ENGINEERING MATERIALS

EC 554

Lecture : 3 **Year: II**

Tutorial : 1 **Part: II**

Course Objective:

i This course will help students to learn about the relationship between structure and properties of materials, application and synthesis of various classes of materials.

ii After completion of this course, students are able to evaluate the criteria for the selection of materials in chemical process industry.

1. Classification of materials and Crystal properties (9 hours)

1.1 Classes of engineering materials, selection of materials, economic, environmental, and societal issues in materials science and engineering.

1.2 Structure of atoms and molecules, bonding in solids, types of bonds and comparison of bonds.

1.3 Structure and imperfections in crystals, crystal structure, crystal geometry, structure of crystalline solids, atomic packing factor and density, miller indices, methods of determining crystal structures, imperfections in crystals, types of imperfection, point imperfection.

2. Phase diagrams and transformations (7 hours)

2.1 Energetics of transition, structure of solids, nucleation, mechanisms, nucleation rates, homogeneous and heterogeneous nucleation.

2.2 Phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic, eutectic phase diagrams, Cd – Bi, Pb – Sn, Cu – Ni, Ag – Cu, Fe – C or Fe – Fe_3C, phase transformations, transformation curves for eutectoid steels, plain carbon steels.

2.3 Effect of addition of alloying elements on the properties of steels, types of steels used in chemical industries.

3. Properties and applications of materials (9 hours)

3.1 Electrical properties of materials – Ohm's law, electrical conductivity, electronic and ionic conduction.

3.2 Energy band structure in solids, electron mobility, electrical resistivity of metals and alloys.

3.3 Semi conductivity – intrinsic semiconductors, extrinsic semiconductors, temperature dependence of carrier concentration, Hall Effect, polarization, piezo and ferroelectricity; magnetic properties – paramagnetism, diamagnetism, ferri and ferromagnetism, soft and hard magnetic materials.

3.4 Thermal properties – specific heat capacity, thermal conductivity, thermal expansion, optical fibre, lasers, properties and applications of materials (iron, steel, stainless steel, nickel, hastelloy, copper alloy, aluminum and its alloy, titanium, PVC, teflon, PTFE glass, acid resistant bricks and tiles).

4. Mechanical properties and deformations of materials (7 hours)

4.1 Deformations – concept of stress and strain, elastic and plastic deformation in materials, stress – strain curves,

4.2 Dislocations in metals – characteristics, slip systems, slip in single crystals, deformation by twinning, multiplication of dislocations, fracture – ductile and brittle, fatigue – S – N curve, crack initiation and propagation, creep, Griffith's criterion.

4.3 Corrosion and mechanical strength, Mechanical strength depends upon thermal property of materials.

4.4 Materials testing (destructive and non-destructive testing), International standard for materials testing.

5. Synthesis, fabrication, and processing of materials (13 hours)

5.1 Fabrication of metals – forming, forging, rolling, extrusion, drawing, casting, powder metallurgy.

5.2 Thermal processing of metals – annealing, full – annealing, normalizing, spheroidizing.

5.3 Fabrication of ceramic materials – glass forming, particulate forming, cementation.

5.4 Synthesis and fabrication of polymers – addition and condensation polymerization, various techniques for polymer processing (casting, extrusion, thermoforming, injection, compression and transfer molding).

5.5 Processing of polymer in nano scale (nano particles and nano fibers), degradation of polymer.

5.6 Criteria for selection of materials in chemical process industry.

References:

1. W. D. Callister Jr, D. G. Rethwisch, "Fundamentals of materials science and engineering: an integrated approach", John Wiley & Sons.
2. R. K. Puri, V. K. Babbar, "Solid State Physics", S. Chand Publishing.
3. B. S. Mitchell, "An introduction to materials engineering and science for chemical and materials engineers", John Willey & sons Publication.
4. V. Raghavan, "Materials Science and Engineering", Prentice Hall of India.

