Course code	Course Name	L-T-P - Credits	Year of Introduction
MT204	HEAT, MASS AND MOMENTUM TRANSPORT	4-0-0-4	2016

Prerequisite : Nil

Course Objectives

- To understand basic concepts related to heat flow, fluid flow, mass transfer, in the context of metallurgical processes
- To become familiar with the mathematical treatment and equations related to above transport phenomena
- To comprehend the science behind process modeling

Syllabus

Transport phenomena - Introduction and Basic Concepts - Molecular Transport and Fluid Flow - flow of Newtonian fluid flow in pipes, annulus, slits and planes, flow of non-Newtonian fluids in pipes - Heat conduction with heat generation - Laminar and turbulent hydrodynamics, thermal and concentration boundary layers - Analysis of flow over flat surface - Heat transfer by Convection, Newton's law of cooling, Combined convection and conduction - The Reynolds Analogy – Heat exchangers- Radiation heat transfer, Mass Transport - Modes of mass transfer - Molecular diffusion- Analogy between mass, heat and momentum transfer, Dispersion, Hydraulic or Darcy's flow in porous media- Chemical kinetics and activation energy, Convective mass transfer, Liquid-solid mass transfer, Liquid-liquid mass transport, Gas-liquid mass transfer,

Course Expected Outcome.

Upon completion of the course, the student will be able to

1. Understand the scientific aspects related to heat flow, fluid flow and mass transfer
2. Learn about related equations, in the above context
3. Understand how transport concepts and equations are used in the modeling of metallurgical processes
4. Obtain the ability to convert actual (descriptive) processes into appropriate equations and then attempt to solve the same
5. Obtain the basic skills essential for process modeling
6. Obtain the ability to carry out complex process calculations

References/Textbooks

1. Bird. R.B, Stewart. W.E and Lighfoot. E.W, Transport Phenomena, John Wiley.
2. Wilty. J.R, Wilson. R.W and.Wicks. C.W, Fundamentals of Momentum Heat and Mass Transfer 2nd Edn., John Wiley
3. Thomson. W.J, Introduction to Transport Phenomena, Pearson Education Asia, New Delhi

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Introduction and Basic Concepts** 1.1 Importance of transport phenomena, 1.2 Analogous nature of transfer process; basic concepts, conservation laws; continuous concept, field, reference frames, 1.3 Substantial derivative and boundary conditions; methods of analysis; 1.4 Differential, integral and experimental methods. 1.5 Phenomenological laws of transport properties, 1.6 Newtonian and non Newtonian fluids; 1.7 Rheological models; theories of transport properties of gases and	10	15%

	liquids; effect of pressure and temperature. 1.8 Units and other physical parameters, unit systems, temperature, mole, concentration, pressure, Energy and heat units		
II	**Molecular Transport and Fluid Flow** 2.1 General method of shell balance approach to transfer problems: Choosing the shape of the shell; Most common boundary conditions, 2.2 Momentum flux and velocity distribution for flow of Newtonian fluids in pipes, 2.3 Momentum flux and velocity distribution for flow of non-Newtonian fluids in pipes, 2.4 Momentum flux and velocity distribution for flow of Newtonian fluids in annulus. 2.5 Momentum flux and velocity distribution for flow of Newtonian fluids in slits and planes, 2.6 Heat conduction with an electrical heat source, chemical heat source and nuclear heat source 2.7 Forced and free convection, 2.8 Mass flux and concentration profile for diffusion in stagnant gas. 2.9 Turbulent phenomena: Phenomenological relations for transfer fluxes, 2.10 Time smoothed equations of change and their applications for turbulent flow in pipes, 2.11 Laminar and turbulent hydrodynamics thermal and concentration boundary layer and their thickness, 2.12 Analysis of flow over flat surface	12	15%
FIRST INTERNAL EXAMINATION			
III	**Heat Transport** 3.1 Basic concepts in heat transfer, heat transfer mechanisms, 3.2 Conduction: Fourier's law of heat conduction, thermal conductivity, Conduction heat transfer - through flat slab/wall and through hollow cylinder, Conduction through solids in series, 3.3 Convection: Newton's law of cooling. Convective heat transfer co-efficient, 3.4 Combined convection and conduction. 3.5 The overall heat transfer coefficient, 3.7 The Reynolds Analogy. Dimensional analysis. Convection correlations. Extended surfaces. 3.8 Log mean temperature differences and simple heat exchanger design. 3.9 General discussion on radiation heat transfer, Stefan-Boltzmann equation. Radiative heat transfer	10	15%
IV	**Mass Transport** 4.1 Basic concepts in mass transport, Some application examples, 4.2 Modes of mass transfer, Molecular diffusion- Fick's law, 4.3 Analogy between mass, heat and momentum transfer, 4.4 Dispersion, Hydraulic or Darcy's flow in porous media, 4.5 Chemical kinetics and activation energy, Film theory, 4.6 Convective mass transfer, Liquid-solid mass transfer, Liquid-liquid mass transport, Gas-liquid mass transfer, 4.7 Aeration and oxygen transport, Air stripping	8	15%
SECOND INTERNAL EXAMINATION			
V	**Momentum Transport** 5.1 Basic concepts in fluid mechanics, Force, unit and dimensions, pressure in fluid, head of fluid, 5.2 Molecular transport for momentum, heat and mass transfer, 5.3 Viscosity of fluids, Newton's law, Momentum transfer, 5.4 Newtonian and non-Newtonian fluids, Fluid flow and Reynolds number, 5.5 Overall mass balance, Control volume and Continuity equation, 5.6 Overall	8	20%

	energy balance, Bernoulli's equation, 5.7 Overall momentum balance, Drag coefficient, Stokes law, 5.8 Flow in packed beds, 5.9 Flow in fluidized bed		
VI	**Analogies between Transport Processes** 6.1 Importance of analogy, 6.2 Analogy concept between momentum, energy and mass transfer. 6.3 Derivations of Prandtl and Reynolds analogies. 6.4 Derivation of Von Karman and Colburn analogies. 6.5 Examples on use of analogies for heat transfer and mass transfer.	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN

Maximum Marks : 100 Exam Duration: 3 hrs

PART A: 8 Questions from Module 1&2 (4+4). 6 questions to be answered. 6x5=30 Marks
PART B: 8 Questions from Module 3&4 (4+4). 6 questions to be answered. 6x5= 30 Marks
PART C: 6 Questions from Module 5&6 (3+3). 4 questions to be answered. 4x10=40 Marks