CONCORDIA UNIVERSITY- FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	T
EXAMINATION: EXAM 1	DATE: February 4, 2014	TIME: 11:45- 13:00	Rooms: H-507
PROFESSOR: M. Paraschivoiu			

SPECIAL INSTRUCTIONS:
Duration: 75 minutes
Instructions: Calculators are permitted. Closed book, no notes or textbook permitted.
Answer all three questions. Each question is worth 10 marks.
You *MUST* show *all* your steps in solving all problems!

Fluid properties:

Water:

$\rho = 1000$ kg/m^3, $\gamma = 9800$ N/m^3, $\mu = 0.001$ N-s/m^2

$\rho = 1.94$ slugs/ft^3, $\gamma = 62.4$ lb/ft^3, $\mu = 2.34\times10^{-5}$ lb-s/ft^2

Question 1 (10 points):

A 25 mm diameter shaft is pulled through a cylindrical bearing as shown in figure 1. The lubricant that fills the 0.3 mm gap between the shaft and the bearing is oil having a viscosity of 0.5 N-s/m^2. Determine the velocity of the shaft if the force P to pull the shaft is 280 N. Assume the velocity distribution in the gap is linear.

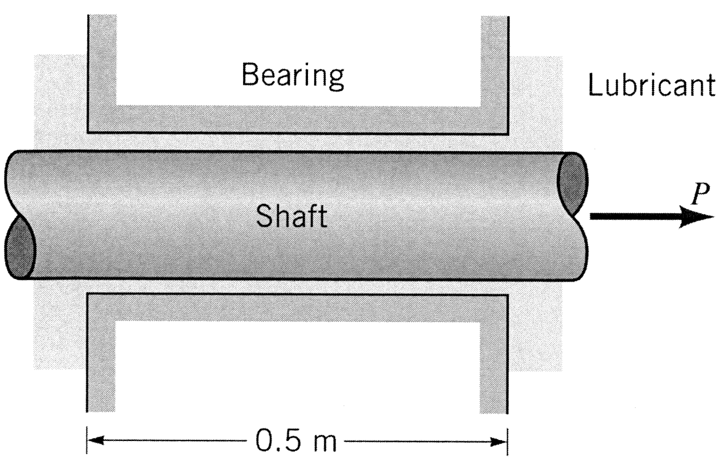


Figure 1.

Question 2 (10 points):

A suction cup is used to support a plate of weight W as shown in Figure 2. For the conditions shown, determine W.

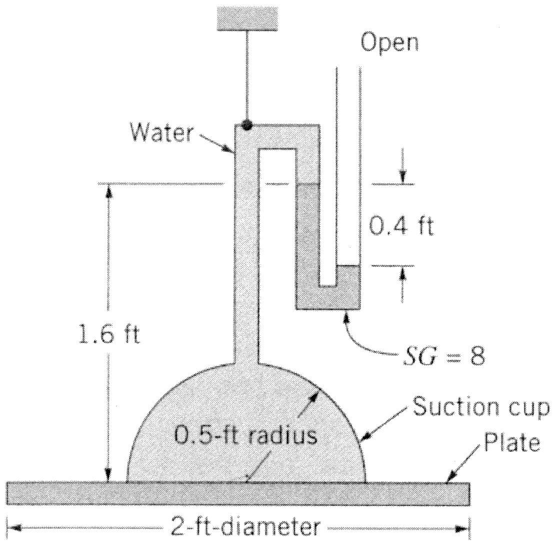


Figure 2

Question 3 (10 points):

The closed vessel of Figure 3 contains water with an air pressure of 10 psi (gage pressure) at the water surface. One side of the vessel contains a spout that is closed by a 6 in diameter circular gate that is hinged along one side as illustrated. The horizontal axis of the hinge is located 10 ft below the water surface. Determine the minimum torque that must be applied at the hinge to hold the gate shut. Neglect the weight of the gate and friction at the hinge.

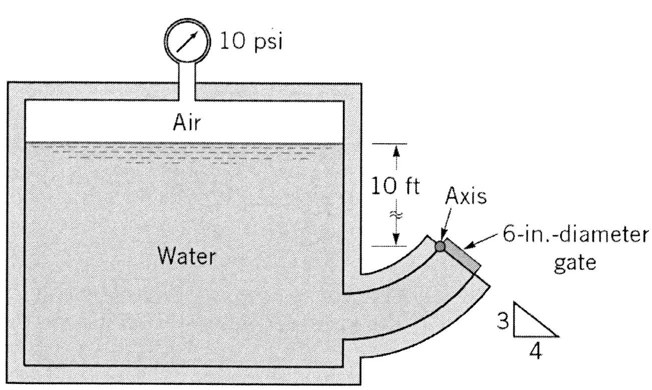
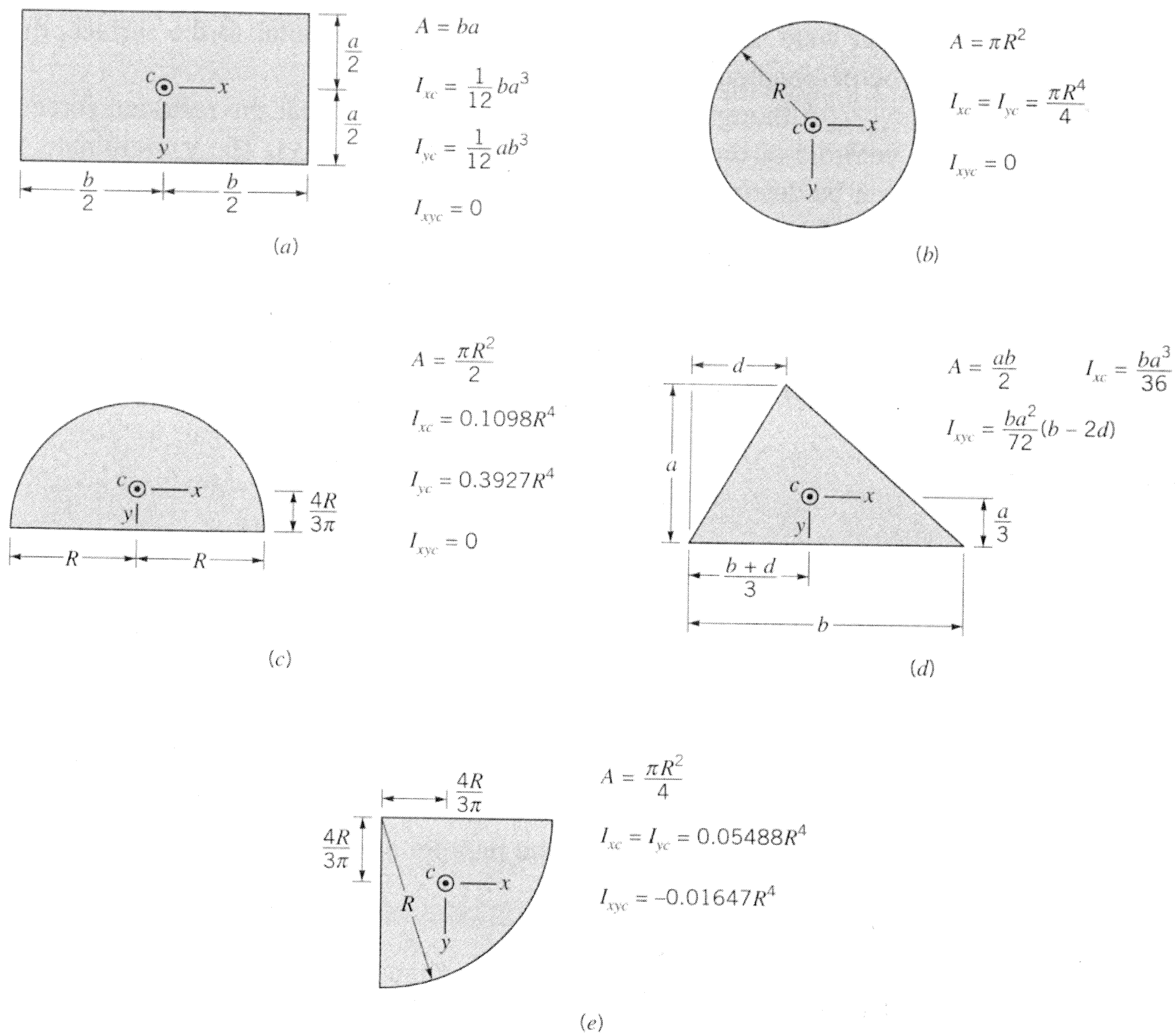


Figure P2.67 (p. 88)

Figure 3



■ **FIGURE 2.18** Geometric properties of some common shapes.

