Question Paper

Exam Date & Time: 14-Nov-2018 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
END SEMESTER EXAMINATION
FLUID FLOW OPERATIONS
ICHM231

FLUID FLOW OPERATIONS [ICHM 231 - S2]

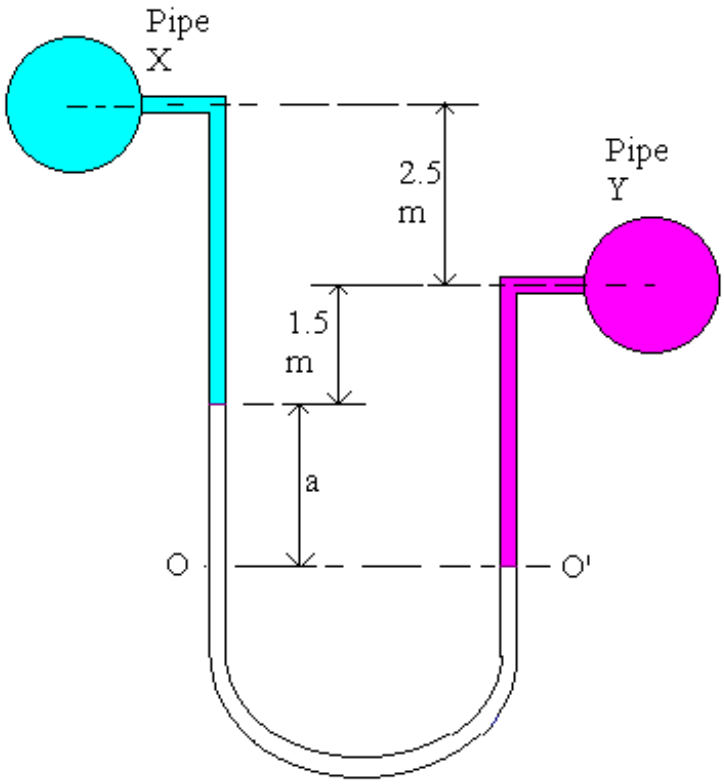
Marks: 100 **Duration: 180 mins.**

A

Answer 5 out of 8 questions.

1) A) Calculate the greatest pressure in a spherical tank of 2 mm diameter, filled with peanut oil of specific gravity 0.92 g/cc, if the pressure measured at the highest point in the tank is 70 kPa. (10)

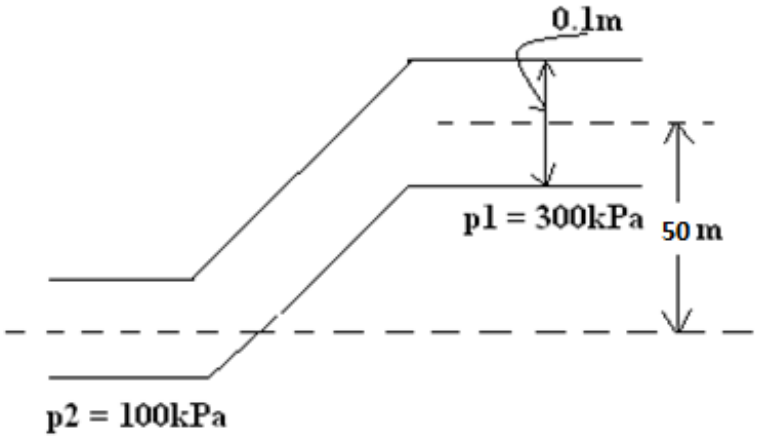
B) A U - tube differential mercury manometer as shown in the figure is connected between two pipes X and Y. Pipe X contains carbon tetra chloride (specific gravity 1.59) under a pressure of 103 kN/m^2 and pipe Y contains oil (specific gravity 0.8) under a pressure of 172 kN/m^2. Pipe X is 2.5 m above pipe Y. Mercury level in the limb connected to pipe X is 1.5 m below the centerline of pipe Y. Find the manometer reading as shown by a centimeter scale attached to it. (10)



2) (10)

A) Raw milk is flowing into a centrifuge through a full 5 cm diameter pipe at a velocity of 0.22 m/s and in the centrifuge it is separated into a cream of specific gravity 1.01 and skim milk of sp. gravity 1.04. Calculate the velocities of flow of skim milk and of the cream if they are discharged through 2 cm diameter pipes. Take the specific gravity of raw milk is 1.035.

