Semester III

CHE-ES301	**Engineering and Solid Mechanics**	2L:1T:0P	**3 credits**

Course Objectives:

Students would be introduced to fundamentals of Engineering Mechanics with emphasis on force systems, axioms, dynamics of rigid bodies. Second part of the course would be an introduction to Solid Mechanics, and students would be introduced to basic concepts of mechanics of deformable media: concept of stress tensor, strain tensor, strain rates, constitutive relations, and applications to one/two dimensional problems.

Contents:

1. Introduction, Point Kinematics: Moving point in various coordinate systems (Cartesian, Cylindrical, Path) **(3L+2T)**

2. Rigid body kinematics: Translation and rotation, relative motion, angular velocity, General motion of a rigid body, General relative motion **(6L+2T)**

3. Equivalent force systems, Resultant forces, Linear and Angular Momentum, Laws of motion (Euler's Axioms), Free Body Diagrams, Dynamics of point mass models of bodies.

(6L+2T)

4. Equilibrium of rigid bodies, distributed forces, Analysis of structures: Trusses, Forces in Beams: Shear Force and Bending Moment

(3L+1T)

5. Frictional forces, Laws of Coulomb friction, impending motion **(3L+1T)**

6. Inertia tensor, Principal Moments of Inertia, Moment of momentum relations for rigid bodies, Euler's Equations of Motion **(3L+1T)**

7. State of stress at a point, equations of motion, principal stress, maximum shear stress, Concept of strain, strain displacement relations, compatibility conditions, principal strains, transformation of stress/strain tensor, state of plane stress/strain. **(4L+2T)**

8. Uniaxial stress and strain analysis of bars, thermal stresses, Torsion of circular bars and thin walled members, Bending of straight/curves beams, transverse shear stresses, deflection of beams, Buckling of columns

(4L+2T)

Total 45 (L+T)

List of Books:

1. Engineering Mechanics, M.P. Poonia, Khanna Publishing House, New Delhi 2019
2. Strength of Materials, D.S. Bedi, Khanna Publishing House

3. Mechanics of Materials, Punmia& Jain, Laxmi Publications
4. Strength of Materials (Mechanics of Solid), R.S. Khurmi, S.Chand Publications

Course outcomes:

Students will be able to

- Understand the use of basic concepts of Resolution and composition of forces
- Analyse beams, truss or any engineering component by applying conditions of equilibrium
- List advantages and disadvantages of various geometric sections used in engineering design
- Understand the different stresses and strains occurring in components of structure
- Calculate the deformations such as axial, normal deflections under different loading conditions

CHE-BS302	**Chemistry-II**	2L:1T:0P	**3 credits**

Course Objectives:

Concepts related to homogeneous and heterogeneous catalysis, mechanisms of industrially important reactions, spectroscopic methods for identification of compounds.

Contents:

1. Homogeneous and Heterogeneous catalysis:
   Homogeneous Lewis acid-base catalysts, organometallic catalysts and industrially examples. Heterogeneous catalysts basic concepts and industrial examples. **(6L+1T)**

2. Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes:
Alkylation and acylation, e.g. alkylation of benzene, phenols, etc.
Halogenation, e.g. chlorination of toluene
Nitration and sulfonation, e.g. nitration, sulfonation of benzene, etc. **(6L+2T)**

3. Mechanisms and recent advances (green chemistry, catalysis, etc.) of following processes:
   Hydrogenation and reductive alkylations, e.g. hydrogenation of nitrobenzene, reductivealkylation reactions of anilines, etc.
   Oxidation, e.g. oxidation of xylenes, etc. **(6L+2T)**

4. Mechanisms and recent advances (green chemistry, catalysis etc.) of following processes:
   Polymerization, e.g. polyethylene, polypropylene, polyester and nylon, etc. **(6L+2T)**

5. Analytical chemistry:
Statistical Aspects, Molecular and atomic spectroscopy method. **(6L+1T)**

6. Analytical chemistry: Thermal & Chromatographic methods. **(6L+1T)**

Total 45 (L+T)

List of Books:

1. Engineering Chemistry, Satyaprakash& Manisha Agarwal Khanna Book Publishing, Delhi
2. A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
3. Essentials of Physical Chemistry, Bahl&Tuli, S.Chand Publishing
4. Applied Chemistry, Sunita Rattan, Kataria
5. Engineering Chemistry, Baskar, Wiley
6. Engineering Chemistry – I, D. Grour Krishana, Vikas Publishing
7. Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co.

Course outcomes:

Students taking the course will

- Get an understanding of the theoretical principles underlying molecular structure, bonding and properties.
- Know the fundamental concepts of structure and function in organic reactions, the use of kinetics and thermodynamics to elucidate mechanisms of reactions.
- Be able to predict reactivity patterns and propose reasonable mechanisms.

