Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

III SEMESTER B.TECH. (BIOTECHNOLOGY)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

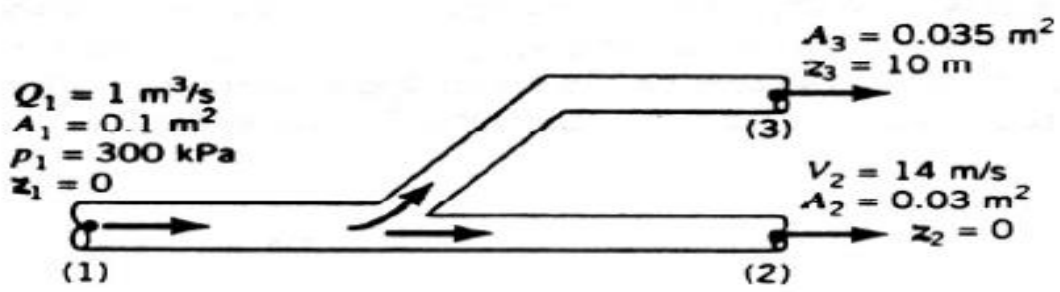
SUBJECT: FLUID FLOW OPERATIONS IN BIOPROCESSING [BIO 2106]

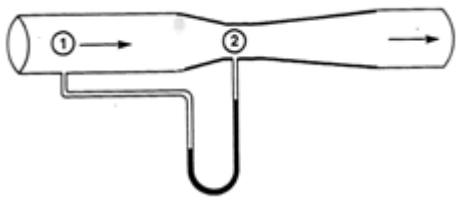
REVISED CREDIT SYSTEM
(06/12/2016)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A.	Classify the fluids based on resistance offered to the flow, density changes and Newton's law of viscosity. Brief them all.	**3**
1B.	What are the devices available for the measurement of pressure at a point? Discuss the working principle of any one of it.	**3**
1C.	On the suction side of a pump a gauge shows a negative pressure of 0.35 bar. Express this pressure in terms of i) Intensity of pressure, kPa ii) Meters of water gauge iii) Meter of oil (specific gravity 0.82) absolute and iv) Centimetres of mercury gauge	**4**
2A.	Water flows through the branching pipe shown in the figure. If frictional effects are negligible, determine the pressure at section (2) and at section (3) 	**6**
2B.	A pump draws a liquid solution (S.G 1.85) from an open storage tank through a 3.067"ID Schedule 40 steel pipe. The efficiency of the pump is 75%. The velocity in suction pipe is 0.925 m/s. The pump discharges through a 2.067"ID Schedule 40 steel pipe to an open overhead tank. The end of the discharge pipe is 20 m above the level of the liquid solution in the feed tank. The friction losses in the entire piping system are 25.9 J/kg. What is the horsepower delivered to the fluid by the pump?	**4**

