FDE-205 Fluid Mechanics – Problem Set I

The problems given out in this problem set were compiled from the following books:
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Fluid Mechanics – Fundamentals and Applications
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3rd Ed. Yunus A. Çengel and John M. Cimbala

1. a- How does the viscosity of liquids and gases change with temperature? Show their trends on a graph!
   b- What is the viscosity of water at 20 °C in `cP` and in `Pa-s`?

2. How do the dynamic and kinematic viscosity of gases and liquids change with temperature?

3. **2–94** A thin plate moves between two parallel, horizontal, stationary flat surfaces at a constant velocity of 5 m/s. The two stationary surfaces are spaced 4 cm apart, and the medium between them is filled with oil whose viscosity is 0.9 N·s/m². The part of the plate immersed in oil at any given time is 2-m long and 0.5-m wide. If the plate moves through the mid-plane between the surfaces, determine the force required to maintain this motion. What would your response be if the plate was 1 cm from the bottom surface (h_2) and 3 cm from the top surface (h_1)?

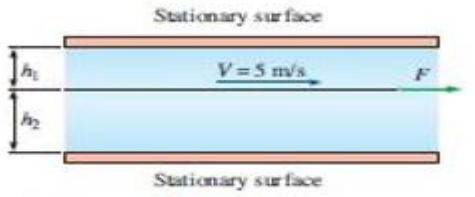


FIGURE P2–94

4.

3–150E Consider a U-tube whose arms are open to the atmosphere. Now equal volumes of water and light oil (ρ = 49.3 lbm/ft^3) are poured from different arms. A person blows from the oil side of the U-tube until the contact surface of the two fluids moves to the bottom of the U-tube, and thus the liquid levels in the two arms are the same. If the fluid height in each arm is 40 in, determine the gage pressure the person exerts on the oil by blowing.

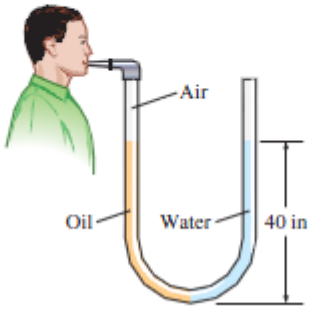
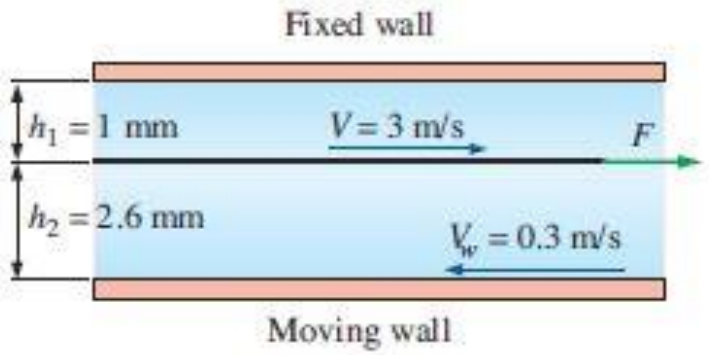


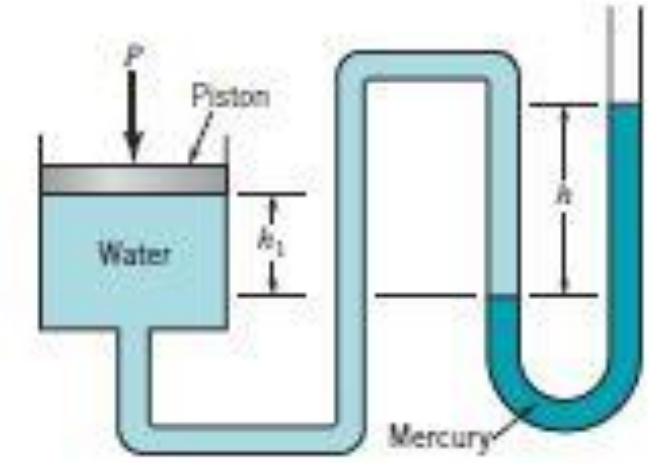
FIGURE P3–150E

Note:
1 lbm/ft³ = 16 kg/m³
1 in = 2.54 cm
Density of water : 1000 kg/m³

5. A thin 30-cm×30-cm flat plate is pulled at 3 m/s horizontally through a 3.6-mm thick oil layer sandwiched between two plates, one stationary and the other moving at a constant velocity of 0.3 m/s, as shown below. The dynamic viscosity of the oil is 0.027 Pa-s. Assuming that the velocity in each oil layer to vary linearly, determine the force that needs to be applied on the plate to maintain this motion.