CHE-BS304	**Biology**	2L:1T:0P	**3 credits**

Course Objectives:
Students will be introduced to the basics of biology such as cell structure and functions, inheritance & evolution, basic concepts of genetics, and an introduction to microbiology.

Contents:
1. Basics: Diversity of life, prokaryotes and eukaryotes, basic cell constituents and macromolecules. **(4L + 2T)**
2. Biochemistry: Metabolism (Catabolism and Anabolism) and Bioenergetics **(9 L + 2T)**
3. Genetics: Basic principles of Mendel, molecular genetics, structure and function of genes and chromosomes, Transcription and Translation, gene expression and regulation. **(9L + 2T)**
4. Cell Biology: Macromolecules, membranes, organelles, cytoskeleton, signaling, cell division, differentiation, motility. **(9L + 2T)**
5. Microbiology: host-microbe interactions, physiology, ecology, diversity, and virology **(4L + 2T)**

Total 45 (L + T)

Text Book:
1. Biology for Engineers (ISBN: 9781121439931), TMH

Course outcomes:
Students will get insight into biology as a science, outlining the diversity, organization and fundamental principles of living systems.

CHE-PC305	**Thermodynamics-II**	2L:1T:0P	**3 credits**

Pre-requisites: Thermodynamics-I

Course Objectives:

To introduce the concepts of fugacity, activity coefficient, vapour-liquid equilibrium and reaction equilibrium. Introduction to molecular thermodynamics.

Contents:

1. Review of first and second law of thermodynamics **(2L+1T)**

2. Vapor-liquid equilibrium: phase rule,simple models for VLE;VLE by modified Raoult's law; VLE from K-value correlations; Flash calculations. **(5L+2T)**

3. Solution Thermodynamics: fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties. **(6L+1T)**

4. Liquid phase properties from VLE, Models for excess Gibbs energy, heat effects and property change on mixing. **(5L+1T)**

5. UNIFAC and UNIQUAC models. **(5L+1T)**

6. Liquid-Liquid Equilibria; Vapor-Liquid-Liquid Equilibria; Solid-Liquid Equilibria; Solid-Gas Equilibria. **(5L+1T)**

7. Chemical reaction equilibria: equilibrium criterion, equilibrium constant, evaluation of equilibrium constant at different temperatures, equilibrium conversion of single reactions, multireaction equilibria. **(5L+1T)**

8. Introduction to molecular/statistical thermodynamics **(3L+1T)**

Total 45 (L+T)

Text Books:

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

References Books:

1.S.Sandler, "Chemical, Biochemical and Engineering Thermodynamics", 4thedition,Wiley,India.

2. Y.V.C.Rao, "Chemical Engineering Thermodynamics", University Press, Hyderabad,1997.
3. G. Halder, "Introduction to Chemical Engineering Thermodynamics", PHI

Other Resources and Study Material

At the end of the course, the student should be able to solve problems involving equilibria of different phases such as VLE, LLE, VLLE, SLE, SVE as well as reaction equilibria.

CHE-PC303	**Fluid Mechanics**	**3L:1T:0P**	**Credits 4**

Objectives:

- The objective of this course is to introduce the mechanics of fluids (fluid statics and fluid dynamics), relevant to Chemical Engineering operations.

- The course will introduce students to forces on fluids, hydrostatic forces on submerged bodies, Eulerian and Lagrangian descriptions of flow, flow visualization, integral analysis involving mass and momentum balances, Bernoulli equation, flow through pipes and ducts, flow measurement and instruments, flow transportation - pumps, blowers and compressors, conservation of mass, linear and angular momentum in differential form, Navier-Stokes equation, viscous flows, skin and form friction, lubrication approximation, potential flows and boundary layer theory. Turbulence and turbulent flows will be introduced.

Contents :

1 . Introduction to fluids, Continuum hypothesis, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization –streamline, pathline, streak line, stress field; viscosity; Newtonian fluid; Non-Newtonian fluid; Reynold's number—its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible flows. (3L + 1T)

2. Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved), Buoyancy, b. Rigid body motion (translation and rotation) Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices –manometer,U-tube,inclined-tube.
(3L + 1T)

3. Kinematics of fluid , Basic laws for a system; relation of system derivatives to the control volume formulation; conservation of mass; continuity equation, momentum balance equation-Introduction to Navier Stoke's and Euler's Equation. Introduction to roational and irrotational flow, momentum correction factor. flow- Eulerian and Lagrangian descriptions. Kinematic decomposition of flow motion (3L + 1T)

4. System and control volume approaches, Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow. Flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; introduction to turbulent flow in a pipe-Prandtl mixing length; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor; head loss; friction factor-Fanning and Darcy, Moody diagram. Major and minor losses; Pipe fittings and valves, schedule no, equivalent diameter (6L + 2T)

5. Flow measurement, Transportation of fluids - Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; Weirs, concept of area meters : Rotameter; Local velocity measurement: Pitot tube. mass flow meter. (4L + 1T)

