ladle furnace processing) – Continuous casting – with emphasis on application of the concepts of physicochemical principles involved, moving/packed bed reactor, gas-liquid two-phase flow, heat transfer with phase change (solidification).

Module IV [10L]

Principles of Hydrometallurgy and Electrometallurgy,

Extraction of Aluminum:

Hall-Heroult process, Electrolytic refining, Pyro & Hydro metallurgical extraction of copper & Zinc; Extraction of Lead, Nickel, Titanium, Recent advances on nanomaterials.

Text Books:

1. Raghavan V. Material Science and Engineering, Prentice-Hall of India Pvt. Ltd., 5th Edition, 2004.
2. Ray H.S., Sridhar R. & Abraham K.P. Extraction of nonferrous metal, Affiliated East-West Press Pvt. Limited, 2008.
3. Callister W.D. Jr & Rethwisch D.G. Material Science and Engineering: An Introduction, John Wiley & Sons, 8th Edition, 2010.
4. Smith W.F., Hashemi J. & Prakash R. Material Science and Engineering, McGraw Hill Education, 5th Edition, 2017.

Books of reference:

1. Vlack L.H.V. Elements of Material Science and Engineering, Addison-Wesley Educational Publishers Inc., 1980.
2. Lakhtin Y. & Weinstein N. Engineering Physical Metallurgy, MIR Publishers, Moscow, 1975.
3. Bogdandy L.V. & Engell H.J. The Reduction of Iron Ores, Springer-Verlag, New York, 1971.
4. Guthrie R.I.L. Engineering in Process Metallurgy, Oxford University Press, 1992.

Subject Name: Human Values And Professional Ethics					
Paper Code: HMTS 2001					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

The student will

1. be aware of the value system and the importance of following such values at workplace.
2. learn to apply ethical theories in the decision making process.
3. follow the ethical code of conduct as formulated by institutions and organizations.
4. Implement the principles governing work ethics.
5. Develop strategies to implement the principles of sustainable model of development.
6. Implement ecological ethics wherever relevant and also develop eco-friendly technology.

Module I [9L]

Human society and the Value System**,**

Values: Definition, Importance and application.

Formation of Values:

The process of Socialization, Self and the integrated personality, Morality, courage, integrity.

Types of Values:

Social Values:

Justice, Rule of Law, Democracy, Indian Constitution, Secularism.

Aesthetic Values:

Perception and appreciation of beauty.

Organizational Values:

Employee:

Employer- rights, relationships, obligations.

Psychological Values:

Integrated personality and mental health.

Spiritual Values &their role in our everyday life, Value Spectrum for a Good Life, meaning of Good Life ,Value Crisis in Contemporary Society; Value crisis at - Individual Level , Societal Level, Cultural Level; Value Crisis management - Strategies and Case Studies.

Module II [9L]

Ethics and Ethical Values, Principles and theories of ethics, Consequential and non-consequential ethics, Egotism, Utilitarianism, Kant's theory and other non-consequential perspectives, Ethics of care, justice and fairness, rights and duties, Ethics-Standardization, Codification, Acceptance, Application .

Types of Ethics:

Ethics of rights and Duties, Ethics of Responsibility, Ethics and Moral judgment, Ethics of care, Ethics of justice and fairness, Work ethics and quality of life at work, Professional Ethics.

Ethics in Engineering Profession:

Moral issues and dilemmas, moral autonomy (types of inquiry), Kohlberg's theory, Giligan's theory (consensus and controversy), Code of Professional Ethics Sample Code of ethics like

ASME, ASCE. IEEE, Institute of Engineers, Indian Institute of materials management, Institute of Electronics and telecommunication engineers.
Violation of Code of Ethics-conflict, causes and consequences.
Engineering as social experimentation, engineers as responsible experimenters (computer ethics, weapons development).
Engineers as managers, consulting engineers, engineers as experts, witnesses and advisors, moral leadership.
Conflict between business demands and professional ideals, social and ethical responsibilities of technologies.
Whistle Blowing:
Facts, contexts, justifications and case studies, Ethics and Industrial Law.
Institutionalizing Ethics:
Relevance, Application, Digression and Consequences.

Module III [9L]
Science, Technology and Engineering.
Science, Technology and Engineering as knowledge and profession-Definition, Nature, Social function and Practical application of science, Rapid Industrial Growth and its Consequences.
Renewable and Non- renewable Resources:
Definition and varieties, Energy Crisis, Industry and Industrialization, Man and Machine interaction, Impact of assembly line and automation ,Technology assessment and Impact analysis Industrial hazards and safety, Safety regulations and safety engineering, Safety responsibilities and rights, Safety and risk, risk benefit analysis and reducing risk.
Technology Transfer:
Definition and Types, The Indian Context.

Module IV [9L]
Environment and Eco- friendly Technology, Human Development and Environment, Ecological Ethics / Environment ethics.
Depletion of Natural Resources:
Environmental degradation, Pollution and Pollution Control.
Eco-friendly Technology:
Implementation, impact and assessment.
Sustainable Development:
Definition and Concept, Strategies for sustainable development, **Sustainable Development:**
The Modern Trends, Appropriate technology movement by Schumacher and later development, Reports of Club of Rome.

Text/ Books of reference:

1. Tripathi A.N. Human Values, New Age International, 2006.
2. Ritzer G. Classical Sociological Theory, The McGraw Hill Companies, 6th Edition, 2010.
3. Doshi S.L. Postmodern Perspectives on Indian Society, Rawat Publications, 2008.
4. Bhatnagar, D.K. Sustainable Development, Cyber Tech Publications, 2008.

5. Kurzwell R. The age of Spiritual Machines, Penguin Books, 1999.

6. Weinberg S.K. Social Problems in Modern Urban Society, Prentice Hall,Inc., 2nd Edition, 1970.
7. Giddens A. Sociology, Polity Press, 6th Edition, 2009.

Subject Name: Environmental Science					
Paper Code: EVSC 2016					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**0**

Course Outcomes:

The subject code EVSC2016 corresponds to basic environmental chemistry for the 2nd year B.Tech students, which is offered as Environmental Sciences and is mandatory for all branches of engineering. The course provides basic knowledge of various environmental pollutions as well as its impact and ways to curb it. The course outcomes of the subject are:

1. Understand the natural environment and its relationships with human activities.
2. Characterize and analyze human impacts on the environment.
3. Integrate facts, concepts, and methods from multiple disciplines and apply to environmental problems.
4. Educate engineers who can work in a multi-disciplinary environment to anticipate and address evolving challenges of the 21stcentury.
5. Understand and implement scientific research strategies, including collection, management, evaluation, and interpretation of environmental data.
6. Design and evaluate strategies, technologies, and methods for sustainable management of environmental systems and for the remediation or restoration of degraded environments.

Module I [6L]

Socio Environmental Impact:

Basic ideas of environment and its component.

Population growth:

Exponential and logistic; resources; sustainable development.

Concept of green chemistry, green catalyst, green solvents.

Environmental disaster and social issue, environmental impact assessment, environmental audit, environmental laws and protection act of India.

Module II [6L]

Air Pollution:

Structures of the atmosphere, global temperature models.

Green house effect, global warming; acid rain: causes, effects and control.

Lapse rate and atmospheric stability; pollutants and contaminants; smog; depletion of ozone layer; standards and control measures of air pollution.

Module III [6L]

Water Pollution:

Hydrosphere;

Pollutants of water:

Origin and effects; oxygen demanding waste; thermal pollution; pesticides; salts. Biochemical effects of heavy metals; eutrophication: source, effect and control.

Water quality parameters:

DO, BOD, COD.

Water treatment:
Surface water and waste water.

Module IV [6L]
Land Pollution:
Sources and control;
Solid waste:
Classification, recovery, recycling, treatment and disposal.
Noise Pollution:
Noise: definition and classification; noise frequency, noise pressure, noise intensity, loudness of noise, noise threshold limit value; noise pollution effects and control.

Text Books:

1. Mahapatra G.K.D. Basic Environmental Engineering and Elementary Biology, Vikas Publishing House P. Ltd., 1st Edition, 2011.
2. De A.K. Environmental Chemistry, New Age International, 2003.
3. DasA.K.&DasM.EnvironmentalChemistrywithGreenChemistry,BooksandAllied P. Ltd.

Books of reference:

1. Santra S. C. Environmental Science, New Central Book Agency P. Ltd, 3rd Edition, 2011.
2. De D. & De D. Fundamentals of Environment & Ecology, S. Chand & Company Ltd., 2010.

LABORATORY

Subject Name: Heat Transfer Laboratory					
Paper Code: CHEN 2251					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

The objective of this course is to provide the practical exposure to the students regarding the application of various heat transfer phenomenon and correlations in various engineering processes. Hands on experience will enable them to analyze working principles of various heat transfer devices including heat exchangers, condensers. After completion of this course students will be able to:

1. Identify different modes of heat transfer and basic laws of heat transfer.
2. Analyze problems involving steady state heat conduction and develop solutions for transient heat conduction in simple geometries.
3. Identify the fundamentals of convective heat transfer process.
4. Evaluate the heat transfer coefficients for forced convection inside duct.
5. Analyze radiation heat transfer between black body surfaces.
6. Analyze heat exchanger/ condenser performance.

Experiments to be performed:

1. Determination of thermal conductivity of a metal bar using Fourier's heat conduction equation.
2. Estimation of heat loss through a lagged pipe and determination of thermal conductivity of insulating material.
3. Determination of heat transfer coefficient of air during heat transfer by forced convection and to study the effect of air velocities on heat transfer co-efficient.
4. Determination of overall heat transfer coefficient in a counter current / parallel flow double pipe heat exchanger and to study the effect of fluid flow rate on overall heat transfer coefficient.
5. Determination of overall heat transfer coefficient and efficiency of a shell and tube heat exchanger and to study the effect of fluid flow rate on overall heat transfer co-efficient.
6. Determination of Stefan Boltzmann constant experimentally.
7. Determination of Biot number for a conductive convective system and validation of lumped system assumption.
8. Determination of heat transfer co-efficient in film-wise & drop-wise condensation.
9. Determination of emissivity of a given radiating surface by applying Kirchhoff's law of thermal radiation.

Text Books:

1. Kern D. Q. Process Heat Transfer, Tata McGraw-Hill, 1997.
2. Dutta B. K. Heat Transfer Principles and Application, PHI Learning Pvt. Ltd., 2015.
3. McCabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.

Book of reference:

1. Ozisik M. N. Heat Transfer: A Basic Approach, McGraw-Hill International Edition, Singapore, 1984.

Subject Name: Programming Basics for Numerical Computation					
Paper Code: CHEN 2252					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**3**	**3**	**1.5**

Course Outcomes:

The objective of this course is to build up the basic knowledge on the programming skill with MATLAB/OCTAVE in order to solve mathematical model relating any chemical engineering process. After completion of the course students will be able to:

1. Generate the algorithm to solve a simple mathematical problem.
2. Formulate the logic required to solve the problem.
3. Generate code for the implementation of the algorithm with the knowledge of the logic required.
4. Read data from formatted input file for further processing of it through written code.
5. Execute loops, functions comparison operations.
6. Analyze the output of the program by representing the output in graphical format.

Programmes to be performed using MATLAB / OCTAVE:

1. Introduction to MATLAB/OCTAVE interface. Execution of statements from command lines, data input for scalars, 1D and 2D arrays, extract elements of arrays, evaluate array size.
2. Write and execute programs through .m file (editor file). Call in-built functions in MATLAB/OCTAVE.
3. Concept of loops (for, while and do-while), "break" and "continue" statement.
4. Usage of comparison operators and conditional statements (if, else andelseif).
5. Write a program to find out the adjoint and transpose of a 2Darray.
6. Write a program to find out the determinant and inverse of a 2Darray.
7. Write a program to check whether a matrix is diagonally dominant or not?
8. Writeaprogramtoplotthevariationofyw.r.t.xforadifferentialequation $\frac{dy}{dx} = \exp(-x)$ using Euler's method. Given at y(0)=1.

Text Books:

1. Pratap R. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, 2010.
2. Nagar S. Introduction to Octave: For Engineers and Scientists, Apress, 1st Edition, 2017.

Books of reference:

1. Attaway S. Matlab: A Practical Introduction to Programming and Problem Solving, Butterworth-Heinemann, 3rd Edition, 2013.
2. Nakamura S. GNU Octave Primer for Beginners, Create space Independent Publishing

Platform, 2nd Edition, 2016.

Subject Name: Engineering Drawing Laboratory					
Paper Code: CHEN 2253					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

The objective of the course is to provide an elaborated concept of engineering drawing and idea on the relevant software for engineering drawing. After completion of the course students will be able to:

1. Student will be able to understand basics of engineering drawing.
2. Student will be able to draw different angular projection view of engineering equipment.
3. Students will be able to draw isometric projection view of engineering equipment.
4. Students will be able to draw cut-section view of engineering equipment.
5. Students will be able to use AutoCAD software for developing engineering drawing layouts.
6. Students will be able to prepare a virtual 3-D representation of an engineering equipment.

Problems to be solved:

1. Introduction to AutoCAD software for drawing in 2D: Drawing and editing commands. Knowledge of setting up layers, dimensioning, hatching, making block, plotting and printing, working with external reference file.
2. Drawing any three of the following item using AutoCAD software.
3. Flange coupling for shaft and vessel or pipe.
4. Pipe joints and fittings, single line and double line pipe line assembly.
5. Stuffing box.
6. Detailed cut section drawing of Globe valve and Stop valve.
7. Piping and instrumentation diagram of any given chemical process.

Assembly drawing of a single stirred jacketed pressure vessel with all its accessories using AutoCAD software. Introduction to AutoCAD software for drawing in 3D: Working in 3-dimensions, Drawing and editing commands, viewing 3D objects, basic solid and wireframe models, extruding, simple revolved objects. Generation of orthographic projections from 3D drawing.

Books of reference:

1. VenugopalK.,EngineeringDrawingandGraphics+AutoCAD,NewAgeInternational (P) Limited, Fourth edition, 2001.
2. Agarwal B. & Agarwal C.M., Engineering Drawing, McGraw Hill Education (India) Private Limited, 2nd Edition, 2014.
3. Lockhart S., Tutorial Guide to AutoCAD 2016, SDC Publication, 2016.

3rd Year 1st Semester (Semester 5)

THEORY

Subject Name: Chemical Process Technology					
Paper Code: CHEN 3101					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

Students will be able to

1. Describe sources and processes of manufacture of various industrially important chemicals.
2. Draw block diagrams/ process flow diagrams of the processes used for manufacture of industrially important chemicals.
3. Explain and calculate economic aspects of Projects involved in manufacturing of Chemicals.
4. Understand the applications of various unit operations involved in the manufacture of various chemicals and other useful materials.
5. Understand the implications of heat & mass transfer and fluid mechanics in chemical engineering industries.

Module I [10L]

Chlor-alkali industries:

Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture,

Mercury-cathode & Membrane process:

flow sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses.

Soda-ash:

Production and consumption pattern, Raw materials, Solvay process: Physicochemical principles of manufacture, carbonation and ammonia recovery step, flow-sheet and sequence of operation, other processes, advancement of process technology and modified Solvay process, major engineering problems, uses.

Industrial Inorganic Acids:

Hydrochloric Acid:

Manufacturing methods, by product Recovery from other production processes, conventional raw materials and principles of manufacture, flow-sheet and sequence of operation, major engineering problems, uses.

