BIOCHEMICAL ENGINEERING
ENCH 463

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

Course Objective:

The objective of this course is to understand biological systems relevant to engineering applications, apply material balance principles to microbial growth systems and understand modern industrial bioprocess and integration concepts.

1. Biological Foundations for Engineers (3 Hours)
- 1.1 Introduction to biotechnology and biochemical engineering
- 1.2 Cell types: prokaryotes vs eukaryotes
- 1.3 Cell structure and major organelles
- 1.4 DNA, RNA and protein synthesis (central dogma)
- 1.5 Enzymes and metabolic pathway

2. Bioenergetics and Cellular Metabolism (4 Hours)
- 2.1 Assimilatory and dissimilatory metabolism
- 2.2 Energy generation in biological systems
- 2.3 Overview of major metabolic pathways
- 2.4 Aerobic vs anaerobic metabolism
- 2.5 Metabolic end products and partial oxidation products

3. Microbial Growth and Stoichiometry (8 Hours)
- 3.1 Phases of microbial growth
- 3.2 Specific growth rate and growth kinetics
- 3.3 Cell growth kinetics
- 3.4 Biomass composition and yield coefficients
- 3.5 Stoichiometry of cell growth and product formation
- 3.6 Material balances for microbial systems

4. Enzyme Kinetics and Biocatalysis (8 Hours)
- 4.1 Introduction to enzymes and their categories
- 4.2 Michaelis–Menten kinetic model
- 4.3 Enzyme inhibition mechanisms
- 4.4 Immobilized enzyme systems
- 4.5 Industrial and medical applications of enzymes

5. Bioreactors and Fermentation Technology (10 Hours)
- 5.1 Introduction to bioreactors
- 5.2 Stirred tank bioreactor design and components
- 5.3 Aeration and agitation in bioreactors
- 5.4 Oxygen transfer concepts and mass transfer limitations
- 5.5 Batch, fed-batch and continuous bioreactor design & operations
- 5.6 Overview of state-of-the-art bioreactor technologies used in modern bioprocessing.

6. Introduction to Downstream Processing (6 Hours)
- 6.1 Importance of downstream processing

6.2 Cell harvesting methods
6.3 Filtration and centrifugation
6.4 Basic chromatography principles
6.5 Drying and product formulation

7. Emerging Bioprocess Technologies (3 Hours)

7.1 Introduction to genetic engineering
7.2 Brief comparison of microbial systems (e.g., Escherichia coli), animal cell cultures and plant cell cultures
7.3 Biopharmaceutical production overview
7.4 Biofuels and bioplastics
7.5 Sustainability and the bioeconomy

8. Industrial Case Studies (3 Hours)

8.1 Limitations of traditional hardware sensors, concepts of inferential measurement, biomass estimation using process variables and digital bioprocess monitoring.
8.2 Selection of suitable microbes, evaluation of feedstock types, execution of pretreatment methods and operational management of bio-butanol fermentation processes.
8.3 Purification and distillation techniques for bio-butanol recovery, alongside energy integration and sustainability analysis.

Tutorial (30 hours)

1. Study of microbial growth kinetics and growth curve analysis
2. Study of biomass and product stoichiometry for microbial systems
3. Material balances and yield coefficient calculations for batch and continuous bioreactors
4. Michaelis-Menten enzyme kinetics and enzyme inhibition
5. Bioreactor design, oxygen transfer and fermentation analysis using computing tools

Practical (15 hours)

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.

Final Exam

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

Chapter	Hours	Mark distribution*
1 and 2	7	10
3	8	10
4	8	10
5	10	14
6	6	8
7 and 8	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Bailey, J. E., & Ollis, D. F. (1986). Biochemical engineering fundamentals (Latest ed.). McGraw-Hill.
2. Doble, M., & Gummadi, S. N. (2007). Biochemical engineering. Prentice Hall.
3. Lee, J. M. (1992). Biochemical engineering. Prentice Hall.
4. Shuler, M. L., & Kargi, F. (2002). Bioprocess engineering: Basic concepts (Latest ed.). Prentice Hall.
5. Slonczewski, J. L., & Foster, J. W. (2011). Microbiology: An evolving science (Latest ed.). W. W. Norton & Company.
6. Trevan, M. D. (1980). Immobilized enzymes: An introduction and applications in biotechnology. John Wiley & Sons.