SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY

Department of Biotechnology			LP: BT 18501 Rev. No: 01 Date: 8.07.2023
B.E/B.Tech/M.E/M.Tech PG Specialisation Sub. Code / Sub. Name Unit	: **Biotechnology** : Biotechnology : BT18501/ Bioprocess engineering : I	Regulation: 2018	

Unit Syllabus: OPERATIONAL MODES OF BIOREACTOR **12+3**

Basic configuration of Fermenter, Batch, continuous and fed batch cultivation, cell recycle cultivation, High cell density cultivation, two stage cultivation, packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. Media design and optimization for fermentation process, Thermal death kinetics of microorganism, Sterilization of liquid media and air, Design of batch and continuous sterilization, Biomass estimation - direct and indirect methods

OBJECTIVE: To provide the students with the basics of bioprocess principles and bioreactor configurations

Session No *	Topics to be covered	Ref	Teaching Aids
1.	Basic configuration of Fermenter- basics, parts of the reactor, basic control systems	T6 (9.1)	GCR/PPT/ BB
2.	Modes of cultivation- Batch, continuous and fed batch	T6 (9.1.2)	GCR/PPT/ BB
3.	Modes of operations- Batch, continuous and fed batch	T6 (9.1.3)	GCR/PPT/ BB
4.	Design of batch and continuous sterilization - Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor	T6 (9.6.2-9.6.5)	GCR/PPT/ BB
5.	Cell recycle cultivation, High cell density cultivation, two stage cultivation	Internet source	GCR/PPT/ BB
6.	Media design- sources, types and parameters to be maintained	T6 (9.7.1)	GCR/PPT/ BB
7.	Optimization of media for fermentation process	T6 (9.7.2)	GCR/PPT/ BB
8.	Kinetics of microorganism- generation time, doubling time	T6 (7.2.1)	GCR/PPT/ BB
9.	Microbial growth kinetics and Thermal death kinetics	T6 (7.2.2)	GCR/PPT/ BB
10.	Problem solving class on growth kinetics	T6	GCR/PPT/ BB
11.	Sterilization of liquid media and air and kinetics	T6(9.4)	Online (GCR)
12.	Design of batch and continuous sterilization	T6(9.4.1-9.4.2)	GCR/PPT/ BB

13.	Problem solving class on Batch and continuous sterilization kinetics	T6(7.1-7.2)	GCR/PPT/ BB
14.	Biomass estimation - direct and indirect methods	T3(7.4)	GCR/PPT/ BB
15.	Problem solving class on Biomass and yield measurements	T3	GCR/PPT/ BB

Content beyond syllabus covered (if any):

Performance measures to be understand for design and analysis of the reactor

* Session duration: 50 minutes

Sub. Code / Sub. Name : BT18501/ Bioprocess engineering
Unit : II

Unit Syllabus: BIOREACTOR SCALE – UP **8+3**

Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors – microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip

OBJECTIVE: To learn the scale up criterions of bioprocesses

Session No *	Topics to be covered	Ref	Teaching Aids
16.	Regime analysis of bioreactor processes – online and off line measurements of processes	T6(10.1-10.3)	GCR/PPT/ BB
17.	Oxygen mass transfer in bioreactors- Film theory and penetration theory	T6(8.2.1)	GCR/PPT/ BB
18.	Gas liquid mass transfer, factors affecting cellular demand	T6(8.3.2)	GCR/PPT/ BB
19.	Microbial oxygen demands- cell uptake rate, OTR from gas bubble to cell	T6(8.6)	GCR/PPT/ BB
20.	Oxygen supply rate and Equation for OTR- static and dynamic	T6	GCR/PPT/ BB
21.	Problem solving on OTR calculations	T6	GCR/PPT/ BB
22.	Mass transfer correlations	T6(8.9)	GCR/PPT/ BB
23.	Problem solving on OUR and KLa determinations	T6	GCR/PPT/ BB
24.	Scale up criteria for bioreactors based on oxygen transfer	T6(8.9.1)	GCR/PPT/ BB
25.	Scale up designs- Power consumption and impeller tip speed	Internet source	GCR/PPT/ BB

26.	Problem solving on scale up of the reactors	Internet source	GCR/PPT/ BB

Content beyond syllabus covered (if any):

Why scale up is a problem in Bioprocess industries?

* Session duration: 50 mins

Sub. Code / Sub. Name : BT18501/ Bioprocess engineering
Unit : III

Unit Syllabus: BIOREACTOR CONSIDERATION IN ENZYME SYSTEMS 8+3

Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors

OBJECTIVE: The students will

Session No *	Topics to be covered	Ref	Teaching Aids
27.	Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions	Internet source	GCR/PPT/ BB
28.	Formulation of dimensionless groups	Internet source	GCR/PPT/ BB
29.	Problem solving- calculation of effectiveness factors	Internet source	GCR/PPT/ BB
30.	Design of immobilized enzyme reactor	T6 (9.1.2)	GCR/PPT/ BB
31.	Non ideal reactors	T4 (5.1- 5.9)	GCR/PPT/ BB
32.	Problem solving on - RTD calculations	T6(9.3.2)	GCR/PPT/ BB
33.	Design of packed bed reactor	T6 (9.6.2)	GCR/PPT/ BB
34.	Design of fluidized bed reactor	T6 (9.6.4)	GCR/PPT/ BB
35.	Design of membrane reactor	T6 (9.6.5)	GCR/PPT/ BB
36.	Problem solving -Pulse Experiments	Internet source	GCR/PPT/ BB
37.	Problem solving – Step experiments	Internet source	GCR/PPT/ BB

