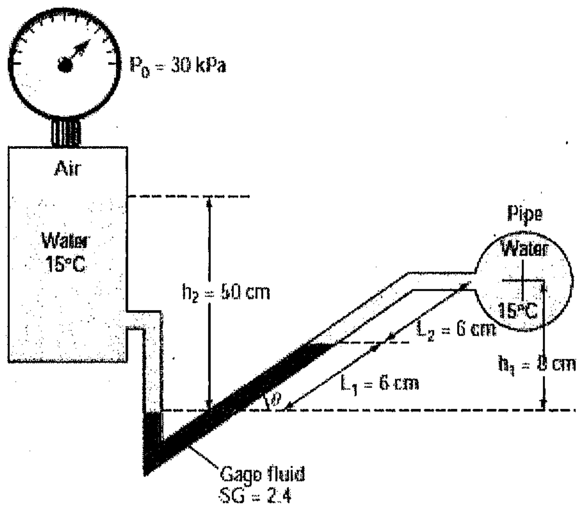
Ref. No. : Ex/Che/PC/B/T/213/2024(S)

B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM – 2024

SUBJECT: MECHANICS OF FLUID Time: Three hours Full Marks 100

No. of Questions/CO		Marks
1/1	A velocity field is given by $\vec{V} = 3x(2+cos(\pi t))\hat{\imath} - 3y(2+cos(\pi t))\hat{\jmath}$ (i)What are the dimensionality and directionality of the flow field? (ii) Derive the equation of streamline at time t=0, passing through (2,4). Does the streamline vary with time? (iii) Is this an irrotational flow? Justify your answer.	(2) (4) (4)
2(a)/4	 (i)The pressure of water flowing through a pipe is measured by the arrangement shown in Fig. 1. For the values given, calculate the pressure in the pipe. (ii)Discuss about the advantages of inclined tube manometer FIG.1	(7) (3)
2(b)/4	A sharped edged 0.5 inch orifice is installed in a1 inch standard steel pipe. Dry air at upstream condition of 20°C and 2 atm flows through the orifice at such a rate that the U tube manometer connected across the taps indicates a reading of 30 cm of red oil. The red oil has a specific gravity of 0.831 referred to water at 20°C. Assume that the orifice discharge coefficient C_o is 0.61. (i)Calculate the weight rate of air flow in the pipe. (ii) Estimate permanent head loss across the orifice	(6) (4)

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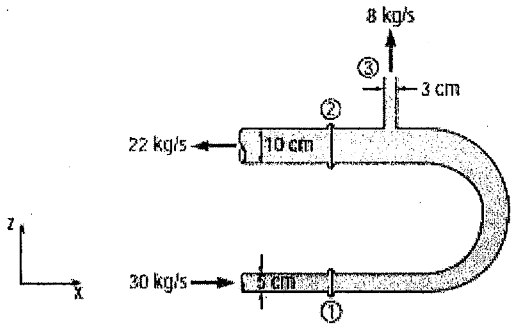
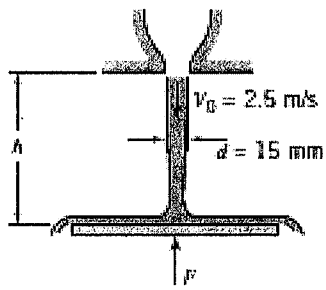
3. (a)/2	Water (ρ=100kg/m^3, μ = 0.001 kg/ms) is flowing into and discharging from a U pipe as shown in Fig. 2 At flange 1 the total absolute pressure is 200 kPa and 30 kg/s flows into the pipe. At flange 2 the total pressure is 150 kPa. At location 3, 8 kg/s of water discharges to atmosphere, which is at 100 kPa. Determine the total x and z directional forces at the two flanges connecting the pipe.  FIG.2	(15)
3(b)/2	 FIG.3 A uniform jet of water leaves a 15 mm diameter nozzle and flows directly downward. The jet speed at the nozzle exit plane is 2.5 m/s. The jet impinges on a horizontal disk and flows radially outward in a flat sheet. Develop an expression for the force required to hold the disk stationary, neglecting the mass of the disk and water sheet.	(15)

