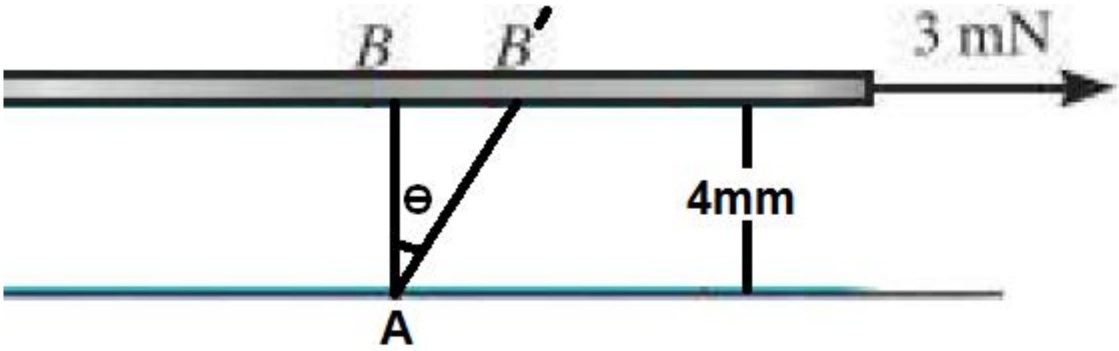
SHEET FLUID -1-

Q1/ At a particular temperature, the viscosity of an oil is $\mu = 0.354$ N. s/ m^2. Determine its kinematic viscosity. The specific gravity is $S = 0.868$.

Q2/The kinematic viscosity of kerosene is $\nu = 2.39(10^{-6})$ m2 /s. Determine its viscosity, considered kerosene has a specific gravity of S= 0.810.

Q3/When the force of 3 mN is applied to the plate, the line AB in the liquid remains straight and has an angular rate of rotation of 0.2 rad/ s. If the surface area of the plate in contact with the liquid is 0.6 m^2, determine the approximate viscosity of the liquid.



Q4/

Water is moving through a pipe. The velocity profile at some section is shown in Fig. below and is given mathematically as $u = (\beta/4\mu)(d^2/4 - r^2)$, where u = velocity of water at any position r, β = a constant, μ = viscosity of water, d = pipe diameter, and r = radial distance from centerline. What is the shear stress at wall of the pipe due to the water? What is the shear stress at a position $r = d/4$? If the given profile persists a distance L along the pipe, what drag is induced on the pipe by the water in the direction of flow over this distance?

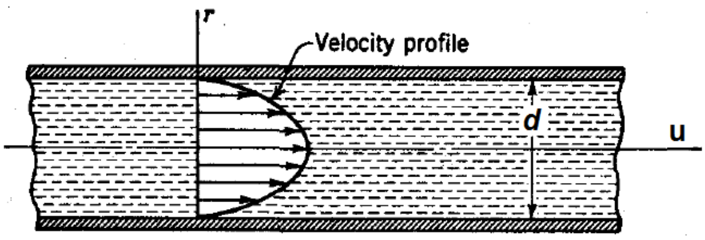
Solution $\quad u = (\beta/4\mu)(d^2/4 - r^2) \qquad du/dr = (\beta/4\mu)(-2r) = -2\beta r/4\mu$

$$\tau = \mu\,(du/dr) = \mu(-2\beta r/4\mu) = -2\beta r/4$$

At the wall, $r = d/2$. Hence,

$$\tau_{\text{wall}} = \frac{-2\beta(d/2)}{4} = -\frac{\beta d}{4} \qquad \tau_{r=d/4} = \frac{-2\beta(d/4)}{4} = -\frac{\beta d}{8}$$

$$\text{Drag} = (\tau_{\text{wall}})(\text{area}) = (\tau_{\text{wall}})(\pi d L) = (\beta d/4)(\pi d L) = \beta d^2 \pi L/4$$