Evaluation Scheme:

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Unit	Chapter	Topics	Marks
1	1	all	16
2	2	all	12
3	3	all	16
4	4	all	12
5	5	all	24
Total			**80**

Environmental Science and Pollution Control
EC555

Lecture : 3 **Year : II**
Tutorial : 1 **Part : II**
Practical : 3/2

Course objectives

This course Structure is aimed to cover *Environmental Science and Pollution Control measures*. In the first section students will be able to understand the relation between environment and human beings (Ecology). Second section will deal with water, air, sound and solid waste pollution, their impacts and possible control measures.

1. Environmental Science **(9 hours)**

1.1 Physical or Abiotic Environment
1.2 Living or Biotic Environment
1.3 Social and Cultural Environment
1.4 Psychological Environment
1.5 Types of ecosystems; Forest, grass land, lentic, marine, desert, wetlands ecosystem structure and functions.
1.6 Components of ecosystem abiotic and biotic, ecosystem boundary, ecosystem function and ecosystem metabolism.
1.7 Brief concept of Environment Impact assessment (EIA)

2. Water Pollution **(9 hours)**

2.1 Types of water pollution and their sources
2.2 Physical pollution of water
2.3 Chemical pollution of water
2.4 Biological pollution of water
2.5 Impacts of water pollution and their remedies
2.6 Significance of DO, BOD and Eutrophication in water quality.
2.7 Water treatment system Oxidation Pond, Facultative Pond, Aerobic Pond and Activated sludge process
2.8 Water quality standards of Nepal

3. Air Pollution **(9 hours)**

3.1 Ambient air Pollutants
3.2 Natural and Anthropogenic sources of air pollutants
3.3 Particulate Matters (PM) their types, sources and impacts
3.4 Measurement of different particulate matters TSP, $PM_{10}$and PM_1
3.5 Indoor Air pollutants and their sources
3.6 Impacts of indoor air pollutants and their control measures
3.7 Air quality standards of Nepal

4. Noise Pollution and Climate Change **(9 hours)**

4.1 Human ear
4.2 Sources and nature of sound
4.3 Noise levels at different places and their effects
4.4 Measurement of noise pollution and its quantification
4.5 Prevention and control of noise pollution
4.6 Climate and weather
4.7 Sun as source of energy
4.8 Temperature inversion
4.9 Aerosols and their impact on climate change

5. Solid Wastes **(9 hours)**

5.1 Sources and types of solid waste
5.2 Characteristics of solid waste
5.3 Impacts of solid waste on environment, human and plant health.
5.4 Components of solid waste management
5.5 Solid waste source of energy

Final Examination

The questions will cover all the chapter of the syllabus. The evaluation scheme will be as follows:

Unit	Chapter	Topics	Marks
1	1	All	16
2	2	All	16
3	3	All	16
4	4	All	16
5	5	All	16
	Total		**80**

Practical

1. Dissolved Oxygen (DO) in different water samples by Winkler's method.
2. Amount of dissolved solid, suspended solid, total solid, volatile solid, pH and conductivity of water samples.
3. Measurement of Particulate matters in ambient air and indoor air.
4. Practical observations of waste water treatment plants.
5. Soil quality assessments in the laboratory (moisture, pH and salinity)
6. Study visits to aquaculture farm and observe the correlation of consumers and producer.
7. Inventory report on hazardous in different industries.

References

1. Sharma B.K., 2001. Environmental Chemistry. Geol Publ. House, Meerut

   De A.K., Environmental Chemistry, Wiley Eastern Ltd.
2. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
3. Pani, B. 2007. *Textbook of Environmental Chemistry*. IK international Publishing House
4. Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. *Air Pollution: Health and Environmental Impacts*. CRC Press, Taylor & Francis.
5. Major Hazards and Their Management G.L. Wells Geoff Wells Publisher: I Chem E Publication year: 1997
6. Environmental Science Eldon Enger and Bradley Smith Mc Graw Hill

CHEMICAL PROCESS INDUSTRIES I
EC 552

Lecture : 3 **Year : II**
Tutorial : 1 **Part : II**

Course Objective:

i. Understand major industrial manufacturing processes of inorganic chemicals.
ii. Learn flow sheeting of processes.