Solution Exam 1 February 4, 2014

Question 1

$D = 25\ mm \quad h = 0.3\ mm \quad \mu = 0.5\ N \cdot s/m^2$

$P = 280\ N \quad l = 0.5\ m$

Find V

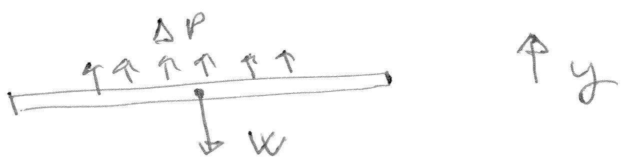
$$\tau = \mu \frac{dV}{dy} \Rightarrow \tau = \mu \frac{V}{h}$$

$$P = \tau \times A = \tau \times \pi D l$$

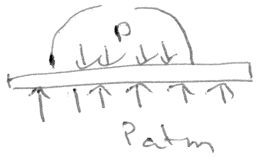
$$\Bigg\} \quad V = \frac{P h}{\mu \pi D l}$$

$$\boxed{V = 4.28\ m/s}$$

Question 2



$\Sigma F_y = 0 \Rightarrow W = \Delta P A \qquad A = \pi (0.5)^2$



$\Delta P = P_{atm} - P = P_{atm} - (P_{gage} + P_{atm})$

$\Delta P = -P_{gage}$

$P_{gage} - 1.6\ \gamma_{water} + 0.4\ \gamma_{water}(SG) = 0$

$P_{gage} = -0.4 \times 62.4 \times 8 + 1.6 \times 62.4 = -99.84\ lbf$

$$\boxed{W = 78.41\ lbf}$$

2.76

2.76 The closed vessel of Fig. P2.76 contains water with an air pressure of 10 psi at the water surface. One side of the vessel contains a spout that is closed by a 6-in.-diameter circular gate that is hinged along one side as illustrated. The horizontal axis of the hinge is located 10 ft below the water surface. Determine the minimum torque that must be applied at the hinge to hold the gate shut. Neglect the weight of the gate and friction at the hinge.

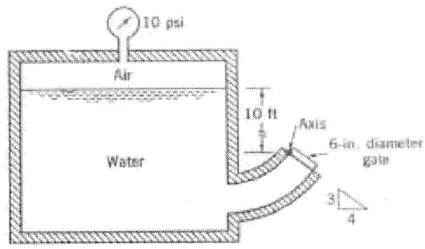
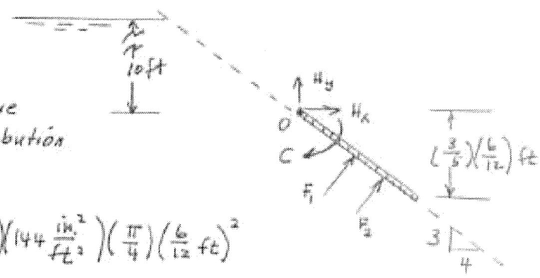


FIGURE P2.76



Let F_1 ~ force due to air pressure, and F_2 ~ force due to hydrostatic pressure distribution of water.

Thus,

$$F_1 = p_{air} A = \left(10 \frac{lb}{in.^2}\right)\left(144 \frac{in.^2}{ft^2}\right)\left(\frac{\pi}{4}\right)\left(\frac{6}{12} ft\right)^2$$

$$= 283 \text{ lb}$$

and

$$F_2 = \gamma h_c A \quad \text{where} \quad h_c = 10 ft + \frac{1}{2}\left[\left(\frac{3}{5}\right)\left(\frac{6}{12}\right) ft\right] = 10.15 ft$$

so that

$$F_2 = \left(62.4 \frac{lb}{ft^3}\right)(10.15 ft)\left(\frac{\pi}{4}\right)\left(\frac{6}{12} ft\right)^2 = 124 \text{ lb}$$

Also,

$$y_{R2} = \frac{I_{xc}}{y_c A} + y_c \quad \text{where} \quad y_c = \frac{10 ft}{\frac{3}{5}} + \frac{1}{2}\left(\frac{6}{12} ft\right) = 16.92 ft$$

so that

$$y_{R2} = \frac{\left(\frac{\pi}{4}\right)\left(\frac{3}{12} ft\right)^4}{(16.92 ft)\left(\frac{\pi}{4}\right)\left(\frac{6}{12} ft\right)^2} + 16.92 ft = 16.92 ft$$

For equilibrium,

$$\sum M_o = 0$$

and

$$C = F_1\left(\frac{3}{12} ft\right) + F_2\left(y_{R2} - \frac{10 ft}{\frac{3}{5}}\right)$$

or

$$C = (283 lb)\left(\frac{3}{12} ft\right) + (124 lb)\left(16.92 ft - \frac{10 ft}{\frac{3}{5}}\right) = \underline{\underline{102 ft \cdot lb}}$$

CONCORDIA UNIVERSITY- FACULTY OF ENGINEERING AND COMPUTER SCIENCE
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COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	T
EXAMINATION: EXAM 1	DATE: February 4, 2014	TIME: 11:45- 13:00	Rooms: H-507
PROFESSOR: M. Paraschivoiu			

SPECIAL INSTRUCTIONS:
Duration: 75 minutes
Instructions: Calculators are permitted. Closed book, no notes or textbook permitted.
Answer all three questions. Each question is worth 10 marks.
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A 25 mm diameter shaft is pulled through a cylindrical bearing as shown in figure 1. The lubricant that fills the 0.3 mm gap between the shaft and the bearing is oil having a viscosity of 0.5 $N\text{-}s/m^2$. Determine the velocity of the shaft if the force P to pull the shaft is 280 N. Assume the velocity distribution in the gap is linear.

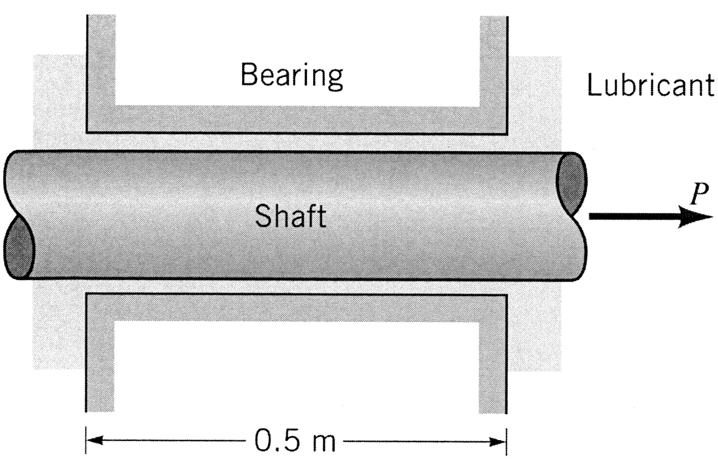

Figure P1.78

Figure 1.

Question 2 (10 points):

A suction cup is used to support a plate of weight W as shown in Figure 2. For the conditions shown, determine W.