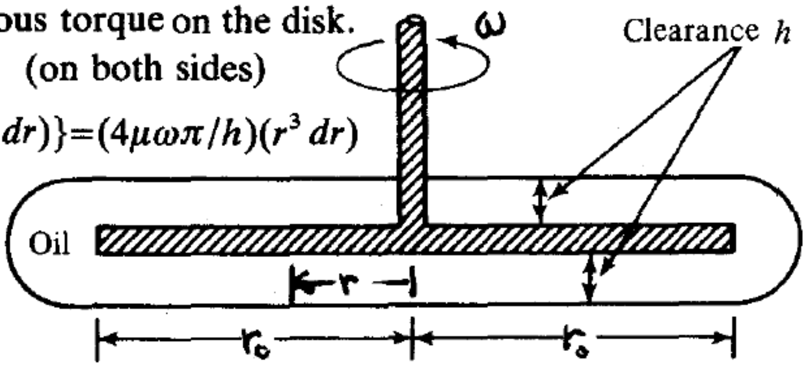


Q5/A disk of radius r_0 rotates at angular velocity ω inside an oil bath of viscosity μ, as shown in Fig. Assuming a linear velocity profile and neglecting shear on the outer disk edges, derive an expression for the viscous torque on the disk.

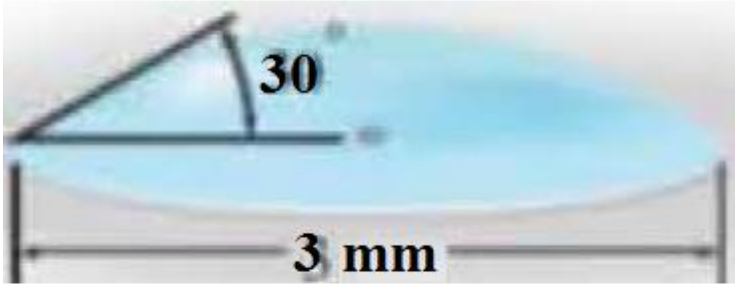
Solution: $\quad \tau = \mu\,(du/dy) = \mu(r\omega/h) \quad$ (on both sides)

$$dT = (2)(r\tau\,dA) = (2)\{(r)[\mu(r\omega/h)](2\pi r\,dr)\} = (4\mu\omega\pi/h)(r^3\,dr)$$

$$T = \int_0^{r_0} \frac{4\mu\omega\pi}{h}(r^3\,dr) = \frac{4\mu\omega\pi}{h}\left[\frac{r^4}{4}\right]_0^{r_0} = \frac{\pi\mu\omega r_0^4}{h}$$



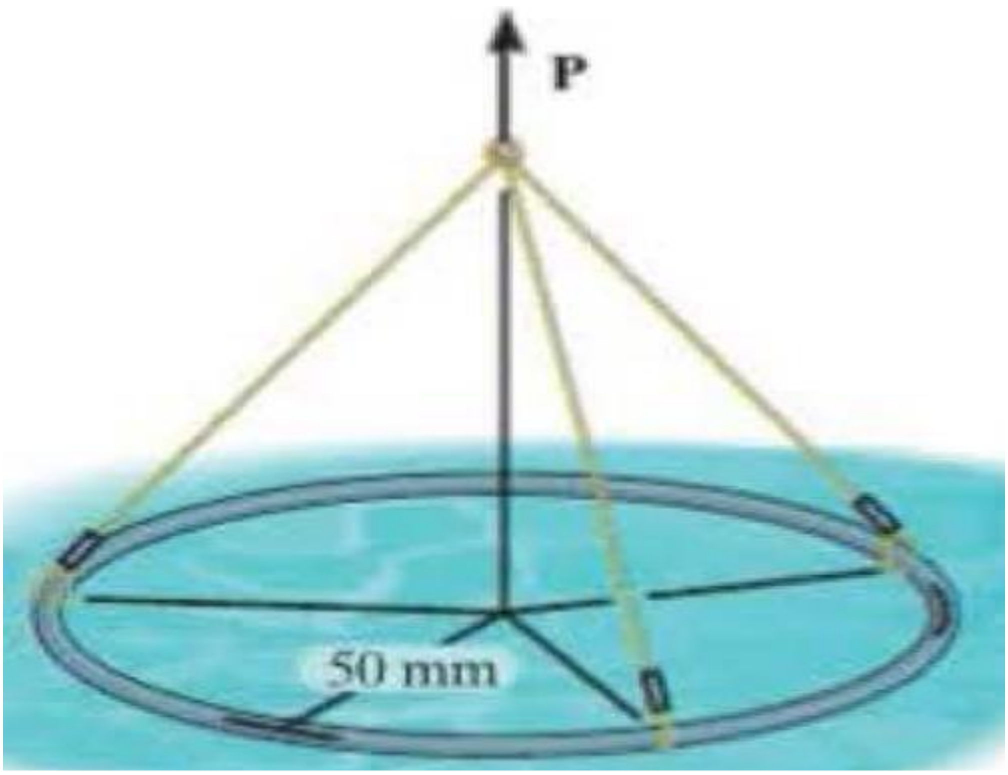
Q6/ many camera phones now use liquid lenses as a means of providing a quick auto-focus. The lenses work by electrically controlling the internal pressure within a liquid droplet thereby affecting the angle of the meniscus of the droplet, and so creating a variable focal length. To analyze this effect, consider, for example, a segment of a spherical droplet that has a base diameter of 3 mm. the pressure in the droplet is 105 Pa and is controlled through a tiny hole at the center.