1. Chlor-Alkali industries **(5 hours)**

1.1 Historical, uses and economics
1.2 Manufacture of soda ash
1.3 Manufacture of chlorine and caustic soda: reactions, types of cells, purification

2. Acid industries **(5 hours)**

2.1 Historical, uses and economics
2.2 Mining procedure of sulfur
2.3 Manufacturing procedure of sulfuric acid by contact process
2.4 Contact process equipment
2.5 Manufacturing procedure of hydrochloric acid

3. Industrial gases **(5 hours)**

3.1 Historical, uses and economics
3.2 Manufacture of carbon dioxide, dry ice
3.3 Manufacture of hydrogen
3.4 Manufacture of nitrogen and oxygen
3.5 Manufacture of acetylene

4. Cement industries **(6 hours)**

4.1 Historical, uses and economics
4.2 Manufacturing procedure of portland cements
4.3 Types, compounds in cements, setting and hardening of cements, other cements
4.4 Manufacturing procedure of refractories and its classifications

5. Glass industries **(3 hours)**

5.1 Historical, uses and economics, compositions
5.2 Manufacturing procedure of glass
5.3 Manufacturing procedure of special glasses

6. Surface coating industries **(2 hours)**

6.1 Historical, uses and economics
6.2 Paints constituents
6.3 Manufacturing procedure of paints
6.4 Types of pigments

7. Phosphate industries **(6 hours)**

7.1 Historical, uses and economics
7.2 Processing of phosphate rock
7.3 Manufacturing procedure of phosphoric acid (wet process)
7.4 Manufacturing procedure of normal superphosphate and triple superphosphate
7.5 Manufacturing procedure of monoammonium phosphate (MAP), and diammonium phosphate (DAP)

8. Nitrogen industries **(6 hours)**

8.1 Historical, uses and economics
8.2 Manufacturing procedure of synthetic ammonia
8.3 Manufacturing procedure of nitric acid
8.4 Manufacturing procedure of urea

8.5 Manufacturing procedure of ammonium nitrate, and ammonium sulfate

9. Potassium industries (2 hours)

9.1 Historical, uses and economics
9.2 Manufacturing procedure of potassium chloride
9.3 Manufacturing procedure of potassium sulfate

10. Water conditioning and environmental protection (5 hours)

10.1 Water conditioning methods
10.2 Types of pollutants, sewage characteristics, environmental protection
10.3 Municipal waste water treatment
10.4 Industrial waste water treatment

Note: There will be one field visit & presentation

References:

1. G. T. Austin, "Shreve's Chemical Process Industries"'. Mc Graw Hill Book Co., New York.
2. S. D. Shukla, G. N. Pandey, "Text book of Chemical Technology", Vol 1 – II, Vikas Publishing, India.
3. R. Gopal and M. Sittig, "Dryden's Outline of Chemical Technology: For The 21st Century", Affiliated East-West Publishers.
4. W. V. Mark, S. C. Bhatia, "Chemical Process Industries Vol I – II", CBS Publishers & Distributors Pvt. Ltd.
5. E. R. Riegel, J. A. Kent, "Riegel's Handbook of Industrial Chemistry, Springer Science & Business Media.
6. K. Othmer, "Encyclopedia of Chemical Technology, Wiley Interscience: New York, Inter Science Publishers.