3A.	An iron pipe (ϵ = 0.15 mm) 5 cm diameter is 5 m long and carries a molasses with discharge of 0.0045 m^3/s (μ = 1.85 cP & ρ=1200 kg/m^3). i) Find the loss of head due to friction. ii) The central 2 m length of pipe is next replaced by a pipe of 7.5 cm diameter, the changes of section being sudden. Determine the loss of head and the corresponding power required in watts due to adoption of this alternative. Expansion and contraction loss coefficients are 0.86 and 0.54 respectively.	**8**
3B.	A crude oil of viscosity 0.95 P and relative density 0.935 is flowing through a horizontal circular pipe of diameter 115 mm and of length 10 m. Calculate the pressure difference at the two ends of pipe, if 120 kg of oil is collected in a tank in 30 s.	**2**
4A.	The density of silica is found to be 3100 kg/m^3. 25.4 gm of this silica is packed into a column of 2.5 cm diameter to form a bed of 28.2 cm. When a pressure drop of 12.5 cm of Hg is established across the bed, it is found that 775 secs are required to drive 250 cm^3 of air through the bed. Bed as the porosity of 0.45. Calculate the average diameter of particles in the silica (assuming spherical) and the surface area per gram of silica. Assume Ergun equation is valid for the studies. Data : μ_{air} = 1.83 X 10^{-5} kg / m s ρ_{air} = 1.24 kg/m^3 ρ_{Hg} = 13550 kg/m^3	**5**
4B.	Particles having a size of 0.10 mm, a shape factor of 0.85, and a density of 1250 kg/m^3 are to be fluidized using air at 25°C and 201.65 kPa abs pressures. The void fraction at minimum fluidizing conditions is 0.41. The bed diameter is 0.68 m and the bed contains 320 kg of solids. Air properties are viscosity = 1.85x10^{-2} cP, density = 2.174 kg/m^3 i) Calculate the minimum height of the fluidized bed ii) Calculate the pressure drop at minimum fluidizing conditions iii) Calculate the minimum fluidizing velocity.	**5**
5A.	What do you mean by priming of a pump? Is it necessary for the operation of the pump?	**2**
5B.	Suggest a device for the removal of undesired gas released during the fermentation in a bioreactor. Justify your selection of device.	**3**
5C.	A venturimeter with a throat diameter of 4.5 cm is fitted into a 10 cm ID pipeline. The coefficient of discharge is 0.98. Calculate the flow through the meter when the reading on a mercury-water manometer connected across the upstream and throat taps is 25 cm. (ρ_{Hg} =13600,ρ_{H2O}=998.2 kg/m^3). Calculate the losses due to friction, in terms of heads, across the meter if loss in the converging cone is equal to loss in the diverging cone.  	**5**

List of formulae

$$N_{\mathrm{Re},p} = \left|\frac{1}{1-\varepsilon}\right| D_p v_s \frac{\rho}{\mu}$$

$$\frac{\Delta P}{L} = \frac{150\mu v_s}{\phi_s^2 D_p^2}\frac{(1-\varepsilon)^2}{\varepsilon^3} + \frac{1.75\,\rho v_s^2}{\phi_s D_p}\frac{(1-\varepsilon)}{\varepsilon^3}$$

$$\frac{\Delta P}{L_{mf}} = (1-\varepsilon_{mf})(\rho_p - \rho)g$$

$$v_{mf} \approx \frac{g(\rho_p - \rho)}{150\mu}\frac{\varepsilon_{mf}^3}{1-\varepsilon_{mf}}\phi_s^2 D_p^2$$