Sulphuric acid:

Raw materials resources, sulphuric acid production processes, Contact process, Physico-chemical principles and general theory of contact reaction with thermodynamic and reaction engineering aspects, different types of catalyst – preparation methodology and relative merits, flow-sheet and sequence of operation, details of major equipments, advancement of process technology and major engineering problems, DCDA process, uses.

Nitric Acid:

Raw materials resources, Ostwald Process–physico-chemical principles, catalyst, process flow sheet and sequence of operation, details of major equipments, uses.

Module II [10L]

Fertilizer Industries:

Nitrogenous fertilizers:

Ammonia-Source of hydrogen; methods of obtaining hydrogen from different sources, source of nitrogen-liquefaction of air and distillation of liquid air; Synthesis of Ammonia- Physico chemical principles, catalyst for synthesis of ammonia, process flow sheet and sequence of operation, details of major equipments.

Urea - Raw materials, manufacturing process with flow sheet, sequence of operation, major equipments details.

Phosphatic fertilizers:

Manufacturing process of super phosphate of lime, single and triple super phosphate, Diammonium phosphate.

Petroleum refining:

Production and consumption pattern, manufacturing technology of petroleum refining: Raw materials, principles of manufacture, flow sheet and sequence of operation, other processes, advancement of process technology and major engineering problems for the production of fuels, lubricants and various other products and by products from petroleum crude

Refinery operations:

Cracking operation**,** Hydrodesulphurisation (HDS & DHDS), Delayed coking, Visbreaking etc

Steam & catalytic cracking of naphtha and downstream products, separation scheme of naphtha cracking. Catalytic reforming of naphtha, catalyst and process variable of BTX reformer.

Synthesis gas and hydrogen production and its use: Steam reforming operation of Naphtha and natural gas.

Module III [10L]

Manufacture of Petrochemicals based on Ethylene:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of EDC, VCM, VAM, Ethylene oxide, Ethanol amine

Manufacture of Petrochemicals based on Propylene:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Acrylonitrile, Acrolein, Propylene oxide, glycerine (acrolein route), Isopropanol Production

Manufacture of Petrochemicals based on C4:

Description, raw material and energy sources and consumptions, operating conditions, catalysts, basic block diagram and simplified process flow diagram for manufacture of Butadiene from C4 cut.

Basic building blocks for manufacture of Benzene, Toluene and Xylene from BTX reformate petroleum crude. Coal based chemicals, fuels.

Module IV [10L]

Common utility services:

Electricity, steam, cooling water, hot oil, refrigeration and chilled water generated from industrially relevant fuels & coal.

Water treatment:

Water for the chemical process industry, Boiler feed-water, Cooling tower water, Demineralised water, Drinking water;

Treatment methodology:

Conventional water treatment procedures, Ion-exchange, Membrane technology etc.

Cement and ceramic materials:

Cement:

Chemical composition of Portland cement, raw materials, dry and wet process for manufacturing cement clinker, setting and hardening of cement.

Ceramic:

Basic raw materials, white-wares, manufacturing process of porcelain and their forming operations.

Refractories:

Properties of Refractories, raw materials, manufacturing techniques of acid refectories, basic Refractories, sintered and fused refractories, insulating refractories.

Glass:

Different types of glass ns their raw materials, manufacturing principles.

Oils and Fats:

Elementary idea, Composition (Fatty acid profile), Methods of extracting vegetable oils; Hydrogenation of oils, Major engineering problems and improved technology; Transesterification and Interesterification through enzymatic route; their applications. Method of soap production.

Text Books:

1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press
2. Austins, G.T., Sherve's Chemical Process Industries, McGraw-Hill, 5th Edn.

Books of reference:

1. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, Indian Institute of Technology, Madras.
2. Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology.

Subject Name: Chemical Reaction Engineering I					
Paper Code: CHEN 3102					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:
Students will be able to:

1. Determine rate equation of a chemical reaction from its kinetic experimental data.
2. Design a suitable reactor for a given chemical reaction.
3. Optimize the size and combination of chemical reactors in view to maximize yield and productivity of a material.
4. Compare the performance of ideal and non-ideal reactors using E(t) and F(t) curves.
5. Analyse a non-ideal reactor and predict conversion of a given chemical reaction.

Module I [10L]
Definition of reaction rate, Stoichiometry of chemical reaction, extent of reaction, limiting reactant, excess reactant, conversion, yeaild and selectivity. Kinetics of homogeneous reaction, Elementary & Non-elementary reactions. Molecularity and order of reaction, Constant volume and variable volume reaction. Determination of rate equation of non-elementary reactions. Temperature dependence of rate constant. Analysis and correlation of experimental kinetic data- data collection and plotting, linearization of rate equations, differential and integral method of analysis.

Module II [10L]
Ideal Reactors:
Introduction and classification; generalized material balance equation, Design equation of batch Reactor, Concept of flow reactors, Space-time and Space-velocity;
Steady-state Mixed Flow Reactor:
Design Equation, Graphical Representation of Design Equation;
Steady-state Plug Flow Reactor:
Design equation, graphical representation.
Multiple-Reactor Systems:
PFRs in Series and/or in Parallel, Equal-size MFRs in Series, MFRs of different sizes in Series, Reactors of Different Types in Series, Recycle Reactor: Definition of Recycle Ratio, Design Equation, and Optimum Recycle ratio.

Module III [10L]
Classification of Multiple Reactions;
Reactions in Parallel:
Qualitative aspects of Product Distribution, Quantitative Treatment of Product Distribution, Definition of Instantaneous and Overall fractional yield, graphical representation;
Reactions in Series:
Successive First- Order Reactions, First-Order Followed by Zero-Order Reaction, Zero-Order Followed by First-Order Reaction, Product Distribution, Quantitative Treatment of PFR, MFR and

Batch Reactor for series, parallel reaction.

Module IV [10L]
Non-ideal reactors, definition of residence time distribution function, E(t) and F(t) curve,
Moments of RTD Function:
Determination of mean residence time and variance from E(t) curve. Residence time distribution (RTD) function of ideal reactors, laminar flow reactor.
Introduction to compartment model of RTD of non-ideal reactors.
Non-ideal reactor modelling with the RTD: **Zero-parameter model:**
Segregation model, maximum mixedness model,
One-parameter model:
Tank-in-series model, dispersion model.

Text Book:

1. Levenspiel O. Chemical Reaction Engineering, 3rd. editions, John Wiley & Sons, 2001.

Books of reference:

1. Fogler H.S. Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2004.
2. Smith J.M. Chemical Engineering Kinetics, 3rd. Edition, McGraw-Hill, 1983.
3. Li S, Li L, Xin F. Reaction Engineering, Chemical Industry Press, 2017.
4. Carberry J.J., Chemical and Catalytic Reaction Engineering, Dover Publications, Inc., 2001
5. Froment G.F., Bischoff K.B., De Wilde J., Chemical Reactor Analysis and Design, 3rd Edition, John Wiley & Sons, Incorporated, 2010.

Subject Name: Mass Transfer I					
Paper Code: CHEN 3103					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:
After completing this course, students will be able to:

1. Frame mathematical equations for a given steady-state or transient diffusion problem and solve them.
2. Determine mass transfer coefficients by using appropriate correlations for a given engineering problem.
3. Analyse the effect of a reaction on a specific diffusion operation.
4. Select either plate or packed column (whichever is appropriate) for a given absorption operation and design the selected type of column.
5. Design a fractional distillation column (plate-type) for a given binary distillation operation.

Module I [10L]
Principles of diffusion, Constitutive equations for steady state and transient diffusion, Fick's Law, Diffusivity and correlations for diffusivity for liquids and gases, convective mass transfer, mass transfer coefficients and their correlations, interphase mass transfer and related theories (Two-film, Penetration, Surface-Renewal and boundary layer theories).

Module II [10L]
Diffusion with chemical reactions:
Industrial applications, analysis of diffusion with chemical reactions by Film and Penetration theory, significance of Hatta number, effect of reaction regimes (slow, fast, instantaneous) on diffusion.
Difference between continuous and staged gas-liquid contacting devices and selection criteria, concept of an equilibrium stage, stage efficiency, transfer unit (number and height), Types of industrial trays and their selection, types of packings.

Module III [10L]
Gas absorption:
Mechanism of absorption, effect of chemical reaction on absorption rate, enhancement factor.
Loading and flooding in a packed tower, design of a packed absorption tower based on film coefficients and overall coefficients, design of a tray column for absorption (graphical method and Kremser equation), significance of absorption factor.

Module IV [10L]
Distillation:
Industrial utility, vapor-liquid equilibria, ideality and deviations from ideality, relative volatility.
Batch distillation and Flash distillation:
Industrial applications, continuous binary rectification, different types of reflux arrangements (top-

tray, pump-back, pump-around) and concept of optimum reflux ratio, application of McCabe-Thiele method for calculation of number of trays in a distillation column, Fenske equation, basic idea of rate-based models for distillation.

Extractive and azeotropic distillation:

Industrial techniques and applications, basic idea of multi-component distillation.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, 3rd edition, 1983.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2nd edition, 2007.
3. Geankoplis, C.J., Transport Processes and Unit Operations, Prentice Hall of India, 3rd edition, 1993.

Books of reference:

1. Henley E.J., Seader J. D., Roper D.K., Separation Process Principles, Wiley, 3rd Edition (International Student Version), 2011.
2. McCabe W.L., Smith J.C., Harriot P., Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
3. Coulson J.M., Richardson J.F., Harker J.H., Backhurst J.R., Coulson and Richardson's Chemical Engineering: Particle Technology and Separation Processes, Vol. 2, Butterworth Heineman, 5th Edition 2002
4. Rosseau R.W., Handbook of Separation Process Technology, Wiley India Pvt. Ltd., 2009
5. Wankat P.C., Separation Process Engineering, Prentice Hall, 2nd edition, 2010

Subject Name: Numerical Methods in Chemical Engineering					
Paper Code: CHEN 3104					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:

1. Given a mathematical problem to be solved numerically, students should be able to identify different computational errors and evaluate them. Students will be able to know how to perform relative and absolute error in each case.
2. Given a linear multivariable problem, students will be able to relate the dependent and independent variables in the appropriate matrix form. Students will be able to identify the broad category of linear algebraic methods to solve the corresponding mathematical problem.
3. Given a non-linear engineering problem requiring single or simultaneous equation, students will be able to select the appropriate numerical algorithm to solve for the unknown variables.
4. Given an engineering problem with time varying solutions, students will be able to select appropriate numerical algorithm (e.g Euler or Runge Kutta method etc.) to determine the dynamic or spatial changes in the dependent variables under given initial/boundary conditions.
5. Given an engineering problem that can be modeled using partial differential equations (PDE), students will be able to identify the type of PDE and its associated boundary conditions. Students will be able to develop the numerical form of the governing equation by applying principles of numerical differentiation.

Module I [10L]

Approximation in numerical computation:

Truncation and rounding errors, Error analysis;

Interpolation: Newton and Lagrange polynomial, Spline interpolation.

Numerical Differentiation: Taylor series forward, backward and central difference scheme using Taylor Series; chemical engineering applications.

Root Finding methods for solution of non-linear equations:

Bisection, Newton-Raphson and Secant methods;

chemical engineering applications.

Module II [10L]

Linear Algebraic Equations:

Gauss Elimination, LU Decomposition and inversion of matrix, Gauss Siedel method.

Numerical Integration:

Trapezoidal Rule, Simpson's rule, integration with unequal segments; chemical engineering

applications.

Module III [10L]
Ordinary Differential Equations:
Euler method, Runge-Kutta Method, Adaptive Runge-Kutta method, Initial and boundary value problem; chemical engineering applications to single and multiple ODEs.

Module IV [10L]
Introduction to partial differential equation, Characterization of PDE; Heat conduction and diffusion problem; Explicit, Implicit and Crank-Nicholson scheme.
Numerical Optimization:
Concept and utility of process optimization ; one variable optimization e.g. Golden Search and Newton's Method;
Unconstrained optimization:
Direct search technique and gradient search technique ; Constrained Optimization: Simplex method.

Text Book:

1. R. Chapra and S. Canale, Numerical Methods for Engineers, 6th Edition, McGraw-Hill Science/Engineering/Math, 2009.

Books of reference:

1. Amos Gilat and Vish Subramaniam, Numerical Methods for Engineers and Scientists, 3rd Edition, John Wiley & Sons Inc, 2014.
2. Gupta S.K., Numerical Methods for Engineers, New Age International (P) Limited Publishers, 1995.
3. Constantinides A., Mostoufi N., Numerical Methods for Chemical Engineers with MATLAB, Prentice Hall PTR, 1999.

Subject Name: Petrochemical Technology					
Paper Code: CHEN 3131					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Students will be able to classify the variety of petrochemical feedstocks, petroleum refinery products and categorize the synthesis gas productions feedstocks.
2. Students will be able to interpret the steam cracking operation of naptha and discuss the production mechanism of petrochemical complexes like EDC, VCM, VAM, EO, EA, ACN, PO, Isopropanol etc.
3. Students will be to classify the catalytic reforming operation of naptha and interpret the production mechanism of synthetic detergent.
4. Students will be able to compare and contrast major polymerization processes in industry and describe various process technologies for Fibers, Elastomers and resins etc.

Module I [10L]

Evolution of petrochemical industry in India, recent trend of petrochemical industry in India,

Petrochemical industry feedstock:

Overview of petroleum refinery industry and its product, natural gas processing; impurities in feedstock for petrochemical industry and the process of their removal.

Synthesis gas production and its use:

Steam reforming operation of Naphtha and natural gas, fuel oil partial oxidation method, Methanol production, synthetic liquid fuel production by Fischer Tropsch process, aldehyde and alcohol production from synthesis gas, ammonia production and its application.

Module II [10L]

Steam cracking operation of naphtha and C_2 to C_4 saturates, downstream separation scheme of naphtha cracking.

Manufacture of Petrochemicals based on Ethylene:

EDC, VCM, VAM, Ethylene oxide, Ethanol amine;

Manufacture of Petrochemicals based on Propylene:

Acrylonitrile, Acrolein, Propylene oxide, glycerine (acrolein route, allyl chloride route, propylene oxide route), Isopropanol ;

Production of Butadiene from C_4 cut.

Module III [10L]

Catalytic reforming of naphtha, catalyst and process variable of BTX reformer, separation of

Benzene, Toluene and Xylene from BTX reformate, pyrolysis gasoline hydrogenation and separation of aromatics, separation of meta xylene from mixed xylenes, alkylation of benzene, production of styrene, cumene and phenol, production of Phthalic anhydride. Synthetic detergent and its classification, production of linear alkyl beanzene and keryl benzene sulfonate from kerosene cut, additives for detergent.

Module IV [10L]
Overview of plastic industry:
Production of LDPE, LLDPE, HDPE, PP, PVC, Polystyrene and their application.
Comparative study of Plastic, fibre and elastomer; production of SBR, Butadiene rubber, production of ABS plastic, polyamide, polyester, acrylic fibre, polycarbonates, production of phenol-formaldehyde resin; overview of polymer processing.

Text Books:

1. A Text on Petrochemicals: B.K.B. Rao, Khanna Publishers, 2011, ISBN 9788174090447 / 8174090444.
2. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers, 2008, ISBN 8174090967.
3. Introduction to Petrochemicals, Sukumar Maity. Oxford and IBH Publishing Co, 2002 ISBN 8120415558.

Books of reference:

1. The Petroleum chemicals Industry: R. F. Goldstein and A. L. Waddams, E & F N Spon (An imprint of Routledge), 1967, ISBN 0419025308.
2. Petrochemical processes: Chauvel, Gulf Publishing Co, 1989, ISBN 0872017729.