Evaluation Scheme:

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Unit	Chapter	Topics	Marks
1	1 & 2	all	**16**
2	3 & 10	all	**16**
3	4 & 5	all	**16**
4	6 & 7	all	**16**
5	8 & 9	all	**16**
Total			**80**

HEAT TRANSFER

EC 553

Lecture : 4 **Year : II**

Tutorial : 1 **Part : II**

Practical : 1.5

Course Objectives:

i. Demonstrate effective approaches to solving 1D/2D heat transfer problems by hand and by using computing tools such as MS Excel, ANSYS and Python or Matlab.
ii. Apply energy balance equations and rate laws to solve conduction (steady and unsteady state), convection and radiation heat transfer problems
iii. Use energy balance approach to solve heat transfer problems involving phase changes (boiling and condensation).
iv. Use energy balance approach, correlations to solve problems with various types of heat exchangers.

1. Fundamentals of heat transfer **(5 hours)**

1.1 Rate equations of conduction, convection and radiation
1.2 Conservation of energy for a control volume
1.3 Analysis of heat transfer problems

2. Steady state one dimensional (1D) conduction **(7 hours)**

2.1 Conduction rate equation
2.2 Thermal properties of matter
2.3 Heat diffusion equations and boundary conditions
2.4 1D conduction for planar, cylindrical and spherical geometries
2.5 Conduction with thermal energy generation
2.6 Heat transfer from extended surfaces

3. Steady state multi-dimensional conduction **(4 hours)**

3.1 Finite difference form of heat equation
3.2 Use of ANSYS or Python for solving problems

4. Time dependent conduction **(4 hours)**

4.1 Lumped capacitance method
4.2 Use of ANSYS or Python for solving problems

5. Fundamentals of convection **(4 hours)**

5.1 Convection boundary layers
5.2 Introduction to convection coefficients
5.3 Laminar and turbulent flow
5.4 Boundary layer equations
5.5 Introduction to dimensionless parameters

6. External forced convection **(4 hours)**

6.1 Introduction to correlation for external flows across flat plates, cylinders and spheres

7. Internal forced convection **(4 hours)**

7.1 Correlations for internal flows across flat plates, cylinders and spheres

8. Natural convection **(4 hours)**

8.1 Governing relations, laminar and vertical flow
8.2 Correlations for internal and external free flows across flat plates, cylinders and spheres

9. Boiling and condensation processes **(6 hours)**

9.1 Boiling modes
9.2 Pool boiling correlations
9.3 Forced convection boiling
9.4 Condensation on planar and radial systems

10. Heat exchanger devices **(6 hours)**

10.1 Types of heat exchangers
10.2 Log Mean Temperature Difference
10.3 Effectiveness – NTU method

11. Fundamentals of radiation **(7 hours)**

11.1 Fundamental concepts
11.2 Radiation intensity, blackbody radiation, emission from real surfaces
11.3 Absorption, reflection and transmission by real surfaces
11.4 Kirchhoff's law
11.5 Gray surface

12. Radiative transfer between surfaces **(5 hours)**

12.1 View factor
12.2 Radiation exchange between opaque, diffuse and gray surfaces
12.3 Multimode heat transfer

Practical:

1. Determine the overall heat transfer coefficient of a composite wall.
2. Determine the heat transfer coefficient in forced convection of air in a tube.
3. Determine the average heat transfer coefficient of vertical cylinder under natural convection.
4. Determine the Stefan Boltzmann constant for a given material.
5. Study the heat transfer phenomena in finned tube heat exchanger.
6. Study of heat transfer conduction from a pin fin.
7. Determine the experimental and theoretical heat transfer coefficient for drop wise and film wise condensation.

References:

1. F. P. Incropera, D. P. DeWitt, T. L. Bergman, A. S. Lavine, "Incropera's Principles of Heat and Mass Transfer", John Wiley & Sons.
2. Y. A. Cengel, A. J. Ghajar, "Heat and Mass Transfer: Fundamentals and Applications", McGraw Hill Education Private Limited.
3. W. L. McCabe, J. C. Smith, P. Harriott, "Unit Operations of Chemical Engineering", McGraw Hill Education Private Limited.
4. D. Q. Kern, "Process Heat Transfer", McGraw-Hill Book Company.
5. J. P. Holman, "Heat Transfer", McGraw-Hill Book Company.