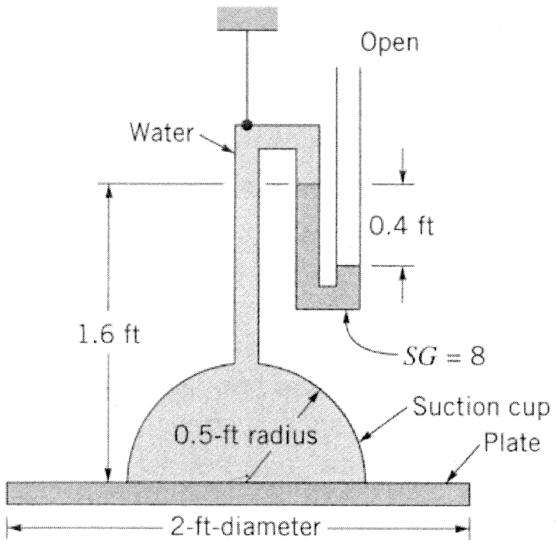

Figure 2

Question 3 (10 points):

The closed vessel of Figure 3 contains water with an air pressure of 10 psi (gage pressure) at the water surface. One side of the vessel contains a spout that is closed by a 6 in diameter circular gate that is hinged along one side as illustrated. The horizontal axis of the hinge is located 10 ft below the water surface. Determine the minimum torque that must be applied at the hinge to hold the gate shut. Neglect the weight of the gate and friction at the hinge.

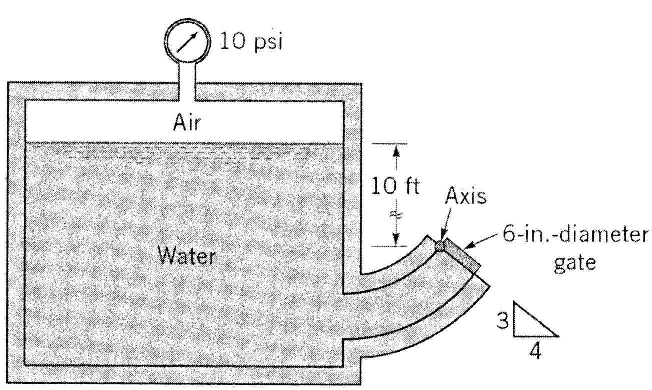

Figure P2.67 (p. 88)

Figure 3

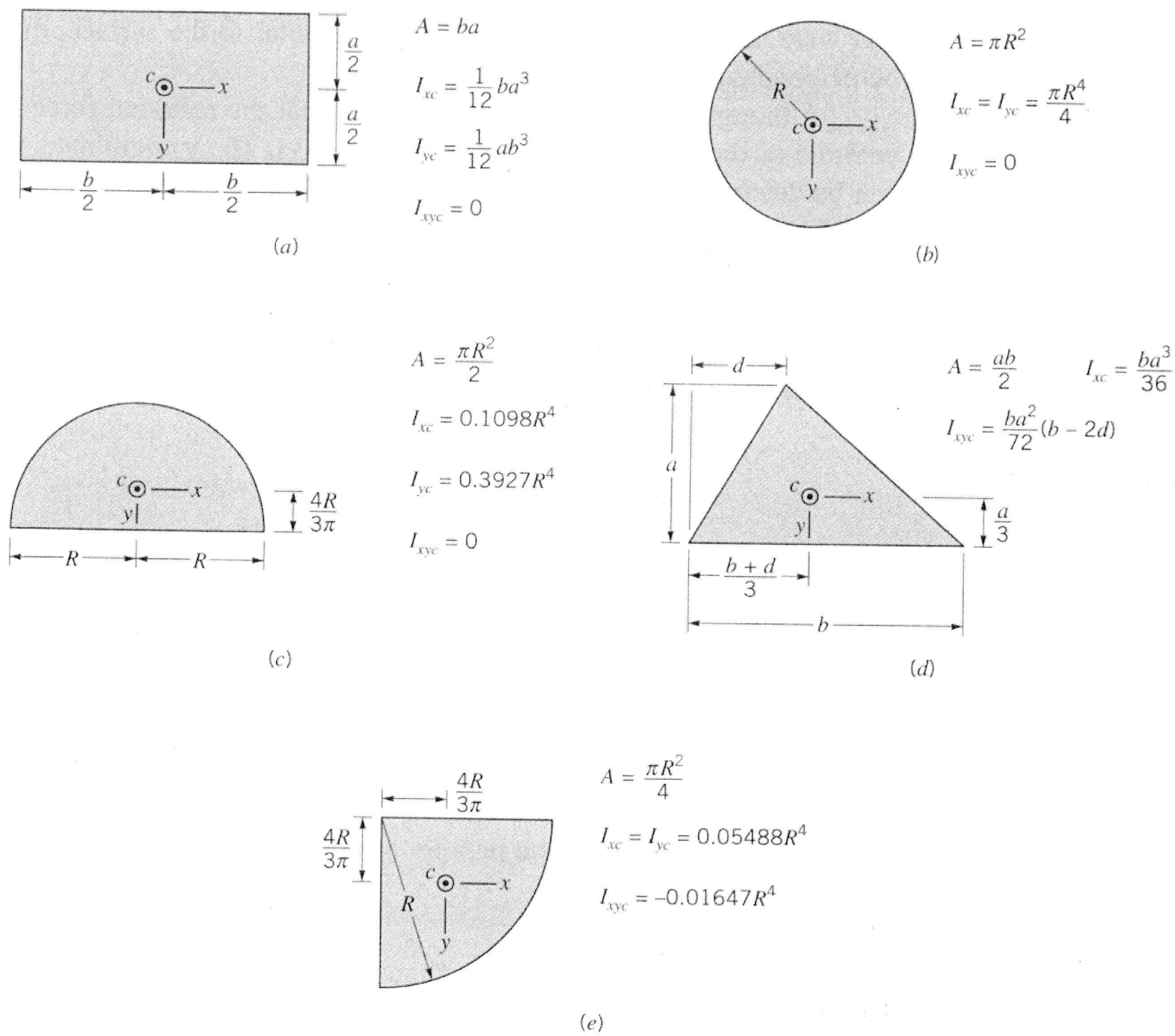

FIGURE 2.18 Geometric properties of some common shapes.

Solution Exam 1 February 4, 2014

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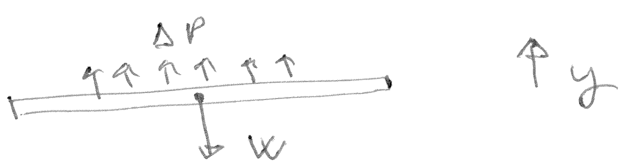
Question 2



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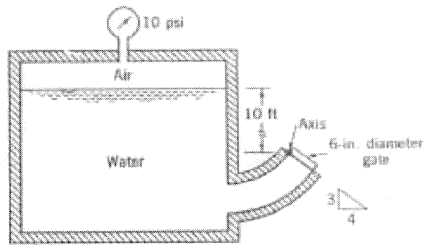
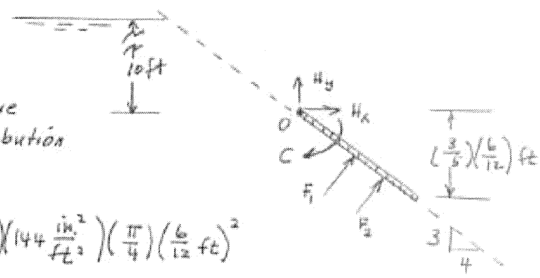


FIGURE P2.76



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DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	AA
EXAMINATION: EXAM 2	DATE: June 12, 2014	TIME: 14:45- 16:00	Rooms: H-531 & H-535
PROFESSOR: M. Paraschivoiu			

SPECIAL INSTRUCTIONS:
Duration: 75 minutes
Instructions: Calculators are permitted. Closed book, no notes or textbook permitted.
Answer all three questions. Each question is worth 10 marks.
You *MUST* show *all* your steps in solving all problems!

