Biochemical Engineering
EC 752

Lecture: 3 | **Year: IV**
Tutorial: 1 | **Part: II**
Practical: 1.5

Course objectives:

i. This course is structured to develop the concept of using biological (natural or organic) materials, such as organisms, cells and certain biomolecules, to develop processes and products.
ii. This course aims to provide an understanding of the role that microorganisms and/or enzymes could play in a variety of bioprocesses and the industrial applications of such processes to the engineering students.

1. Introduction (10 hours)

1.1. Introduction to biochemical engineering.
1.2. Application of biochemical engineering principles.
1.3. Cell theory, organization, structure and chemical composition of cell.
1.4. Introduction to microbiology.
1.5. Microbial diversity, classification, environmental impact on micro-organisms.
1.6. Concept of cell culture.

2. Microbial kinetics (9 hours)

2.1. Cell growth cycle (prokaryote and eukaryote).
2.2. Cell Growth kinetics, simple and diauxic, Monod growth kinetics in batch and continuous culture.
2.3. Death kinetics of cells and spores.
2.4. Kinetics of product formation.
2.5. Molecular concepts.

3. Bioenergetics and transport mechanisms (8 hours)

3.1. Assimilatory and dissimilatory processes, metabolic pathways of the cell, energy patterns in biological systems.
3.2. Metabolic organization and regulations, metabolic end products (aerobic, anaerobic and partial oxidation).
3.3. Stoichiometry of cell growth and product formation.
3.4. Biological transport mechanism across the membrane, active transport, passive transport, diffusion.

4. Enzymology (10 hours)

4.1. Enzymes: definition, nomenclature, classification.
4.2. Enzyme substrate complex and thermodynamics of enzyme action.
4.3. Enzymatic reaction kinetics (single substrate and multiple substrate), non-ideal enzyme kinetics.
4.4. Modulation, and regulation of enzyme activity.
4.5. Enzyme inhibition and application.
4.6. Enzyme immobilization technology, methods and its application.
4.7. Industrial and medical utilization of immobilized cells and enzymes.

5. Bioprocess and Bio-reactors (8 hours)

5.1. Fundamental bioprocesses, scaling principles and challenges for bioprocess scale up.
5.2. Bioreactors: definition, classification and characterization.
5.3. Design and types of ideal bioreactors: batch, fed batch, continuous.
5.4. Photobioreactor, Membrane bioreactor.
5.5. Cell as a bioreactor.
5.6. Downstream processing: separation and purification techniques (filtration, centrifugation, and chromatography).

Practical

1. Study of enzymatic activity of amylase on various carbohydrates.
2. Enzymatic digestion of protein into amino acid and its quantification.
3. Determination of Michaelis-Menten constants and specific enzyme activity through Michaelis-Menten and Lineweaver-Burk plots.

4. Study the effects of different parameters (temperature, pH, agitation) on microbial fermentation or enzyme activity in aerobic condition.
5. Acidogenesis/Methanogenesis process demonstrations in an anaerobic bioreactor
6. Enzyme immobilization/entrapment in calcium alginate beads.
7. Design and optimize growth media for specific microorganisms, considering nutrient requirements.
8. Microbial cell growth optimization (acclimation of biomass) and viability assays.

References

1. M. T. Madigan, K. S. Bender, D. H. Buckley, “Brock Biology of Microorganisms”, Pearson, Global edition.
2. M. L. Shuler, F. Kargi, “Bioprocess Engineering: Basic Concepts”, Prentice Hall.
3. J. E. Bailey, D. F. Ollis, “Biochemical Engineering Fundamentals”, McGraw Hill.
4. M. Doble, S. N. Gummadi, “Biochemical Engineering”, Prentice Hall.
5. H. W. Blanch, D. S. Clark, “Biochemical Engineering”, Marcel Dekker, New York.
6. M. D. Trevan, “Immobilized Enzymes: An Introduction and Applications in Biotechnology”, John Wiley & Sons Inc.

Evaluation Scheme:

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

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**

* 20 marks is allotted for the internal assessment.