Evaluation Scheme:

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as follows:

Unit	Chapter	Topics	Marks
1	1 & 2	all	**16**
2	3, 4 & 5	all	**16**
3	6, 7 & 8	all	**16**
4	9 & 10	all	**16**
5	11 & 12	all	**16**
Total			**80**

Thermodynamics I

EC 551

Lecture: 3 **Year: III**

Tutorial: 1 **Part: II**

Course Objectives:

i. Learn the basic concepts, the first law and the second law of thermodynamics.
ii. Understand the concept of Gibbs free energy, residual properties of volume, internal energy, enthalpy, entropy, and heat effects.
iii. Understand the flow processes, refrigeration and liquefaction processes.

1. Introduction **(4 hours)**

1.1 The scope of thermodynamics
1.2 Thermodynamic system and processes
1.3 State functions, thermodynamics properties
1.4 Energy, Heat and Work

2. The First Law and Other Basic Concepts **(8 hours)**

2.1 Joule's experiments, Internal energy
2.2 The first law of thermodynamics
2.3 Energy balance for closed systems
2.4 Thermodynamic state and state functions
2.5 Equilibrium, Phase rule, Reversible process
2.6 Constant – V and constant – P processes
2.7 Enthalpy , Heat capacity
2.8 Mass and energy balances for open systems

3. Volumetric Properties of Pure Fluids **(8 hours)**

3.1 P V T behavior of pure substances
3.2 Virial equations of state
3.3 The ideal gas
3.4 Application of the Virial Equations
3.5 Cubic equations of state

4. Heat Effects **(6 hours)**

4.1 Sensible heat effects
4.2 Latent heat of pure substances
4.3 Standard heat of reaction
4.4 Standard heat of formation
4.5 Standard heat of combustion
4.6 Temperature dependence of ΔH°
4.7 Heat effects of industrial reactions

5. The Second Law of Thermodynamics **(10 hours)**

5.1 Statements of the second law
5.2 Heat engines
5.3 Carnot's equations
5.4 Entropy
5.5 Entropy changes of an ideal gas
5.6 Mathematical statement of the second law
5.7 Entropy balance for open systems
5.8 Ideal work and lost work

6. Applications of Thermodynamics to Flow Processes **(4 hours)**

6.1 Applications to flow processes
6.2 Nozzles, turbines, compressors

7. Refrigeration and Liquefaction **(5 hours)**

7.1 The Carnot refrigerator
7.2 The Vapor-compression cycle

7.3 The choice of refrigerant
7.4 Absorption refrigeration
7.5 The heat pump
7.6 Liquefaction processes

Total	**80**

References:

1. J. M. Smith, H. C. Van Ness, M. M. Abbott, "Chemical Engineering Thermodynamics," McGraw-Hill International Edition.
2. Y. A. Cengel, M. A. Boles, "Thermodynamics: An Engineering Approach", McGraw-Hill.
3. T. E. Daubert, "Chemical Engineering Thermodynamics", McGraw-Hill Book Company.
4. S. I. Sandler, "Chemical and Engineering Thermodynamics", John Wiley and Sons, Inc.
5. B. G. Kyle, "Chemical and Process Thermodynamics", Prentice Hall.
6. M. D. Koretsky, "Engineering and Chemical Thermodynamics", Wiley.

Evaluation Scheme:

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Unit	Chapter	Topics	Marks
1	1 & 4	all	16
2	2	all	16
3	3	all	16
4	5	all	16
5	6 & 7	all	16

NUMERICAL METHODS
SH603

Lecture : 3 **Year : III**
Tutorial : 1 **Part : I**
Practical : 3

Course objective:
To introduce numerical methods used for the solution of engineering problems. The course emphasizes algorithm development and programming and application to realistic engineering problems.

