MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

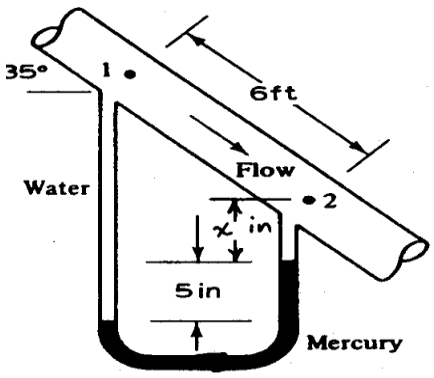
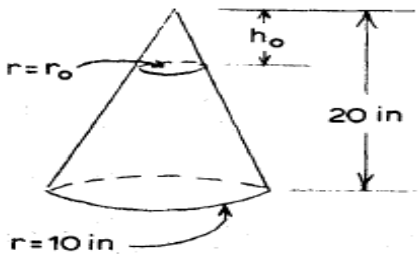
III SEMESTER B.TECH. EXTERNAL EXAMINATIONS MARCH 2021

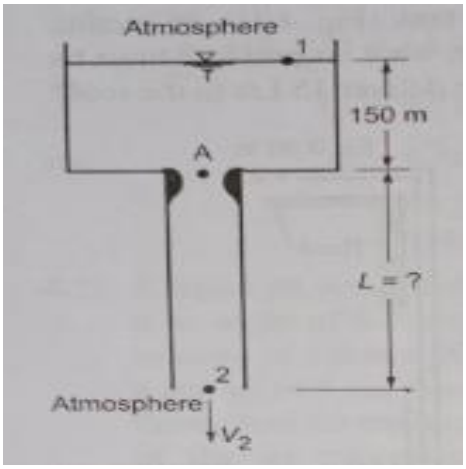
SUBJECT: FLUID FLOW OPERATIONS IN BIOPROCESSING [BIO2154]

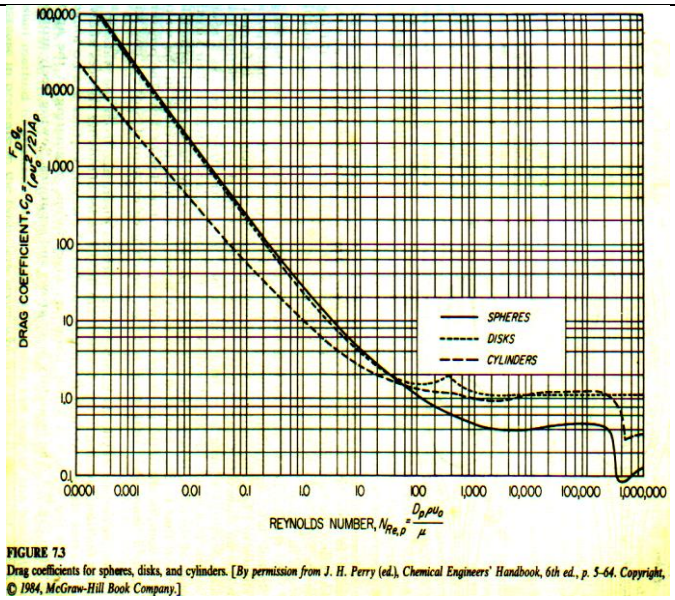
Date of Exam: 12/03/2021 Time of Exam: 2.00 PM – 5.00 PM Max. Marks: 50

Instructions to Candidates:

- Answer ALL the questions & missing data may be suitable assumed

1A.	An open U tube manometer is being used to measure the absolute pressure p_a in a vessel containing air. The pressure p_b is atmospheric pressure which is 754 mmHg. The liquid in the manometer is water having a density of 1000 kg/m^3. Assume that the density of air is 1.3 kg/m^3 and that the distance Z is very small. The reading R is 0.514 m. Calculate p_a in kPa.	**4**
1B.	Water flows downward in a pipe at 35^o, as shown in figure. The pressure drop $P_1 - P_2$ is partly due to gravity and partly due to friction. The mercury manometer reads a 5-in height difference. What is the total pressure drop $P_1 - P_2$? What is the pressure drop due to friction only between 1 and 2? Does the manometer reading correspond only to friction drop? 	**4**
1C.	Find the height of the free surface if 0.8 ft^3 of water is poured into a conical tank 20 in high with a base radius of 10 in. 	**2**
2A.	The outlet at the bottom of a tank is so formed that the velocity of water at point A is 2.0 times the mean velocity within the outlet pipe. What is the greatest length of pipe L	**4**