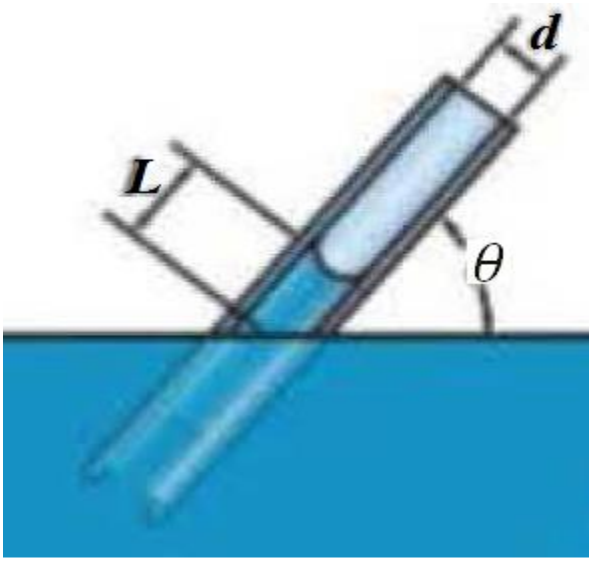
If the tangent at the surface of the droplet is 30°. Determine the surface tension at the surface that holds the droplet in place.

Q 7/The marine water strider *Halobates* has a mass of 0.36 g. If it has six slender legs اطراف رفيعة. Determine the minimum contact length of all of its legs combined to support itself مجتمعة لتثبيت نفسه in water. Take σ =72.7 mN/m, and assume the legs are thin cylinders that are water repellent نسيج يصمد بالماء. Ans. 24.3 mm

Q8/ The ring has a weight of 0.2 N and is suspended on the surface of the water for which σ =73.6 mN/ m. a) Determine the vertical force P needed to pull the ring free from the surface. *Note:* this method is often used to measure surface tension. b) Determine the surface tension of the water. If it take a force of P = 0.245N to lift the ring free from the surface. Ans. a) b) 0.0716 N/m.



Q9/the tube has an inner diameter d and is immersed in Water at an angle θ from the vertical. Determine the average length L to which water will rise along the tube due to capillary action. The surface tension of the water is σ and the density is ρ.
Ans. $4\sigma/(\rho g d \sin\theta)$.



Q10/ One litre of crude oil weighs 9.6 N. Calculate its specific weight, density and specific gravity.
[**Ans.** 9600 N/m^3; 979.6 kg/m^3 ; 0.9786]

Q11/ A piston 796 mm diameter and 200 mm long works in a cylinder of 800 mm diameter. If the annular space is filled with a lubricating oil of viscosity 5 cp (centi-poise), calculate the speed of descent of the piston in vertical position. The weigh of the piston and axial load are 9.81 N. [**Ans.** 7.84 m/s]

Q12/ Find the capillary rise of water in a tube 0.03 cm diameter. The surface tension of water is 0.0735 N/m. [**Ans.** 9.99 cm]

Q13/ Calculate the specific weight, density and specific gravity of two litres of a liquid which weight 15 N. [**Ans.** 7500 N/m^3, 764.5 kg/m^3, 0.764]

Q14/A 150 mm diameter vertical cylinder rotates concentrically inside another cylinder of diameter 151 mm. Both the cylinders are of 250 mm height. The space between the cylinders is filled with a liquid of viscosity 10 poise. Determine the torque required to rotate the inner cylinder at 100 r.p.m. [**Ans.** 13.87 Nm]

Q15/ Assuming that the bulk modulus of elasticity of water is 2.07×10^6 kN/m^2 at standard atmospheric conditions, determine the increase of pressure necessary to produce 1% reduction in volume at the same temperature.