1. Introduction, Approximation and errors of computation (4hours)
- 1.1. Introduction, Importance of Numerical Methods
- 1.2. Approximation and Errors in computation
- 1.3. Taylor's series
- 1.4. Newton's Finite differences (forward , Backward, central difference, divided difference)
- 1.5. Difference operators, shift operators, differential operators
- 1.6. Uses and Importance of Computer programming in Numerical Methods.

2. Solutions of Nonlinear Equations (5 hours)
- 2.1. Bisection Method
- 2.2. Newton Raphson method (two equation solution)
- 2.3. Regula-Falsi Method , Secant method
- 2.4. Fixed point iteration method
- 2.5. Rate of convergence and comparisons of these Methods

3. Solution of system of linear algebraic equations (8 hours)
- 3.1. Gauss elimination method with pivoting strategies
- 3.2. Gauss-Jordan method
- 3.3. LU Factorization
- 3.4. Iterative methods (Jacobi method, Gauss-Seidel method)
- 3.5. Eigen value and Eigen vector using Power method

4. Interpolation (8 hours)
- 4.1. Newton's Interpolation (forward, backward)
- 4.2. Central difference interpolation: Stirling's Formula, Bessel's Formula
- 4.3. Lagrange interpolation
- 4.4. Least square method of fitting linear and nonlinear curve for discrete data and continuous function
- 4.5. Spline Interpolation (Cubic Spline)

5. Numerical Differentiation and Integration (6 hours)
- 5.1. Numerical Differentiation formulae
- 5.2. Maxima and minima
- 5.3. Newton-Cote general quadrature formula
- 5.4. Trapezoidal, Simpson's 1/3, 3/8 rule
- 5.5. Romberg integration
- 5.6. Gaussian integration (Gaussian – Legendre Formula 2 point and 3 point)

6. Solution of ordinary differential equations (6 hours)
- 6.1. Euler's and modified Euler's method
- 6.2. Runge Kutta methods for 1st and 2nd order ordinary differential equations
- 6.3. Solution of boundary value problem by finite difference method and shooting method.

7. Numerical solution of Partial differential Equation (8 hours)
- 7.1. Classification of partial differential equation(Elliptic, parabolic, and Hyperbolic)
- 7.2. Solution of Laplace equation (standard five point formula with iterative method)
- 7.3. Solution of Poisson equation (finite difference approximation)
- 7.4. Solution of Elliptic equation by Relaxation Method
- 7.5. Solution of one dimensional Heat equation by Schmidt method

Practical:
Algorithm and program development in C programming language of following:
1. Generate difference table.
2. At least two from Bisection method, Newton Raphson method, Secant method
3. At least one from Gauss elimination method or Gauss Jordan method. Finding largest Eigen value and corresponding vector by Power method.
4. Lagrange interpolation. Curve fitting by Least square method.
5. Differentiation by Newton's finite difference method. Integration using Simpson's 3/8 rule
6. Solution of 1^{st} order differential equation using RK-4 method
7. Partial differential equation (Laplace equation)
8. Numerical solutions using Matlab.

References:

1. Dr. B.S.Grewal, "Numerical Methods in Engineering and Science ", Khanna Publication.
2. Robert J schilling, Sandra l harries , " Applied Numerical Methods for Engineers using MATLAB and C.", Thomson Brooks/cole.
3. Richard L. Burden, J.Douglas Faires, "Numerical Analysis", Thomson / Brooks/cole
4. John. H. Mathews, Kurtis Fink ,"Numerical Methods Using MATLAB" ,Prentice Hall publication
5. JAAN KIUSALAAS , "Numerical Methods in Engineering with MATLAB" , Cambridge Publication

Evaluation scheme:

The questions will cover all the chapters of the syllabus. The evaluation scheme will be as indicated in the table below

Unit	Chapter	Topics	Marks
1	1 & 2	all	**16**
2	3	all	**16**
3	4	all	**16**
4	5	all	**16**
	6	6.1, 6.2	
5	6	6.3	**16**
	7	all	
Total			**80**