Last name: ______________________________

First name: ______________________________

Signature: ______________________________

I.D.: ____________________

Question 1	
Question 2	
Question 3	
Total	

Fluid properties:

Water:

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$\rho = 1.94\ slugs/ft^3$, $\gamma = 62.4\ lb/ft^3$, $\mu = 2.34\times10^{-5}\ lb\text{-}s/ft^2$

Gravity:

$g = 9.81\ m/s^2$

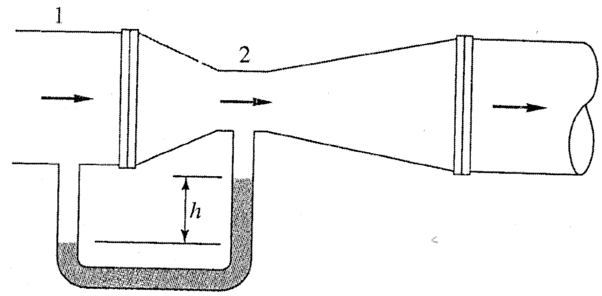
$g = 32.2\ ft/sec^2$

Question 1 (10 points):

The pressure drop in a venturi meter (Figure 1) varies only with the fluid density, pipe approach velocity, and diameter ratio of the meter. A model venturi meter tested in water shows a 5kPa pressure drop when the flow velocity is 4 m/s. If the flow rate is 9 m^3/min what is the pipe diameter at the constriction (location 2)?

Note: $\rho_{mercury} = 13600\ kg/m^3$

Answer:



$\Delta p = 5\,000\ Pa$

$V = 4\ m/s$

$Q = 9\ m^3/min$

$$Q = V_1 \frac{\pi D_1^2}{4} = V_2 \frac{\pi D_2^2}{4}$$

$$Q = 9/60 = 0.15\ \frac{m^3}{s}$$

$$D_1 = \sqrt{\frac{4Q}{\pi V_1}} = \sqrt{\frac{4 \times 0.15}{\pi \times 4}} = 0.2185\ m$$

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

$$\sqrt{\frac{\Delta p + \frac{1}{2}\rho V_1^2}{\frac{1}{2}\rho}} = V_2 = \sqrt{\frac{5\,000 + \frac{999}{2} 16}{\frac{999}{2}}} = 5.1$$

$$D_2 = \sqrt{\frac{4 \times 0.15}{\pi \times 5.1}} = 0.1935\ m$$

Question 2 (10 points):

Oil (SG=0.88) flows in an inclined pipe at a rate of 8.5 m^3/min as shown in Figure 2. If the differential reading in the water manometer is 0.9 m, calculate the power (in kW) that the pump supplies to the oil if viscous losses are negligible.

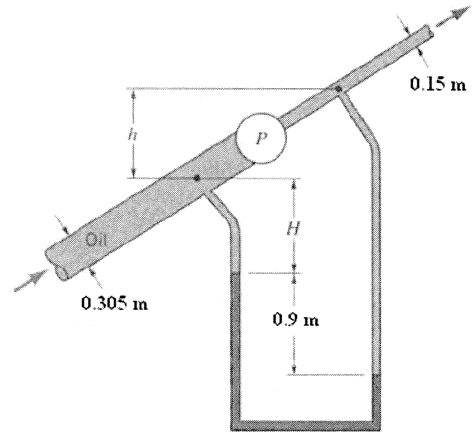


Figure 2.

$SG_{oil} = 0.88$

Answer:

$$V_1 = \frac{4Q}{\pi (0.305)^2} = 1.939 \text{ m/s}$$

$$V_2 = \frac{4Q}{\pi (0.15)^2} = 8.0147$$

$$Q = \frac{8.5}{60} = 0.142 \text{ m}^3/\text{s}$$

Energy eq.

$$\frac{P_1}{\gamma_{oil}} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma_{oil}} + \frac{V_2^2}{2g} + z_2$$

hydrostatics

$$P_1 - \rho g H + \rho_m g (0.9) = P_2 + \rho g h + \rho g H + \rho g (0.9)$$

$$h_p = \frac{1}{\gamma_{oil}}(P_2 - P_1) + \frac{V_2^2}{2g} - \frac{V_1^2}{2g} + h$$

$$= \frac{1}{\gamma_{oil}}(-\gamma_{oil} - \gamma_m)0.9 + \frac{V_2^2}{2g} - \frac{V^2}{2g}$$

$$= \left(-1 + \frac{1}{0.88}\right)0.9 + \frac{8^2}{2\times 9.8} - \frac{1.93^2}{2\times 9.8}$$

$$= 0.123 + 3.26 - 0.19 = 3.193 \text{ m}$$

$$\dot{w}_{net} = h_p \times \gamma_{oil} \times Q = 3.193 \times 9800 \times 0.88 \times 0.142 = 3.9 \text{ kW}$$

Question 3 (10 points):

Water flows through a horizontal, 180° pipe bend as illustrated in Figure 3. The flow cross-sectional area is constant at a value of 9000 mm^2. The flow velocity everywhere in the bend is 15 m/s. The pressures at the entrance and exit of the bend are 210 and 165 kPa, respectively. Calculate the horizontal (x and y) components of the anchoring force needed to hold the bend in place.

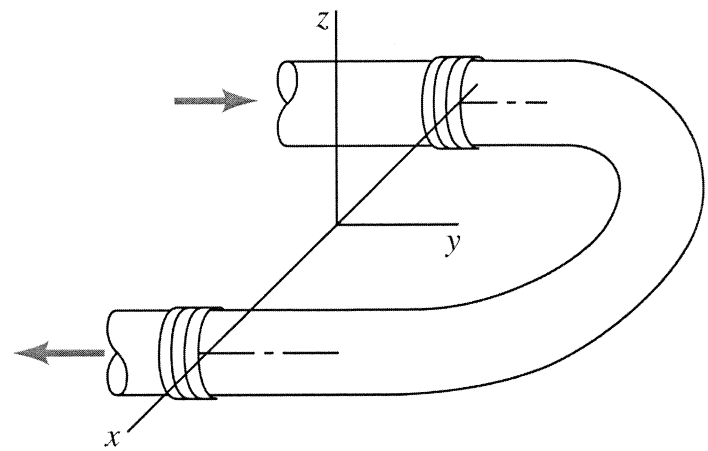


Figure 3

Answer:

5.40

5.40 Water flows through a horizontal, 180° pipe bend as is illustrated in Fig. P5.40. The flow cross section area is constant at a value of 9000 mm^2. The flow velocity everywhere in the bend is 15 m/s. The pressures at the entrance and exit of the bend are 210 and 165 kPa, respectively. Calculate the horizontal (x and y) components of the anchoring force needed to hold the bend in place.