[**Hint.** $K = 2.07 \times 10^6$ kN/m^2 ; $-dV/V = 1/100 = 0.01$

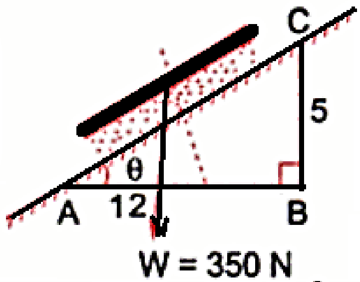
Increase in pressure $(dp) = K * (-dV/V) = 2.07 \times 10^6 \times 0.01 = 2.07 \times 10^4$ kN/m^2. **Ans.**]

Q16/ A square plate of size 1 m × 1 m and weighing 350 N slides down an inclined plane with a uniform velocity of 1.5 m/s. The inclined plane is laid on a slope of 5 vertical to 12 horizontal and has an oil film of 1 mm thickness. Calculate the dynamic viscosity of oil.

[**Hint.** $A = 1 \times 1 = 1\ m^2$, $W = 350$ N, $u = 1.5$ m/s, $\tan\theta = \frac{5}{12} = \frac{BC}{AB}$

Component of weight along the plane = $W \times \sin\theta$

where $\sin\theta = \frac{BC}{AC} = \frac{5}{13}$ $\quad \left(\because AC = \sqrt{AB^2 + BC^2} = \sqrt{12^2 + 5^2} = 13\right)$



∴ $F = W\sin\theta = 350 \times \frac{5}{13} = 134.615$

Now $\tau = \mu\,(du/dy)$, where $du = u - 0 = u = 1.5$ m/s and $dy = 1$ mm $= 1 \times 10^{-3}$ m

or $\frac{F}{A} = \mu\frac{du}{dy}$, $\therefore \mu = \frac{F}{A} \times \frac{dy}{du} = \frac{134.615}{1} \times \frac{1 \times 10^{-3}}{1.5} = 0.0897\ \frac{Ns}{m^2} = 0.897$ poise **Ans.**]

Q16/ The gage pressure in a liquid at a depth of 3 m is read to be 28 kPa. Determine the gage pressure in the same liquid at a depth of 9 m.

Q17/ The absolute pressure in water at a depth of 5 m is read to be 145 kPa. Determine (*a*) the local atmospheric pressure, and (*b*) the absolute pressure at a depth of 5 m in a liquid whose specific gravity is 0.85 at the same location.

Q18/ Show that 1 kgf/cm^2 = 14.223 psi.

Q19/ A 90.7 kg man has a total foot imprint area of 464.5 cm^2. Determine the pressure this man exerts on the ground if (*a*) he stands on both feet and (*b*) he stands on one foot.

Q20/ Consider a 70-kg woman who has a total foot imprint area of 400 cm^2. She wishes to walk on the snow, but the snow cannot withstand pressures greater than 0.5 kPa. Determine the minimum size of the snowshoes needed (imprint area per shoe) to enable her to walk on the snow without sinking تغور.

Q21/ A vacuum gage connected to a tank reads 15 kPa at a location where the barometric reading is 750 mm Hg. Determine the absolute pressure in the tank. Take ρ_{Hg} =13,590 kg/m^3.
Answer: 85.0 kPa

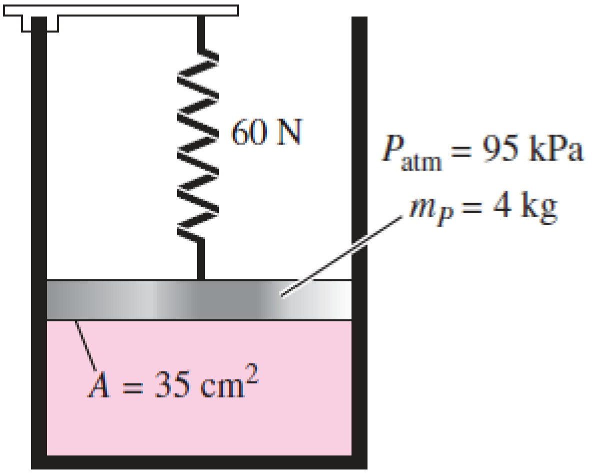
Q22/ A pressure gage connected to a tank reads 344.7 kPa at a location where the barometric reading is 29.1 mm Hg. Determine the absolute pressure in the tank. Take ρ_{Hg} = 13600 kg/m^3.
Answer: 441.2 kPa.