Corrosion Science & Engineering
EC 753

Lecture: 4 **Year: IV**
Practical: 1.5 **Part: II**

Course Objective:

i. Understand the knowledge of corrosion engineering and its control methods

1. Basics of Corrosion Engineering (9 hours)

1.1 Overview of corrosion engineering, science and technology, Basics of electrochemical corrosion
1.2 Corrosion types
1.3 Corrosion tendency & electrode potential
1.4 Potential-pH (H_2O, Fe, Zn, Pb) diagrams & their applications in corrosion engineering

2. Corrosion & Electrode Polarization (6 hours)

2.1 Electrode-solution interface & corrosion
2.2 Activation and diffusion controlled processes
2.3 Corrosion theories- heterogeneous, homogeneous & mixed-potential theory

3. Corrosion Kinetics & Measurement (6 hours)

3.1 Evans diagram, corrosion potential & current
3.2 Corrosion rate determination; weight loss, polarization resistant & impedance spectroscopy methods, related numerical

4. Preventive Strategies of Corrosion (12 hours)

4.1 Design aspect of corrosive environment control
4.2 Design aspects of corrosion protective coatings: metal-, paint-, & cement-coatings
4.3 Fabrication of corrosion-resistant alloys
4.4 Performance & formulation of green corrosion inhibitors
4.5 Cathodic protection strategies: principles, classifications, affecting factors & monitoring, design aspects
4.6 Passivity: definitions, influencing parameters, theories- oxide film formation & adsorption, application of mixed potential theory, anodic passivation

5. Engineering Aspects of Corrosion (12 hours)

5.1 Corrosion affecting metallurgical & mechanical properties of iron and steels
5.2 Corrosion & control aspects of reinforced concrete structure
5.3 Corrosion & control aspects of buried metal-pipe
5.4 Corrosion & control aspects of water treatment & steam system
5.5 Corrosion & control aspects of implant metal/alloy in human body fluid

References:

1. R. W. Revie, H. H. Uhlig, “Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering”, John Wiley & Sons Inc., New York, USA, 2008.
2. P. R. Roberge, “Corrosion Engineering: Principles and Practice”, McGraw-Hill Co., Inc., New York, USA, 2008.
3. L. L. Shreir, “Corrosion”, Vol I and II, Butterworths, Kent, USA, 1976.
4. M. Pourbaix, “Atlas of Electrochemical Equilibria in Aqueous Solutions”, NACE, Houston, 1974.
5. J. O’M. Bockris, A. K. N. Reddy, M. Gamboa-Aldeco, “Modern Electrochemistry: Fundamentals of Electrodics”, Vol. 2A, Kluwer/Plenum Publ., New York, USA, 2000.
6. J. O’M. Bockris, A. K. N. Reddy, “Modern Electrochemistry: Electrodics in Chemistry, Engineering, Biology and Environmental Science”, Vol. 2B, Kluwer/Plenum Publ., New York, USA, 2000.
7. J. Bhattarai, “Frontiers of Corrosion Science”, Kshitiz Publ., Kathmandu, Nepal, 2010.

Practical:

1. Study the effect of pH on the rate of corrosion of materials (steel).
2. Study the effect of brine with or without oxygen on the corrosion of steel.
3. Demonstrate the effect of electrically connecting together two dissimilar metals in a solution to form an electrochemical cell.
4. Effect on rate of corrosion due to stray voltage between metals in a corrosive environment.
5. Cathodic protection by impressed voltage.
6. Study the effect of internal stress on corrosion rate of steel.
7. Experimental works on mechanical properties of corroded metal/alloy.

Evaluation Scheme:

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

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

* 20 marks is allotted for the internal assessment.

Mines, Fuels & Energy
EC 755

Lecture: 3 **Year: IV**
Tutorial: 1 **Part: II**
Practical: 1.5

Course Objectives:

i. Identify various types of solid, liquid & gaseous fuels and their combustion mechanism.
ii. Provide students with knowledge about various industrial combustion appliances.
iii. Recognize diverse energy sources and their respective pathways of production along with its application.

1. Mining of fuels **(10 hours)**

1.1 Types of fuels, present scenario and consumption of fuels.
1.2 Solid Fuel: Coal origin, its classification, composition and properties, Coal mining its preparation and washing.
1.3 Liquid Fuel: Origin and Classification of petroleum, Properties of petroleum products.
1.4 Gaseous Fuel: Introduction, Properties of gaseous fuel.
1.5 Mines and Energy resources in Nepal

2. Types of Non-Renewable fuels **(8 hours)**

2.1 Solid fuels: Coal Conversion, Coal gasification, Direct & Indirect coal liquefaction.
2.2 Liquid fuels: Petroleum, Liquid fuels from sources other than petroleum.
2.3 Gaseous fuels: Types of gaseous fuels: Natural gases, Methane from coal mines, LPG, Hydrogen, Purification of gaseous fuels.