6. A piston having a cross-sectional area of 0.07 m^2 is located in a cylinder containing water as shown in the following figure. An open U-tube manometer is connected to the cylinder as observed in the figure. For h1=60 mm and h=100 mm, what is the value of the applied force, P, acting on the piston? The weight of the piston is negligible, and the SG of the mercury is 13.6.



7. The pressure of water flowing through a pipe is measure by the arrangement shown below. For the values given, calculate the pressure in the pipe.

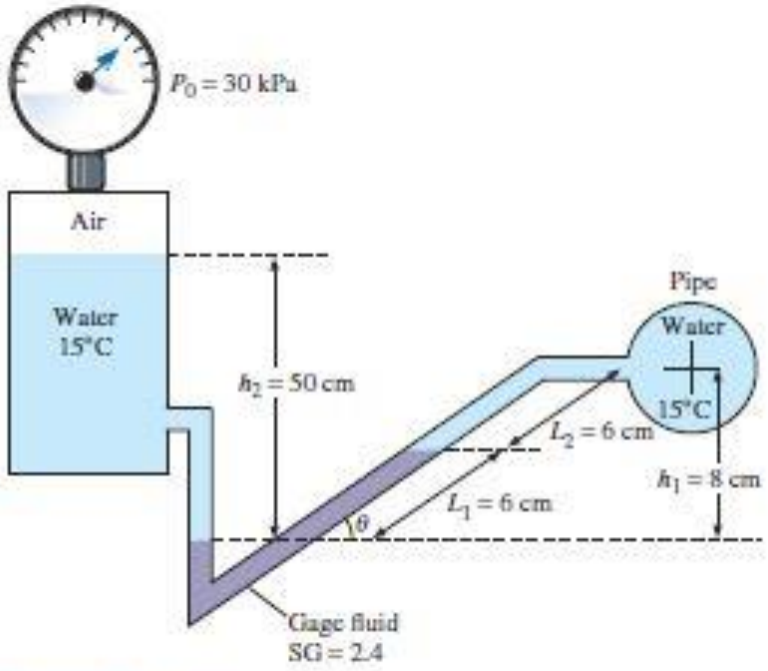
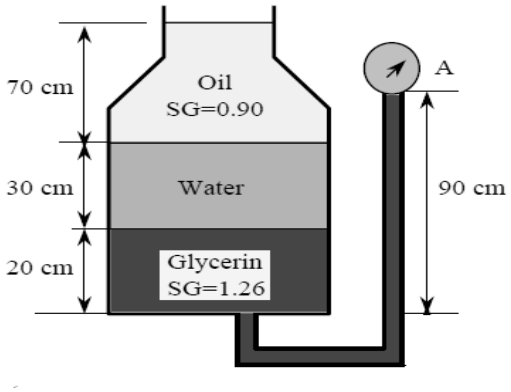


FIGURE P3–156

9. A tank which is open to atmosphere contains different fluids. It is connected to a U-tube manometer as shown in the picture. Calculate the pressure at point A. (ρ_{water} =1000kg/m^3)



10.

2–125 Consider laminar flow of a Newtonian fluid of viscosity μ between two parallel plates. The flow is one-dimensional, and the velocity profile is given as $u(y) = 4u_{max}[y/h - (y/h)^2]$, where y is the vertical coordinate from the bottom surface, h is the distance between the two plates, and u_{max} is the maximum flow velocity that occurs at midplane. Develop a relation for the drag force exerted on both plates by the fluid in the flow direction per unit area of the plates.

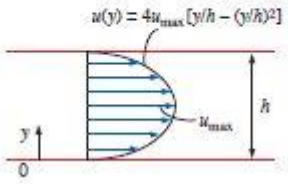


FIGURE P2–125

Note:
Drag force is given by the following equation:

$$F_D = 2 \cdot \tau \cdot A$$