SECOND SEMESTER 2020-21

COURSE HANDOUT

Date: 16.01.2021

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No : **CHE F421**
Course Title : **BIOCHEMICAL ENGINEERING**
Instructor-in-Charge : **AMIT JAIN**

1. Course Description:

Basics of Microbiology and Biochemistry; Introduction to Biochemical engineering, Mass and energy balance in microbial processes; Microbial growth, Substrate utilization and product formation kinetics; Medium and air sterilization; Enzyme kinetics and immobilized enzyme systems; Design of batch, continuous and fed-batch bioreactors; Transport Phenomena in biological reactors; Scale-up principles for biochemical processes; Instrumentation and control of bioprocesses, Bio separations.

2. Scope and Objective of the Course:

The objective of the course, as implied by the course content above, is to introduce fundamental biochemical engineering and bioprocess technology concepts and their commercial implications to the students from chemical engineering. To accommodate those students who do not have the biological background, the course will first introduce the basic concepts from microbiology, biochemistry, and the central dogma of biology. Subsequently, the emphasis will be on the application of the principles of chemical engineering to biological processes.

3. Text Books:

TB: "Biochemical Engineering Fundamentals" by James E. Bailey and David F. Ollis (2010) 2nd Ed. McGraw Hill International Edition.

4. Reference Books:

R1: "Bioprocess Engineering: Basic Concepts" by Michael L. Shuler and Fikret Kargi (2005) Third Indian Reprint, Pearson Education.
R2: "Biochemical Engineering" by Harvey W. Blanch & Douglas S. Clark (1997), Marcel Dekker, Inc., New York.
R3: "Coulson and Richardson's Chemical Engineering", Vol. 3 by J F Richardson and D G Peacock, 3rd Ed., Asian Books Private Limited, New Delhi.
R4: Will be shared, dynamically, in the classes. Students are advised to remain updated!

5. Course Plan:

Module Number	Lecture session	Reference	Learning Outcome
1. Introduction to Biochemical Engineering; Basics of Biology	L.1.1. Introduction to biochemical engineering; Biologists and engineers perspective; Handout discussion.	TB: Ch.-1 R1: Ch.-1	Understanding on engineers and biologist roles.
	L.1.2 - L.1.3. Basics of biology; Overview of biotechnology; Diversity in microbial cells, Cell constituents, Chemicals for life.	TB: Ch.1-2; R1: Ch.-2	Remembering the basics of microbiology. Evaluating bacterial species
	L.1.4. Current state of the art	R4	Keeping updated with the latest developments within this module
2. Enzyme-catalysis: Reaction kinetics & application	L.2.1 - L.2.2. Enzyme kinetics: Introduction, Mechanistic models, experimental determination of rate parameters, Effects of pH and temperature, insoluble substrate.	TB: Ch. 3; R1: Ch.-3	Evaluating enzyme catalyzed reaction rates. Create Enzyme-catalyzed reaction models.
	L.2.3 – L.2.4. Immobilized enzyme systems: Enzyme immobilization methods, their limitations & applications, Immobilized enzyme kinetics.	TB: Ch. 4; R1: Ch.-3	
	L.2.5. Current state of the art	R4	Keeping updated with the latest developments within this module
3. Bioenergetics and Metabolic Pathways	L.3.1 - L.3.2. Metabolic stoichiometry and energetics: Major metabolic pathways, Respiration, Nitrogen Fixation, Biosynthesis, Transport across cell membranes.	TB: Ch.-5; R1: Ch.-5 & Ch.-7	Understand various metabolic pathways and cell energetics.
	L.3.3. Current state of the art	R4	Keeping updated with the latest developments within this module
4. Stoichiometry and Kinetics of Cell Growth & Product Formation	L.4.1 – L.4.3. Cell growth in batch & continuous cultures; Growth kinetics quantification	TB: Ch.-7; R1: Ch.-6	Evaluating growth yield and yield coefficients. Analyzing cell growth, product formation and kinetics.
	L.4.4. Stoichiometric calculations, Yield and yield coefficients.		

