Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT205	**Bioprocess Calculations**	**3-1-0-4**	**2016**

Prerequisite : Nil

Course objectives

- To prepare students for making analysis of chemical and biochemical processes through calculations
- To develop in them a systematic approach towards solution of problems involved in the design, development and analysis of process engineering systems.

Syllabus

Fundamentals of Material Balances – Material Balances with chemical reactions – Material Balances without chemical reactions – Material and energy balances for sterilization, industrial fermentation, downstream processing and waste treatment processes - Fundamentals of Energy Balances – Stoichiometry of cell growth and product formation – thermodynamics of microbial growth and product formation

Expected Outcomes

Upon successful completion of this course, the students will be able to

- Solve basic calculations in bioprocess engineering.
- Carry out material and energy balances for various unit operations.
- Calculate percentage yield, selectivity, and extent of reaction.
- Formulate growth medium based on stoichiometry and elemental balances.
- Calculate heat of reaction for microbial growth and product formation.

Reference Books

1. K.V. Narayanan, B. Lakshmikutty, *Stoichiometry and Process Calculations*, Prentice Hall of India, 2006.
2. David M. Himmelblau, James B. Riggs, *Basic Principles and Calculations in Chemical Engineering*, Prentice Hall, 2012.
3. B.I. Bhatt, S.M. Vora, *Stoichiometry*, Fourth edition, Tata McGraw Hill, 2004.
4. P.M. Doran, *Bioprocess Engineering Principles*, 2/e, Elsevier- Academic Press, 2013.
5. R.M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, 3/e, John Wiley and Sons, 2000.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Fundamentals of material balances:** Law of conservation of mass, types of material balance problems - total and component balances, steady and unsteady state processes, batch and continuous processes. Concept of tie element, basis for calculations, independent material balance equations and degrees of freedom, steps for solving material balance problems – simple numerical examples.	7	15%
II	**Material balances without chemical reactions:** Material balances for unit operations like evaporation, crystallization, drying, leaching, adsorption, extraction, absorption and distillation. Bypass, recycle and purging	8	15%

	operations – simple numerical examples.		
FIRST INTERNAL EXAM			
III	**Material balances with chemical reactions:** Definition of terms like limiting reactant, excess reactant, percentage yield and selectivity, extent of reaction- simple numerical examples. Combustion of solid, liquid and gaseous fuels, heating value of fuels, proximate and ultimate analysis of coal, Orsat analysis. Recycle and purge involving chemical reactions – Simple Numerical examples	10	15%
IV	**Fundamentals of energy balances:** Law of conservation of energy, components of energy balance equations- Heat and work, kinetic energy, potential energy and flow energy, internal energy and enthalpy - Heat capacities. Energy balance in cyclic processes, energy balance for flow and non- flow processes- simple numerical examples.	7	15%
SECOND INTERNAL EXAM			
V	Material and energy balances for sterilization, industrial fermentation, downstream processing and waste treatment processes - simple numerical examples and case studies.	10	20%
VI	**Stoichiometry of cell growth and product formation**: Overall growth stoichiometry- medium formulation and yield factors, elemental material balances for growth, electron balances, product formation stoichiometry, theoretical oxygen demand and maximum possible yield – simple numerical examples. **Thermodynamics of microbial growth and product formation:** Heat of reaction with and without oxygen as principal electron acceptor - simple numerical examples.	10	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3 hours

The question paper consists of Part A, Part B and Part C.

Part A consists of three questions of 15 marks each uniformly covering Modules I and II. The student has to answer two questions (15×2=30 marks).

Part B consists of three questions of 15 marks each uniformly covering Modules III and IV. The student has to answer two questions (15×2=30 marks).

Part C consists of three questions of 20 marks each uniformly covering Modules V and VI. The student has to answer two questions (20×2=40 marks).

Note : Each question can have a maximum of 4 subparts, if needed.