Subject Name: Energy Engineering					
Paper Code: CHEN 3132					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
Students will be able to:

1. Apply Knowledge of the various energy sources and their operating characteristics.
2. Acquire knowledge of different crude oil extraction process and various characterization techniques of fossil fuels.
3. Acquire knowledge on the processing of crude oil along with an estimation of various value-added products.
4. Acquire knowledge on the non-conventional energy resources and their utilization.

Module I [10L]
Introduction:
Conventional (fossil energy) and non-conventional (alternative energy) resources & reserves. Global Energy production & consumption pattern. Production &consumption pattern in India.
Solid Fuels:
Biomass, Wood and Charcoal. Classification & Rank of Coal, Peat, Lignite, Sub- Bituminous coal, Bituminous coal, Anthracite coal, Cannel &Bog head coal.
Coal Reserves in India Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal.
Theory of coal pyrolysis and Carbonization:
Low Temperature Carbonization (LTC), High Temperature Carbonization (HTC), Horizontal & Vertical Gas Retorts, Coke Ovens-Beehive & Byproduct Slot type. Recovery of byproducts. Details of Structural configuration and operating principles of Coke ovens including Charging and Discharging Mechanism.

Module II [10L]
Liquid Fuels:
Constitution of petroleum, theory of formation of crude petroleum oil. Characterization of crude oil & petroleum fuels, on shore and off-shore oil exploration.
Parameters and testing logistics of petroleum products:
Octane no., Cetane no., Pour point, Smoke point, Cloud point, Flash point, Fire point, Aniline point and Diesel index. Processes of a typical Indian refinery involving Operation and flow-sheet of crude

distillation plant; Thermal & catalytic cracking and reforming processes; coking, visbreaking, Fluid catalytic cracking and Hydrocracking.
Concept of Modern Refinery integrated with downstream petrochemicals units which manufacture naphtha-based aromatics as well as propylene-based polymers.

Liquid fuel from coal:

Fischer Tropsch process.

Module III [10L]

Gaseous Fuels:

Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed. Producer gas, Water gas with Carburetion, oil gas, coke-oven gas, blast furnace gas, Flow sheet & operation of Natural Gas and LPG. Coal Bed Methane. Integrated Gasification Combined Cycle.Removal of carbon dioxide from flue gas and utilising it for preparation of methanol or injecting high pressure CO_2 in the oil field etc.

Bio Gas:

Principles and Operation of Aerobic & Anaerobic digestors, Biogas generation and management& flow sheet with special reference to waste utilization.

Module IV [10L]

Solar Energy:

Devices for measurement of solar flux. Solar thermal and solar PV, Different types of solar collectors (Flat plate, parabolic, concentric & heliostat), Solar Pond, Photovoltaic cells, Chemical storage, Efficiency of Solar devices – Tracking.

Geothermal Energy & Wind Energy:

Utilization of Geo thermal Energy; Ocean Thermal Energy Conversion (OTEC).

Nuclear energy:

Sources of Nuclear fuels, Indian scenario; Nuclear reactions and power generation by Nuclear reactors- Breeder reactor- reaction &operation.
Generation of hydrogen and use as source of energy which in turn also reduce CO_2 generation.

Fuel Cells:

Types, Construction, Principle of Operation, Applications.

Fuels from Renewable Sources :

Bio Fuels, Preliminary concepts of Illumination Engineering—CFL and LED lights.

Text Books/Books of reference:

1. Mc Cabe W.L., Smith J.C. & Harriot P. Unit Operations of Chemical Engineering, McGraw-Hill, 7th edition, 2017.
2. Sarkar S. Fuels and Combustion, Universities Press, 3rd Edition, 2009.
3. Gupta O.P. Elements of Fuels, Furnaces and Refractories, Khanna publishers, 1989.
4. Bhatia S.C., Gupta R.K. Textbook of Renewable Energy, Woodhead Publishing India, 2018.
5. Sukhatme S. P., Solar Energy, Tata McGraw Hill, 1996.
6. Srinivasan S. Fuel Cells: From Fundamentals to Applications, Springer, 2006

Subject Name: Bioprocess Engineering					
Paper Code: CHEN 3141					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

The objective of this course is to provide basic approaches pertaining to Bio-chemical Engineering and Bio-Separation Technology to B. Tech students of Chemical Engineering.

1. The students will be able to solve biochemical reaction engineering problems for predicting rate equation for both enzymatic and live cell fermentation process.
2. The students will be able to design bioreactors for free enzymatic reaction under enzyme uninhibited/inhibited conditions.
3. The students will be able to select suitable bioreactor and its design and scale up for whole cell catalysed reactions.
4. The students will be able to suitable modern separation techniques for isolation, purification and quantitative separation of target biomolecule from live cells.

Module I [10L]

Principles of enzyme catalysis Proteins as enzymes; Michaelis- Menten kinetics; Briggs Halden theory Kinetics and Statistics; Inhibition; Effect of pH and temperature; Enzymology; methods of immobilization, diffusional limitations in immobilized enzyme systems.

Module II [10L]

Microbial growth Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Agitation and aeration:

Types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of kLa, power requirement for agitation in gaseous and non gaseous systems.

Module III [10L]

Bioreactors Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors. Scale up,

Operation and control of bioreactors:
Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Module IV [10L]
Bio-separations Biomass removal; Biomass disruption;
Membrane-based techniques:
Membrane Modules and quantification techniques to assess their performances;
Extraction; Adsorption and Chromatography. Industrial Processes and Process economics Description of industrial processes;

Text Books:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Coulson & Richardson, Chemical Engineering, Vol-2, Butterworth Heinemann, 5th Edition, 2002.

Books of reference:

1. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.
2. Biochemical Engineering, Marcel Dekkar, Inc, 2007.
3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Subject Name: Industrial Safety and Hazard Analysis					
Paper Code: CHEN 3142					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Ability to use important technical fundamentals of chemical process safety and to impart basic knowledge that allows the students to evaluate occupational safety and health hazards in the workplace.
2. Ability to analyze the effects of workplace exposures, injuries and illnesses, fatalities.
3. Ability to use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.
4. Ability to use logic based quantitative risk analysis.

Module I [10L]

Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II [10L]

Tools for hazards identification:

HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index. .

Module III [10L]

Risk analysis concept and methodology:

Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number.

Module IV [10L]

Control of chemical plant hazards, Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England),

Bhopal (India), Seveso (Italy), Pasadona (Texas).

Text Book:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety: Fundamentals with Applications:, Prentice Hall, 1990.

Books of reference:

1. Kharbanda O.P.and Stallworthy E. ., Safety in Chemical Process Industries: Heinmann .Professional Publishing LTD.1988.
2. Wentz C.A. Hazardous Waste management: Mc-Graw Hill.
3. Cutter S.L. Environmental Risks & Hazards, Prentice Hall, 1994.
4. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and How They Could Have Been Avoided, 5th, Edition, Butterworth-Heinemann / IChemE.

LABORATORY

Subject Name: Numerical Computation Laboratory					
Paper Code: CHEN 3151					
ContactHours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

After completion of the course the students will be able to

1. Acquire the basics of MATLAB.
2. Formulate the logic for the chosen numerical method to solve any chemical engineering problem.
3. Write MATLAB to apply the logic of an algorithm.
4. Acquire skills to debug code for syntax error.
5. Acquire skills to troubleshoot code to obtain correct solutions.
6. Acquire skills to graphically depict solutions.

Programmes on Numerical Computations (Tool for programming: MATLAB):

1. Basic MATLAB programming on matrix operations (multiplications, divisions, addition, subtraction, transpose, determinant). Programming on loop and conditional blocks.
2. Solution of Linear System by Gauss Elimination method: Steady state solution of isothermal CSTR in Series in which a first-order reaction is taking place.
3. Solution of Linear System by Gauss-Seidel iterative method: Steady state solution of isothermal CSTR in Series in which a first-order reaction is taking place.
4. Solution of a non-linear equation by Newton-Raphson method.
5. Evaluation of any intermediate value for a continuous function using Lagrangian interpolation scheme.
6. Solution to find the volume of a PFR for a first order steady state isothermal reaction using Simpson's $1/3^{rd}$ rule for integration.
7. Numerical solution of ODEs by Euler's method: Unsteady-state solution of multiple reactions in a CSTR or Binary distillation column.
8. Numerical solution of ODEs by 4^{th} order Runge-Kutta method: Unsteady-state solution of multiple reactions in a CSTR or Binary distillation column.

9. Solution of one-dimensional unsteady state heat conduction problem using Taylor series based Finite Difference Method – Implicit scheme using Tri-diagonal Matrix Algorithm (TDMA).

Text Book:

1. Pratap R., Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, 2010.

Book of reference:

1. Al-Malah, K. MATLAB Numerical Methods with Chemical Engineering Applications, 1st Edition, McGraw-Hill Education, 2013.

Subject Name : Chemical Reaction Engineering Laboratory					
Paper Code : CHEN 3152					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Course Outcomes:

Student will able to

1. Analyze the rate kinetics for anisothermal homogeneous liquid phase reaction in a semi-batch and batch reactor.
2. Draw concentration vs. time curve form isothermal continuous stirred tank reactor for the reaction of ethyl acetate and NaOH.
3. Determine the conversion for a non-catalytic homogeneous reaction in an isothermal PFR (coiled type).
4. Analyze the rate constants for a non-catalytic homogeneous reaction in a packed bed reactor.
5. Determine the equilibrium adsorption constant for a heterogeneous catalytic reaction in an U.V. photoreactor.
6. Plot exit age distribution curve for a non-catalytic liquid phase reaction in a coiled PFR and determine the mean residence time for pulse input of tracer.

At least eight experiments are to be performed

1. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an isothermal high pressure and/or atmospheric batch reactor.
2. Experimental studies on kinetics of a homogeneous liquid phase reaction in an isothermal semi high pressure and/or atmospheric batch reactor.
3. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a Spiral plug flow reactor.
4. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an

isothermal CSTR.

5. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a packed bed reactor.
6. Experimental studies on RTD in a tubular PFR using pulse input of tracer and measurement of axial dispersion coefficient.
7. Experimental studies on kinetics of a heterogeneous catalytic reaction in a UV photoreactor.
8. Experimental studies on RTD in a packed bed reactor using pulse input of tracer and measurement of axial dispersion coefficient.
9. Experimental studies on kinetics of hydrolysis of ethyl acetate in presence of acid catalyst in an adiabatic batch reactor.
10. Experimental studies on kinetics of sulfonation of toluene in an isothermal batch reactor.

Text Books:

1. Fogler H. S. Elements of Chemical Reaction Engineering, 4th. Edition, Prentice Hall, 2006
2. Levenspiel O. Chemical Reaction Engineering, 2nd. & 3rd. editions, Wiley Eastern Ltd. 1987.

Books of reference:

1. Rawlings J. B. and Ekerdt J. G. Chemical Reactor Analysis and Design Fundamentals, Nob Hill Publishing, 2002.
2. Smith J.M. Chemical Engineering Kinetics, 3rd. Edition, MGH, 1956.
3. Hill C.G. Chemical Engineering Kinetics and Reactor Design, Wiley, 2014.
4. Schmidt L. D. The Engineering of Chemical Reactions, 2nd. Edition, Oxford, 2007.
5. Berty J. N. Experiments in Catalytic Reaction Engineering, Elsevier, 1989.

Subject Name: Energy Engineering Laboratory					
Paper Code: CHEN 3153					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	0	0	2	2	1

Course Outcomes:

Students will be able to

1. Perform analysis of solid and gaseous fuel.
2. Determine important properties including carbon residue, aniline point of fuel oil.
3. Determine flash point, fire point, kinematic viscosity of oil using appropriate apparatus.
4. Determine calorific values of solid, liquid and gaseous fuel using suitable apparatus.
5. Determine vapour pressure of petroleum product and perform atmospheric distillation of petroleum product in suitable equipment.
6. Perform experiment on non-conventional energy source.

At least eight experiments are to be performed: Theoretical basis for the experiment will be discussed in detail before each experiment starts.

1. Proximate analysis of Coal.
2. Determination of carbon residue of fuel oil.
3. Determination of aniline point of a fuel oil.
4. Determination of moisture content of fuel oil by Dean & Stark apparatus.
5. Atmospheric Distillation of a petroleum product.
6. Determination of Flash Point & Fire Point of an oil by Abel apparatus.
7. Determination of Flash Point & Fire Point of oil by closed-cup Pensky Marten apparatus.
8. Determination of kinematic viscosity of oil by Redwood Viscometer.
9. Determination of calorific value of gaseous fuel by Junker's apparatus.
10. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.

Books of reference:

1. Sarkar S. Fuels and Combustion, Universities Press, 3rd Edition, 2009.
2. Gupta O.P. Elements of Fuels, Furnaces and Refractories, Khanna publishers, 1989.

Subject Name: Chemical Reaction Engineering-II					
Paper Code: CHEN 3111					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	3	0	03	3	3

Course Outcomes:

1. Ability to participate in catalyst development programme.
2. Ability to characterize newly developed catalyst.
3. Ability to design catalytic reactors.
4. Ability to design non catalytic reactors involving solid fluid reaction.
5. Ability to design reactors involving mass transfer with chemical reactions.

Module I [13L]

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts, Promoter and inhibitors, Physical and chemical adsorption, Adsorption isotherms, Determination of surface area by BET method and pore volume distribution of the Catalyst.

Module II [13L]

Kinetics of solid catalysed gas phase reaction, , Diffusion and Chemical Reactions in catalysis, Effectiveness factor, Identification of rate controlling regime, Experimental methods for finding rates, Differential and Integral reactors, Comparison of Experimental Reactors, Design concept.

Module III [13L]

Non Catalytic Solid Fluid Reactions:

Unreacted Core Model for spherical particles of unchanging size, Identification of rate controlling regimes, Rate of Reaction for Shrinking Spherical particles, Application to Design.

Module IV [13L]
Fluid- Fluid Reactions:
Kinetic regime for Mass Transfer and Reaction, Rate equation for Instantaneous Reactions, Rate equation for Fast Reactions, Rate equation for Intermediate Reactions, Rate equation for Slow Reactions, Slurry Reaction Kinetics, Application to Design, reactive Distillation and Extractive Reactions. Evaluation of conversion in non-ideal reactors from RTD study using experimental data and model equations; Details of Two parameter models.

Text Books:

1. Foggler H. S. Elements of Chemical Reaction Engineering, Prentice Hall, 2001.
2. Levenspiel O. Chemical Reaction Engineering, 3rd. ed. Wiley Eastern Limited**.**

Books of reference:

1. Carberry, J. Dover J., Chemical and Catalytic Reaction Engineering, Books on Chemistry, 2001.
2. Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde. Chemical Reactor Analysis and Design, John Wiley & Sons, Incorporated, 2010.

3rdYear 2ndSemester (Semester6)

THEORY

Subject Name: Process Control and Instrumentation					
Paper Code: CHEN 3201					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	3	0	0	3	3

Course Outcomes:

The objective of the course is to introduce the different components of a feedback control loop, namely, processes, controllers, measuring instruments and final control elements and provide an overview on different control strategies. The course will help develop concepts on mathematical models based on transfer function approach for single loop systems, and generate the idea of stability and controller tuning methods in a feedback control system. The course ends with an overview on process flow diagram (PFD) and piping and instrumentation diagram (P & ID) of chemical processes. After completion of the course, students will be able to:

1. Develop models of simple chemical processes, understand the dynamic and static behavior of the processes.
2. Perform linearization of nonlinear systems, understand transfer functions and solve equations using Laplace transforms.
3. Understand working principles of different types of controllers, and develop ideas on different control strategies.
4. Unravel the notion of stability in control systems through different techniques, get an idea on different stability criteria, and successfully evaluate the performance criteria of feedback controllers.
5. Understand the working principles of different measuring elements, control valves and develop basic concepts on process flow diagram and piping and instrumentation diagrams of chemical process plants.