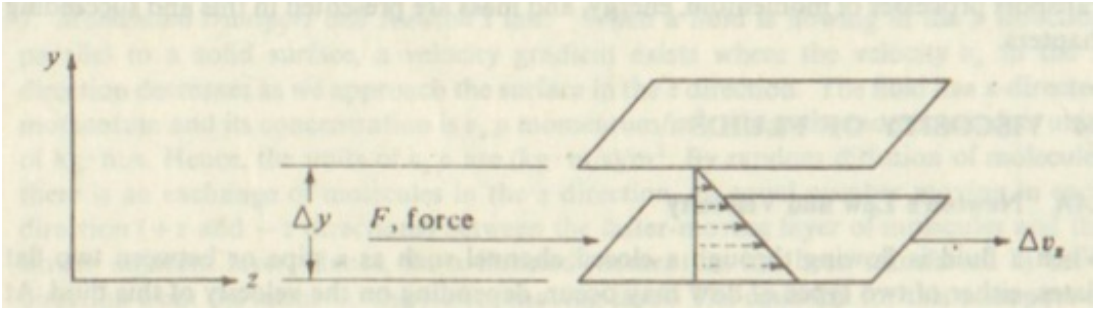
B) (10) Water flows steadily through the pipe shown in figure such that the pressure at sections 1 & 2 are 300 kPa & 100 kPa respectively. Determine the diameter of pipe at section 2, if the velocity at section 1 is 20 m/s and viscous effects are negligible.



3) (10)

A) In the following figure the distance between the two parallel plates is 0.00914 m and the lower plate is being

pulled at a relative velocity of 0.366 m/s greater than the top plate. The fluid used is soybean oil with viscosity of 4 x $I0^{-2}$ Pa s at 303 K
(i) Calculate the shear stress and the shear rate in SI units.
(ii) If glycerol at 293 K having a viscosity of 1.069 kg/ms is used instead of soybean oil, what relative velocity in m/s is needed using the same distance between plates so that the same shear stress is obtained as in part (i)? Also. what is the new shear rate?



B) Write the following (10)
(i) Hydraulic mean radius
(ii) Minimum fluidization velocity
(iii) Fanning friction factor
(iv) roughness ratio
(v) Sphericity factor

4) (10)

A) 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 0.415 m. Calculate P_a in kPa.

B) Water having a density of 998 kg//m^3 is flowing at a rate of 1.676 m/s in a 3.068" diameter horizontal pipe at a pressure P_1 68.9 kPa. It then passes to a pipe having an ID of 2.067". Assume no frictional losses (10)
(i) Calculate the new pressure P_2 in 2.067" pipe.
(ii) If the piping is vertical and flow is upward, calculate the new pressure P_2. The pressure tap for P_2 is 0.457 m above the tap for P_1.

5) (10)

A) A venturi meter having a throat diameter of 38.9 mm is installed in a line having an ID of 102.3 mm. It meters

water having a density of 999 kg/m^3. The measured pressure drop across the venturi is 156.9 kPa. Venturi coefficient C_v is 0.98. Calculate the flow rate?

