III SEMESTER B.TECH. (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOV/DEC 2018

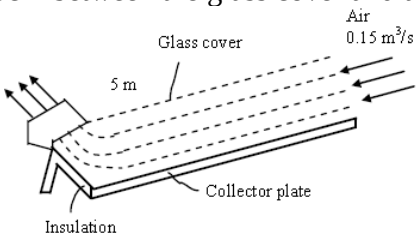
SUBJECT: FLUID FLOW OPERATIONS IN BIOPROCESSING [BIO 2106]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A.	Consider a U-tube whose arms are open to the atmosphere. Now water (ρ=1000kg/m^3) is poured to the U-tube from one arm and light oil (ρ=790kg/m^3) from the other. One arm contains 70cm high water, while the other arm contains both fluids with an oil to water height ratio of 6. Determine the height of each fluid in that arm.	**3**
1B.	Explain the variation of shear stress with the rate of deformation for Newtonian and non-newtonian fluids. Give examples for each.	**4**
1C.	A flat plate of area 1.5 x 10^6 mm^2 is pulled with the speed of 0.4 m/s relative to another plate located at a distance 0.15 mm apart from it. Find the force and power required to maintain the speed, if the fluid separating them having viscosity as 1 Pa.s.	**3**
2A.	The flow rate of methanol at 20° C (ρ = 788.4kg/m^3 and μ = 5.857X10^{-4} kg/m.s) through a 4 cm diameter pipe is to be measured with a 3 cm orifice meter equipped with a mercury manometer across the orifice plate. If the differential height of the manometer is read to be 11 cm, determine the flowrate of methanol though the pipe and the average flow velocity. Assume C_d=0.61, $\rho_{mercury}$ = 13600 kg/m^3. List the assumptions.	**3**
2B.	A horizontal venturimeter with inlet diameter 200mm and throat diameter 100mm is used to measure the flow of water. The pressure at inlet is 0.18N/mm^2 and the vacuum pressure at the throat is 280mm of mercury. Find the rate of flow. The value of C_d may be taken as 0.98.	**3**
2C.	Consider an air solar collector that is 1m wide and 5m long and has a constant spacing of 3cm between the glass cover and the collector plate. Air flows at an average temperature  of 45°C at a rate of 0.15m^3/s through the 1m wide edge of the collector along the 5m long passageway. Disregarding the entrance and roughness effects, determine the pressure drop in the collector. Given friction factor = 0.0271. The properties of air at 1 atm and 45° are ρ = 1.109 kg/m^3, μ = 1.941×10-5 kg/m·s, and ν = 1.750×10-5 m^2/s.	**4**
3A.	A horizontal pipe 150mm in diameter is joined by sudden enlargement to a 225 mm diameter pipe. Water is flowing through it at a rate of 0.05m^3/s. Find loss of head due to abrupt expansion, pressure difference in the two pipes, and change in pressure if the change of section is gradual without any loss.	**4**

3B.	Oil of viscosity 9 poise and specific gravity 0.9 is flowing through a horizontal pipe of 60mm diameter. If the pressure drop in 100m length of the pipe is 1800kN/m^2, determine rate of flow of oil and the center-line velocity.	**3**
3C.	A fluid with absolute viscosity 1.5 poise and density 848.3kg/m^3 is flowing through a 30cm diameter pipe. If the head loss in 3000m length of pipe is 20m, assuming a laminar flow determine the velocity and Fanning friction factor.	**3**
4A.	Oil with a density of 850kg/m^3 and kinematic viscosity of 0.00062 m^2/s is being discharged by a 5mm diameter 40m long horizontal pipe from a storage tank open to the atmosphere. The height of the liquid level above the center of the pipe is 3m. (i) Disregarding the minor losses, determine the flowrate of oil through the pipe. (ii) What is the physical mechanism that causes friction factor to be higher in turbulent flow.	**3**
4B.	Write on (i) How does the wall shear stress vary along the flow direction in a fully developed region in laminar and turbulent flow? (ii) How are friction factor and pressure loss related and also pressure loss and pumping power requirement related for a given mass flow rate?	**3**
4C.	During a high Reynolds number experiment , the total drag force acting on a spherical body of diameter D = 12cm subjected to airflow at 1 atm and 5°C is measured to be 5.2N. The pressure drag acting on the body is calculated by integrating the pressure distribution (measured by the use of pressure sensors throughout the surface) to be 4.9N. Determine the friction drag coefficient of the sphere and also verify id the flow is turbulent. Given The density and kinematic viscosity of air at 1 atm and 5°C are ρ = 1.269 kg/m^3 and $\nu = 1.382\times10^{-5}$ m^2/s. The drag coefficient of sphere in turbulent flow is C_D = 0.2, and its frontal area is A = $\pi D^2/4$.	**4**
5A.	Elucidate (a) the various flow patterns observed in agitation (b) dependence of fluid properties on the flow regime.	**4**
5B.	Explain the working principle of a rotameter with a sketch.	**3**
5C.	Calculate the terminal settling velocity of dust particles having diameter 60µm in air at 294K and 101.32 kPa. The dust particles may be considered spherical with a density of 1280kg/m^3. Assume Stoke's region. Air properties ρ=1.137kg/m^3, $\mu=1.90\text{x}10^{-5}$ Pa.s. Also define the terminal settling velocity.	**3**