Module I [10L]

Introductory concept:

Introduction to process dynamics and control: need for control and automation, classification of variables, design elements in control system, general modeling principles: balance equations, state variables, state equations, input output models, lumped and distributed parameter systems, steady state and dynamic behavior.

Transfer functions and first order processes:

Concept of linearity, linearization of nonlinear processes, concept of deviation variables, Laplace transforms: solution of ODEs using Laplace transforms, introduction to different forcing functions, transfer functions of single input, single output processes (SISO), transfer functions of multiple input multiple output (MIMO) processes, dynamic response of first order system to different forcing functions, pure capacitive, pure dead time processes, first order plus dead time process, Padé approximation, interacting and non-interacting processes.

Module II [10L]

Higher order processes and representative process models:

Higher order process: underdamped, critically damped and overdamped systems, second order plus dead time model, development of empirical model: model development using linear and nonlinear regression, fitting first and second order models using step test results,

case studies of simple process models:

Stirred tank heater, continuous stirred tank reactor, shell and tube heat exchanger, distillation column, U-tube manometer,

Notion of stability:

Concept of open loop and closed loop transfer function, characteristic equation, Routh-Hurwitz criteria, root-locus analysis, direct substitution method, frequency response analysis and their applications: Bode plot, Bode and Nyquist stability criteria.

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Module III [10L]

Introduction to feedback control, elements of control loop, block diagram of different chemical process units, servo and regulatory problem concept, P, PI, PD, PID, on-off controllers and their transfer function, dynamics and analysis of feedback controlled processes,

Design of feedback controller:

Performance criteria (ISE, ITAE, IAE etc), controller tuning methods, Cohen-Coon method, $1/4^{th}$ decay ratio method, direct synthesis method, gain and phase margins, process reaction curve method, Ziegler-Nichols method, robustness analysis; compensation for large dead time and inverse response, Smith predictor.

Other control strategies:

Feed forward, ratio and cascade control, split range, selective, override and auctioneering control, concepts of adaptive, inferential, multiloop and multivariable control.

Module IV [10L]

Measuring instruments (sensors) and final control elements (actuators):

Principles of measurement, error analysis, static and dynamic characteristics of instruments,

Final control elements/Actuators:

Different types of control valves, characteristic curve and transfer function,

Measuring instruments/sensors:

Temperature measurement:

Filled system Thermometer, Thermocouples, Resistance temperature detectors, radiation and optical pyrometers, pressure measurement: Manometer, elastic deformation: bourdon, bellows, diaphragm; and

Electrical type gauges:

Strain gauge, piezoelectric and pressure transducers, variable inductance and capacitance transducers, L.V.D.T for pressure measurement, low pressure and vacuum pressure measurement, L.V.D.T for pressure measurement, low pressure and vacuum pressure measurement,

Flow measurement:

Orifice plate, venture tube, flow nozzle, laminar flow element, segmental wedge, rotameters, pitot tubes, hot wire anemometers, positive displacement flowmeter,

Level measurement :

Resistive, inductive and capacitive techniques, ultrasonic and radiation methods, air purge system (bubbler method), composition measurement: chromatography, spectrophotometry.

Concepts on process flow diagram, Piping and instrumentation diagram:

Parts of a process flow diagram (PFD), equipment symbols, controllers, valves that affect system operation, major bypass and recirculation lines, temperature, pressure, composition and flowrates of different streams, parts of a piping and instrumentation diagram (P & ID), differences between PFD and P & ID, case studies.

Text Books:

1. Coughanowr D.R. Process system analysis and control, Tata McGraw-Hill, Inc., 2nd edition, 1991
2. Stephanopoulos G. Chemical Process Control: An Introduction to Theory and Practice—pHI Learning Pvt. Ltd., 1st edition, 1984
3. Eckman D.P. Industrial Instrumentation, Wiley Eastern Ltd., 1st edition, 2004.

Books of reference:

1. Patrnabais D. Principles of Industrial Instrumentation, Tata McGraw Hill, Publishing Ltd., 1st edition, 1999.
2. Seborg D.E., Edgar T.F., & Mellichamp D.A. Process Dynamics and Control, John Wiley and Sons, 2nd edition, 2004.
3. Fribance A.E. Industrial Instrumentation Fundamentals, McGraw-Hill, Kogakusha, 1962.
4. Bequette B.W. Process Control Modelling, Design and Simulation, Prentice Hall, 1957.
5. Luyben W.L. Process Modelling, Simulation and Control for Chemical Engineers, McGraw Hill, 1990.

Subject Name: Mass Transfer II					
Paper Code: CHEN 3202					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Students will be able to analyze various humidification, dehumidification processes and and will be able to design cooling towers.
2. Students will be able to analyze commercial extraction and leaching operation and determine number of equilibrium stages required for a given separation.
3. Students will be able to understand mechanism of drying, calculate drying time for batch dryers and compute rate of drying in batch and continuous modes of drying operation.
4. Students will be able to develop concepts on crystal properties, kinetics and thermodynamics associated with crystallization process, and design the crystallization equipments.
5. Students will be able to classify membrane separation processes based on driving forces, understand their applications and develop ideas on some of these processes and their applications in industries.

Module I [10L]

Humidification and Dehumidification:

Introduction, terminology and definitions, dry and wet-bulb thermometry, adiabatic saturation curve, the psychrometric chart and its use, psychrometric line & Lewis relation, recirculating liquid gas humidification-cooling, dehumidification of gas.

Cooling Tower

Introduction, classification of cooling tower, construction and operation, theory of counter flow cooling towers, design of cooling tower, make up water requirement.

Module II [10L]

Liquid- Liquid Extraction:

Introduction, liquid-liquid equilibria, ternary diagram, selectivity, distribution coefficient, choice of solvent, stage wise extraction, single stage, multistage extraction – cross current counter current, determination of number of equilibrium stages by graphical method, differential extractor, super critical fluid extraction.

Leaching:

Introduction to leaching, factors affecting leaching operation, leaching equipment, batch process, continuous multistage processes- calculation of number of stages, constant / variable underflow.

Module III [10L]

Drying:

Introduction to drying, mechanism of drying and drying equilibria; drying rate curve, rate of drying for batch dryers, rate of drying for continuous dryers, drying time calculation from drying rate curve, through and cross-circulation drying, classification and selection of dryer, novel drying technologies, industrial applications.

Crystallization:

Introduction to crystallization, solid-liquid phase equilibria, crystallization kinetics, crystal properties,

crystallization technology, crystallization equipments, design of crystallizer, industrial applications.

Module IV [10L]

Overview of membrane separation:

Classification of membrane separation processes, types of membranes and their applications, various models and applications, membrane fouling.

Membrane separation processes:

Ultrafiltration, dialysis, reverse osmosis, reverse osmosis in water treatment plant, pervaporation, electric field enhanced membrane separation process, micellar enhanced ultrafiltration, liquid membrane.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, International Edition, 1981.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
3. Geankoplis C.J., Transport processes and Separation Process Principles, Prentice Hall of India, Fourth Edition, 2004.

Books of reference:

1. Coulson J.M., Richardson J.F. Chemical Engineering Vol. 2, Elsevier Science, 5th Edition, 2002
2. McCabe W.L., Smith J.C., Harriott P. Unit Operations in Chemical Engineering, McGraw-Hill Education, 7th Edition, 2005.
3. King C.J. Separation Processes, Dover Publications, Inc., 2nd Edition, 2013.
4. Seader J.D., Henley E.J., Roper D.K., Separation Process Principles, John Wiley Inc., 3rd Edition, 2010.
5. Rosseau R.W., Handbook of Separation Process Technology, Wiley India Pvt. Ltd., 2009.
6. Wankat P.C., Separation Process Engineering, Prentice Hall, 2nd edition, 2010.

Subject Name: Computational Fluid Dynamics					
Paper Code: CHEN 3231					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of the course is to provide an elaborated concept of different numerical tools to solve flow dynamics for a fluid inside a defined domain. After completion the students will be able to:

1. Given a flow domain to be analysed, the students will be able to classify the type of fluid flow that is occurring in a particular physical system and use the appropriate model equations to investigate the flow.
2. Given a flow domain to be interpreted mathematically, the students will be able to apply the knowledge of discretization of the said domain using grid generation technique and to apply different numerical schemes (such as Finite Difference Method, finite volume method and ADI method) to simulate the domain.
3. Given a flow domain to be simulated, the students will be able to illustrate the concepts of force balance (Navier Stoke's equation) against a control volume and to apply different finite volume algorithms (Upwind scheme, Central Difference scheme, Hybrid scheme and Power law scheme) according to the appropriateness of the scheme specific to that volume.
4. Given a flow domain to be emulated, the students will be able to illustrate the concepts for grid arrangement (Collocated and Staggered Arrangement) for pressure-velocity coupled equation and apply the appropriate numerical tools (SIMPLE, SIMPLE-R, SIMPLE-C and artificial compressibility method).

Module I [10L]
Derivation of conservation of mass, momentum and energy equation with continuum assumption; Lagrangian and Eulerian Representations of Fluid Flow; Generalized form of advection-Diffusion Equation with source term along with initial condition and boundary conditions; Concept of periodic boundary conditions.

Module II [10L]
Basic concepts of grid generation and mapping; Grid generation and mapping for stretched grid for a highly viscous flow over a flat plate;
Concept of discretization:
Taylor series FDM and CV based FVM one-dimensional unsteady state heat diffusion equation: Treatment of boundary conditions; Numerical solution of PDE - Explicit method Stability Convergence Consistency; Direct Method - Thomas (Tri- diagonal Matrix) Algorithm; Iterative method - ADI method; Advantage of ADI method over TDMA.

Module III [10L]
Interpolation algorithms in Finite Volume Methods:
Upwind scheme, Central Difference scheme, Hybrid scheme and Power law scheme; Special features of Navier Stokes Equation; Discretization of Convective and Viscous Terms; Discretization of Pressure Terms and Body Forces; Arrangement on Grid Collocated and Staggered Arrangement.

Module IV [10L]
Algorithms for Unsteady Problems:
Calculation of Pressure:
Explicit and Implicit Time Advance Schemes;
Pressure Correction Methods:
Evaluation of pressure from Equation of Continuity; Velocity correction; SIMPLE, SIMPLE-R and SIMPLE-C.
Relaxation Iterative scheme:
Over and under relaxation; Discussion on Artificial Compressibility method.

Text Book:

1. Ferziger J. H. and Peric M. Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2001.

Books of reference:

1. Patankar S. V., Numerical Heat Transfer and Fluid Flow, 1st Edition, CRC Press, 1980.
2. Pletcher R. H., Tannehill J. C. and Anderson D. A. Computational Fluid Mechanics and Heat Transfer, 3rd Edition, CRC Press, 2012.

Subject Name: Novel Separation Processes					
Paper Code: CHEN 3232					
Contact hours	**L**	**T**	**P**	**Total**	**Credit Points**
per week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Students will be able to compare different membrane separation and develop the method for the fabrication of Inorganic and organic, symmetric and asymmetric membrane fabrication using phase inversion technique.
2. Students will be able to illustrate the process for membrane characterization and construct the transport equation through membrane for various membrane separation processes including pervaporation, dialysis.
3. Students will be able to understand the role of external fields and surfactants on different separation processes.
4. Students will be able to couple electrophoretic effects with separation techniques and understand the advantages of doing so.

Module I [10L]

Basic membrane separation process:

Size exclusion based membrane separation process (Microfiltration, ultrafiltration, nanofiltration, reverse osmosis); transport equations (concept of knudsen diffusivity and molecular diffusion); Models for water and solute transport in RO, Types of membrane material; Difference between symmetric membrane and composite membrane in view of the mechanical properties of the membrane; Membrane characterization techniques; Membrane modules, Applications of different membrane modules and a concept of shear enhanced membrane modules like VSEP.

Module II [10L]

Fabrication of membrane (Inorganic and organic); overview on phase inversion technique;

Concentration driven processes:

Concept of dialysis and fabrication of dialysis membrane, Haemodialysis, Electro dialysis; Understanding VLE and its application in pervaporation and membrane distillation; Gas sorption and permeation in a polymer; Concept of chromatographic separation techniques like gel filtration model ; Overview on membrane chromatography process.

Module III [10L]

External field assisted separation processes:

Centrifugal separation:

Basic principle, separation of liquids by centrifugation techniques, types of centrifuges and their

applications;

Thermal diffusion:

Principles and applications, extraction: ultrasound and microwave assisted extraction processes, supercritical fluid extraction, extraction with pulse electric field, applications, field flow fractionation;

Surfactant based separation processes:

Liquid membranes: fundamentals and modelling, types of liquid membrane, preparation of liquid membranes, applications; micellar enhanced separation processes and applications, cloud point extraction.

Module IV [10L]

Electrophoresis:

Electrokinetic effects;

Principles of electrophoresis:

Concept of electrical double layer and Debye length;

Generalized potential distribution in flat plate geometry of an electrolyte:

Development of Poisson Boltzman equation, Debye-Huckel approximation, potential distribution around a sphere under Debye Huckel approximation, concept of zeta potential, electrophoretic velocity and mobility calculation, Helmholtz-Smolouchoski equation, types of electrophoresis: gel and capillary.

Electrophoresis coupled with separation:

Coupling electrophoresis with ultrafiltration system:

Effect of electric field in gel layer and osmotic pressure controlled ultrafiltration, enhancement of permeate flux in ultrafiltration using electric field; electroosmosis: origin of electroosmotic flow, flow profile in open tube, thickness of double layer, electroosmotic mobility in open tubular capillary columns, electroosmotic flow velocity in packed columns, applications; elctrochromatography: principles and applications, ion exchange processes and applications, ion exchange chromatography in electric field, voltage programmed electrochromatography, applications .

Text Books:

1. Rousseau R.W. Handbook of Separation Process Technology, John Wiley & Sons, 2009.
2. Seader J.D., Henley E.J., Roper D.K. Separation Process Principles, Wiley Publications, 1957.
3. Li N.N. Advanced Membrane Technology and Applications, John Wiley and Sons, 2008.
4. Tsuda T. Electric Field Applications in Chromatography, Industrial and Chemical Processes VCH Publishers, New York 1995.
5. Lundanes E., Reubsaet L., Greibrokk T. Chromatography basic principles, sample preparations and related methods, Wiley Publications, 2013.

Books of reference:

1. De S., Sarkar B., Dasgupta S. Electric Field enhanced Membrane separation system: principles and typical applications, Nova Science Publishers, 2009.
2. Kislik V.S. Liquid Membranes, Principles and Applications in Wastewater treatment, Elsevier publications, 2009.
3. Coulson J.M., Richardson J.F. Chemical Engineering Vol. 2, Elsevier Science, 5th Edition, 2002
4. Wankat P.C. Separation Process Engineering, 2nd edition, Pearson Education, Inc. 2007.
5. McHugh M., Krukonis V. Supercritical Fluid Extraction, Butterworth Heineman, 1994.
6. Wankat W.C. Large Scale adsorption and chromatography, CRC Press Inc., 1986.
7. Ramirez C., Peters K. Extraction Techniques for Food Processing, ED-Tech Press, 2018.