B) Brine of specific gravity 1.2 is flowing through a 10 cm I.D. pipeline at a maximum flow rate of 1200 liters/min. A sharp edged orifice connected to a simple U-tube mercury manometer is to be installed for the purpose of measurements. The maximum reading of the manometer is limited to 40 cm. Assuming the orifice coefficient to be 0.62, calculate the size of the orifice required. (10)

6) A) A rotameter calibrated for metering has a scale ranging from 0.014 m^3/min to 0.14 m^3/min. It is intended to use this meter for metering a gas of density 1.3 kg/m^3 with in a flow range of 0.028 m3/min to 0.28 m^3/min. What should be the density of the new float if the original one has a density of 1900 kg/m^3? Both the floats can be assumed to have the same volume and shape. (10)

B) Water is flowing over an 70Âº V-notch with a constant head of 0.2 m into a tanks of cross-sectional area 0.5m^2. If the level in the tank rises 0.8 m in 20 seconds,
(i) Determine the coefficient of discharge of the notch.
(ii) What would be the head for a 90Â° v-notch with a coefficient of discharge of 0.9 when water is flowing at the same rate as measured in part (i)? (10)

7) A) Hydrocarbon oil (viscosity 0.025 Pa s and density 900 kg/m^3) is transported using a 0.6 m diameter, 10 km long pipe. The max allowable pressure drop across the pipe length is 1 MPa. Due to a maintenance schedule on this pipeline, it is required to use a 0.4 m diameter, 10 km long pipe to pump the oil at the same volumetric rate as in the previous case. Estimate the pressure drop for the 0.4 m diameter pipe. Assume both pipes are smooth and in the range of operating conditions, the Fanning friction factor is given by $f = 0.079\ Re^{-0.25}$ (10)

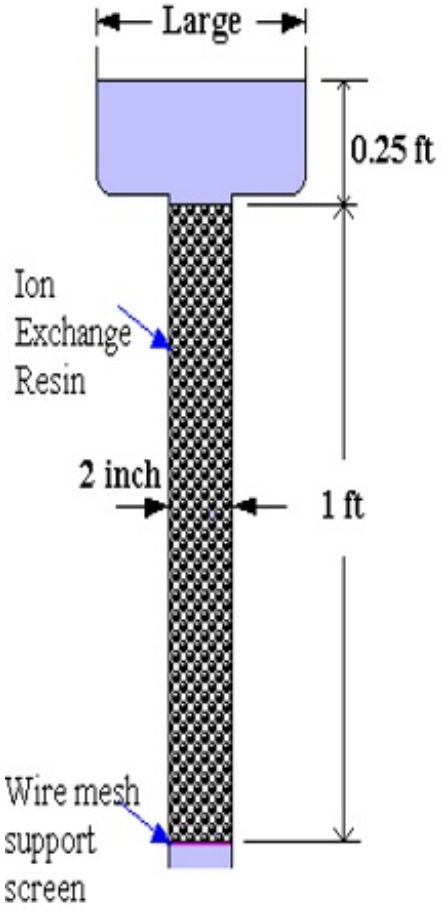
B) Water at 20ÂºC is pumped from a storage tank through 100 m of 3 cm diameter pipe. The pipe line has TWO globe valves which are fully open and THREE 90Âº elbows. Water is discharged into another tank through a spray nozzle. The discharge is at a height of 20 m above the level of water in (10)

the storage tank. The pressure required at the nozzle entrance is 4 x10^5 N/m^2. Flow rate of water 1 kg/sec. Viscosity is 0.975 cP

$$f = 0.0014 + 0.125/Re^{0.32}$$

Estimate
(i) Energy loss due to friction
(ii) Pump work required per kg of water
(iii) Theoretical HP required for the pump
Data: Equivalent length in terms of pipe diameter:
Open globe valve = 300D
90ÂºElbow =30D

8) A) Figure shows a water softener in which water trickles by gravity over a bed of spherical ion-exchange resin particles, each 0.05 inch in diameter. The bed has a porosity of 0.33. Calculate the volumetric flow rate of water. Assume laminar flow. (10)



B) Solid particles having a size of 0.12 mm, a shape factor of 0.88 and a density of 1000 kg/m^3 are to be fluidized using air at 2 atm abs and 25ÂºC. The voidage at minimum fluidization is 0.42. (10)

(i) If the cross section of the empty bed is $0.3m^2$ and the bed contains 300 kg of solid, calculate the minimum height of the fluidized bed.
(ii) Calculate the pressure drop at minimum fluidization conditions.

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