Content beyond syllabus covered (if any):

Real equipment always deviates from the ideals, concept analysis using E curve

* Session duration: 50 mins

Sub. Code / Sub. Name : BT18501/ Bioprocess engineering
Unit : IV

Unit Syllabus: METABOLIC STOICHIOMETRY AND ENERGETICS 9+3

Stoichiometry of cell growth and product formation - elemental balances - degrees of reduction of substrate and biomass - available electron balances - yield coefficients of biomass and product formation - maintenance coefficients - energetic analysis of microbial growth and product formation - oxygen consumption and heat evolution in aerobic cultures - thermodynamic efficiency of growth

OBJECTIVE: The students will gain knowledge on

Session No *	Topics to be covered	Ref	Teaching Aids
38.	Stoichiometry of cell growth and product formation	T3(7.3)	GCR/PPT/ BB
39.	Elemental balances	T3(7.3.1)	GCR/PPT/ BB
40.	Problem solving class on Elemental balance calculations	T3	GCR/PPT/ BB
41.	Degrees of reduction of substrate and biomass	T3 (7.3.2)	GCR/PPT/ BB
42.	Problem solving class on degree of reduction	T3	GCR/PPT/ BB
43.	Available electron balances	T3(7.3.3)	GCR/PPT/ BB
44.	Yield coefficients of biomass and product formation and Maintenance coefficients	T3	GCR/PPT/ BB
45.	Problem solving class on biomass yield calculations	T3 (7.4)	GCR/PPT/ BB
46.	Problem solving class on Product yield calculations	T3	GCR/PPT/ BB
47.	Energetic analysis of microbial growth and product formation	T6(5.10)	GCR/PPT/ BB
48.	Oxygen consumption and heat evolution in aerobic cultures	Internet source	GCR/PPT/ BB
49.	Thermodynamic efficiency of growth	T6(5.10.4)	GCR/PPT/ BB

Content beyond syllabus covered (if any):

Gross error analysis in the measurements

* Session duration: 50 mins

Sub. Code / Sub. Name : BT18501/ Bioprocess engineering
Unit : V

Unit Syllabus: MODELLING AND SIMULATION OF BIOPROCESSES 8+3

Product formation kinetics – Leudeking-Piret models - substrate and product inhibition on cell growth and product formation, Plasmid replication and plasmid stability model, Structured and Unstructured models, Bioprocess Data Analytics and Machine Learning

OBJECTIVE: The students.

Session No *	Topics to be covered	Ref	Teaching Aids
50.	Product formation kinetics- growth associated, non- growth associate and mixed growth associated	T6(5.10.1)	GCR/PPT/ BB
51.	Leudeking-Piret model	T6(5.10.2)	GCR/PPT/ BB
52.	substrate and product inhibition on cell growth and product formation- Tessier, Moser and Contois model	T6(5.10.3)	GCR/PPT/ BB
53.	Plasmid replication and plasmid stability model	T2 (3.6)	GCR/PPT/ BB
54.	Structured models- Compartmental models	Internet source	GCR/PPT/ BB
55.	Structured models- Metabolic models	T6 (7.4.2)	GCR/PPT/ BB
56.	Unstructured models- Product formation kinetics	T2 (3.3)	GCR/PPT/ BB
57.	Microbial enzyme kinetic models and their applications in PBR and Tubular reactor	T6(7.6)	GCR/PPT/ BB
58.	Thile modulus and effectiveness factor calculations	T6(7.7)	GCR/PPT/ BB
59.	Bioprocess Data Analytics and Machine Learning	Internet source	GCR/PPT/ BB
60.	Systematically interrogate bioprocess data to ascertain characteristics (such as nonlinearity, multicollinearity, and dynamics)	Internet source	GCR/PPT/ BB

Content beyond syllabus covered (if any):
Applications of models in Biotechnology

* Session duration: 50 mins

REFERENCES

TEXT BOOKS:

1. Jens. N, John. V and Gunnár. L, "Bioreaction engineering principles", 2nd Edition, Kulwer Academic, 2002.
2. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, 2nd Edition, Marcel Dekker Inc. 2002.
3. Shuler. M, Kargi. M., and Delisa. M, "Bioprocess Engineering: Basic Concepts", 3rd , revised, Pearson Education, 2017.
4. Doran Pauline M, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 1995.
5. Nielsen, J. and Villadsen, J., Bioreaction Engineering Principles, 2nd Ed., Springer, 2007.
6. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, 2nd Ed, McGraw Hill, 1986.
7. Stanbury, P.F., Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books, 2nd Ed., MPG Books Ltd, 1995

	Prepared by	Approved by
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Date	08-07-2023	8/7/23
Remarks *: If the same lesson plan is followed in the subsequent semester/year it should be mentioned and signed by the Faculty and the HOD.		

10/7/23