8. Fong Leung W.W. Centrifugal separations in biotechnology, Elsevier Academic Press, 2007.
9. Bungay P.M., Lonsdale H.K., de Pinho M.N., Synthetic Membranes:: Science, Engineering and Applications, Springer,1986.
10. Ho W. S., Sircar K.K. Membrane Handbook, Springer, 1992.
11. Nath K. Membrane Separation Processes, Prentice Hall Learning Pvt. Ltd., 2008.
12. Cheryan M. Ultrafiltration and Microfiltration Handbook, CRC Press, 1998.
13. Wilson K. Wilson, Walker J. Principles and Techniques of Practical Biochemistry, Cambridge Univ. press, 2000.

Subject Name: Nanotechnology					
Paper Code: CHEN 3233					
Contact hours per week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of the course is to provide an elaborated concept of different unit operations that are required in an industry. After completion of the course students will be able to:

1. Exhibit knowledge of the fundamentals of solid state physics, lattice and atomic structure, energy bands and different types of bonding in matter.
2. Classify the various types of process used in nano-manufacturing of 1D, 2D and 3D nanostructures.
3. Exhibit knowledge of the relevant physical, chemical, mechanical, electrical and optical properties of materials in nano configuration.
4. Exhibit understanding and decide on measurements and instruments used for characterizing nanomaterial.

Module I [10L]
Introduction:
Introduction to nano dimensions and nano materials;
Structure of Solids:
Lattices, unit cell, bravais lattice, 3D lattice; Reciprocal Space, brillouin zones, Wigner-seitz cells. Wave diffraction, lattice vibration, energy bands, semiconductors types with energy bands; Introductory concepts of Density of States and Quantum Well, Potential Well; Bohr radius, band gaps and quantum confinement effects; Quantum tunneling effect; Excitons and Plasmons; Mechanical, Optical, Electronic and Magnetic property changes due to size reduction.

Module II [10L]
Nano-Synthesis:
Solid Synthesis :
Mechanical, thermal and laser processing, sputtering, arc-discharge.
Liquid Synthesis:
Electrochemical etching, sol-gel process, colloidal process; micro emulsion process, Langmuir-Blodgett Process.
Gas Phase and Hybrid Synthesis:

Molecular beam epitaxy; ion cluster beam deposition, CVD.

Biological Synthesis:

Plant-based synthesis, fungi and bacteria based methods; Synthesis using biological templates e.g. s-layers, ferritin etc.; concept of self-assembly, alkanethiol-bond and synthesis using DNA.

Module III [10L]

Instruments and Characterization:

Principles and uses of Optical microscope, confocal microscope; Electron microscope, Transmission electron microscope; Principles and uses of different types scanning probe microscope; Principles and use of Atomic Force Microscope; Principles and uses of X-ray diffractometer ; Principles and uses of UV-Vis-

NIR Spectroscope ; X-ray spectrometer; Elements of FTIR and Raman spectroscopy ;
Principles and uses of Auger electron microscope.

Module IV [10L]

Nano-Lithography, Applications of Nanomaterials:

Introduction to photolithography:

Principles and applications; Ebeam / Ion and X ray Lithography - principles and applications;

Nanolithography:

Types, principles and applications;

Soft Lithography:

Types, principles and applications;

Nanomaterials:

Synthesis and applications of various nanomaterials e.g. carbon nano tubes, porous silicon, aerogel, cryogel, coreshell nanoparticle and others.

Text Book:

1. Sulabh K. Kulkarni, NANOTECHNOLOGY: Principles & Practices; Springer International Publishing, 2015.

Books of reference:

1. Thomas Varghese & K.M. Balakrishna, Nanotechnology: An Introduction to Synthesis, Properties and Applications of Nanomaterials, Atlantic Publishers, 2011.
2. Introduction to Nanoscience & Nanotechnology by K. K. Chattopadhyay & A. N. Banerjee PHI publication, 2009.

Subject Name: Water and Liquid Waste Management					
Paper Code: CHEN 3221					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:
The objective of this course is to provide approaches of Domestic/ Industrial Water and Liquid Waste Management for interdisciplinary B Tech students.

1. The students will be able to identify the importance of Legislative orders prevalent in India concerning Water and Liquid Waste Management.
2. The students will be able to describe the methodology of Establishing and Operating Water and Liquid Waste intensive processes.
3. The students will be able to use the principles of Water Management in order to conserve water and solve water-shortage problems prevalent in India.
4. The students will be able to design the Water Treatment and Wastewater Treatment plants following the standard code of practice.

Module I [10L]
Introduction to Water Quality and its Storage. Methodology of Water flow measurement; Classification and various Water and Wastewater Standards prevalent in India. Legislative aspects including Water Act. 1974 and its revisions; Consent to Establish and Consent to Operate water intensive industries; Water conservation methodologies in 1) Process industry, 2) Construction industry and 3) Service industry; Rainwater Harvesting and various recharge techniques. Principles of Water Audit.

Module II [10L]
Water pollution:
Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with BOD, COD, TS, TDS, SS; Waste water treatment: primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA;
Non-conventional:
WSP, anaerobic treatment with special reference to AFFR, UASB, numerical problems associated with all

topics sited here.

Module III [10L]
Preliminaries of Water treatment processes;
Basic design consideration:
Pre-design, Raw water intake, Screening and aeration, Water conveyance, Coagulation, Flocculation and Precipitation, Sedimentation, filtration, colour, taste and odor control, Disinfections and fluoridation,
Water quality :
Physico Chemical and Bacteriological quality. Water Treatment Plant with design criteria: Slow sand bed and Rapid sand bed filter, layout, Process control, Non conventional water treatment processes and its design, numerical problems associated with all topics sited here.

Module IV [10L]
Liquid Waste Management in selected process industries:
Fertilizer, refineries and petrochemical units, pulp and paper industries, Tanneries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives. Case Studies.

Text Books:

1. Wendell P. Ela, Gilbert M. Masters, Introduction to Environmental Engineering and Science, PHI, Ed 3rd Edition.
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill – 2002.
3. Arceivala S.J., Wastewater treatment for pollution control, TMH, 2nd Edition.
4. Montogomery, J.M., Water Treatment Principles and Design, John Willey and Sons.

Books of reference:

1. Mahajan, S.P., Pollution Control in Process Industries, Tata Mc Graw Hill, 2008.
2. Davis M., Cornwell, D, Introduction to Environmental Engineering, Tata Mc GrawHill, 2012.
3. Standard Methods for Examination of Water and Wastewater, APHA / AWWA, 20th Edition.
4. Manual of Water Supply and Treatment: CPHEEO, Ministry of Urban Development, Govt. of India, 1999.
5. Water Treatment Plant Design, 5th Edition: ASCE and AWWA, 1912.
6. Design of Water treatment Plant - Part I, A G Bhole, Indian Water Works Association.

Subject Name: Industrial Safety and Hazard					
Paper Code: CHEN 3222					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

1. Ability to use important technical fundamentals of chemical process safety and to impart basic knowledge that allows the students to evaluate occupational safety and health hazards in the workplace.
2. Ability to analyze the effects of workplace exposures, injuries and illnesses, fatalities.
3. Ability to use safety programs to prevent or mitigate damage or losses and to develop preventative measure to avoid accident.
4. Ability to use logic based quantitative risk analysis.

Module I [10L]

Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II [10L]

Tools for hazards identification:

HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index. .

Module III [10L]

Risk analysis concept and methodology:

Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number.

Module IV [10L]

Control of chemical plant hazards, Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadona (Texas).

Text Book:

1. Crowl D.A. and .Louvar J.F. Chemical Process Safety: Fundamentals with Applications:, Prentice Hall, 1990.

Books of reference:

1. Kharbanda O.P.and Stallworthy E., Safety in Chemical Process Industries: Heinmann.Professional Publishing LTD.1988.
2. Wentz C.A. Hazardous Waste management: Mc-Graw Hill,
3. Cutter S.L. Environmental Risks & Hazards, Prentice Hall, 1994.
4. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and How They Could Have Been Avoided, 5th, Edition, Butterworth-Heinemann/IChemE .

Subject Name: Economics for Engineers					
Paper Code: HMTS-3201					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Course Outcomes:

The student will be able to:

1. Evaluate a project and estimate the total cost of the project.
2. Apply financial analytical methodologies to prepare a report regarding the financial performance of an organization.
3. Participate actively in an organization's capital budgeting process.
4. Provide vital inputs regarding the pricing of a product.
5. Apply the knowledge of the interplay of various economic variables and indicators in workplace.
6. Provide insight about different accounting concepts and apply broader concepts like costs, revenues, assets, liabilities, capital, profit, investment and interest.

Module I [6L]

Market: Meaning of Market, Types of Market, Perfect Competition, Monopoly, Monopolistic and Oligopoly market.

The basic concept of economics – needs, wants, utility.

National Income-GDP, GNP. Demand & Supply, Law of demand, Role of demand and supply in price determination, Price Elasticity.

Inflation:

Meaning, reasons, etc.

Module II [4L]

Business:

Types of business, Proprietorship, Partnership, Joint-stock company, and cooperative society – their

characteristics.

Banking:

Role of commercial banks; credit and its importance in industrial functioning.

Role of central bank:

Reserve Bank of India.

International Business or Trade Environment.

Module III [8L]

Financial Accounting:

Journals, Ledgers, Trial Balance, Profit & Loss Account, Balance Sheet. Financial Statement Analysis (Ratio and Cash Flow analysis).

Cost Accounting:

Terminology, Fixed, Variable and Semi-variable costs.

Break Even Analysis.

Cost Sheet. Budgeting and Variance Analysis. Marginal Cost based decisions.

Module IV [12L]

Time Value of Money:

Present and Future Value, Annuity, Perpetuity. Equity and Debt, Cost of Capital.

Capital Budgeting:

Methods of project appraisal - average rate of return - payback period - discounted cash flow method: net present value, benefit cost ratio, internal rate of return.

Depreciation and its types, Replacement Analysis, Sensitivity Analysis.

Text Books:

1. R**.** Narayanswami, Financial Accounting- A Managerial Perspective. Prentice-Hall of India Private Limited. New Delhi.
2. Horne, James C Van, Fundamentals of Financial Management. Prentice-Hall of India Private Limited, New Delhi.
3. H. L. Ahuja., Modern Economic Theory. S. Chand. New Delhi.
4. Newman, Donald G., Eschenbach, Ted G., and Lavelle, Jerome P. Engineering Economic Analysis. New York: Oxford University Press.2012.

Subject Name: Indian Constitution and Civil Society					
Paper Code: INCO 3016					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**0**

Course Outcomes:
The learner will be able to:

1. Analyse the historical, political and philosophical context behind the Indian Constitution-making process.
2. Appreciate the important principles characterizing the Indian Constitution and institute comparisons with other constitutions.
3. Understand the contemporaneity and application of the Indian Constitution in present times.
4. Critique the contexts for constitutional amendments in consonance with changing times and society.
5. Establish the relationship between the Indian Constitution and civil society at the collective as well as the individual levels.
6. Consciously exercise the rights and the duties emanating from the Indian Constitution to one's own life and work.

Module I
Introduction to the Constitution of India:
Historical Background,
Making of Indian Constitution:
The process of framing the constitution, the constituent assembly.

Module II

Salient Features of the Indian constitution
Comparison with the constitutions of other countries.

Module III
Relevance of the Constitution of India.
Constitution and Governance.
Constitution and Judiciary.
Constitution and Parliament-Constitutional amendments.

Module IV
Constitution and Society- democracy, secularism, justice.
Constitution and the individual citizen- Fundamental Rights, Directive Principles of state policy and Fundamental duties.

Books of reference:

1. C.M. Elliot, (ed.), Civil Society and Democracy, OUP, Oxford, 20012.
2. David Held et.al (ed), The Idea of the Modern State, Open Univ. Press, Bristol, 1993.
3. Neera Chandoke, State and Civil Society, Sage, Delhi, 19953.

LABORATORY

Subject Name: Process Control Laboratory					
Paper Code: CHEN 3251					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**2**	**2**	**1**

Course Outcomes:

1. Students will be able to understand the basics of instrumentation and process control through a hands-on practical experience.
2. Students will able to determine the dynamics of level and temperature measurement process.
3. Students will able to determine the dynamics of two capacity liquid level process by using U-tube manometer.
4. Students will able to identify open and closed loop control system and able to design process control system components to meet desired needs within realistic constraints.
5. Students will be able to use standard test signals to identify performance characteristics of first and second-order systems.
6. Students will able to calculate the characteristics of control valves.

At least any eight of the following experiments are to be performed:

1. Study on the dynamic characteristics of first order liquid level system.
2. Study on the dynamic characteristics of U-tube manometer (second order system).

3. Study on the dynamic characteristics of compound (interacting) second order system.
4. Study on the dynamic characteristics of compound (non-interacting) second order system.
5. Study on the response of controlled variable for a feedback control system with P, PI & PID controller.
6. Study on the flow characteristics and determination of discharge coefficient for different type pneumatic control valves.
7. Experiment on calibration of a load cell.
8. Liquid level measurement using air-purge method.
9. Determination of time constant of thermocouple during temperature measurement.
10. Experiment on calibration of pressure gauge using Dead-weight tester.
11. Experiment on flow measurement using wet gas meter.

Text Books:

1. G. Stephanopoulos. Chemical Process Control: An Introduction to Theory and Practice, pHI, 1st ed., 1984.
2. D.R. Coughanowr. Process system analysis & Control, McGraw-Hill, Inc., 2nd ed., 1991.
3. D. Patranabis. Principles of Industrial Instrumentation, Tata McGraw Hill, Publishing Ltd., 1st ed., 1999.

Subject Name: Mass Transfer Laboratory					
Paper Code: CHEN 3252					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**3**	**3**	**1.5**

Course Outcomes:

The objective of the course is to provide an overview of different mass transfer operation relevant to process industry. After completion of the course students will be able to:

1. Perform batch distillation and verify the validity of Rayleigh's equation for a given binary solution.
2. Conduct gas absorption experimentally in a packed bed and wetted wall tower.
3. Analyze continuous and batch mode of drying operation.
4. Construct adsorption isotherm.
5. Estimate diffusivity of vapour in air.
6. Perform liquid liquid extraction in batch mode / continuous mode.

Experiments to be performed:

1. Study on batch distillation and verification of Rayleigh's equation.
2. Study binary distillation in a packed/ plate column.
3. Study on isolation of a natural product by steam distillation.
4. Determination of mass transfer coefficient during absorption study in a packed bed and wetted

column.

5. Study on batch drying operation to plot drying rate characteristic curve under a constant drying condition in a tray dryer.
6. Study of drying in rotary dryer & finding out correlation between volumetric heat transfer coefficient and mass velocity of air.
7. Verification of adsorption isotherm for batch adsorption of dye on activated charcoal.
8. Determination of diffusivity of an organic vapour in air.
9. Study on extraction of benzoic acid / acetic acid from aqueous solution using ether.

Text Books:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill, International Edition, 1981.
2. Dutta B.K., Principles of Mass Transfer and Separation Processes, Prentice Hall of India, 2007.
3. Geankoplis C.J., Transport processes and Separation Process Principles, Prentice Hall of India, Fourth Edition, 2004.

Books of reference:

1. King, C. J. Separation Processes: McGraw Hill, Chemical Engineering Series.
2. Mc Cabe W.L., Smith J.C. Harriot P. Unit Operations in Chemical Engineering: McGraw Hill, Seventh Edition.
3. Richardson J. F. and Harker J.H. with J.R. Backhurst J.R. Coulson and Richardson's Chemical Engineering, Volume 2, Fifth Edition, Pergamon Press.
4. Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill.

