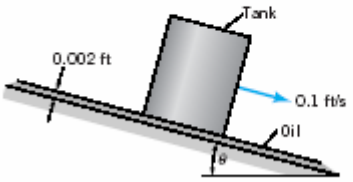
Franklin W. Olin College of Engineering
ENGR 3310: Transport Phenomena

Problem Set 1

Assigned: 9/9/04 Fall 2004
Due: 9/16/04 by 5:00 pm

Problem 1:

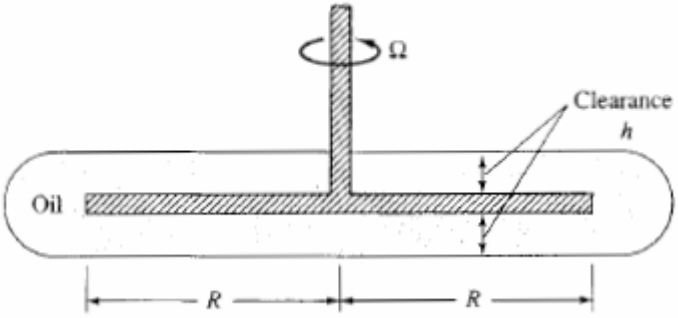
1.56 A 40-lb, 0.8-ft-diameter, 1-ft-tall cylindrical tank slides slowly down a ramp with a constant speed of 0.1 ft/s as shown in Fig. P1.56. The uniform-thickness oil layer on the ramp has a viscosity of 0.2 lb · s/ft^2. Determine the angle, θ, of the ramp.



■ FIGURE P1.56

Problem 2:

***P1.54** A disk of radius R rotates at an angular velocity Ω inside a disk-shaped container filled with oil of viscosity μ, as shown in Fig. P1.54. Assuming a linear velocity profile and neglecting shear stress on the outer disk edges, derive a formula for the viscous torque on the disk.



P1.54

Problem 3:

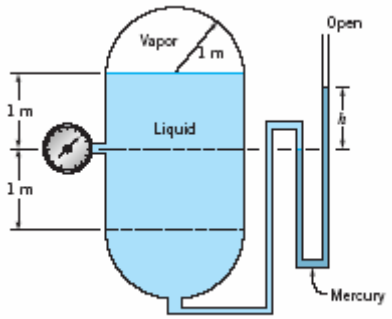
A solid cylindrical needle of diameter d, length L, and density ρ_n may float in liquid of surface tension σ. Neglect buoyancy and assume a contact angle of 0°. Derive a formula for the maximum diameter d_{max} able to float in the liquid. Calculate d_{max} for a steel needle (SG = 7.84) in water at 20 °C.

Problem 4:

2.8 Blood pressure is commonly measured with a cuff placed around the arm, with the cuff pressure (which is a measure of the arterial blood pressure) indicated with a mercury manometer (see Video 2.1). A typical value for the maximum value of blood pressure (systolic pressure) is 120 mm Hg. Why wouldn't it be simpler, and cheaper, to use water in the manometer rather than mercury? Explain and support your answer with the necessary calculations.

Problem 5:

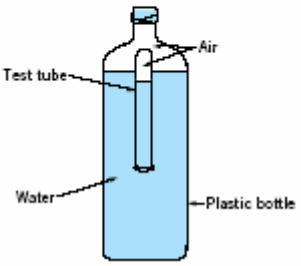
2.35 The cyclindrical tank with hemispherical ends shown in Fig. P2.35 contains a volatile liquid and its vapor. The liquid density is 800 kg/m^3, and its vapor density is negligible. The pressure in the vapor is 120 kPa (abs), and the atmospheric pressure is 101 kPa (abs). Determine: (a) the gage pressure reading on the pressure gage; and (b) the height, h, of the mercury manometer.



■ FIGURE P2.35

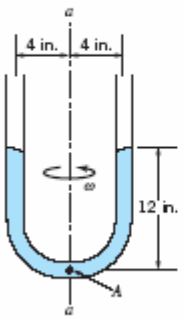
Problem 6:

2.86 An inverted test tube partially filled with air floats in a plastic water-filled soft drink bottle as shown in Video V2.5 and Fig. P2.86. The amount of air in the tube has been adjusted so that it just floats. The bottle cap is securely fastened. A slight squeezing of the plastic bottle will cause the test tube to sink to the bottom of the bottle. Explain this phenomenon.



Problem 7:

2.99 The U-tube of Fig. P2.99 is partially filled with water and rotates around the axis a–a. Determine the angular velocity that will cause the water to start to vaporize at the bottom of the tube (point A).



■ FIGURE P2.99

Problem 8:

4.5 The x and y components of velocity for a two-dimensional flow are $u = 3$ ft/s and $v = 9x^2$ ft/s, where x is in feet. Determine the equation for the streamlines and graph representative streamlines in the upper half plane.