Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT201	**Fluid Flow and Particle Technology**	**3-1-0-4**	**2016**

Prerequisite : Nil

Course Objectives

- To serve as a basis for two fundamental unit operations namely, fluid flow and particle technology, which find limitless applications in bioprocess engineering.
- To emphasise on the applications of fluid flow, in the backdrop of existing basic theory.

Syllabus

Properties and nature of fluids, fluid flow characteristics, flow through pipe, transportation and metering of fluids, flow past immersed bodies, Particle technology, describing the size of a single and populations of particles, particle size analysis, particle size reduction, solid-solid and solid-liquid separations, storage and transport of solids.

Expected outcome

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

- Apply fluid properties to analyze and solve fluid mechanics problems.
- Apply key concepts of fluid flow, to any specific domain of bioprocessing.
- Understand the principles of flow measurement and transportation of fluids.
- Understand and apply the basic methods of characterization of particles and bulk solids
- Analyze solid-solid and solid-liquid separation processes

Reference Books

1. McCabe W. L., J. C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, 6/e, McGraw Hill, 2000.
2. Martin J. Rhodes, *Introduction to Particle Technology*, 2/e, John Wiley & Sons, 2008.
3. Coulson J. M and J. F Richardson, *Chemical Engineering: Fluid flow, Heat transfer and Mass transfer (Vol - I)*, 5/e, Butterworth-Heinemann, 1999.
4. Coulson J. M and J. F Richardson, *Chemical Engineering: Particle technology and Separation processes (Vol - II)*, 5/e, Butterworth-Heinemann, 1999.
5. Perry R. H. and D.W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7/e, McGraw Hill, 1997.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Properties and nature of fluids** - Ideal fluid, Real fluid, Density, Specific weight, Specific Volume, Capillarity and Surface Tension, Viscosity, Vapour pressure, Absolute and Gauge Pressures. Fluid Statics - Forces on fluids and hydrostatic equilibrium, Measurement of Pressure using different types of manometers. Forces on submerged bodies - Buoyancy, Stability of floating and submerged bodies.	8	15%

II	**Introduction to fluid flow**- Flow of incompressible fluids- Classification of flow - Steady and unsteady state flow, uniform and non-uniform flow, Stream line, Streak line, Path line, Stream tube, Velocity Potential - Laminar and Turbulent flow - Reynold's Experiment. Equations of Change for isothermal systems - Equation of Continuity, Equation of Motion - Navier Stoke's Equation and Euler equation (derivations not required). Newtonian and non- Newtonian fluids - Momentum flux and Newton's Law of Viscosity. Flow in boundary layers - Boundary layer separation and Wake formation.	8	15%
FIRST INTERNAL EXAM			
III	**Flow through pipe** - Bernoulli Equation, Correction factors in Bernoulli Equation, Pump work – Numerical problems, Shear stress and Velocity distribution in circular channel. Hagen-Poiseuille Equation, Laminar flow of non-Newtonian fluids, Velocity distribution for turbulent flow, The friction factor chart, Fanning Equation- Numerical problems.	8	15%
IV	**Transportation and Metering of Fluids** - Pipes and tubes, Pipe joints, Valves – Materials of construction, Pumps- Reciprocating and Centrifugal pumps, Characteristics of centrifugal pumps - Priming, Cavitation, NPSH, Water hammer, Loss of head and power in centrifugal pumps, Characteristic curves. Flow measurement - Orifice meter, Venturi meter, Rotameter, Pitot tube, Weirs and notches, velocity meters	8	15%
SECOND INTERNAL EXAM			
V	**Flow past immersed bodies**- Drag coefficient - Flow through packed bed - Kozney Carman equation, Blake Plummer equation and Ergun equation. Motion of Particles through fluids - Motion from gravitational and Centrifugal fields - Terminal Settling velocity, Stoke's law- Intermediate law - Newton's law – Hindered Settling. Fluidization - Advantages and disadvantages, Applications, Minimum Fluidization velocity, Pressure drop-flow rate diagrams. Types of fluidization.	12	20%
VI	**Particle technology** – Describing the size of a single particle- Shape factor, mean diameter, Description of populations of particles, Particle size analysis-methods of particle size measurement-Sieving, microscopy, sedimentation, permeametry, electrozone sensing, laser diffraction, ICI sedimentation, Photosedimentation, Elutriation, common methods of displaying size distribution-Arithmetic and Log-normal distributions. Particle size reduction – particle fracture mechanisms, models for predicting energy requirements and particle size distribution, types of size reduction equipments,	12	20%

	factors affecting choice of equipments. Particle size enlargement - interparticle forces, granulation, equipments for granulation. Solid-liquid separation-Filtration and centrifugation, Sedimentation and Decantation, flocculation, Solid-solid separation - screening, air classification (theory only). Storage and transportation of bulk solids - Different methods and types of conveyors.		
END SEMESTER EXAMINATION			

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..