Question Paper

Exam Date & Time: 14-Nov-2019 (02:00 PM - 05:00 PM)

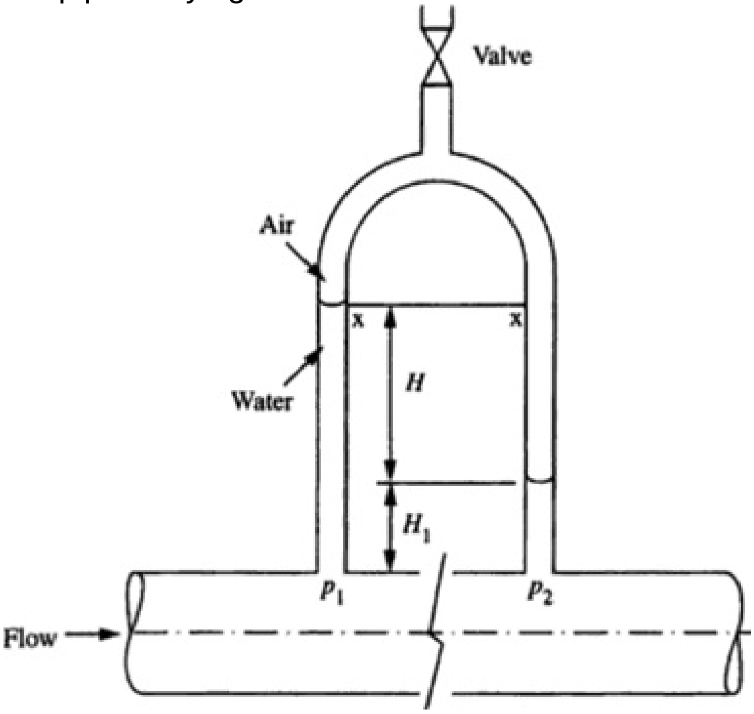
MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
END SEMESTER THEORY EXAMINATIONS
NOVEMBER 2019
III SEMESTER B.sc (Applied Sciences) in Engg.
FLUID FLOW OPERATIONS [ICHM 231]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.
Missing data, if any, may be suitably assumed.

1) A) Derive an expression for pressure drop in a pipe when connected to an inverted manometer (refer the figure), and determine the pressure drop in the pipe carrying water if a differential head of 40 cm is recorded. (6)

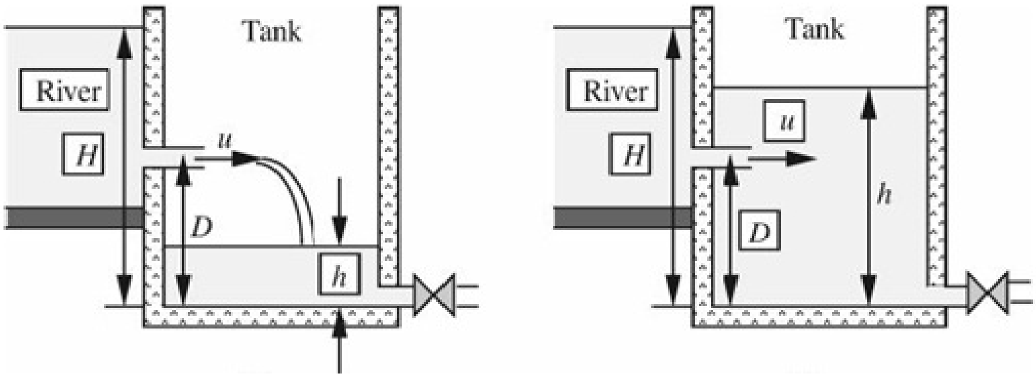


B) A thin-walled pipe, of diameter 4 in., is held stationary in a river flowing at 6 ft/s parallel to its axis. The pipe contains a sharp-edged orifice, of diameter 3 in., with a contraction coefficient of 0.62 based on the area. Neglecting entry losses and shear forces on the pipe, and assuming that the orifice is distant from either end of the pipe, calculate the pressure drop across the pipe and the flow rate through it. (8)

C) Explain the rheological characteristics of non-Newtonian fluids. (6)

2) Fig. shows a concrete tank that is to be filled with water from an adjacent (12)