Subject Name: Process Equipment Design & Drawing Laboratory					
Paper Code: CHEN 3253					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**3**	**3**	**1.5**

Course Outcomes:

Students will be able to:

1. Apply their theoretical knowledge for the design of engineering equipments relevant to chemical engineering.
2. Design a suitable flow-meter for the measurement of fluid flow through a pipe.
3. Select a suitable storage vessel for storing a given amount of fluid.
4. Design important process equipment like heat exchangers, distillation column or reactor of given duty.
5. Develop engineering drawing report as per their design using AutoCAD.

Each student shall be allotted design problems on sl. no 1, 2 & 3 at the beginning of the 6th semester and the student shall carryout complete process and mechanical design under supervision of a faculty member. The student shall also prepare engineering drawing of the equipment in AutoCAD and submit complete design report at specified time during 6th semester to the supervising faculty member.

Assessment would be made on the basis of the submitted report and the viva voce examination conducted during the practical examination at the end of 6th semester.

Design to be performed:

1. Design and Drawing of Orifice meter / Venturimeter / Rotameter. (Any one)
2. Design and Drawing of Pressure vessel.
3. Design and Drawing of Shell & tube heat exchangers/ Distillation column/ Reactor (Any one).

Books of reference:

1. Mahajani, V.V., Umarji S.B; Joshi's Process Equipment Design; 5th Edition, Trinity press, 2014.
2. Brownell L.E and Young E.H. Process Equipment Design, J Wiley & Sons, 1959.
3. Sinnott R.K. Chemical Engineering Design, 4th Edition, Vol 6, Elsevier Publication, 2005.
4. Kern D.Q, Process Heat Transfer, Indian Edition, McGraw Hill Education (India) PVT LTD, 1997.

Subject Name: Term Paper & Technical Seminar					
Paper Code: CHEN 3293					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**4**	**4**	**2**

A seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question–answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question-answer session and the report submitted, giving equal weightage on each component.

4th Year 1st Semester (Semester 7)

THEORY

Subject Name: Modern Instrumental Methods of Analysis					
Paper Code: CHEN 4131					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: IMA Lab.

Course Outcomes:

By the end of the course the students

1. Should be able to define a problem where the determination and/or measurement of some chemical species is required.
2. Should develop sufficient knowledge about the major instrumental methods of chemical analysis so that they can determine what technique should be used to solve a particular problem.
3. Should be able to perform and advice as an expert the details of Instrumental Analysis Techniques needed by Industries to solve problems of related field.
4. Should gain the background necessary for a scientific expert witness to present new techniques in a court of law.

Module I [10L]

Introduction to types of Analytical Methods and Instruments for Analysis. Cultivation of right attitude to work and utilize various Instrumental Techniques.

An introduction to absorption Spectroscopy:

Terms Employed in Absorption Spectroscopy Quantitative Aspects of Absorption Measurements. Basic Scientific laws to govern Spectrophotometry.

UV-Vis Spectrophotometry:

Absorbing Species, Some Typical Instruments, nature of cuvette in spectrophotometry, Application of Absorption Measurement to Qualitative Analysis, Quantitative Analysis by Absorption Measurements, Photometric Titrations, Automatic Photometric and Spectrophotometric Analysis, Nephelometry, Turbidimetry.

Module II [10L]

Atomic Spectroscopy:

Theory of Flame Spectroscopy, Flame Characteristics, Atomizers for Atomic Spectroscopy. Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, Atomic Fluorescence Spectroscopy.

Emission Spectra, Arc and Spark Sources, Argon Plasma Sources, Instruments for Emission Spectroscopy, Applications of Emission Spectroscopy.

Module III [10L]

Infrared spectrometry:

Theory of Infrared Absorption, Infrared Instrument Components, Some Typical Instruments, Sample Handling Techniques, Qualitative Applications of Infrared Absorption, Quantitative Applications, Infrared Fourier Transform Spectroscopy, Hadamard Transform, Spectroscopy.

Introduction to X-Ray Techniques:

Fundamental Principles, Instrument Components, X-Ray Fluorescence Methods, X-Ray Diffraction Methods, The Electron Microprobe Method, X-Ray Photoelectron Spectroscopy.

X-Ray Fluorescence Spectrometry (XRF) : its working principle and application.

Nuclear Magnetic Resonance Spectroscopy (NMR):
Theory of Nuclear Magnetic Resonance, Experimental Methods of NMR Spectroscopy, Environmental Effects on Proton NMR Spectra
Applications of Proton NMR, Application of Proton NMR to Quantitative Analysis, Fourier Transform NMR, Electron Spin Resonance Spectroscopy.
The Mass Spectrometer:
Mass Spectra, Qualitative Applications of Mass Spectrometry
Quantitative Applications of Mass Spectrometry.

Module IV [10L]
Chromatographic Techniques:
Gas Chromatography, various columns in Gas Chromatography, operation methodologies of Gas Chromatography, Recent developments: GC-MS, Applications in Industrial Sector
Essentials of Liquid Column Chromatography, Choice of solvent, choice of detector, Applications in Industrial Sector.
High Performance Liquid Chromatography: Essentials, Retention time, Selectivity, resolution equation, Height equivalent to a theoretical plate and its importance, case studies.
Industrial Applications and methodologies for specific species: Mercury, Chromium, Arsenic: case studies.

Text Books:

1. 1 Willard, H., Meritt, L.l., Dean, J.A., and F.A.Settle, F. A. : Instrumental Methods of Analysis, 6th Edition, CBS.
2. Douglas, A, and Donald, M. W,. Principles of Instrumental analysis, 2nd. Ed.Saunders College, Philadelpha, 1980.
3. Hofmann, Andreas and Clokie, Samuel, Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 8th Ed. 2018.

Books of reference:

1. Ewing, G.W.,: Analytical Instrumentation Hand book, Marcell Dekker, New York, 1990.
2. Operations Manuals of GC, GC-MS, Cary-60 Spectrophotometry, AAS & IR by Agilent Technologies, India , 2019.

Subject Name : Petroleum Refinery Engineering					
Paper Code: CHEN 4132					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Prerequisites: Chemical Technology, Basics of Material & Energy Balance

Course Outcomes:

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

1. Understand the oil refining process.
2. Categorize associated downstream processing technologies, operations and economics.
3. Grasp the principles for improving refinery economics.
4. Develop the essential knowledge and skills required to work as an engineer in the oil, gas and petrochemical sectors.

Module I [10L]

Introduction:

Origin and formation of petroleum, reserves and deposits of the world, Indian petroleum Industry, composition of petroleum, crude oil analysis.

Refinery feedstock and Product: Crude pretreatment, dehydration and desalting, pipe still heater, atmospheric and vacuum distillation of crude oil, natural gas, associated gas, dissolved gas, refinery off gas, LPG, reid vapour pressure, ASTM distillation, octane number and cetane number.

Evaluation of crude oil properties and design of crude oil distillation column:

Dehydration and desalting of crude, ASTM and TBP distillation of crude, properties of crude oil fractions, design of crude oil distillation column.

Module II [10L]

Treatment of refinery products, additives, blending of gasoline, treatment of gasoline, kerosene, lubes and lubricating oils, waxes, Furnace Design.

Thermal and catalytic cracking:

Coking and thermal process, delayed coking, catalytic cracking, cracking feed stocks and reactors, effect of process variables, FCC cracking, catalyst coking and regeneration, design concepts, new designs for fluidized-bed catalytic cracking units.

Catalytic Reforming:

Objective and application of catalytic reforming process reforming catalysts, reformer feed reforming reactor design continuous and semi regenerative process.

Module III [10L]

Hydro treating and Hydrocracking:

Objectives & hydrocracking reactions, hydrocracking feed stocks, modes of hydrocracking, effects of process variables, hydro treating process and catalysts Resid hydroprocessing, effects of process variables, reactor design concepts.

Isomerization, Alkylation and Polymerization:
Isomerization process, reactions, effects of process variables. alkylation process, feedstocks, reactions, products, catalysts and effect of process variables.
Polymerization: Objectives, process, reactions, catalysts and effect of process variables.

Module IV [10L]
Lube Oil Manufacturing:
Propane deasphalting solvent extraction, dewaxing, additives production from refinery feedstocks.
Environmental issues and New Trends in petroleum refinery operations:
Ecological consideration in petroleum refinery, waste water treatment, control of air pollution, new trends in refinery, alternative energy sources, biodiesel, hydrogen energy from biomass.

Text Books:

1. W.L..Nelson " Petroleum Refining Engineering " Mc Graw- Hill.
2. R.N.Watkins, " Petroleum Refinery distillation " Gulf Publishing Co.
3. Robert A Mayers " Hand book of petroleum refining process ".
4. James G Speight " The chemistry and technology of petroleum ".
5. J.H. Gary and G.E. Handwerk " Petrolem Refinery Technologies and economics ".

Subject Name : Environmental Engineering					
Paper Code: CHEN 4133 (PE IV)					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Environmental Science, Chemical Reaction Engineering

Course Outcomes:

At the end of the course the students should be able:

1. To apply the knowledge of Legislation concerning Environmental Engineering & Pollution Control prevalent in India.
2. To utilize the knowledge base of Solid Waste Management in order to achieve Swachh Bharat Mission.
3. To solve problems of Air Pollution and Water Pollution in batch and flow system and design suitable instruments/equipments .
4. To design Environmental Management Plan for chemical industries.

Module I [10L]

Types of environments and their pollutants. Classification of pollutants. Legislative aspects including Bengal Smoke Nuisance Act, Water Act. 1974, Air Act 1981 and effluent standards, Genesis and Role of EPA,

Air pollution:

Sources and effects of different air pollutants, Sampling and analysis of air pollutants, Air pollution control methods and equipment, Cyclone Separator, Baghouse, ESP, Venturi Scrubber.

Module II [10L]

Water pollution:

Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with: BOD, COD, TS, TDS, SS;

Waste water treatment:

Primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA;

Non conventional:

WSP, anaerobic treatment with special reference to AFFR, UASB.

Module III [10L]

Solid waste management:

Sources and classification, public health aspects, Methods of collection and disposal methods: open dumping, landfill, incineration, composting, vermiculture; Solid waste management using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludges. Management and

handling of Biomedical waste; E-waste – classification and re-use and disposal; Hazardous waste management – Electro-chemical and photo-chemical oxidation - dye waste, chrome slag –case studies.

Module IV [10L]
Pollution control in selected process industries:
Fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Radioactive wastes, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives Case Studies.

Text Books:

1. Rao, C.S., Environmental Pollution Control Engineering, New Age International, 2nd Edition,
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill – 2002.
3. Arceivala, S.J., Wastewater treatment for pollution control, TMH, 2nd Edition.

Books of reference:

1. Mahajan, S.P, Pollution Control in Process Industries, Tata Mc Graw Hill, 2008.
2. M. Davis, Cornwell, D, Introduction to Environmental Engineering, Tata Mc Graw Hill, 2012.
3. M. N. Rao, H V N Rao, Air Pollution, Tata Mc Graw HilL, 2007.
4. Stern, Arthur (Ed.), Air Polution Vol I-- VIII, Elsevier, 3rd Edition, 2014.
5. Standard Methods for Examination of Water and Wastewater, APHA /AWWA, 20th Edition.

Subject Name: Principles of Management					
Paper Code: HMTS4101					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

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

1. To study the evolution of Management.
2. To understand various management functions and have some basic knowledge on different aspects of management.
3. To understand the planning process in an organization.
4. To understand the concept of organizational structure.
5. To demonstrate the ability to direct, lead and communicate effectively.
6. To analyse and isolate issues and formulate best control methods.

Module I [8L]
Management:
Definition, nature, purpose and scope of management
Skills and roles of a Manager, functions, principles;
Evolution of Management Thought:
Taylor Scientific Management, Behavioural Management, Administrative Management, Fayol's Principles of Management, Hawthorne Studies.
Types of Business organization:
Sole proprietorship, partnership, company-public and private sector enterprises -Organization culture and Environment –Current trends and issues in Management.

Module II [8L]
Planning:
Types of plans, planning process, Characteristics of planning, Traditional objective setting, Strategic Management, premising and forecasting.
Organizing:
Nature and Purpose-Formal and informal, organizational chart, organization structure-types-line and staff authority, departmentalization, delegation of authority, centralization and decentralization.
Controlling:
Concept, planning-control relationship, process of control, Types of Control, Control Techniques .
Human Resource Management:
HR Planning, Recruitment, Selection, Training and Development, Performance Management, Career

planning and management.

Module III [8L]
Directing:
Foundations of individual and group behaviour –motivation –motivation theories –motivational-Techniques –job satisfaction –job enrichment –leadership –types and theories of leadership –Communication –process of communication –barrier in communication –effective communication –

communication and IT.
Decision-Making:
Process, Simon's model of decision making, creative problem solving, group decision-making.
Coordinating:
Concepts, issues and techniques.

Module IV [8L]
Leading:
Managing Communication: Nature & function of communication, methods of interpersonal communication, barriers of effective communication, direction of communication flow, role of technology in managerial communication.
Motivating Employees:
Define motivation, compare and contrast early theories of motivation, compare and contrast contemporary theories of motivation & current issues.
Being an Effective Leader Define leader/ leadership, compare and contrast early theories of leadership, understand three contingency theories, understand modern views on leadership. Motivation, Leadership, Communication, Teams and Teamwork.
Management by Objectives (MBO):
Management by exception; Styles of management: (American, Japanese and Indian), McKinsey's 7-S Approach, Self-Management.

Books of reference:

1. Stephen P. Robbins andMary Coulter, "Management", Pearson Education, 2017, 13th edition.
2. Koontz H. and Weihrich H., "Essentials ofManagement", Mcgraw Hill Int. Ed., 2015,10thedition.
3. Bhat Aand Kumar A. "Management: Principles, Processes & Practices", Oxford University Press, 2016, 2ndedition.
4. Robbins, Coulter, and DeCenzo, "Fundamentals of Management", Pearson Education, 2016, 9th edition.
5. RichardL.Daft, "Management", Cengage Learning, 10thedition.

Subject Name : Thin Film based Microstructure Fabrication					
Paper Code: CHEN 4121					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Chemical Reaction Engineering, Physics, Chemistry

Course Outcomes:

The objective of this course is to provide an idea about the fabrication technology of thin film devices installed for different applications. At the end of the course

1. The students will be able to identify different applications using thin film based technology.
2. The students will be able to illustrate the basic concept of thin film based microstructure fabrication.
3. The students will be able to demonstrate different types of thin film deposition technologies and outline different techniques on thin film patterning.
4. The students will be able to interpret characterization results for thin films after analysing it in different measuring instruments and to summarize optical, electrical and mechanical behaviour of thin films.

Module I [10L]

Application of thin films in solar cells, solid state and memory devices; Gas kinetics: Maxwell-Boltzmann Distribution, Knudsen diffusion, Mean free path, Transport properties (Diffusion, Viscosity, Heat), Surface physics(Adsorption, Surface diffusion, Nucleation, Growth, Stress, Adhesion), Growth modes from a thermodynamic perspective; Basics of clean room fabrication for thin film devices.

Module II [10L]

Thin Film Deposition Techniques:

Epitaxy, lattice misfit and defects in epitaxial films, Molecular beam epitaxy (MBE), Silicon heteroepitaxy,

Chemical vapour deposition (CVD):

Reaction types, bulk and surface transport processes.

Physical Vapor Deposition methods:

Evaporation, sputtering, laser assisted methods.

Module III [10L]

Thin Film Patterning Techniques; Etching (wet and dry), RIE, Chemomechanical polishing, Overview of various types of lithography; Photolithography and resist technology.

