Semester IV

Material Science
CHE-ES401
3L: 0T: 0P
3 credits

Objectives:

The objective of the course will be to give the students a basic introduction to the different classes of materials relevant to engineering in general, and Chemical Engineering in particular. The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics.

Contents:

1. Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal expansion, elastic modulus and melting point of materials, Role of materials selection in design, structure-property-processing-performance relationships. **(4L)**

2. Miller indices of directions and planes, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials. **(4L)**

3. Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults. **(4L)**

4. Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behavior of metals, ceramics and polymers, tensile test, plastic deformation, necking, creep behavior and fatigue.

(4L)

5. Semi-crystalline materials: Classification, structure and configuration of ceramics, polymers, copolymers, liquid crystals and amphiphiles

(10L)

6. Non-crystalline/amorphous materials: Silicates, glass transition temperature, viscoelasticity

(4L)

7. Polymer nano-composite materials: Nanocomposites, role of reinforcement-matrix interface strength on composite behavior**.**

(4L)

8. Corrosion, Degradation and Recycling.

(4L)

9. Biomaterials, material related to catalyst such as zeolites, silica etc. and other selected materials. **(4L)**

10. Introduction to experimental techniques: XRD, NMR, PSA, etc. for material characterization highlighting links between molecular structure and macroscopic properties. **(3L)**

Total 45 (L)

List of Text Books:

1. V. Raghavan Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.

2. 2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

List of Reference Books:

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.

2. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley Publisher.

3. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Course outcomes:

At the end of this course, students will have a fair understanding of hard and soft materials, including polymers and composites, their characterization, properties, and use in engineering applications.

Heat Transfer
CHE-PC402
3L: 1T: 0P
4 credits

Objectives:

- Basic Concepts of Heat Transfer
- Design and Rating of Heat exchangers with and Without Phase Change
- Design and Rating of Compact Heat Exchangers

Contents:

1. Heat Transfer Fundamentals: Modes of heat transfer, thermal diffusivity and heat transfer coefficient; Differential equations of heat transfer; special forms. **(3L+1T)**

2. Conductive heat transfer - one dimensional problem, heat transfer from extended surfaces, two and three dimensional problems, Insulation. **(6L+2T)**

3. Convective heat transfer - natural and forced convection; Dimensional analysis; Thermal boundary layer; Analogies and Correlations. **(6L+2T)**

4. Design of heat transfer equipment - double pipe heat exchanger, concept of LMTD, DPHE sizing; shell and tube heat exchanger - Kern's method for design, effectiveness-NTU method, construction aspects in brief, Bell Delaware Method. **(9L+3T)**

5. Design aspects of finned tube and other compact heat exchangers. **(6L+2T)**

6. Basics of Heat transfer with phase change - Introduction to boiling, Introduction to condensation. **(3L+ 1T)**

7. Design aspects of Condensers, Reboilers and Evaporators. **(6L + 2T)**

8. Heat Transfer to Agitated tanks, unsteady state heat transfer. **(3L + 1T)**

9. Introduction to Radiative Heat Transfer, Design aspects of Furnaces. **(3L + 1T)**

Total 60(L+T)

List of Text Books:

1. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed.,Wiley (2007).
2. W. J. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGraw Hill (2005).
3. J. P. Holman, S. Bhattacharya, Heat Transfer, 10th Ed., Tata McGraw-Hill (2011).
4. D. Q. Kern, Process Heat Transfer, Tata-McGraw Hill (1997).
5. B. K. Dutta, Heat Transfer – Principles and Applications (2004).
6. Er. R. K. Rajput, Heat and Mass Transfers, S. Chand Publications.