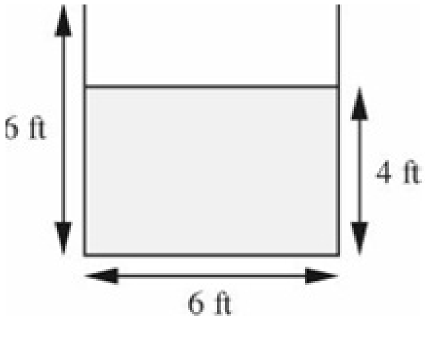
A) river. The level of the river is H = 10 ft above the base of the tank, and the short connecting pipe, which offers negligible resistance, discharges water at a height D = 4 ft above the base of the tank. The inside cross-sectional area of the pipe is a = 0.1 ft^2, and that of the tank is A = 1,000 ft^2. Derive an algebraic expression for the time t taken to fill the tank, and then evaluate it for the stated conditions



B) Derive steady-state energy balance equation with the help of a neat schematic diagram. Clearly mention all the assumptions considered. (8)

3) A) Derive Hagen-Poiseuille law for pipe flow with the help of a neat schematic diagram. Clearly mention all the assumptions considered. (10)

B) The irrigation ditch shown in Fig. has a cross section that is 6 ft wide × 6 ft deep. It conveys water from location 1 to location 2, between which there is a certain drop in elevation. With a flow rate of Q = 72 ft^3/s of water, the ditch is filled to a depth of 4 ft. If the same ditch, transporting water between the same two locations, were completely filled to a depth of 6 ft, by what percentage would the flow rate increase? Start by applying the overall energy balance between points 1 and 2, and assume that the friction factor remains constant. (10)



4) A) For a liquid flowing through a packed bed, derive an expression for the pressure drop per unit length of the bed with the help of a neat schematic diagram. Clearly mention all the assumptions considered. (10)

B) **Data for Q.No. 4B. & 4C.: (Note: Refer the expression derived in Q.No. 4A to solve.)** (6)

$D_p = 1*10^{-3}\,m; \rho_f = 1000 kg/m^3; \mu_f = 1*10^{-3}\,kg/m.s; \rho_s = 2500 kg/m^3$

When u_0 is 0.005 m/s and ε = 0.5, calculate the ratio of the viscous loss to the kinetic energy loss.

C) **Data for Q.No. 4B. & 4C.: (Note: Refer the expression derived in Q.No. 4A to solve.)** (4)

$D_p = 1*10^{-3} m; \rho_f = 1000 kg/m^3; \mu_f = 1*10^{-3} kg/m.s; \rho_s = 2500 kg/m^3$

On further increasing u_0, minimum fluidization is achieved. Assuming that the porosity of the bed remains unaltered, determine the pressure drop per unit length (in Pa/m) under minimum fluidization condition.

5) A) Explain the working principle of centrifugal pump with the help of a neat schematic. (8)

B) List out the differences between positive-displacement reciprocating and rotary pumps. (6)

C) Describe the fluid dynamics in a fluidized bed with the help of a neat plot. (6)

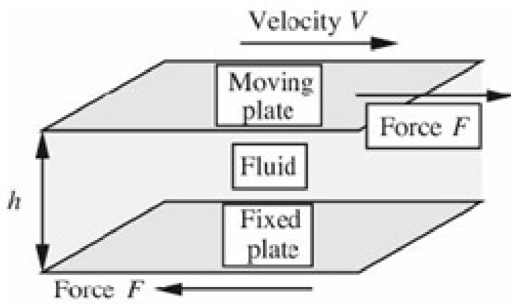
6) A) Consider the situation in Fig., with h = 0.2 cm and V = 2.0 cm/s. The pressure is atmospheric throughout. (12)

(a) If the fluid is air at 20 °C, evaluate the shear stress τ_a (dynes/cm^2). Does τ vary across the gap? Explain.

(b) Evaluate τ_ω if the fluid is water at 20 °C. What is the ratio τ_ω/τ_a?

(c) If the temperature is raised to 90 °C, does τa increase or decrease? What about τ_ω?

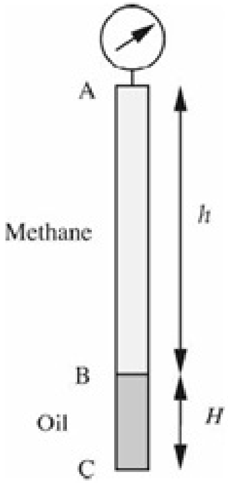
Note: n = 0.768; μ_0 = 0.0171 cP @ T_0 = 0 °C; a = 29.76; b = -5.24