Module IV [10L]
Characterization of thin films: Measuring Instruments for structure-thickness, topography, inhomogeneity, crystallography, bonding, point defects, composition, and optical, electrical and mechanical behaviour of thin films.

Text Books:

1. Ohring, M., Materials Science of Thin Films, 2nd Ed., Academic Press, 2001.
2. Smith D.L. Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional, 1995.

Book of reference:

1. Harmut F. & Khan H.R. Handbook of Thin Film Technology, Springer-Verlag Berlin Heidelberg, 2015.

Subject Name : Particle Characterization					
Paper Code: CHEN 4122					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Mechanical operations, Heat and Mass transfer, Physics

Course Outcomes:

Students will be able to:

1. Classify particle characteristics and understand the basic principles of the morphological characterization techniques.
2. Explain the basic principles of surface and interfacial characterization and apply the knowledge gained on characterization techniques in practical field.
3. Apply the knowledge gained on chemical and compositional characterization techniques in practical field.
4. Identify the necessity of advanced particle characterization techniques and gain a basic understanding of nanoparticle characterization techniques.

Module I [10L]

Introduction:

Definition of particle, industrial applications, eg. Paints, coatings and other particles in solvents, composite materials, particles in human healthcare, why is particle characterization necessary? Classification of particle characteristics, Morphological characterization of particles: shape analysis methods, shape characterization techniques, decision rules, particle sizes, particle size distributions, particle counters, static and dynamic methods of size analysis, image particle analysis eg. optical microscopy, transmission electron microscopy, light scattering, laser diffraction, acoustic spectroscopy, photon correlation spectroscopy, characterization techniques of nanoparticles: Size analysis: dynamic light scattering, static light scattering.

Module II [10L]

Structural and interfacial characterization:

Concept of surfaces, subsurfaces and core, pores and defects,
Structural characterization techniques:
AFM, XRD, SEM,
Interfacial characterization:
Adsorption, surface adhesion, adhesion force measurement, particle removal methods, particle cohesion, transport properties of particles.

Module III [10L]
Chemical and compositional characterization of particles:
Chemical processes involving particles, eg. burning of droplets and particles, dissolution, sublimation, particulate sampling methods like coating, impactors, filters, chromatographic and mass spectrometric techniques,
Chemical characterization techniques:
EDS/WDS, Energy spectroscopic chemical analysis (ESCA), Scanning Auger microscopy, secondary ion mass spectroscopy (SIMS), Time of Flight SIMS (TOF-SIMS), FTIR, μ-Raman, atomic absorption Spectrometry (AAS), X-ray fluorescence analysis(XRF), particle induced X-ray emission(PIXE), neutron activation analysis (NAA).

Module IV [10L]
Advanced characterization techniques:
Relevance of advanced characterization to material development, advanced diffraction techniques, advanced surface characterization techniques, advanced microscopic and spectroscopic techniques,
Nanoparticle characterization:
Properties and techniques, practical relevance of particle characterization.

Text Books:

1. J.K. Beddow, Particulate Science and Technology, Chemical Publishing Co., New York, 1980.
2. J. Seville, C-Y.Wu, Particle Technology and Engineering, Butterworth-Heineman, 2015.
3. S. Zhang, L. Li, A. Kumar, Materials Characterization Techniques, CRC Press 2008.
4. R.B. Bird, W.E. Stewart, E.N. Lightfoot, Transport Phenomena, John Wiley and Sons, 2007.

Books of reference:

1. C.R. Brundle, C.A. Evens Jr., S. Wilson, Encyclopedia of Materials Characterization, Butterworth Heineman, Boston, 1992.
2. J. Goldstein, D.E. Newbury, D.C. Joy, C.E. Lyman, Scanning Electron Microscopy and X-Ray Microanalysis, Springer Science, 2003.
3. D. B. Williams, C.B. Carter, Transmission Electron Microscopy, Plenum Press, 2004.
4. M. Hosokawa, K. Nogi, M. Naito, T. Yokoyama, Nanoparticle Technology Handbook, Elsevier, 2007.

Subject Name : Industrial Total Quality Management					
Paper Code: CHEN 4126					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Prerequisites: Mathematics I , Mathematics II

Course Outcomes:

1. Identify and control the quality of processes and hence that of products or goods & services by applying basic statistical tools.
2. Draw various types of Control Charts and analyze to ascertain the state of the process.
3. Develop different sampling plans to evaluate the quality of various types of defects.
4. Apply the techniques of Quality Circles and Kaizen in order to enhance work culture and Total Quality status in an organization.

Module I [10L]

Basic concepts:

Three paradigms of management and evolution of concept of quality management,

Organization:

Its basic objectives and goal, Mission and Vision, customer and secondary customer, Deming's wheel, bottom line: profit vs quality, historical developments with contribution of different scientists.

Basic statistical concepts associated with quality management, measurement of central tendency and dispersion, range versus variance, Random variables and expected value calculations, quality and process capability, probability distributions, concept of statistical quality control.

Module II [10L]

Tools and techniques for improvement in TQM: type A and type B techniques with a special reference to SWOT Analysis, brainstorming, stratification, Pareto Analysis, Ischikawa diagram, check sheet.

Use of control charts and process engineering techniques for implementing the quality plan: X—R chart, moving average chart, p-chart and c-chart.

Module III [10L]
Principles of Acceptance sampling:
Single–double and multiple sampling, AOQ, AQL, LTPD, Chain sampling plan, Dodge-Romig plan.
Philosophy and concept of quality circle:
Formation, steering committee, power and functions of leader, dy. Leader, coordinator, facilitator, case studies.

Module IV [10L]
Principles of Kaizen and Gemba principles. Concept of Six Sigma standards, case studies.
Different standards:
ISO, BS and Bureau of Indian Standards, details of ISO 9000 series, ISO 14000 series and SA 8000, OSHAS 18000 and the certification authorities.

Text Books:

1. Grant, Eugene and Leavenworth, Richard, Statistical Quality Control, TMH, 7th Edition2012.
2. Udpa, S R , Quality Circles: Progress through Participation, TMH, 1992.
3. Bedi, Kanishka, Quality Management, Oxford University Press.

Books of reference:

1. H. Lal Total Quality Management- A Practical Approach (1st Edition): New Age International, 1990.
2. Sundararaju, S. M., Total Quality Management – A Primer: TMH, 1995.
3. Mitra, Amitava, Fundamentals of Quality Control and Improvement, 2nd Edition.; Prentice- Hall of India, 1998.
4. Subburaj Ramasamy, Total Quality management, Mc-Graw Hill Education (India) Pvt. Ltd, 2012.

Subject Name : Soft Methods in Microstructure Fabrication					
Paper Code: CHEN 4127					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Prerequisites: Chemistry, Physics

Course Outcomes:

After completion of the course students will be able to:

1. Demonstrate the concept of microscopic system.
2. Identify various applications and fabrication methods of microfluidics.
3. Illustrate the basics of hydrogels and its fabrication technologies.
4. Summarise the concept of organometallic structure and compare various methods of self-assembly of organic molecules in nanostructures.

Module I [10L]

Forces in microscopic systems, significant microscopic scales in liquids and gases, examples of microfluidic structures, various mechanical, biological and chemical applications, Microfluidics and lab-on-chip devices, inertial microfluidics, interfacial phenomena, microfluidics in drops and bubbles.

Module II [10L]

Polymers in microfluidics Fabrication methods for microfluidics:

Thick resist lithography, polymer bulk and surface micromachining, microstereo lithography, micromolding, paper based devices. Assembly and packaging.

Module III [10L]

Hydrogels and its classification,

Synthesis of hydrogels:

Emulsion and precipitation polymerization, Core-shell structured materials, Block-copolymer micelles, Applications of hydrogels.

Module IV [10L]

Synthesis of organic nanomaterials on surface:

Organometallic structure, Significance of self-assembly of organic molecules in nanostructures,

Methods of self-assembled structure:

Reprecipitation, Gelation, Langmuir–Blodgett Technique, Layer-by-Layer Assembly, Self-assembly in solution.

Text Books:

1. Introduction to Microfluidics by Patric Tabeling OUP Oxford, Reprint, 2010.
2. Fundamentals and Applications of Microfluidics by Nam-Trung Nguyen and Steven T. Wereley. Artech House Publishers; 2nd edition 2006.
3. Soft Matter Nanotechnology: From Structure to Function by Xiaodong Chen and Harald Fuchs. Wiley-VCH; 1st edition 2015 .

Books of reference:

1. Biomaterials and Nanotechnology for Tissue Engineering by S Sethuraman, U M Krishnan, A Subramanian, 2016, CRC Press.
2. Nanotechnology Applications for Tissue Engineering, 1st Edition, Editors: Sabu Thomas, Yves Grohens, & Neethu Ninan. 2015, Elsevier.
3. Biological Applications of Microfluidics edited by Frank A. Gomez.

HONOURS COURSE

Subject Name : Industrial Process Control and Instrumentation					
Paper Code: CHEN 4111					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**1**	**0**	**4**	**4**

Prerequisites: Process Control and Instrumentation**,** Process Control Laboratory

Course Outcomes:

1. After completion of the course students will be able to:
2. Formulate mathematical models explaining the static and dynamic behavior of chemical processes.
3. Solve equations arising out of dynamic behavior of systems using Laplace transformation.
4. Develop the concept of stability and apply the stability criteria suitably.
5. Apply knowledge of the control strategies for different control configuration and controller tuning.
6. Specify the required instrumentation for measurement of various process parameters in chemical process plants and understanding working principles.

Module I [13L]:

Introduction to process Control & Instrumentation, general types of control configurations, mathematical modeling of a stirred tank reactor, mixing process, tubular heat exchanger, ideal binary distillation column, degrees of freedom and process controllers.

Transfer functions of first order processes, dynamic responses of first order systems to different forcing

functions.

Module II [13L]:
Higher Order Processes:
Interacting/ Non-interacting systems, second order processes, under damped, critically damped and over damped systems, dynamic system with dead time, Pade approximation. Controllers and Final control elements, control system design by frequency response, stability criteria, stability analysis.

Module III [13L]:
Performance criteria (ISE, ITAE, IAE etc.), Multiloop systems: Cascade control, feed forward control, ratio control, Smith predictor, internal model control. Controller tuning,
Control valves, Sizing, Valve characteristics.
Analysis of complex processes: Control of a steam jacketed kettle, dynamic response of a gas absorber, Heat conduction into a solid.

Module IV [13L]:
Principles of measurement, error Analysis, static and dynamic characteristics of instruments.
Temperature measurement:
Filled system thermometer, thermocouples, resistance temperature detector, radiation and optical pyrometers;
Pressure measurement:
Manometers: U tube manometer, inclined limb manometer,

Elastic deformation: bourdon, bellows,
Diaphragm and electrical type gauges: strain gauge, piezoelectric, pressure transducers.
Vacuum gauges: mechanical, electrical and ionization types;
Flow:
Head flow meters, area flow meters, positive displacement flow meters, mass and magnetic flow meters;
Level measurement : Air purge system,
Composition analysis:
Chromatography, spectrophotometry.
Concepts on process flow diagram, Piping and instrumentation diagram, Differences between PFD and P & ID.

Text Books:

1. Process system analysis & Control-D.R. Coughanowr, McGraw-Hill, Inc., 2nd ed., 1991.
2. Chemical Process Control: An Introduction to Theory and Practice-George Stephanopoulos, pHI, 1st ed., 1984.
3. Industrial Instrumentation-D. P. Eckman, Wiley Eastern Ltd., 1st ed., 2004.

Books of reference:

1. Principles of Industrial Instrumentation-D. Patranabis, Tata McGraw Hill, Publishing Ltd., 1st ed., 1999.
2. Process Dynamics and Control-D.E. Seborg, T.F. Edgar, and D.A. Mellichamp, John Wiley & Sons, 2nd ed., 2004.
3. Process Control Modeling, Design and Simulation-B. Wayne Bequette, Prentice Hall, 1957.
4. Process Modeling, Simulation and Control for Chemical Engineers-William L. Luyben, McGraw Hill, 1990.

LABORATORY/SESSIONAL

Subject Name : Design & Simulation Laboratory I					
Paper Code: CHEN 4151					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Prerequisites: MATLAB Basics, Basic course on CFD, Modeling and Simulation

Course Outcomes:

The students will be able to:

1. Illustrate basic theory of MATLAB SIMULINK for the simulation of chemical engineering processes.
2. Apply dynamic simulation of CSTR and mixing process using MATLAB SIMULINK.
3. Apply their knowledge on ANSYS for performing CFD simulations of chemical engineering processes.
4. Perform basic CFD simulations for obtaining temperature distribution in two-dimensional geometries.
5. Analyse the effects of mixing on product yield from a continuous stirred tank reactor.
6. Perform basic simulations of mixing processes and momentum transfer using DWSIM.

Programmes to be performed:

1. Basics of MATLAB Simulink tool application for performing dynamic simulation of a chemical process.
2. Dynamic modeling and simulation of a slurry mixing and pumping process.
3. Dynamic simulation of a continuous stirred tank reactor for van de Vusse reaction.
4. Introduction to the use of ANSYS for CFD simulation.
5. Solve for temperature distribution in a rectangular plate using CFD.
6. Model a mechanically agitated stirred tank reactor using CFD.
7. Introduction to DWSIM, utility of physical property and thermodynamic packages, simulation of a simple mixing process involving two components, simulation of major and minor losses for fluid flow through pipelines.

Text Books:

1. Jain S. Modeling and Simulation using MATLAB – Simulink, Wiley, 2013.
2. Ferziger J. H. and Peric M. Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2001.
3. Stolarski T., Nakasone Y., Yoshimoto S., Engineering Analysis with ANSYS software, Butterworth-Heineman, 2018.

Books of reference:

1. Chidambaram M. Mathematical Modelling and Simulation in Chemical Engineering, Cambridge University Press, 2018.
2. Computational flow modelling for Chemical Reactor Engineering, Vivek V. Ranade, Academic Press, 2002.
3. Anderson J.D. Computational Fluid Dynamics, the basics with Applications, McGraw-Hill, Inc., 1995.
4. Incropera F.P., DeWitt D.P., Fundamentals of Heat and Mass Transfer, Wiley 2006.
5. Finlayson B.A., Introduction to Chemical Engineering Computing, Wiley, 2012.

Subject Name : Project I					
Paper Code: CHEN 4195					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**0**	**7**	**3.5**

Course Outcomes:

1. Given a project topic, students will be able to identify the problem.
2. Students will be able to plan and organize experiments for obtaining necessary data for solving the problem.
3. Students will be able to analyze and interpret the data obtained from the appropriate experiments.
4. Students will be able to work as part of a team which may be multidisciplinary in some cases.
5. Students will be able to effectively communicate the results by way of **written (Publications, Project report)** and/or **oral (viva-voce, presentation)** communication.
6. Students will be able to educate themselves about the impact of various socio-economic, environmental and political factors on the design and implementation of a solution to a real-life engineering problem.

Each student shall be required under the supervision of a faculty to carry out a project work or investigation on an industrial/academic research problem. The project/research work has to be carried out by the student himself occasionally consulting his supervisor. The project/research problem will be allotted to the student at the beginning of the seventh semester indicating the jobs to be done by the student.

An internal committee, chaired by the departmental head, will perform two interim assessments during the semester in presence of student supervisor. Evaluation by the committee will be based on regularity of attendance and incremental progress of work done during the semester. The committee evaluation will be given due consideration for the student's final grade assessment. The allotted marks for the interim evaluation will be 20, while the rest of the marks will be on the report and on supervisor's discretion.

