



Allowed Tables and Charts: (None)

Answer all the following Questions (Two Pages) [100 Marks for all]

Question (1) (25 Marks)

- (a) The rotating-cylinder viscometer in Figure 1 shears the fluid in a narrow clearance, Δr , as shown. Assume a linear velocity distribution in the gaps. If the driving torque M is measured, find an expression for the dynamic viscosity μ by (a) neglecting, and (b) including the bottom friction. (10 Marks)
- (b) The cylindrical tank with hemispherical ends shown in Figure 2 contains a volatile liquid and its vapor. The liquid density is 800 kg/m^3 and its vapor density is negligible. The pressure in the vapor is 120 kPa (abs) , and the atmospheric pressure is 101 kPa (abs) . Determine:
 (i) The gage pressure reading on the pressure gage. (8 Marks)
 (ii) The height, h , of the mercury manometer. (7 Marks)

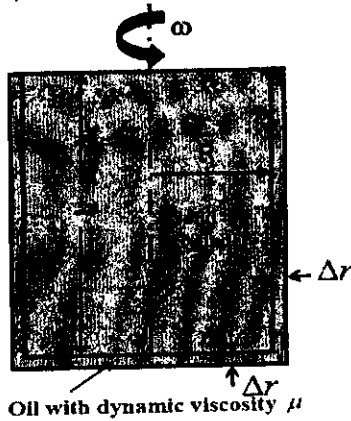


Figure 1

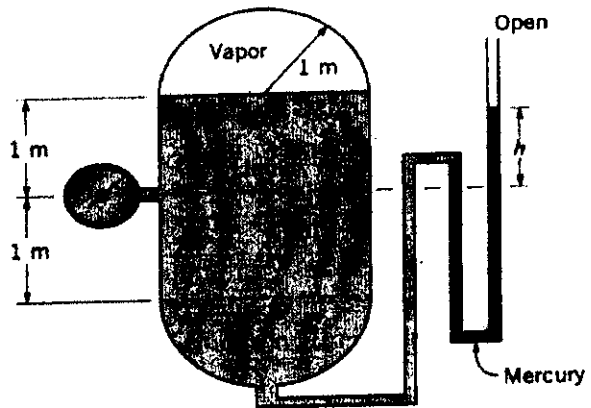


Figure 2

Question (2) (25 Marks)

- (a) Derive expressions for the forces acting on horizontal, vertical and inclined immersed surfaces and the locations of the forces. (10 Marks)
- (b) A structure is attached to the ocean ($\gamma_{\text{water}} = 10100 \text{ N/m}^3$) floor as shown in Figure 3. A hatch of 2 m diameter is located in an inclined wall and hinged on one edge. Determine the minimum air pressure, P_1 , within the container to open the hatch. Neglect the weight of the hatch and friction in the hinge. (10 Marks)
- (c) An open cylindrical tank of 1 m diameter contains water at a depth of 0.7 m when at rest. As the tank is rotated about its vertical axis the center of the fluid surface is depressed. At what angular velocity will the bottom of the tank first be exposed? No water is spilled from the tank. (5 Marks)

Question (3) (30 Marks)

- (a) Derive Bernoulli's equation and explain the meaning of each term. (5 Marks)
- (b) A pipe carrying water has a $30 \text{ cm} \times 15 \text{ cm}$ venturi meter which is positioned inclined at 30° to the horizontal. The flow is upwards and the converging cone is 45 cm in length and the C_d of the meter is 0.98 . A differential U-tube manometer with mercury as measuring fluid is connected to the inlet and to the throat and shows a differential height of 30 cm . (13 Marks)
- i) - Calculate the discharge in the pipe.
 ii) - If the pressure at the inlet section is 50 KPa determine the pressure at the throat.
 iii) - Find the head loss in the converging section of the venturi meter.

- (c) A converging elbow (see Figure 4) turns water through an angle of 135° in a vertical plane. The flow cross section diameter is 400 mm at the elbow inlet, section (1), and 200 mm at the elbow outlet, section (2). The elbow flow passage volume is 0.2m^3 between sections (1) and (2). The water volume flow rate is $0.4\text{m}^3/\text{s}$ and the elbow inlet and outlet pressures are 150 kPa and 90 kPa. The elbow mass is 12 kg. Calculate the horizontal (x-direction) and vertical (z-direction) anchoring forces required to hold the elbow in place. (12 Marks)

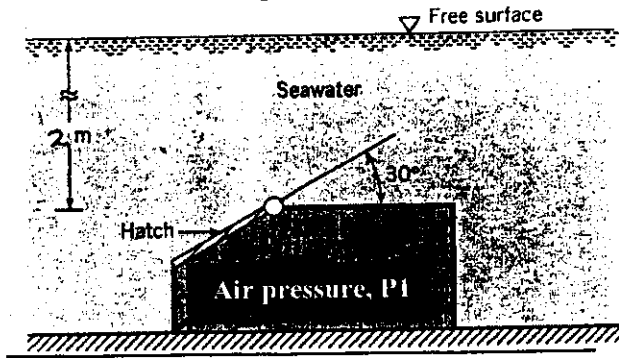


Figure 3

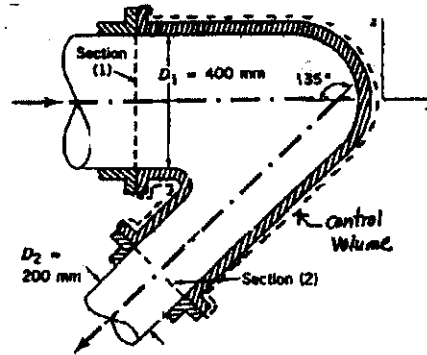


Figure 4

Question (4)

(20 Marks)

- (a) Water is handled by a system of pipes as shown in the Figure 5. The details are being as follows:

Pipe	Length (m)	Diameter (m)
$A_1B = A_2B$	100	0.5
BC	300	0.75
CD	500	0.3
CE	400	0.25
CF	500	0.3

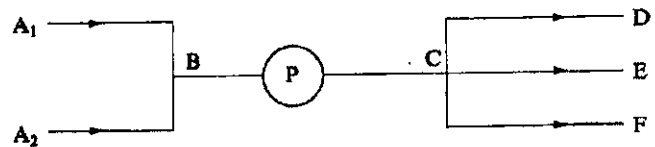


Figure 5

The friction coefficient for all pipes (Darcy friction factor f) = 0.02. The elevation of outlets D, E and F is 100 m above the elevation of inlet A, and A2. All outlets and inlets are open to atmosphere. If the mean velocity in the pipes A_1B and A_2B is 2.5 m/s, calculate the flow rate through the pump P, The pressure difference across the pump and the power consumed. Take the pump efficiency as 76%. (10 marks)

- (b) A pipeline conveying water between reservoirs A and B is 30.5 cm diameter and 366 m long. The difference of head between the two surfaces is 4.12 m. Determine the flow rate considering $f = 0.02$. It is required to increase the flow by 50% by duplicating the diameter of a portion of the pipe. If the head and friction factor are unchanged and minor losses are ignored, find the length of the doubled portion. (10 marks)

Question	1	2	3	4	Work & Oral Exam through a semester
ILOs	A8, A13,	B1, B2, C16	A8, B3, C18	A8, B1, C1	A8, A13, B1, B2, B3, C1, C16

Best Wishes

Prof. Kamal Ibrahim, Prof. Wageeh El-Askary and Assoc. Prof. Samy El-Behery