Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

I SEMESTER M.TECH (INDUSTRIAL BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: TRANSPORT PHENOMENA IN BIOPROCESSING [BIO 505]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitable assumed.

1A.	Consider an incompressible fluid, flowing under laminar flow conditions in a plane of narrow slit of length L and width W formed by two flat parallel walls that are at a distance of $2B$ apart. End effects may be neglected because $B << W << L$. The fluid flows under the influence of pressure difference Δp. Using a differential shell momentum balance, determine the expressions for the steady-state shear stress distribution, velocity profile, maximum velocity and average velocity:	**5**
1B.	A fungus is used to produce an extra cellular polysaccharide by fermentation of glucose. After 4 days fermentation, the following measurements of shear stress and shear rate were made with a rotating cylinder viscometer. Plot the rheogram for this fluid and determine the appropriate non-Newtonian parameters:	**5**
2A.	Apply "no slip boundary condition" for a fluid flowing i. through a circular pipe ii. between two parallel plates	**2.5+2.5**
2B.	Assume that a sterile fermentation media (0.27 cP) is flowing through a circular pipe under laminar conditions. The distribution of velocity, u (m/sec) with radius 'r' in 'm' inside the pipe of 0.025 m diameter is given by, $u = 3 - K r^2$, where K is a constant. Determine i. the rate of flow in m^3/s ii. the shearing force between the fluid and the pipe wall per 'm' length of pipe.	**2.5+2.5**

Table for 1B:

Shear stress (N/m^2)	0.0002	0.0019	0.0049	0.056	0.14	1.77	5.00	55.9
Shear rate (s^{-1})	0.1	0.5	1	5	10	50	100	500

3A.	Consider a spherical aggregate of bacterial cells (assumed homogeneous) of radius *R*. Under certain circumstances, the oxygen metabolism rate of the bacterial cells is almost zero order with respect to oxygen concentration and may be approximated by an effective volumetric reaction rate $r_{O2} = k_0'''$. The diffusion may be described by Fick's law with an effective pseudo binary diffusivity for oxygen in the bacterial medium D_{O2-M}. Neglect transient and convection effects because the oxygen solubility is very low in the system. i. Perform the shell mass balance inside the particle. ii. Derive an expression for concentration of oxygen inside the aggregate. iii. What will happen if oxygen concentration becomes zero inside the aggregate at a certain radial distance? Give suggestions to rectify this problem:	**2+4+4**
4A.	Suspended plant cells form spherical aggregates approximately 1.5 mm in diameter. The substrate uptake (zero order) is measured using a packed bed reactor; medium is recirculated with a superficial liquid velocity of 0.83 cm/s. At a bulk concentration of 8 mg/L, the substrate is consumed at a rate of 0.28 mg per g wet weight of cells per hour. Assume that the density and viscosity of the medium are similar to water and the specific gravity of wet cells is 1. The effective diffusivity of the substrate in the aggregates is 9×10^{-6} cm^2/s, or half that in the medium. [$Sh = 0.95\ Re_p^{0.5} Sc^{0.33}$] i. Does external mass transfer affect the substrate uptake rate? ii. Does the internal mass transfer affect the substrate uptake rate? iii. Determine the total effectiveness factor. Comment on its value:	**4+4+2**
5A.	A heated sphere of diameter *D* is placed in a large amount of stagnant fluid. Consider the heat conduction in the fluid surrounding the sphere in the absence of convection. The thermal conductivity *k* of the fluid may be considered constant. The temperature at the sphere surface is T_R and the temperature far away from the sphere is T_a. i. Set up the differential equation describing the temperature *T* in the surrounding fluid as a function of *r*, the distance from the center of the sphere and determine the temperature profile. ii. From the temperature profile, obtain an expression for the heat flux at the surface. Equate this flux to flux given by Newton's law of cooling and show that the Nusselt number is equal to 2.	**5+5**
6A.	Consider a cylindrical wire of radius R and length L through which electrical current is passed. Take the heat produced per unit volume by the electrical wire is S_e, current density is I, electrical conductivity is k_e and thermal conductivity is k. i. Perform shell energy balance and establish the temperature distribution inside the wire. ii. To what extent does the maximum temperature differ from the average temperature? iii. What is the total rate of heat transferred from the wire?	**4+4+2**