Q23/ A pressure gage connected to a tank reads 500 kPa at a location where the atmospheric pressure is 94 kPa. Determine the absolute pressure in the tank.

Q24/ The barometer of a mountain hiker reads 930 mbars at the beginning of a hiking trip and 780 mbars at the end. Neglecting the effect of altitude on local gravitational acceleration, determine the vertical distance climbed. Assume an average air density of 1.20 kg/m^3.
Answer: 1274 m

Q25/ The basic barometer can be used to measure the height of a building. If the barometric readings at the top and at the bottom of a building are 730 and 755 mm Hg, respectively, determine the height of the building. Take the densities of air and mercury to be 1.18 kg/m^3 and 13,600 kg/m^3, respectively.

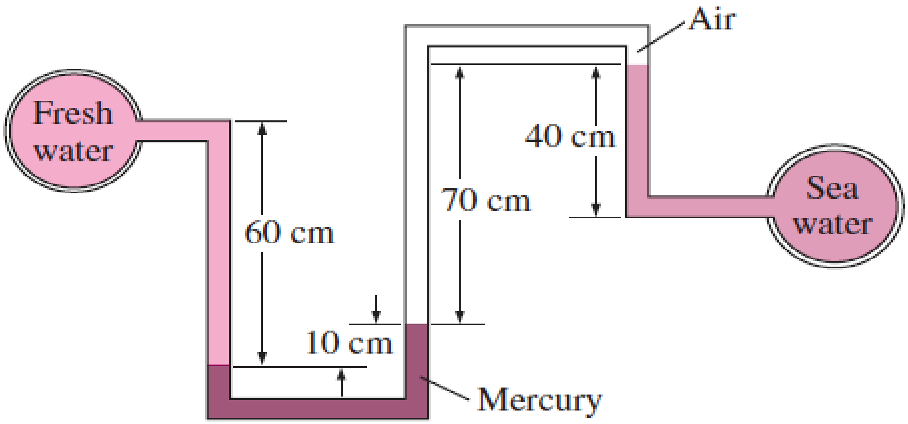
Q26/ A gas is contained in a vertical, frictionless piston–cylinder device. The piston has a mass of 4 kg and a cross-sectional area of 35 cm^2. A compressed spring above the piston exerts a force of 60 N on the piston. If the atmospheric pressure is 95 kPa, determine the pressure inside the cylinder.
Answer: 123.4 kPa



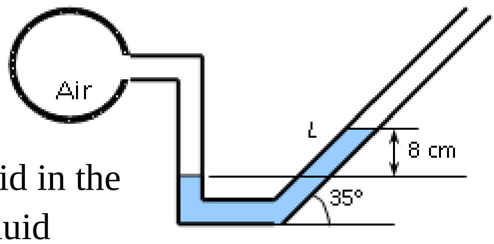
Q27/ Blood pressure is usually measured by wrapping لف a closed air-filled jacket equipped with a pressure gage around the upper arm of a person at the level of the heart. Using a mercury manometer and a stethoscope, the systolic pressure الضغط الانقباضي (the maximum pressure when the heart is pumping) and the diastolic pressure الضغط الانبساطي (the minimum pressure when the heart is resting) are measured in mm Hg. The systolic and diastolic pressures of a healthy person are about 120 mm Hg and 80 mm Hg, respectively, and are indicated as 120/80. Express both of these gage pressures in kPa, psi, and meter water column. (1bar= 14.5 psi)

Q28/ Consider a 1.8-m-tall man standing vertically in water and completely submerged in a pool. Determine the difference between the pressures acting at the head and at the toes الاقدام of this man, in kPa.