	L.4.5. Current state of the art	R4	Keeping updated with the latest developments within this module
5. Transport Phenomena, Scale-up and Sterilization in Bioprocess Systems	L.5.1 – L.5.2. Gas-liquid mass transfer in cellular systems, Forced convective mass transfer, Scaling of mass-transfer equipment	TB: Ch.-8 R1: Ch.-10	Understanding mass/heat transfer, scale-up and sterilization issues in biological systems. Analyzing relevant dimensionless numbers and their significance.
	L.5.3. Heat transfer in bioprocess systems and various correlations		
	L.5.4. Sterilization of bioprocess fluids		
	L.5.5. Current state of the art	R4	Keeping updated with the latest developments within this module
6. Bioreactor design and analysis	L.6.1 – L.6.3. Submerged liquid fermentation bioreactors - batch, continuous, semi-continuous, combination of reactors; Reactors for enzyme reactions and immobilized cells.	TB: Ch.-9; R1: Ch.-9	Analyzing and evaluating various reactor configurations. Creating efficient reactor configuration for optimal conversion.
	L.6.4. Current state of the art	R4	Keeping updated with the latest developments within this module
7. Instrumentation and control of bioprocesses	L.7.1 – L.7.3. Physical and chemical sensors for the medium and gases, On-line/Off-line sensors, Computers and interfaces, Data analysis, Process control, Machine learning	TB: Ch.-10; R1: 10; R4	Understanding limitations of actual process-control strategies for bioreactors in comparison to other established industries (e.g. petrochemicals) and ideas/opportunities to improve this situation
8. Product purification and recovery	L.8.1 – L.8.3. Strategies, separation of soluble and insoluble products, cell disruption, purification and integration of processes.	TB: Ch.-11; R1: Ch.-11	Understanding existing downstream processes. Applying engineering principles for product separation.
	L.8.4. Current state of the art	R4	Keeping updated with the latest developments within this module

9. Bioprocess Economics	L.9.1 – L.9.2. Process economics, Bioproduct regulation, Industrial production of fine chemicals, bulk oxygenates etc., Anaerobic methane production	TB: Ch. 12; R4	Understanding economic and regulatory aspects of bioprocesses and keeping updated with current state of the art
10. Industrial Utilization of Mixed Cultures	L.10.1 – L.10.3. Introduction to mixed cultures, Models for mixed culture interaction, Case studies, Applications of mixed cultures in the long-term space missions	TB: Ch.13 & Ch. - 14; R1: Ch.16; R4	Understanding the mixed culture. Envisioning utility and dynamics of mixed cultures for various applications

6. Evaluation Scheme:

Component	Duration (minutes)	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Examination	90	35	As announced by AUGSD	Open Book
Comprehensive Examination	120	40	As announced by AUGSD	Open Book
Project: Presentations & Report	In-Class & Take-home (15-20 per group)	25	Equally spreaded throughout the semester (February onwards)	Open Book

7. Chamber Consultation Hour: To be announced in the class.

8. Notices: All the notices would be put up on the Google Classroom.

9. Make-up Policy: Make-up request for the mid-semester examination is to be submitted 7 days in advance of the exam (or within 72 hrs. in case of medical emergency). For comprehensive examination the request is often made to AUGSD.

- It is mandatory to submit the necessary supporting documents (such as: listed below) along with make-up request:
  - Letter of invitation/selection for a national/international event where the applicant is representing BITS Pilani.
  - Proof of hospitalization, medical certificate, prescription, medicine purchase bill, etc.
  - Network outage (state wide/city wide/region wide) announcement in public media.
- There is no makeup for the project presentations. However, students can mutually change the dates with permission from I/C.

10. Note (if any):

- Students have to adhere to the class timings and participate in class room discussion.
- Attending classes would certainly make difference in learning & marks would reflect the same.

Instructor-in-Charge
Course No. CHE F421