	which may be used without producing cavitation? Atmospheric pressure = 95.480 kPa (abs) and vapor pressure = 4.00 kPa (abs). Neglect all other losses.  	
2B.	A turbine is set 40 m below the water level of a reservoir and is fed by a 60 cm diameter pipe. A short pipe of 45 cm diameter discharges the water from the turbine to atmosphere. If a total frictional loss of 10 m is assumed and the turbine efficiency 85 %, estimate the power output.	**4**
2C.	A flat plate of area 3.0 x 10^6 mm^2 is pulled with the speed of 0.6 m/s relative to another plate located at a distance 0.30 mm apart from it. Find the force and power required to maintain the speed, if the fluid separating them having viscosity of 1 Pa.s.	**2**
3A.	A fluid with absolute viscosity 1.5 poise and density 848.3 kg/m^3 is flowing through a 30 cm diameter pipe. If the head loss in 3000 m length of pipe is 20 m, assuming a laminar flow determine the viscosity and fanning friction factor.	**3**
3B.	Water is to be pumped from a pond to the top of a tower 1829cm above the water level in the pond. It is desired to deliver 0.34 m^3/min of water at a pressure of 2.08atm. The pipe line consists of 122m length of straight pipe of 7.62cm ID with EIGHT elbows of 90º & FOUR gate valves. Calculate the HP of the pump having an efficiency of 80%: f= 0.046 / $Re^{0.2}$. Equivalent length in terms of pipe dia: Gate valve = 7D and 90ºElbow = 32D.	**4**
3C.	A sphere having a diameter of 0.042 m is held in a small wind tunnel, where air at 37.8 ºC and 1 atm abs and various velocities is forced past it. Determine the drag coefficient and force on the sphere for velocity of 2.3 x 10^{-2} m/s. Use Stoke's law if it is applicable else correlate C_D from the below reference graph. (Density and viscosity of air are 1.137 kg/m^3 and 1.90 x 10^{-5} kg/m.s respectively).	**3**

	 **FIGURE 7.3** *Drag coefficients for spheres, disks, and cylinders. [By permission from J. H. Perry (ed.), Chemical Engineers' Handbook, 6th ed., p. 5-64. Copyright, © 1984, McGraw-Hill Book Company.]*	
4A.	Calculate the shape factor of a solid particle of cylindrical shape if length of a cylinder is 1.5 times the diameter.	**2**
4B.	An oil of density 900 kg/m^3 and viscosity 6 mNs/m^2 is passed vertically upwards through a bed of catalysts consisting of approximately spherical particles of diameter 0.2 mm and density 2600 kg/m^3. At approximately what mass rate of flow per unit area of bed will Fluidization. Assume voidage at incipient fluidization as 0.48.	**5**
4C.	Air flows through a packed bed of powdery material of 2 cm depth at a superficial gas velocity of 1 cm/s. A manometer connected to the unit registers a pressure drop of 2 cm of water. The bed has a porosity of 0.4. Assuming that Kozney-Carmann equation is valid for the range of study, estimate the particle size of the powder? Density and viscosity of air are 1.23 kg/m^3 and 1.8x10^{-5} kg/m-s respectively.	**3**
5A.	A fermenters (cylindrical) of diameter 3m has four baffles is used to culture an anaerobic organism. A Rushton turbine mounted in the reactor is operated at a speed of 100rpm. The density of broth is 1000 kg/m^3. As the cells grow, the viscosity of the broth changes. Compare the power requirements when the viscosity is: (i) Approximately that of water; and (ii) 100 times greater than water. Use the following relationships for the flow conditions: Type of flow | Power number correlation *Laminar* | $N_P = 6000 / Re_i$ *Transition* | $N_P = 600 / Re_i$ *Turbulent* | $N_P = 6 + (1/Re_i)$	**4**
5B.	A Pitot tube is installed along the axis of a horizontal pipe of 76 mm inner diameter. Air at 40 ^{o}C and 105 kPa flows through the pipe. Calculate the rate of flow of air, if the reading of the water differential manometer connected across the tube is 12 mm. Viscosity of air at 40 ^{o}C is 0.019 mPa-s. Take v_{avg}/v_{max}=0.81 for Re_{max} between 60000 to 70000.	**4**
5C.	Differentiate between venturimeter and orifice meter.	**2**