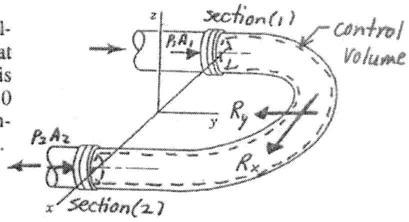


FIGURE P5.40

This analysis is similar to the one of Example 5.11. A fixed, non-deforming control volume that contains the water within the elbow between sections (1) and (2) at an instant is used. The horizontal forces acting on the contents of the control volume in the x and y directions are shown. Application of the x-direction component of the linear momentum equation (Eq. 5.22) leads to

$$R_x = \underline{\underline{0}}$$

Application of the y-direction component of the linear momentum equation yields

$$-v_1 \rho v_1 A_1 - v_2 \rho v_2 A_2 = p_1 A_1 - R_y + p_2 A_2$$

or

$$R_y = \rho A_1 v_1 (v_1 + v_2) + p_1 A_1 + p_2 A_2$$

Thus

$$R_y = \left(999 \frac{kg}{m^3}\right) \frac{(9000\ mm^2)}{\left(1000 \frac{mm}{m}\right)^2} \left(15 \frac{m}{s}\right)\left(15 \frac{m}{s} + 15 \frac{m}{s}\right)\left(1 \frac{N}{kg \cdot \frac{m}{s^2}}\right) + \frac{(210\ kPA)(9000\ mm^2)}{\left(1000 \frac{mm}{m}\right)^2 \left(\frac{1}{1000 \frac{N}{m^2 \cdot kPA}}\right)}$$

$$+ \frac{(165\ kPA)(9000\ mm^2)}{\left(1000 \frac{mm}{m}\right)^2 \left(\frac{1}{1000 \frac{N}{m^2 \cdot kPA}}\right)}$$

$$R_y = \underline{\underline{7420}}\ N$$

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DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	AA
EXAMINATION FINAL EXAM	DATE July 2, 2014	TIME 9:00- 12:00	Rooms H-429 & H-435
PROFESSOR M. Paraschivoiu			
SPECIAL INSTRUCTIONS: Duration: 180 minutes Instructions: Calculators are permitted. Closed book, no notes or textbook permitted. Answer all five questions. Each question is worth 20 marks. You *MUST* show *all* your steps in solving all problems!			

Last name: ______________________________

First name: ______________________________

Signature: ______________________________

I.D.: ____________________

Question 1	
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Question 5	
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Gravity:

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Question 1 (5 points each correct answer): Write the letter of the corresponding correct answer in the answer box. Only one letter in the box is accepted.

In order to produce the greatest increase in the flow rate of water through a cylindrical pipe that connects two large reservoirs located at different elevations:

A) the length of the pipe must be increased

B) the radius of the pipe must be increased

C) the roughness of the pipe must be increased

D) the friction factor of the pipe must be increased

E) a turbine must be added

ANSWER: B

The outlet of a large reservoir of water is changed from a depth h to a depth 4h from the surface of the water. What is the effect of this change on the velocity of the water leaving the reservoir?

A) has no effect on velocity

B) increases the velocity by 2

C) increases the velocity by 4

D) increases the velocity by 8

E) increases the velocity by 16

ANSWER: B

Water flows through a venturi meter placed in a pipe. The entrance is identified as location 1 and the constriction is location 2. Assume friction losses to be negligible.

Which of the following statements is incorrect?

A) The pressure at 1 is higher than the pressure at 2.

B) The flow rate depends on the diameter at the constriction (location 2).

C) The pressure difference between 1 and 2 depends on the flow rate.

D) The pressure difference between 1 and 2 depends on the velocity at 1.

E) The pressure difference between 1 and 2 depends on the ratio of diameters of the pipe and constriction.

ANSWER: B

Water flows downwards into the atmosphere as a free jet of diameter d. Due to surface tension the pressure inside the jet will be slightly higher than the surrounding atmospheric pressure. Determine the difference in pressure as a function of surface tension σ and jet diameter d.

A) The pressure difference is σ/d.

B) The pressure difference is $2\sigma/d$.

C) The pressure difference is $4\sigma/d$.

D) The pressure difference is $0.5\sigma/d$.

E) None of the above.

ANSWER: B

Question 2 (20 points):

The right angle gate is hinged at C and holds water as shown in Figure 1. Calculate the force P needed to hold the gate such that point B is located at 5 m from the bottom and the surface of water is at 10 m from the bottom. The width of the gate is 2 m (into the page). Neglect the weight of the gate.

Note: $I_{xc} = \frac{1}{12} b a^3$ *for a rectangular plate.*

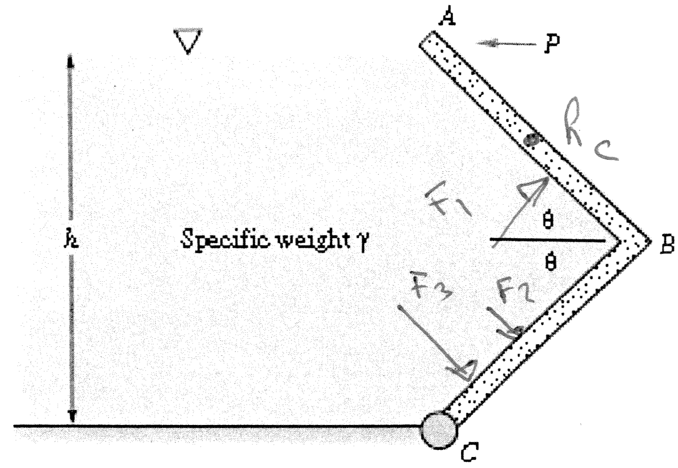


Figure 1

Solution

$$F_1 = \gamma h_c A = 9800 \times 2.5 \times 7.07 \times 2$$
$$= 346 \text{ KN}$$

$$F_2 = \gamma \frac{h}{2} A = 9800 \times 5 \times 7.07 \times 2$$
$$= 2 \times 346 \text{ KN} = 693 \text{ KN}$$

$$F_3 = \gamma h_c A = 9800 \times 2.5 \times 7.07 \times 2$$
$$= 346 \text{ KN}$$

$$\Sigma M_c = 0$$

$$P \times 10 - F_1 (2.35) - F (3.535) - F_3 (2.354)$$

$$P = 408 \text{ KN}$$

Question 3 (20 points):

Air flows into the atmosphere from a nozzle and strikes a vertical plat as shown in Figure 2. A horizontal force of 12 N is required to hold the plate in place. Assume the flow to be incompressible with ρ = 1.2 kg/m^3 and frictionless.

a. Calculate the reading on the pressure gage.
b. Calculate the horizontal force on the nozzle due to the flow of air.

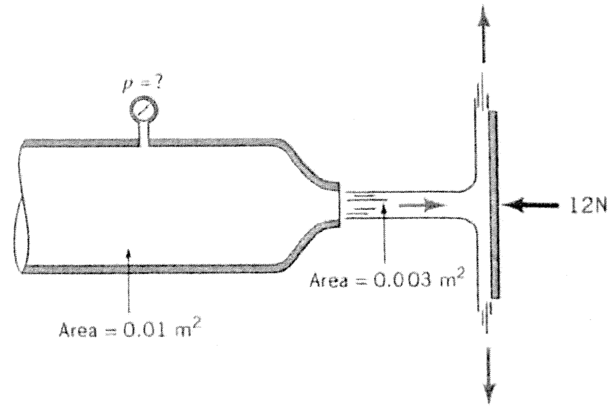


Figure 2.

Solution

a) $F = \rho V^2 A$ $\quad V = \sqrt{\frac{F}{\rho A}} = \sqrt{\frac{12}{1.2 \times 0.003}} = 57.7 \text{ m/s}$

continuity

$V_1 A_1 = V_2 A_2 \Rightarrow V_1 = V_2 \frac{A_2}{A_1} = 57.7 \times \frac{0.003}{0.01} = 17.3 \text{ m/s}$

Bernoulli

$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$

$P_1 = \frac{1}{2}\rho (V_2^2 - V_1^2) = \frac{1}{2} \times 1.2 \times (57.7^2 - 17.3^2)$

$P_1 = 1820 \text{ Pa}$

b) $P_1 A_1 - F = -\rho V_1^2 A_1 + \rho V_2^2 A_2$

$F = 1820(0.01) + 1.2 \times 17.3^2 \times 0.01 - 1.2 \times 57.7^2 \times 0.003$

$= 18.2 + 3.64 - 12 = 9.8 \text{ N}$

Question 4 (20 points):

The capillary rise (h) of a liquid in a tube is dependent on surface tension (σ), the fluid density (ρ), the tube diameter (d), gravity (g) and the contact angle (θ).

a) Determine a set of dimensionless groups for this problem.

b) If the capillary rise h_1 is known for a given experiment, what will h_2 be in a similar case if the diameter d and surface tension σ are reduced by half of the original value, the density ρ is doubled and the contact angle contact angle θ remains the same? Note: show that the two cases are similar and then derive a relation between h_2 and h_1.