6. Differential analysis: mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Stokes law, Skin drag and pressure drag Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body; packed bed; concept of Sphericity; Ergun equation, modified friction factor (5L + 2T)

7. Potential flow, Potential function, Solution of Laplace equation Introduction; different types of fluidization; minimum fluidization velocity; governing equation; industrial uses. (4L + 1T)

8. 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, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps (6L + 2T)

9. Similitude analysis, Lubrication approximation (3L + 1T)

10. Compressible flows, fan, blower and compressor. (3L + 1T)

Boundary layer theory, Blasius solution, Boundary layer separation. Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition, Spectral nature of turbulence and Kolmogorov hypothesis. (5L + 2T)

Total 60 (L+T)

Text books

1) S.S. Rattan, Fluid Mechanics, Khanna Publishing House, New Delhi 2018
2)Unit operations of Chemical Engineering: McCabe, Smith and Harriot,TMH, 6th Edn.
3) O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005

References:

1) Introduction to Fluid Mechanics. R. W. Fox, P. J. Pritchard and A. T. McDonald, John wiley
2) Fluid Mechanics, A.K. Mohanty, PHI
.3) M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
4). V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011
5) Transport Process and Unit Operations: Geankoplis, 3rd Edn. PHI
6) Principles of Unit Operations: Foust and Wenzel, Wiley, 1980

CHE-PC306	**Material and Energy Balance Computations**	**3L:1T:0P**	**4 credits**

Objectives
The course will serve as a basis for all further chemical engineering courses that are part of the curriculum**.**

Contents :
1. Introductory concepts of units, physical quantities in chemical engineering, dimensionless groups, "basis" of calculations [3L + 1T]

2. Material Balance: Introduction, solving material balance problems without chemical reaction [6L+2T]

3. Material Balance: With chemical reaction, Concept of stoichiometry and mole balances, examples, including combustion [6L+2T]

4. Material Balances with recycle, bypass and purge [6L+2T]

5. Gases, Vapours and Liquids: Equations of state, Vapour pressure, Clausius-Clapeyron equation, Cox chart, Duhring's plot, Raoult's law,. (6L+2T)

6. Energy balance: open and closed system, heat capacity, calculation of enthalpy changes (6L+2T)

7. Energy balances with chemical reaction: Heat of reaction, Heat of combustion (6L+2T)

8. Crystallization, Dissolution. (3L+1T)

9. Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use. (3L+1T)

Total 60 (L+T)

Suggested Text Books
1. Himmelblau, D. M., Riggs, J. B. "Basic Principles and Calculations in Chemical Engineering", Eighth Ed., Pearson India Education Services, 2015.
2. Bhatt, B. I., Vora, S. M., "Stoichiometry", Fourth Edition, Tata McGraw Hill Publishing Company Ltd, 2004.

Suggested References Books
1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Hougen, O. A., Watson, K. M., Ragatz, R. A., "Chemical Process Principles, Part-I Material & Energy Balances", Second Edition, CBS Publishers & Distributors, 2004
3. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.

4. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

Course outcomes

Students completing the course will

- ✓ Develop mastery over process calculations relevant to chemical engineering processes
- ✓ Be able to handle elementary flow-sheeting, material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge.
- ✓ Be familiar with equations of state and properties of gases and liquids, including phase transition

CHE-ES391	**Engineering Workshop**	1L:0T:4P	**3 credits**

Course Objectives:

The idea of this course is to understand the concepts involved in product realization by carrying out manufacturing shop exercises. Hands-on practice with manufacturing shop exercises and assembly leading to realization of a new product in a group. Students will also be introduced to the importance of manufacturing planning.

Contents:

1. Introduction to the course and its objectives; mandatory briefing on shop-floor safety. Introduction to all manufacturing forms, and introduction to basic tools (hand tools and power tools **(2L+2P)**

2. Overview of engineering materials and forms in which they are commonly available as raw materials. Typical component manufacture with materials like wood. **(2L+2P)**

3. Overview of shape realization by manufacturing, measurement of manufactured parts. Associated with: Machine shop exercises- involving sawing, turning and drilling, milling, grinding and joining. Inspection of manufactured component using simple metrology instruments. **(5L+5P)**

4. Overview of computer numerically controlled machines Machine shop exercise using CNC - Part modeling, CNC program generation and cutting part on CNC milling machine **(2L+2P)**

5. Use of plastics and composites as engineering materials Practicals: Hands-on exercise involving plastics - use of vacuum forming, injection/compression molding, extrusion, ultrasonic welding of plastic components etc. **(4L+4P)**

Total 15L + 15P *[**1L means one tutorial turn (typically, 1 hour) and 1P means one practical turn (typically, 3-4 hours)].

Course outcomes:

Students will realize the importance of

- Manufacturing planning
- Computer numerically controlled machines