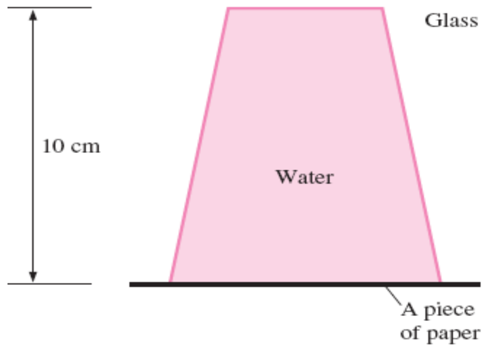
Q29/ Freshwater and seawater flowing in parallel horizontal pipelines are connected to each other by a double U-tube manometer, as shown in Fig.
a) Determine the pressure difference between the two pipelines. Take the density of seawater at that location to be ρ= 1035 kg/m^3. Can the air column be ignored in the analysis? ρ_{air} = 1.2 kg/m^3 b) replacing the air with oil whose specific gravity is 0.72. Ans. a) 3.39 kPa, b) 8.34 kPa.



Q30/ When measuring small pressure differences with a manometer, one arm of the manometer may be inclined to improve the accuracy of the reading. (The pressure difference is still proportional to the *vertical* distance and not the actual length of the fluid along the tube.) The air pressure in a circular duct is to be measured using a manometer whose open arm is inclined 35 degrees from the horizontal. The density of the liquid in the manometer is 0.81 kg/L, and the vertical distance between the fluid levels in the two arms of the manometer is 8 cm. Determine the gage pressure of air in the duct and the length of the fluid column in the inclined arm above the fluid level in the vertical arm.
Ans. 636 Pa , 13.9 cm

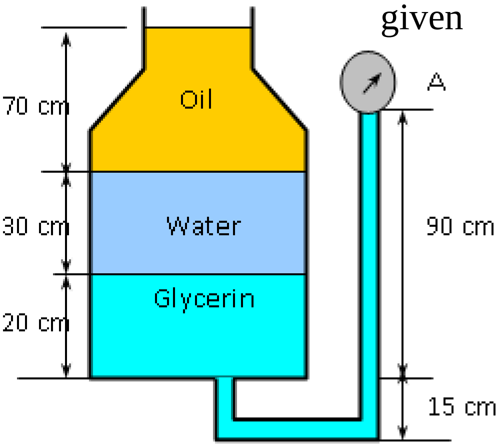


Q31/A glass that is fully filled with water and covered with a thin paper is inverted. Determine the pressure at the bottom (narrow end) of the glass, and explain why water does not fall out. Ans. 99 kPa

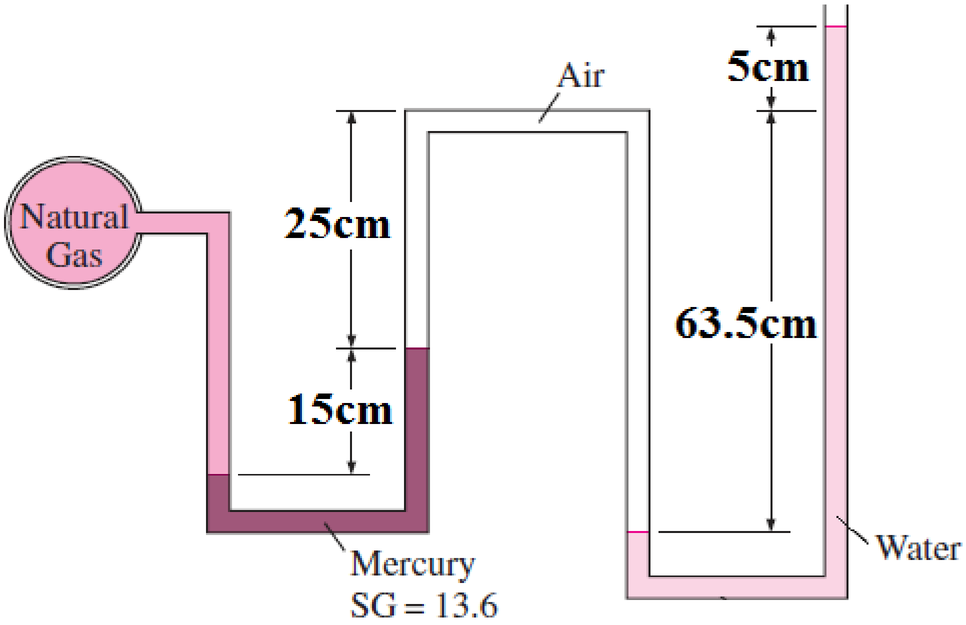


Q32/A multi-fluid container is connected to a U-tube. For the given specific gravities and fluid column heights, determine the gage pressure at A. Also determine the height of a mercury column that would create the same pressure at A.