Solution

a) $$\frac{h}{d} = fn\left(\frac{\sigma}{\rho g d^2}, \theta\right)$$

b) Same $$\left[\frac{\sigma}{\rho g d^2}\right]_{old} = \left[\frac{\sigma/2}{\rho\, 2g \left(\frac{d}{2}\right)^2}\right]_{new} = \left[\frac{\sigma}{\rho g d^2}\right]_{new} \Rightarrow \text{Similar}$$

$$\frac{h_1}{d} = \frac{h_2}{(d/2)} \Rightarrow h_2 = \frac{h_1}{2}$$

Question 5 (20 points):

Water flows in the pipe shown in figure 3. The pipe is smooth and the specific gravity of Mercury is 13.6.

Calculate the volumetric flow rate in this pipe.

Recall that the major head loss in pipe flow is given in term of friction factor as:

$$h_{Lmajor} = f\frac{L}{D}\frac{V^2}{2g}$$

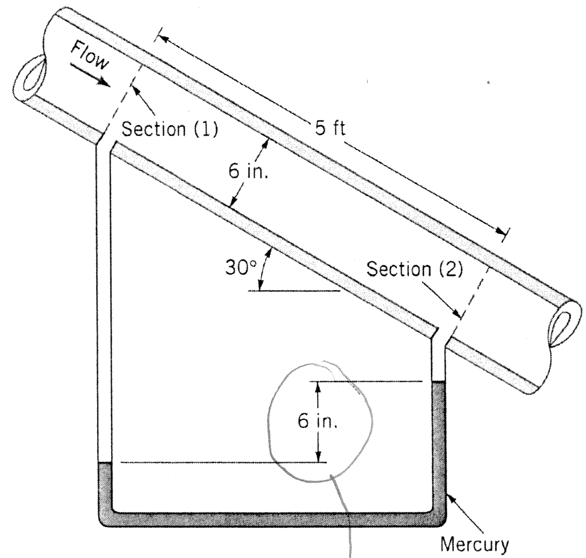


Figure 3

use ft

hydrostatic

$$\frac{P_1}{\gamma} + z_1 = \frac{P_2}{\gamma} + z_2 - 0.5 + \frac{\gamma_{Hg}}{\gamma}\,0.5$$

Energy Eq.

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} - \left(\frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}\right) = h_L$$

Same $V_1 = V_2$

$$0.5(13.6 - 1) = f\frac{L}{D}\frac{V^2}{2g} = f\left(\frac{5}{0.5}\right)\left(\frac{V^2}{2g}\right)$$

smooth pipe

assume $Re = 10^5$ $\quad f = 0.018$

$$V = \sqrt{\frac{2g \times 6.3}{10 \times f}} \qquad V = 47.5 \text{ ft/sec}$$

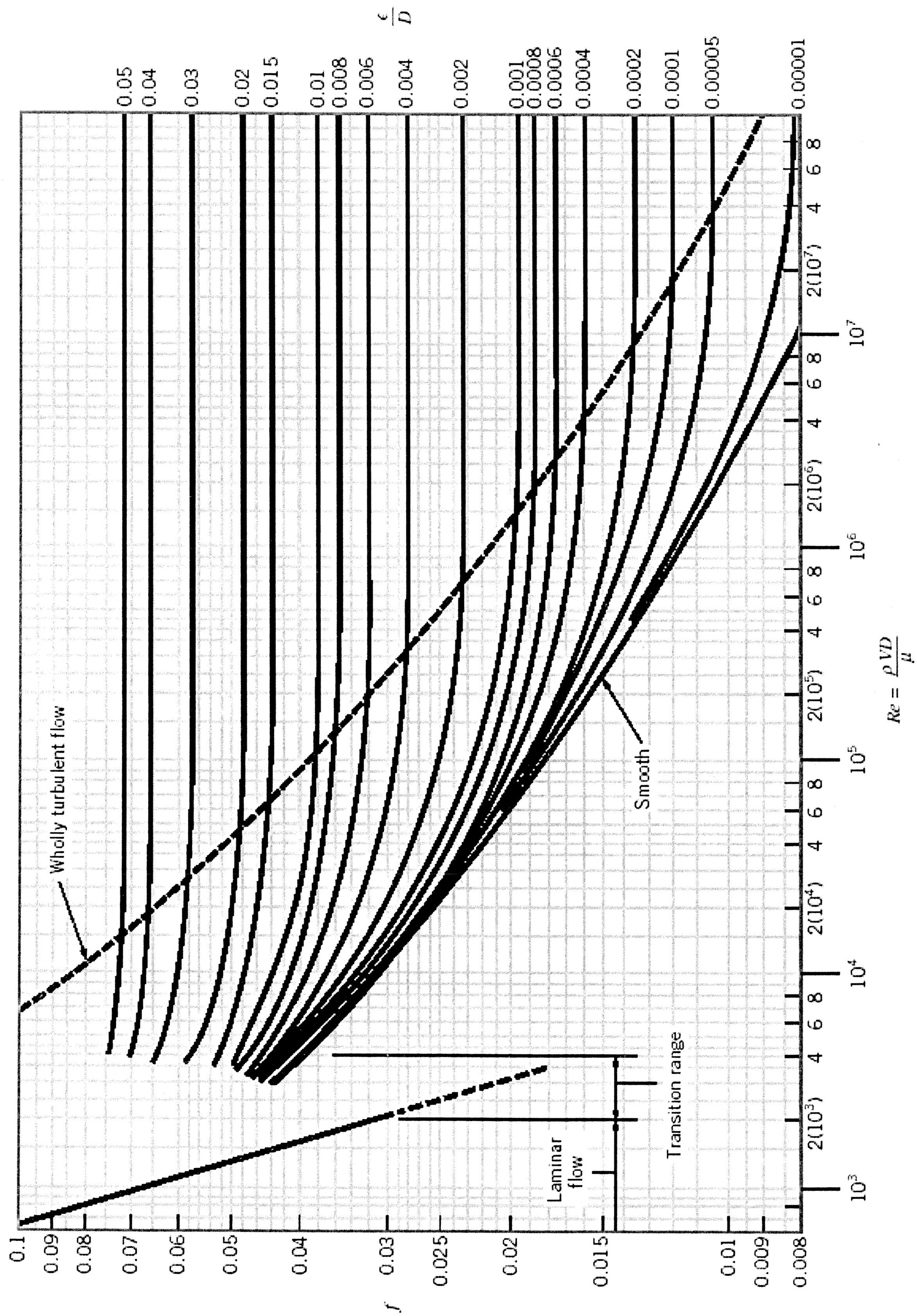
$$Re = \frac{\rho V D}{\mu} = 1.97\ 10^6$$

$$f = 0.01 \qquad V = \sqrt{\frac{40.57}{0.01}} \rightarrow Re = 2.6\ 10^6 \qquad \text{converged!}$$

$$Q = V \times A = 63 \text{ ft/s} \times \frac{\pi}{4} d^2$$

$$= 63 \times \frac{\pi}{4} \times 0.5^2 = 12 \text{ ft}^3/\text{s}$$

Moody Diagram



CONCORDIA UNIVERSITY- FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	EA to EG
EXAMINATION EXAM 1	DATE October 3, 2015	TIME 13:00- 14:15	Rooms H-535 & H-937
PROFESSOR M. Paraschivoiu			
SPECIAL INSTRUCTIONS: Duration: 75 minutes Instructions: Calculators are permitted. Closed book, no notes or textbook permitted. Answer all three questions. Each question is worth 10 marks. You *MUST* show *all* your steps in solving all problems!			