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No. of Questions		Marks
4(a)/3	Water is pumped from the reservoir to an overhead tank by using a centrifugal pump. The head rise (ΔH) of the pump is 120 m. The level of water in the overhead tank (Z2) is 6m above the level of water in the reservoir (Z1). The suction line (reservoir to pump suction) length is 20m, the discharge line (pump discharge to overhead tank) length is 30m (excluding the fittings). Inside diameter of the commercial steel pipe (ε/D=0.0018) is 2.5 cm. The suction line has one open globe valve and one standard 90° elbow. The discharge piping has one fully open globe valve, one swing check valve, two 90° standard elbow and one orificemeter (β=0.5). Mercury manometer (ρ_{Hg}=13600 kg/m^3) is used for orificemeter. <u>Name of fittings</u> <u>Loss coefficients</u> Fully open globe valve 8.2 Swing check valve 2.9 90° standard elbow 1.5 The discharge coefficient for orifice is 0.61. For β=0.5, permanent energy loss as fraction of pressure difference across the orifice is 73%. (i) Calculate the power transmitted to the fluid by the pump. (ii) The flow rate of water pumped (iii) The reading of orificemeter (Δh) (iv)Draw the EGL and HGL.	(5) (10) (5) (5)
4(b)/3	Consider a packed bed consisting of spherical particles (ρ_p= 1300 kg/m^3) of average diameter 1 mm. The bed is 1 m in diameter by 3 m long. Water (ρ=1000 kg/m^3) is used to fluidized the bed. At minimum fluidizing condition the void fraction, ϵ of the bed is 0.4. At the operating condition, the bed height is increased by 2 times. Calculate (i) void fraction of the bed at operating condition (ii) the pressure drop across the bed under such condition, (ii) operating flow rate of water. Ergun equation for flow through packed bed having spherical particles is given below: $\frac{(-\Delta P_f)g_c}{L}\frac{D_p}{\rho V_o^2}\frac{\varepsilon^3}{(1-\varepsilon)} = 150\frac{(1-\varepsilon)}{N_{Re_p}} + 1.75; V_o$ is the superficial velocity.	(5+5+5)

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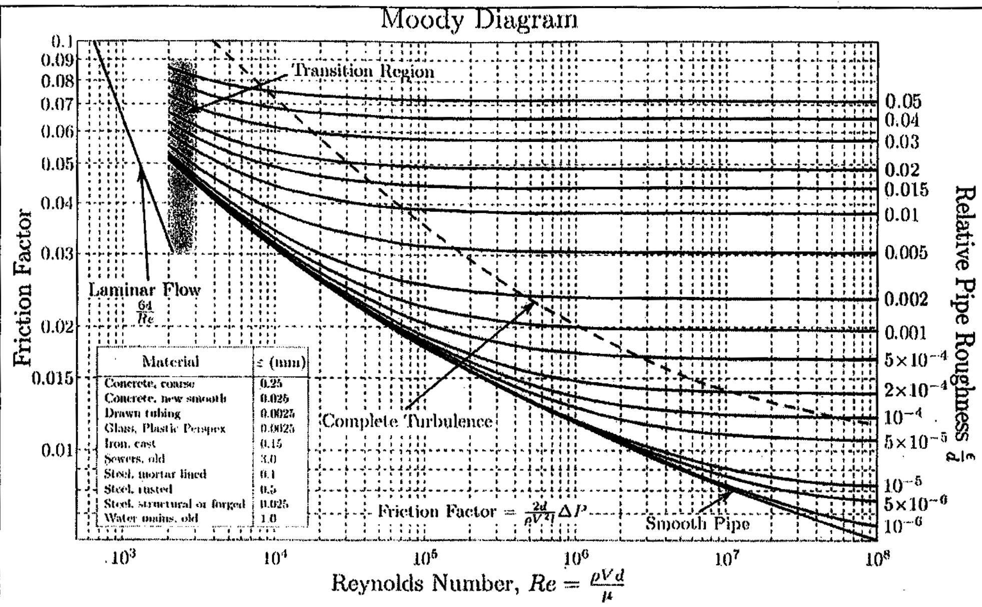
Moody Diagram
Friction Factor
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.015
0.01
Transition Region
Laminar Flow
64/Re
Material | ε (mm)
Concrete, coarse | 0.25
Concrete, new smooth | 0.025
Drawn tubing | 0.0025
Glass, Plastic Perspex | 0.0025
Iron, cast | 0.15
Sewers, old | 3.0
Steel, mortar lined | 0.1
Steel, rusted | 0.5
Steel, structural or forged | 0.025
Water mains, old | 1.0
Complete Turbulence
Friction Factor = 2d/(ρV²l) ΔP
Smooth Pipe
Relative Pipe Roughness ε/d
0.05
0.04
0.03
0.02
0.015
0.01
0.005
0.002
0.001
5×10⁻⁴
2×10⁻⁴
10⁻⁴
5×10⁻⁵
10⁻⁵
5×10⁻⁶
10⁻⁶
10³
10⁴
10⁵
10⁶
10⁷
10⁸
Reynolds Number, Re = ρVd/μ