3. Combustion Thermodynamic **(4 hours)**

3.1 Combustion thermodynamics
3.2 Mechanism and Kinetics of Combustion

4. Combustion of Fuels **(8 hours)**

4.1 Combustions of solid fuels: Suspension firing, Fuel-Bed firing, Fluidized-Bed firing.
4.2 Combustion of liquid fuels: Atomizers
4.3 Combustion of gaseous fuels: Gas burners

5. Combustion Appliances **(5 hours)**

5.1 Boilers: Industrial Boilers, Fluidized-Bed Boilers.
5.2 Furnaces: Industrial furnaces, process furnaces and kilns
5.3 Combustion Control System

6. Energy **(10 hours)**

6.1 Perpetual energy sources: Solar, Wind and Tidal.
6.2 Renewable energy sources: Energy from biomass and wastes through Biological, Chemical and Physical route, Hydropower and Geothermal
6.3 Energy storage devices

References:

1. S. Sarkar, “Fuels & Combustion”, Universities Press, 2009.
2. J. Griswold, “Fuels Combustion and Furnaces”, Mc-Graw Hill Book Company Inc.
3. R. H. Perry, “Perry’s Chemical Engineers’ Handbook,” McGraw-Hill, New York, 1997.
4. O. P. Gupta, “Elements of Fuels, Furnaces & Refractories”, Khanna Publishers.

Practical:

1. Determination of flash and fire point of bituminous materials.
2. Determination of viscosity of petroleum product.
3. Atmospheric distillation of petroleum product.
4. Determination of aniline point of petroleum product.
5. Determination of cloud and pour point of petroleum product.
6. Estimation of solar radiation using solar PV sensor.
7. Calibration of solar PV sensor with standard pyranometer.

Evaluation Scheme:

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

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

* 20 marks is allotted for the internal assessment.

Polymer Engineering
EC 753

Lecture: 4 **Year: IV**
Practical: 1.5 **Part: II**

Course Objectives:

i. The objective of the course is to present in-depth study of polymer science and engineering.
ii. Students can use basic properties of polymer to develop the final products applied in different fields.

1. Introduction (8 hours)

1.1 Definition, natural and synthetic polymer, classification of polymers based on polymer structure and mechanism of polymerization
1.2 Polymer structure: Copolymers, Polymer chain configuration, conformation and tacticity, geometric isomerism
1.3 Molecular Weight Estimation: Average molecular weight, number average and weight average, methods for the estimation of molecular weight, polydispersity

2. Properties of polymers (10 hours)

2.1 Introduction to rheology: Definition and basic principles, flow and viscoelastic behavior, relationship between polymer rheology and polymer processing
2.2 Rheometry: Capillary Rheometer, Couette Rheometer, Cone-and-Plate Rheometer
2.3 Mechanical properties: Stress-strain, creep, fracture behavior
2.4 Glass transition temperature and factors affecting it
2.5 Thermal behavior of polymers
2.6 Biodegradation and water permeability

3. Polymer technology (8 hours)

3.1 Polymerization techniques: Bulk, Solution, Solid-State, Gas-Phase, and Plasma Polymerization
3.2 Processing of Films: Principle, technology and operation of equipment, die design for film making.
3.3 Processing of Fibers: Melt and solution spinning operation, general principles of fluid flow, dry and wet spinning of fibers, effect of spinning on filament structure and properties,

4. Commercial polymers and their engineering applications (10 hours)

4.1 Polyethylene, Polycarbonates, nylons, Polyvinyl acetate, Polyacrylonitrile, Polymethyl methacrylate, amino and epoxy based resins and their commercial applications
4.2 Polymer additives and reinforcements: Plasticizers, fillers and reinforcements, stabilizers, flame retardants, colorants
4.3 High performance polymers for following applications: automobile, aerospace, transportation and other engineering and high tech applications.

5. Advanced topics (9 hours)

5.1 Synthesis, characterization and applications of Piezo-electric, Pyro-electric and Ferro-electric polymers
5.2 Conductive polymers and their applications
5.3 Metal/polymer composite and applications,
5.4 Ceramic/polymer composite and application
5.5 Carbon nanomaterials reinforced polymer composite and applications

References:

1. J. R. Fried,” Polymer Science and Technology”, Prentice Hall, 2014.

2. R. O. Ebewele, “Polymer Science and Technology”,2000, CRC Press
3. H. S. Kaufman, J. J. Falcetta, “Introduction to Polymer Science & Technology”, SPE Textbook, John Wiley & Sons 2010.
4. Jr. C. E. Carraher, “Introduction to Polymer Chemistry”, CRC Press, Taylor & Francis group 2012.

Practical:

1. Fabrication of thin film from solvent casting
2. Fabrication of nonwoven yarn from thermoplastic polymer
3. Synthesis of Bakelite using monomer
4. Polymer processing using extrusion process
5. Estimation of contact angle of liquid drop on polymer surface
6. Polymer industry visit and observation.

Evaluation Scheme:

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

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**

* 20 marks is allotted for the internal assessment.