Last name: ______________________________

First name: ______________________________

Signature: ______________________________

I.D.: ______________________

Tutorial Section: ______________________

Question 1	
Question 2	
Question 3	
Total	

Fluid properties:

Water:

ρ = 999 kg/m^3, γ = 9800 N/m^3, μ = 0.001 N-s/m^2
ρ = 1.94 slugs/ft^3, γ = 62.4 lb/ft^3, μ =2.34×10^{-5} lb-s/ft^2

Gravity:

g = 9.81 m/s^2
g = 32.2 ft/sec^2

Atmospheric pressure:

P_{atm} = 101 000 Pa
P_{atm} = 14.7 psi or 2120 psf

Question 1 (10 points):

The space between two 6 in.-long concentric cylinders is filled with glycerin (viscosity = 8.5×10^{-3} lb-s/ft^2). The inner cylinder has a radius of 3 in. and the gap width between cylinders is 0.1 in. Determine the torque and the power required to rotate the inner cylinder at 180 rev/min (6π rad/s). The outer cylinder is fixed. Assume the velocity distribution in the gap to be linear.

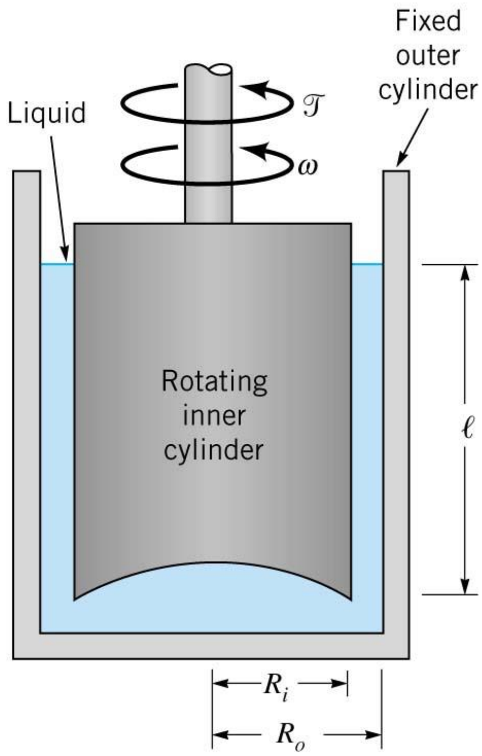


Figure 1.

Question 2 (10 points):

Water on the left side of a right-angle gate keeps the gate close due to a block as shown in Figure 2. Neglect the mass of the gate. The gate has a width of size 1 m.

a) Calculate the vertical force on the hinge.
b) Calculate the horizontal force on the hinge.

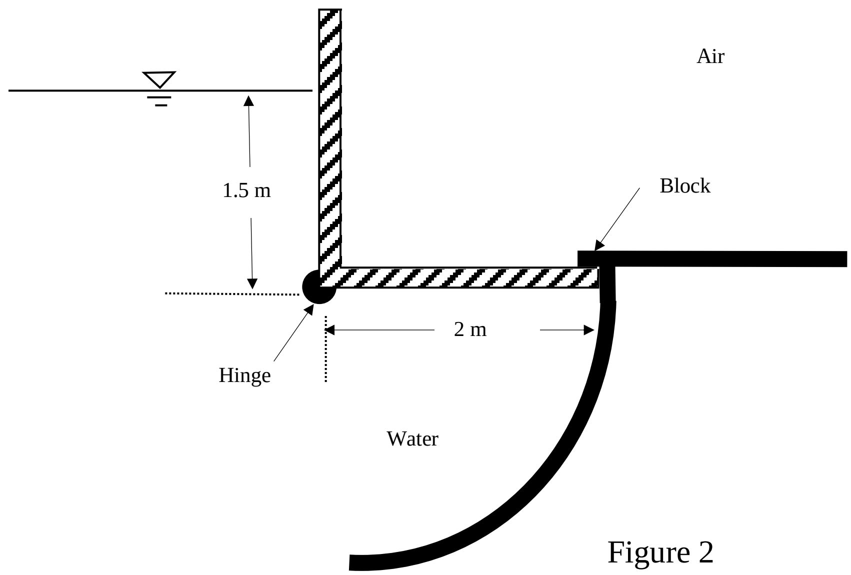
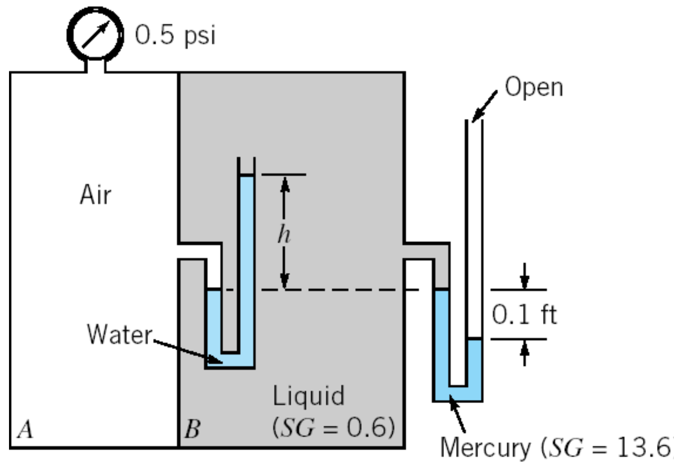


Figure 2

Question 3 (10 points):

Compartments A and B of the tank shown in Figure 3 are closed and filled with air and a liquid with a specific gravity equal to 0.6. Determine the manometer reading, h, if the atmospheric pressure is 14.7 psi and the pressure gage reads 0.5 psi. Neglect the effect of the weight of the air.