List of Reference Books:

1. Bejan, A., A. D. Kraus, Heat Transfer Handbook, John Wiley (2003).

Course outcomes:

Students will be able to

- Identify and select type of shell and tube exchanger based on TEMA classification
- Design double pipe heat exchanger, Shell and tube heat exchanger, finned tube and other compact heat exchangers

Mass Transfer-I
CHE-PC403
3L: 0T: 0P
3 credits

Course Objectives:

Basic Concepts of Mass Transfer, Staged and Continuous Contact equipment design, gas absorption and distillation

Contents:

1. Constitutive laws of diffusion; unsteady state diffusion. **(3L)**

2. Convective mass transfer, interphase mass transfer and mass transfer coefficients, mass transfer correlations. **(6L)**

3. Mass transfer theories/models. **(3L)**

4. Effect of chemical reaction on mass transfer. **(9L)**

5. Equilibrium stages and transfer units: number and height of transfer units; stage efficiency. **(6L)**

6. Gas absorption plate and packed column design; reactive absorption. **(3L)**

7. Batch distillation; continuous binary fractionation. **(9L)**

8. Azeotropic distillation; use of steam. **(3L)**

9. Introduction to multicomponent distillation. **(3L)**

Total 45 L

List of Text Books:

1. Binay K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
2. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983.

3. E.D. Cussler, Diffusion - Mass Transfer in Fluid Systems, Cambridge
4. University Press, Cambridge 1984.
5. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.

List of References Books:

1. W. M. Deen, Analysis of Transport Phenomena, Oxford University Press, 1998.
2. W. J. Thompson, Introduction to Transport Phenomena, Prentice Hall, 2000.

Course Outcomes:

Students will be

- Able to design staged and continuous contactors
- Familiar with special distillation techniques such as steam distillation and azeotropic distillation

Numerical Methods in Chemical Engineering
CHE-PC404
2L: 0T: 2P
3 credits

Pre-requisites: Mathematics – I, Mathematics - II

Course Objectives:

To introduce students to numerical methods used to solve engineering problems, in particular chemical engineering problems, using numerical methods and computer programming. Fundamentals of numerical methods/algorithms to solve systems of different mathematical equations (e.g. linear/ nonlinear algebraic equations, ordinary /partial differential equations), will be introduced. The course would enable students to write their own computer programs using programming languages like C and commercial software like Matlab. Hands-on experience will be provided to apply these computer programs to solve problems in different areas of chemical engineering e.g. fluid flow, heat and mass transfer, chemical reaction engineering etc. Practical classes are to involve solving actual chemical engineering problems through computer programming and coding.

Contents:

1. Introduction, Approximation and Concept of Error & Error Analysis.

(2L)

2. Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations.

(4L)

3. Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations.

(3L)

4. Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression.

(4L)

5. Numerical integration: Trapezoidal rule, Simpson’s rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

(3L)

6. Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems

involving single, and a system of ODEs.

(10L)

7. Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.

(4L)

Total 30 L

Practical Session
Numerical Methods in Chemical Engineering Lab
CHE-PC491
0L: 0T: 2P
1 credits

Practical description [No. of turns (2 hrs)]

1. Introduction to use of computers for numerical calculations
(1P)

2. Solution of linear algebraic equations using Gauss elimination, Gauss-Siedel etc. **(2P)**

3. Solution of a non-linear equations using bracketing and Newton-Raphson method.

(2P)

4. Interpolation and Approximation.

(2P)

5. Numerical integration

(2P)

6. Euler method

(1P)

7. Runge-Kutta methods for ODEs

(2P)

8. Solution of system of ODEs using simple methods

(1P)

9. Solution of simple PDEs

(2P)

Total 15 P

Text Book:

1. S. K. Gupta, Numerical Methods for Engineers, New Academic Science, 2012.

List of Reference Books:

1. S. C. Chapra & R. P. Canale, Numerical Methods for Engineers with Personal Computer Applications, McGraw Hill Book Company, 1985.
2. R. L. Burden & J. D. Faires, Numerical Analysis, 7th Ed., Brooks Coles, 2000.
3. K. E. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1978.
4. W. H. Press et. al., Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course outcomes:

Students will be able to solve chemical engineering problems involving

- Linear and non-linear equations
- Ordinary and partial differential equations using programming languages like C and softwares like MATLAB.

Chemical Reaction Engineering - I
CHE-PC405
3L: 1T: 0P
4 credits

Pre-requisites: Material and Energy Balance Computations

Course Objectives:

- Basic Concepts of Kinetics and Rate Laws
- Design and Rating of Ideal Reactors including heat effects
- Interpretation of Rate data
- Design and Rating of Reactors involving multiple reactions including heat effects
- Analysis of Non-ideal flow Behavior in Reactor

Contents:

1. Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory. **(8L+2T)**

2. Ideal reactors - generalized material balance, design equations, graphical interpretation.

(4L+2T)

3. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors - solving design equations for constant and variable density systems, reactors in series and parallel.