Ans. 0.471 kPa, 0.353 cm

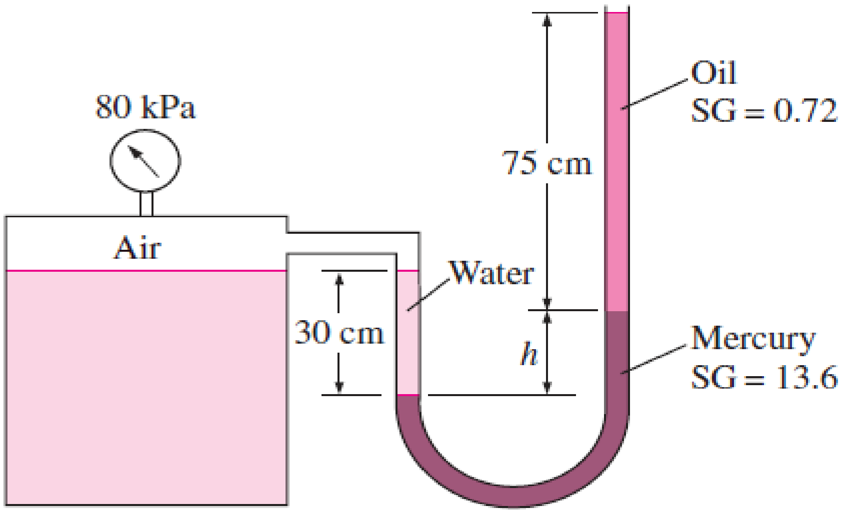


Q33/The pressure in a natural gas pipeline is measured by the manometer shown in Fig. with one of the arms open to the atmosphere where the local atmospheric pressure is 97.9 kPa. a) Determine the absolute pressure in the pipeline. b) Replacing air by oil with a specific gravity of 0.69.

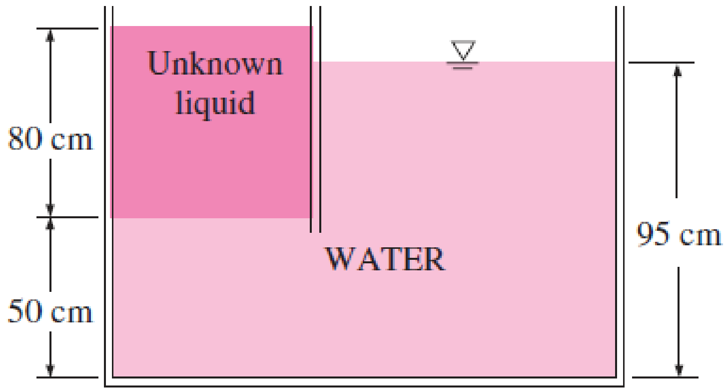


Q34/The gage pressure of the air in the tank shown in Fig. is measured to be 80 kPa. a) Determine the differential height *h* of the mercury column. b) Repeat for a gage pressure of 40 kPa.

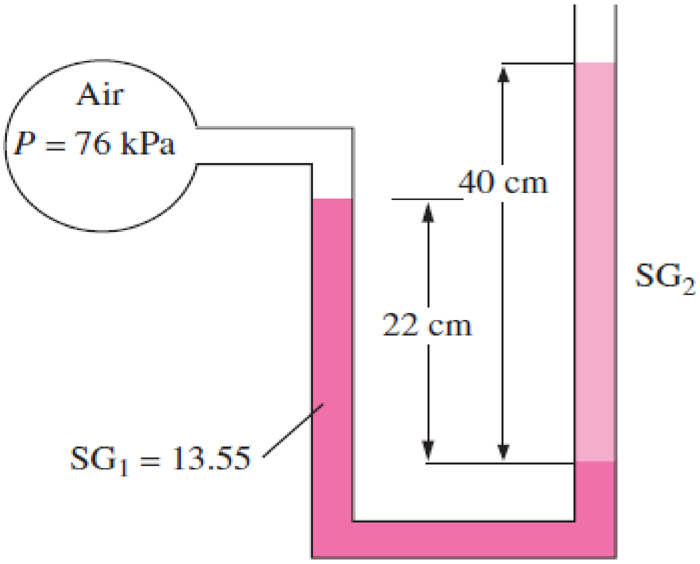
Ans. a) 0.582m, b) 0.282m.