Transport Phenomena
EC 756

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

Course Objectives:

i. Acquire understanding of the fundamental mechanisms behind the transport of momentum, energy and mass
ii. Apply shell balance method to derive equations of change for momentum, energy and mass
iii. Implement the equations to solve practical analytical problems to understand the distribution of velocity, temperature and concentration in the system

1. Introduction and momentum transport (4 hours)

1.1. Levels of transport phenomena and conservation laws
1.2. Molecules to continuum
1.3. Convective and molecular momentum flux tensor
1.4. Total momentum flux
1.5. Viscosity and principle of corresponding states

2. Shell balance and velocity distributions (4 hours)

3.1. Shell balances and boundary condition
3.2. Flow of a falling film
3.3. Flow through a circular tube
3.4. Flow of two adjacent immiscible fluids
3.5. Flow around a sphere

3. Equations of change for isothermal systems (6 hours)

3.1. Equation of continuity and motion
3.2. Equations of change for mechanical energy
3.3. Common simplifications of equation of motion
3.4. Solving problems with one independent variable
3.5. Turbulent flows and equation of change for Newtonian fluids

4. Mechanism of energy transport (4 hours)

4.1. Fourier's law
4.2. Work and total energy flux vector
4.3. Thermal conductivity and principle of corresponding states
4.4. Thermal conductivity of gases, liquids, solids and composite solids

5. Equations of change for non-isothermal systems (5 hours)

5.1. Energy equations and special forms
5.2. Boussinesq equations for free and forced convection
5.3. Equations of change and one independent variable problems
5.4. Equation of change for Newtonian fluids
5.5. Temperature profile near a wall

6. Interphase transport in non-isothermal systems (4 hours)

6.1. Heat transfer coefficients
6.2. Forced convection through slits and tubes
6.3. Forced convection around submerged objects
6.4. Forced convection through packed beds

7. Mechanisms of mass transport (4 hours)

7.1. Species concentrations, mass and molar flux vectors
7.2. Fick's law
7.3. Total mass and molar flux vectors
7.4. Diffusivity and principle of corresponding states
7.5. Diffusivity of gases

8. Shell balance and concentration distributions (6 hours)

8.1. Shell balances and boundary condition
8.2. Diffusion through solids and away from slightly soluble sphere
8.3. Diffusion in homogeneous and heterogeneous chemical reaction

8.4. Diffusion through a stagnant gas film
8.5. Diffusion and reaction inside a porous catalyst

9. Equations of change for binary mixtures (4 hours)

9.1. Continuity equation for binary mixture
9.2. Binary mixtures conservation laws and molecular fluxes
9.3. Equations of change and steady state problems
9.4. Unsteady state diffusion problems

10. Multicomponent macroscopic balances (4 hours)

10.1. Macroscopic mass and energy balance
10.2. Macroscopic mechanical energy balance
10.3. Solving steady state problems

References:

1. R. B. Bird, W. E. Stewart, E. N. Lightfoot, D. J. Klingenberg, "Introductory Transport Phenomena", Wiley.
2. R. B. Bird, W. E. Stewart, E. N. Lightfoot, "Transport Phenomena", Wiley.
3. W. M. Deen, "Analysis of Transport Phenomena", Oxford University Press.
4. J. L. Plawsky, "Transport Phenomena Fundamentals", CRC Press.
5. W. J. Thomson, "Introduction to Transport Phenomena", Prentice Hall.
6. J. R. Welty, G. L. Rorrer, D. G. Foster, "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley & Sons, Inc.

Evaluation Scheme:

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

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

* 20 marks is allotted for the internal assessment.

Project II
EC 757

Project II is the continuation of the Project I.

Practical: 6 **Year: IV**
Part: II

Course Objective:

i To continue the remaining task of chemical engineering design/research project carried out in Project I.
ii To make students able to document and present the project well.

General Procedures:

The students group formed to do project I will have to complete the remaining task of their respective projects in the project II. The consultation hour of supervisor will be six hours per week. The final presentation will be scheduled as per the time convenient to the examination committee, supervisor(s) and the students.

Course Requirements:

A final written report, in the format provided by the department, need to be submitted 2 weeks before the end of eight semester by each group to the Department of Applied Sciences and Chemical Engineering. The report will be evaluated by the respective supervisor(s), and if comply it will be accepted for the final presentation.

The final presentation will be scheduled as per the guidelines of examination control division (ECD), IOE, at the end of the eight semester. Each group have to present their work to the committee formed by the department. The committee includes HoD and DHoD of Applied Sciences and Chemical Engineering, project supervisor(s), and external examiner.

20 marks are allocated for internal assessment and 80 marks for end term.