Figure 3



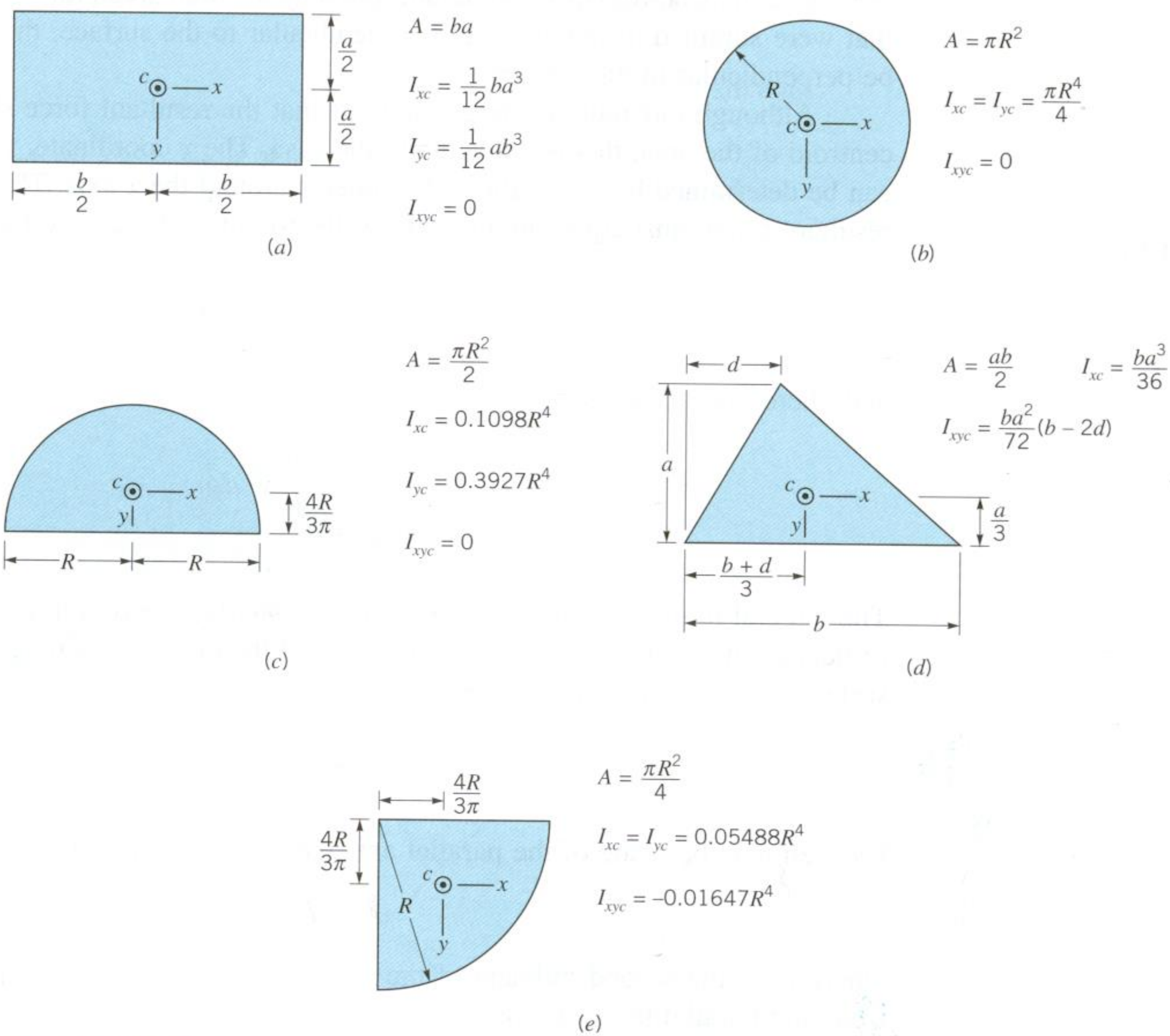


FIGURE 2.18 **Geometric properties of some common shapes.**

CONCORDIA UNIVERSITY- FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE		NUMBER	SECTION
FLUID MECHANICS I		ENGR 361	EA to EG
EXAMINATION EXAM 2	DATE November 14, 2015	TIME 13:00- 14:15	Rooms H-535 & H-937
PROFESSOR M. Paraschivoiu			

SPECIAL INSTRUCTIONS:
Duration: 75 minutes
Instructions: Calculators are permitted. Closed book, no notes or textbook permitted.
Answer all three questions. Each question is worth 10 marks.
You *MUST* show *all* your steps in solving all problems!

Last name: ______________________________

First name: ______________________________

Signature: ______________________________ **I.D.:** ______________________

Tutorial Section: ______________________

Question 1	
Question 2	
Question 3	
Total	

Fluid properties:

Water:

$\rho = 1000\ kg/m^3$, $\gamma = 9800\ N/m^3$, $\mu = 0.001\ N\text{-}s/m^2$
$\rho = 1.94\ slugs/ft^3$, $\gamma = 62.4\ lb/ft^3$, $\mu = 2.34\times10^{-5}\ lb\text{-}s/ft^2$

Atmospheric pressure:

$P_{atm} = 101\ 000$ Pa
$P_{atm} = 14.7$ psi or 2120 psf

Question 1 (10 points):

A 3-in-diameter horizontal jet of water strikes a flat plate as indicated in Figure 1.

a) Determine the jet velocity if a 10-lb horizontal force is required to allow the plate to move at a constant speed of 10 ft/s to the right.

b) Calculate the power (P) generated by the jet on the moving plate.

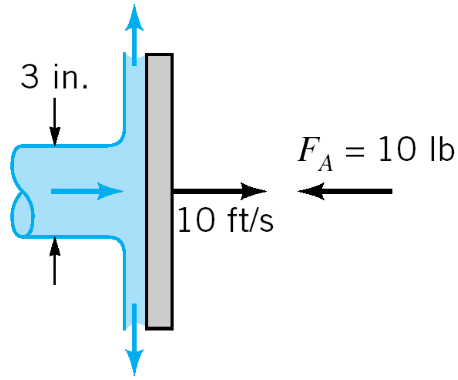


Figure 1

Question 2 (10 points):

Water flows upwards as a free jet from a circular 6 inch diameter pipe as shown in Figure 2a. The exit speed is 16 ft/s and the jet reaches a height h from the exit plane. Assume that viscous effects are negligible and that the flow is steady.

a) Determine the height *h*?
b) What is the value of *z* if the pipe is rotated by 10° as shown in figure 2b)?

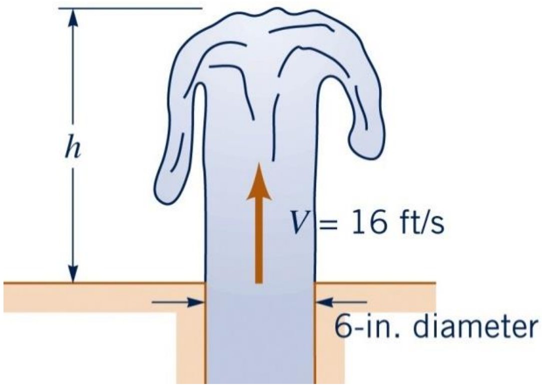


Figure 2a)

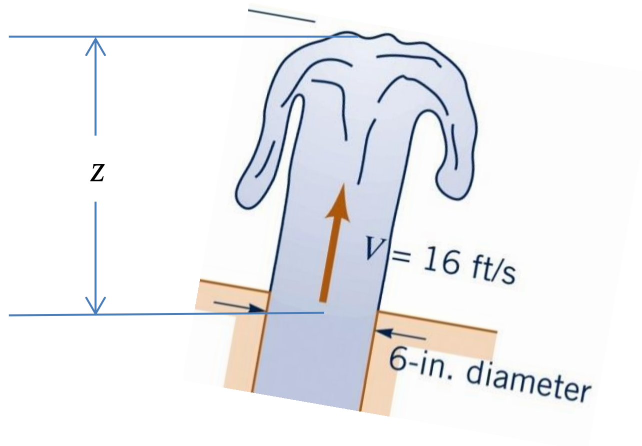


Figure 2b)

Question 3 (10 points):

Water is to be pumped from the large tank shown in figure 3 with an exit velocity of 6 m/s. It was determined that the original pump (pump 1) that supplies 1 kW of power to the water does not produce the desired velocity. Hence, it is proposed that an additional pump (pump 2) be installed as indicated to increase the flow rate to the desired value. ***How much power must pump 2 add to the water?*** The head loss for this flow is $h_L = 250\ Q^2$, where h_L is in (m) and Q is in (m^3/s).

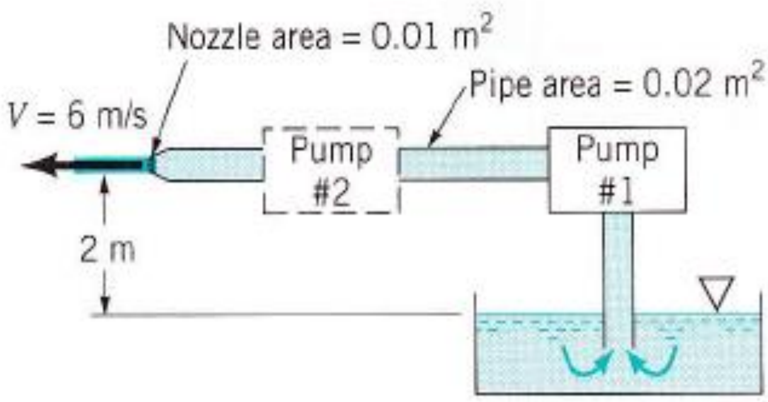


Figure 3.