Report must be prepared according to the template given for PROJECT I (CHEN 4195). The report in duplicate has to be submitted in typed and bound form one week before the commencement of the 7th semester examination. The examination shall include oral presentation of the research work and a viva-voce before a committee of at least two members of faculty appointed by the HOD including the Supervisor. Equal weightage shall be given on oral presentation and viva voce.

Subject Name : Industrial Training					
Paper Code: CHEN 4191					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**0**	**0**	**2**

Course Outcomes:

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

1. Develop a concrete idea of industrial set up and its associated complexity.
2. Evaluate the classroom knowledge against the real life application.
3. Learn the sequence of activities that lead to a finished product from the raw material.
4. Learn about activities other than design and manufacturing that are necessary for producing the goods and services.
5. Develop the ability to identify problems when a process does not deliver the planned output.
6. Develop ability to write report on an observed process.

Students sent for Industrial Training during Summer Recess after 6th Semester for a duration of four weeks will submit two copies of Training Report (only Hard/Spiral bound is allowed) on or before a notified date, to the Faculty In-charge, In-plant Training. The Viva voce would be held before commencement of Practical Examination.

Report should consist of:

1. Copy of Training Certificate & allotment order (if any).
2. A general overview of the Plant.
3. The products and raw material sources of the Plant.
4. Process description/flow diagram of individual units.
5. Environment & Safety Aspects, Techno-economics /Corporate Social responsibility work of the organization if any.
6. For Training in R & D organizations/project Work, overview of work with sketches, Objectives, Materials & Methods, Result & Discussions are to be included instead of items mentioned in points 2-5.

4th Year 2nd Semester (Semester 8)

THEORY

Subject Name : Project Engineering					
Paper Code: CHEN 4231 (PE V)					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Basics of Material & Energy Balance, Economics for Engineers

Course Outcomes:

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

1. Understand the basics of project engineering and apply that to organize the activities of project engineering for economic analysis of the project.
2. Apply cost and profitability analysis for the project under considerations and study the preliminary feasibility of the project.
3. Implement innovative ideas to optimization of the plant design components in regard to requirement of energy, time and ultimately cost.
4. Perform network analysis of the project and critically examine the schedule for the completion and cost impacts for the project.

Module I [10L]

Basic preliminaries of Project Engineering, Role of a Project Engineer, scale up and scale down techniques, fixed capital and working capital, manufacturing cost, plant location and plant lay out--different considerations including SEZ and its specialties, plant utilities, safety measures. Time value of money, simple interest, nominal and effective interest rates, compound and continuous interest, present worth and discount, annuity, perpetuity and capitalized costs, Pay out period.

Module II [10L]

Depreciation:

Types of depreciation, Depletion, concepts of service life, salvage value, and book value, straight-line method, Declining balance method, double declining balance method, sum of the years digit method and sinking fund method for determination of depreciation, modified accelerated cost recovery system (MACRS), Alternative investment, Choices among various alternatives, Replacements, Various methods of profitability evaluation for replacements, Calculation on Return on investment. GDP and national growth.

Module III [10L]

Optimum Design and Design strategy:

Basic principle of Optimum Design, general procedure for determining optimum conditions, Breakeven analysis, Optimum production rate in plant, determination of optimum economic pipe diameter and optimum flow rate in condenser, minimum cost analysis, economics in selection of materials.

Module IV [10L]

Project scheduling:

Bar chart, Milestone chart, Concept of network analysis: Numbering network, PERT, CPM, statistical distribution associated with PERT network, Earliest expected time and latest allowable occurrence time calculation, Slack, determination of critical path, crashing of network.

Text Books:

1. Peters, Max S and Timmerhaus, Claus D, Plant Design and Economics for Chemical Engineers, Mc Graw Hill, 4th Ed., 1991.
2. Srinath, L S, PERT and CPM – Principles and Applications, Affiliated East West Press, 3rd Ed., 1989.

Books of reference:

3. Vilbrandt, F C, Dryden, Charles E, Chemical Engineering Plant Design, Mc Graw Hill, 2nd Ed., 1942.
4. SEZ Act and Policies, 53rd Amendment, Ministry of Commerce and Industry, Department of Commerce, 31.12.2019.
5. Sinnot, R K, Chemical Engineering Design, Coulson & Richardson's Chemical Engineering Series, Vol. 6, Elsevier, 4th Ed. 2005.

Subject Name : Process Integration					
Paper Code: CHEN 4232					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Process Heat Transfer, Mass Transfer I, Thermodynamics I and II

Course Outcomes:

After completing this course students will be able to:

1. Perform pinch analysis on a given Heat exchange system to identify non-optimal arrangements.
2. Design a Heat Exchanger Network (HEN) for a given heat exchange problem.
3. Analyze and optimize a HEN with respect to cost, energy requirement, area requirement etc.
4. Design energy-integrated process systems for distillation, chemical reaction, evaporation, refrigeration and cogeneration.

Module I [10L]

Introduction to Process Integration, Areas of application, Available techniques for Process Integration, Onion Diagram, Role of thermodynamics in Process design and integration, Introduction to Pinch Technology, differences with energy auditing, utility of pinch technology.

Module II [10L]

Methodology of Pinch technology:

Concepts of $\Delta T_{min,}$ Data extraction, Targeting; Optimization by Supertargeting;

Elements of pinch technology:

Grid diagram, Composite curve, Problem table algorithm, Grand Composite curve; Various **Targeting objectives:**

Energy targeting, Area targeting, Number of units targeting, Cost targeting.

Module III [10L]

Design of a Heat Exchanger Network (HEN):

Heuristic rules, Pinch design methods, Maximum Energy Recovery (MER) design; Concepts of multiple utilities and design for multiple utility pinches, threshold problems;

Evaluation of a HEN:

Loops and paths.

Module IV [10L]

Equipment for Heat Integration:

Heat Engines and Heat pumps, appropriate placement of heat engines and heat pumps relative to pinch, Heat integration in Evaporators and Refrigerators, Heat integration for batch and continuous reactor systems, distillation columns;

Heat and power Integration:

Steam turbine and Gas turbine integration for cogeneration.

Text Books:

1. Shenoy V.U. Heat Exchanger Network Synthesis, Gulf Publishing Company, USA, 1995.
2. Kemp I.C. Pinch analysis and Process Integration (2nd edition), Butterworth-Heinemann, 2007.

Book of reference:

1. Smith R. Chemical Process Design, McGraw Hill, 1995.

Subject Name : Fuel Cell Technology					
Paper Code: CHEN 4221					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**0**	**3**

Prerequisites: Chemistry I & Chemistry II

Course Outcomes:

1. Able to understand fundamentals of electrochemistry, thermodynamics, fluid mechanics, and heat and mass transfer, appropriate for the design or review of components of fuel cells and fuel cell systems.
2. Analyze the fuel cell technology and compare different types of fuel cell systems.
3. Calculate the various losses in fuel cells and analyse the fuel cell power plant sub systems.
4. Defend the significance of fuel cell technology in the new global energy scenario.

Module I [10L]

Fundamentals and classification of fuel cells; Thermodynamic efficiency.

Electromotive force of fuel cells:

Standard electrode potentials; Effect of concentration; Nernst equation.

Rate of electrode processes:

Types of polarization; Surface reactions; Oxygen electrodes; Hydrogen electrodes; Overall performance, Comparison on battery Vs fuel cell.

Module II [10L]

Low temperature fuel cells:

Hydrogen–oxygen fuel cells:

Alkaline and polymeric membrane types; Active catalyst and its dispersion; Heat and mass transfer; Construction and design; Limiting problems;

Low temperature fuel cells of other types:

Methanol fuel cell, hydrocarbon fuel cell.

High temperature fuel cells:

Advantages; Molten electrolyte fuel cell; Solid electrolyte fuel cell; Construction.

Other non-hydrogen fuel cells, relative merits and demerits, Polarization curve- Activation loss, Ohmic loss, and Mass transport loss.

Module III [10L]

Air de-polarised cells; Biochemical fuel cells; Regenerative cells; Micro fuel cells.

Fuel cell operation:

Supply of fuel; Electrical arrangement; Removal of products; Heat management of fuel cell, Materials for battery construction; Production and purification of fuels, limitation of low temperature fuel cell.

Module IV [10L]

Application of fuel cell systems:

Large scale power generation; Power plant for vehicles; Domestic power; Fuel cells in space. Fuel cell economics; Future trends in fuel cells, polarization curve, US-DoE target.

Text Books:

1. Recent Trends in Fuel Cell Science and Technology, Editors: Basu, S. (Ed.) (2007).
2. Kordesch, K.; Simader, G. Fuel Cells and Their Applications. VCH: 1996.

Book of reference:

1. Fuel Cell Handbook (Seventh Edition), EG&G Technical Services Inc., Eg&g Technical Services Inc, U. S. Department of Energy (2016).

Subject Name : Introduction to Solar and Wind Technology					
Paper Code: CHEN 4222					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**3**	**0**	**0**	**3**	**3**

Prerequisites: Process Heat Transfer, Thermodynamics-I, Fluid Mechanics, Engineering Physics.

Course Outcomes:

After completing this course students will be able to:

1. Understand different technologies used for solar collectors.
2. Students will be able to evaluate the performance and efficiency of different devices that extract power from solar energy.
3. Students will be able to understand the main components of wind energy system and its functions.
4. Understand the different types of wind turbines.

Module I [10L]

Introduction to Radiation heat transfer:

Blackbody radiation, Stefan-Boltzman Law, Wien's Displacement Law, emissivity, absorptivity, radiation view factor, radiation shield.

Solar radiation:

Sun earth geometric relationship, solar angles, sun's trajectories in different seasons, zenith solar time, air mass, solar beam, total solar radiation & diffuse radiation, solar radiation on different surfaces at different angles, extraterrestrial radiation. Attenuation of solar radiation by the atmosphere, beam and diffuse components of hourly and daily radiation, clearness index.

Module II [10L]

Solar Thermal Collector:

Flat plate collector, Unglazed, Single and double glazed solar collectors, Optical losses and thermal losses, thermal analysis and performance characteristics. Concentrating solar collectors: General description; concentrators, receivers, Orienting/tracking requirements, Parabolloid dish collectors, Scheffler dish, Linear Fresnnel Reflector Collector.

Introduction to Solar PV:

Crystal structure, band theory, energy band diagrams, Fermi level, intrinsic and extrinsic semiconductor, Standard solar cell structure, I-V characteristics, FF, Voc, Isc, Pmax, conversion efficiency, losses in solar cell, Rs, Rsh, impact of radiation and temperature; Silicon wafer based solar PV technology, Single and poly crystalline silicon solar cells; Thin film technology of solar cell, Merits and demerits of thin film technologies.

Module III [10L]
Basics of Wind Energy Conversion:
Power available in the wind spectra, Wind turbine power and torque,
Classification of wind turbines: Horizontal axis and Vertical axis,
Characteristics of wind rotors, Aerodynamics of wind turbines(Airfoil, Aerodynamic theories, Axial momentum theory, Blade element theory, Strip theory), Rotor design, Rotor performance.
Analysis of wind regimes:
The wind (Local effects, Wind shear, Turbulence, Acceleration effect, Time variation), Measurement of

wind (Ecological indicators, Anemometers, Cup anemometer, Propeller anemometer, Pressure plate anemometer, Pressure tube anemometers, Sonic anemometer, Wind direction).

Module IV [10L]
Wind energy conversion systems:
Wind electric generators (Tower, Rotor, Gear box, Power regulation, Safety brakes, Generator; Induction generator, Synchronous generator. Fixed and variable speed operations, Grid integration), Wind farms, Offshore wind farms, Wind pumps (Wind powered piston pumps, Limitations of wind driven piston pumps; The hysteresis effect, Mismatch between the rotor and pump characteristics, Dynamic loading of the pump's lift rod, Double acting pump, Wind driven roto-dynamic pumps, Wind electric pumps).

Text Books:

1. Sukhatme S. &Nayak J.,Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.
2. Solanki C.S.; Solar Photovotaics – Fundamentals, Technologies and Applications; PHI Learning, 3rd edition, 2015.
3. Efstathios E. (Stathis) Michaelides,Renewable Energy Sources, Springer, 2012.
4. SathyajithMathew,Wind Energy: Fundamentals, Resource Analysis and Economics,Springer, 2006.

Books of reference:

1. Goswami D.Y., Kreith F.&Kreider J.F.; Principles of solar Engineering, Tyalor and Francis, Philadelphia, 2000.
2. N.K.Bansal and M.K.Kleeman, Renewable Sources of Energy and Conversion Systems, Tata McGraw-Hill, 1984.

LABORATORY/SESSIONAL

Subject Name : Project II					
Paper Code: CHEN 4295					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**0**	**17**	**8.5**

Course Outcomes:

1. Given a project topic, students will be able to identify the problem.
2. Students will be able to plan and organize experiments for obtaining necessary data for solving the problem.
3. Students will be able to analyze and interpret the data obtained from the appropriate experiments.
4. Students will be able to work as part of a team which may be multidisciplinary in some cases.
5. Students will be able to effectively communicate the results by way of **written (Publications, Project report)** and/or **oral (viva-voce, presentation)** communication.
6. Students will be able to educate themselves about the impact of various socio-economic, environmental and political factors on the design and implementation of a solution to a real-life engineering problem.

Each student shall continue to work on the project work/research problem allotted to him at the beginning of the seventh semester under supervision of a faculty member.
After completion of all assigned jobs, the report must be prepared according to the template given for PROJECT II (CHEN 4295). The report prepared in duplicate has to be submitted by the student in typed and bound form one week before the commencement of the eight semester (final) examination. The evaluation shall include Report and Viva voce. The examination shall be conducted in presence of external expert and the student's supervisor.

Subject Name : Design & Simulation Laboratory II					
Paper Code: CHEN 4251					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**1.5**

Prerequisites: MATLAB Basics, Basic course on CFD, Modeling and Simulation, Design & Simulation Laboratory I

Course Outcomes:

The student will be able to:

1. Model controller action for heat exchange operation.
2. Apply MATLAB Simulink/equivalent software in dynamic simulation of a heat exchange operation.
3. Simulate a multiphase reactor using CFD.
4. Calculate condenser and re-boiler load, distillate and bottoms composition as well as number of ideal stages for a binary distillation column using appropriate simulation software.
5. Determine the effect of change of system temperature and/or pressure on the performance of a distillation column by dynamic simulation using appropriate simulation software.
6. Simulate the performance of an isothermal CSTR using appropriate simulation software.

Programmes to be performed:

1. Design of a PID feed-forward controller for controlling output fluid temperature in shell and tube heat exchanger.
2. Model a fluidized bed polymerization reactor using CFD.
3. Simulation of a basic distillation column for separation of a binary mixture using appropriate simulation software.
4. Simulation of CSTR performance for carrying out a first order isothermal liquid-phase reaction using appropriate simulation software.

Text Books/ books of reference:

1. Stephanopoulos G. Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall India Learning Private Limited, 2008.

2. Anderson J.D. Computational Fluid Dynamics, the basics with Applications, McGraw-Hill, Inc., 1995.

Subject Name : Grand Viva					
Paper Code: CHEN 4297					
Contact Hours	**L**	**T**	**P**	**Total**	**Credit Points**
Per Week	**0**	**0**	**0**	**0**	**1**

Viva – Voce examination shall be conducted to ascertain the students' overall grasp of the principles of Chemical Engineering and allied subjects. Evaluation of students would be conducted by a panel consisting of at least four Faculty members.