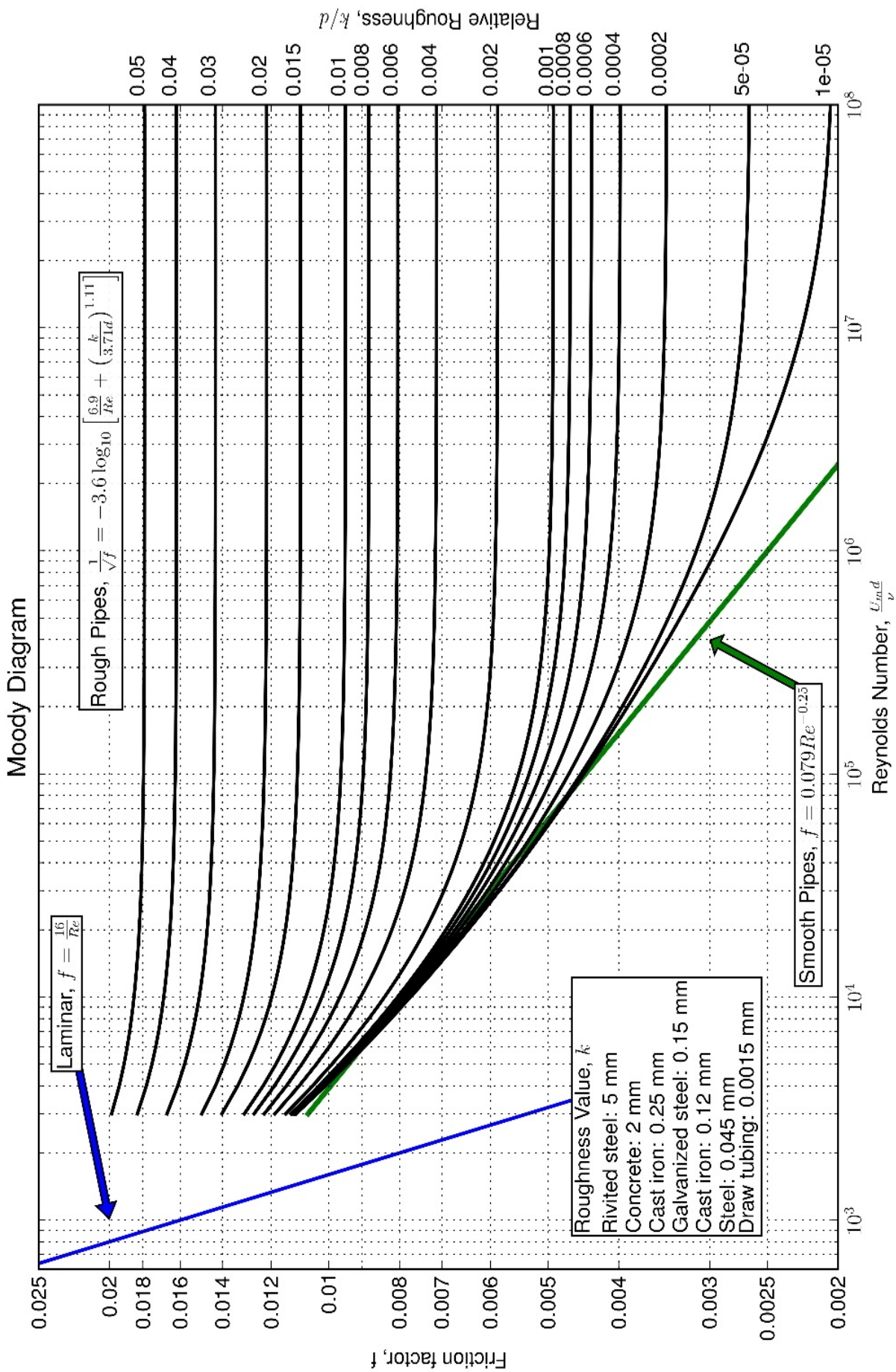
$$v_{mf} \approx \left[\frac{\phi_s D_P g(\rho_p - \rho)\varepsilon_{mf}^3}{1.75\rho}\right]^{1/2}$$

$$\frac{150}{\phi_s^2}\frac{(1-\varepsilon_{mf})}{\varepsilon_{mf}^3} N_{\mathrm{Re},mf} + \frac{1.75}{\phi_s}\frac{}{\varepsilon_{mf}^3}\left(N_{\mathrm{Re},mf}\right)^2 = \left(\rho D_P^3 / \mu^2\right) g(\rho_p - \rho)$$

$$N_{\mathrm{Re},mf} = \left[33.7^2 + 0.0408\left(\rho D_P^3 / \mu^2\right) g(\rho_p - \rho)\right]^{1/2} - 33.7$$

$$v_t = \frac{g D_p^2 (\rho_p - \rho)}{18\mu}$$

$$v_t = 1.75\sqrt{\frac{g D_p (\rho_p - \rho)}{\rho}}$$


Moody Diagram
Laminar, $f = \frac{16}{Re}$
Rough Pipes, $\frac{1}{\sqrt{f}} = -3.6 \log_{10} \left[\frac{6.9}{Re} + \left(\frac{k}{3.71d} \right)^{1.11} \right]$
Smooth Pipes, $f = 0.079 Re^{-0.25}$
Roughness Value, k
Rivited steel: 5 mm
Concrete: 2 mm
Cast iron: 0.25 mm
Galvanized steel: 0.15 mm
Cast iron: 0.12 mm
Steel: 0.045 mm
Draw tubing: 0.0015 mm
Friction factor, f
Reynolds Number, $\frac{U_m d}{\nu}$
Relative Roughness, k/d
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
5e-05
1e-05
0.025
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.007
0.006
0.005
0.004
0.003
0.0025
0.002
10^3
10^4
10^5
10^6
10^7
10^8