(9L+3T)

4. Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis. **(8L+2T)**

5. Multiple reactions - conversion, selectivity, and yield, and series, parallel, independent and mixed series- parallel reactions. **(8L+2T)**

6. RTD theory and analysis of non-ideal reactors. **(9L+3T)**

Total 60 (L+T)

Text Books:

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001.

References Books:

1. Chemical Reaction Engineering by Octave Levenspiel, 3rd Edition, John Wiley & Sons 2001

Course outcomes:

Students will be able to

- Design chemical reactors involving heat effects optimally using minimum amount of data
- Fix some problems related to operability and productivity
- Operate reactors in a safe manner for single and multiple reactions
- Analyse the non-ideality in the reactors

UNIVERSAL HUMAN VALUES 2: UNDERSTANDING HARMONY (HASS- II)
CHE-HS406
3L: 0T: 0P
3 credits
N.B.:- The course has 28 lectures and 14 practice sessions in 5 modules

Course Objectives:

1. Development of a holistic perspective based on self-exploration aboutthemselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

Contents:

Module 1:
Course Introduction - Need, Basic Guidelines, Content and Process for Value Education
1. Purpose and motivation for the course, recapitulation from Universal Human Values-I
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation - as the process for self-exploration
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfillment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario 6. Method to fulfill the above human aspirations: understanding and living in harmony at various levels.
Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking

Module 2:
Understanding Harmony in the Human Being - Harmony in Myself!
7. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
8. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility
9. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
10. Understanding the characteristics and activities of 'I' and harmony in 'I'
11. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail
12. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3:

Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship
13. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
14. Understanding the meaning of Trust; Difference between intention and competence
15. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
16. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
17. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

Module 4:

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence
18. Understanding the harmony in the Nature
19. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self- regulation in nature
20. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space 21. Holistic perception of harmony at all levels of existence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5:

Implications of the above Holistic Understanding of Harmony on Professional Ethics
22. Natural acceptance of human values
23. Definitiveness of Ethical Human Conduct
24. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order 25. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people- friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
26. Case studies of typical holistic technologies, management models and production systems

27. Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations
28. Sum up.
Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. to discuss the conduct as an engineer or scientist etc.

Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.

2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.

3. The Story of Stuff (Book).

4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi

5. Small is Beautiful - E. F Schumacher.

6. Slow is Beautiful - Cecile Andrews

7. Economy of Permanence - J C Kumarappa

8. Bharat Mein Angreji Raj - PanditSunderlal

9. Rediscovering India - by Dharampal

10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi

11. India Wins Freedom - Maulana Abdul Kalam Azad

12. Vivekananda - Romain Rolland (English)

13. Gandhi - Romain Rolland (English)

Course outcomes:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind. They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction. This is only an introductory foundational input. It would be

desirable to follow it up by a) faculty-student or mentor-mentee programs throughout their time with the institution b) Higher level courses on human values in every aspect of living. e.g. as a professional.

Assessment:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.
Example:
Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks
Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

Environment Science (Mandatory non-credit course)

We as human being are not an entity separate from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects these ethoses. There is a direct application of this wisdom even in modern times. Idea of an activity based course on environment protection is to sensitize the students on the above issues through following two types of activities.

(a) Awareness Activities:

i) Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste
ii) Slogan making event
iii) Poster making event
iv) Cycle rally
v) Lectures from experts

(b) Actual Activities:

i) Plantation
ii) Gifting a tree to see its full growth
iii) Cleanliness drive
iv) Drive for segregation of waste
v) To live some big environmentalist for a week or so to understand his work
vi) To work in kitchen garden for mess
vii) To know about the different varieties of plants
viii) Shutting down the fans and ACs of the campus for an hour or so

List of Books:

1. Textbook of Environmental Studies, Erach Bharucha, University Press
2. Environmental Studies, MP Poonia & SC Sharma, Khanna Publishing House
3. Environmental Studies, Rajagopalan, Oxford University Press