Q35/The top part of a water tank is divided into two compartments, as shown in Fig. Now a fluid with an unknown density is poured into one side, and the water level rises a certain amount on the other side to compensate for this effect. Based on the final fluid heights shown on the figure, determine the density of the fluid added. Assume the liquid does not mix with water.

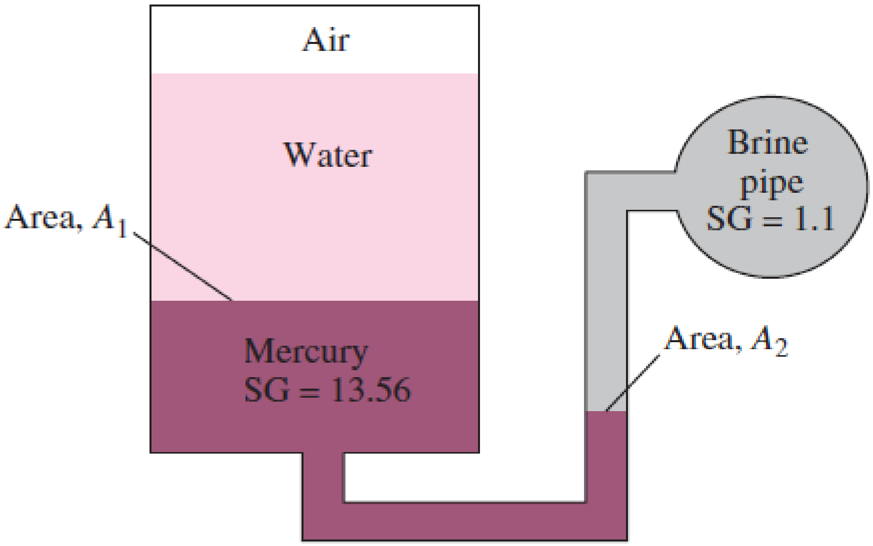


Q36/Consider a double-fluid manometer attached to an air pipe shown in Fig. If the specific gravity of one fluid is 13.55, determine the specific gravity of the other fluid for the indicated absolute pressure of air. Take the atmospheric pressure to be 100 kPa. *Ans:* 5.0

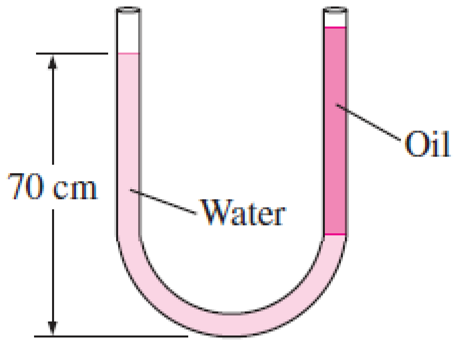


Q37/Consider the system shown in Fig. If a change of 0.7 kPa in the pressure of air causes the brine–mercury interface in the right column to drop by 5 mm in the brine level in the right column while the pressure in the brine pipe remains constant, determine the ratio of *A*2/*A*1

Ans. 0.134



Q38/Consider a U-tube whose arms are open to the atmosphere. Now water is poured into the U-tube from one arm, and light oil (ρ=790 kg/m^3) from the other. One arm contains 70-cm-high water, while the other arm contains both fluids with an oil-to-water height ratio of 4. Determine the height of each fluid in that arm. Ans. 0.168m, 0.673m.



Q39/A retaining wall الجدار الحاجز against a mud slide انزلاق الطين is to be constructed by placing 0.8-m-high by 0.2-m-wide rectangular concrete blocks (ρ=2700 kg/m^3) side-by-side. The friction coefficient between the ground and the concrete blocks is f = 0.3, and the density of the mud is 1800 kg/m^3. Determine the mud height at which (a) the blocks will overcome friction and begin sliding and (b) the blocks will tip over. Ans. a) 0.38m , b) 0.52m