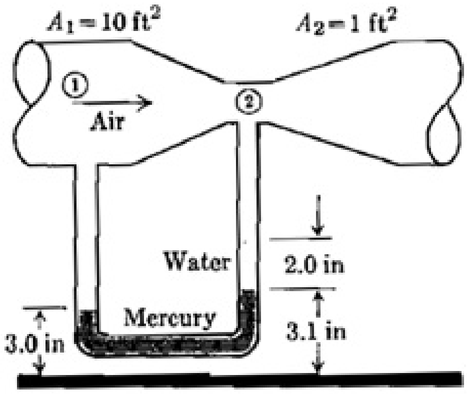
B) Fig. shows a well that is 12,000 ft deep. The bottom H = 2, 000-ft portion is filled with an incompressible oil of specific gravity s = 0.75, above which there is an h = 10, 000-ft layer of methane at 100 °F, which behaves as an ideal isothermal gas whose density is not constant. The gas and oil are static. The density of water is 62.3 lb/ft^3. (8)

(a) If the pressure gauge at the top of the well registers p_A = 1, 000 psig, compute the absolute pressure p_B (psia) at the oil/methane interface.

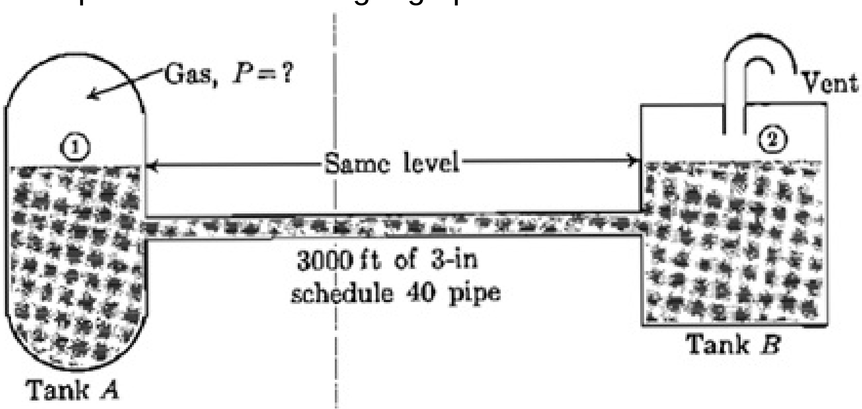
(b) Also compute (p_C - p_B), the additional pressure (psi) in going from the interface B to the bottom of the well C.



7) A) The Venturi meter in Fig. has air flowing through it. The manometer, as shown, contains both mercury and water. The cross-sectional areas at the upstream location and at the throat are 10 and 1 ft^2, respectively. What is the volumetric flow rate of the air? The discharge coefficient Cv equals 1.0. (10)

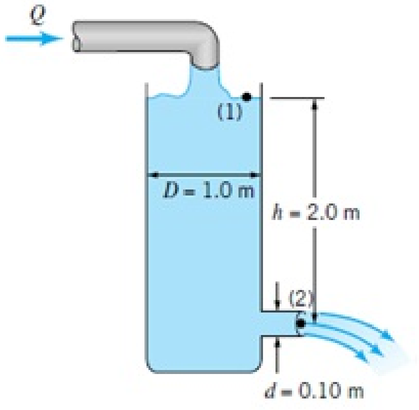


B) Oil at a rate of 100 gal/min is flowing steadily from tank A to tank B through 3000 ft of 3-in schedule 40 pipe (actual inside diameter is 3.068 in); see Fig. The oil has a density of 58 lbm/ft^3 and a viscosity of 100 cP. The levels of the surfaces are the same in both tanks. Tank B is vented to the atmosphere. What is the gauge pressure in tank A? (10)



8) A) A stream of water of diameter d = 0.1 m flows steadily from a tank of diameter D = 1 m as shown in Fig. Don't neglect the kinetic energy at point 1. Determine the flowrate, Q, needed from the inflow pipe if the water depth remains constant, h = 2.0 m. Investigate and conclude from the ratio of (8)

flowrates assuming kinetic energy presence and absence at point 1.



B) A polymer of density ρ = 0.80 g/cm^3 and viscosity μ = 230 cP flows at a rate Q = 1,560 cm^3/s in a horizontal pipe of diameter 10 cm. Evaluate the following, all in CGS units: (a) the mean velocity, u_m; (b) the Reynolds number Re, hence verifying that the flow is laminar; (c) the maximum velocity, u_{max}; (d) the pressure drop per unit length, -dp/dz; (e) the wall shear stress, τ_ω; (f) the Fanning friction factor, f_F; and (g) the frictional dissipation F for 100 cm of pipe. (12)

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