Pascal's paradox

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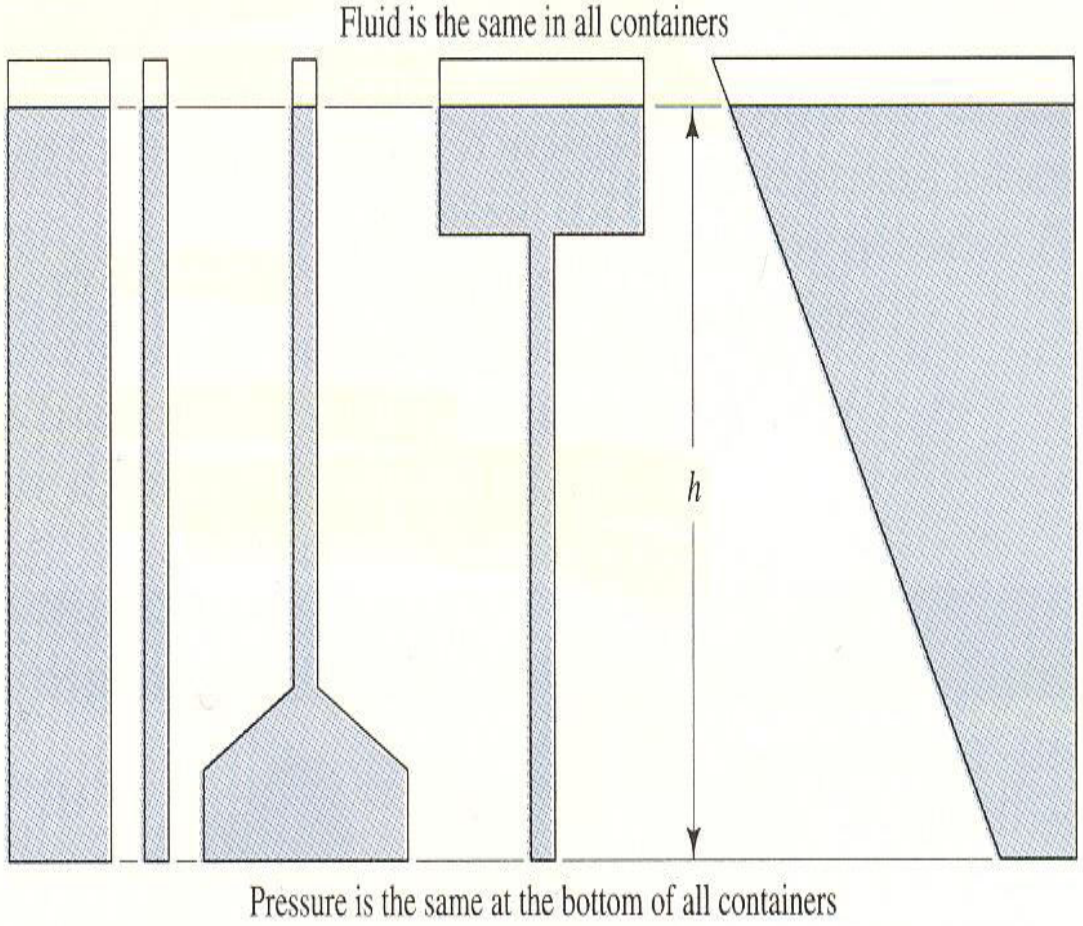
Pascal's paradox

- Pressure depends only on the elevation and the type of the fluid; NOT on the size of the fluid container
- All containers have the same pressure at the bottom!!

-referred to as the Pascal's Paradox

FIGURE 3.7 Illustration of Pascal's paradox.



The role of elevation also comes into play with respect to pressure in a water distribution system

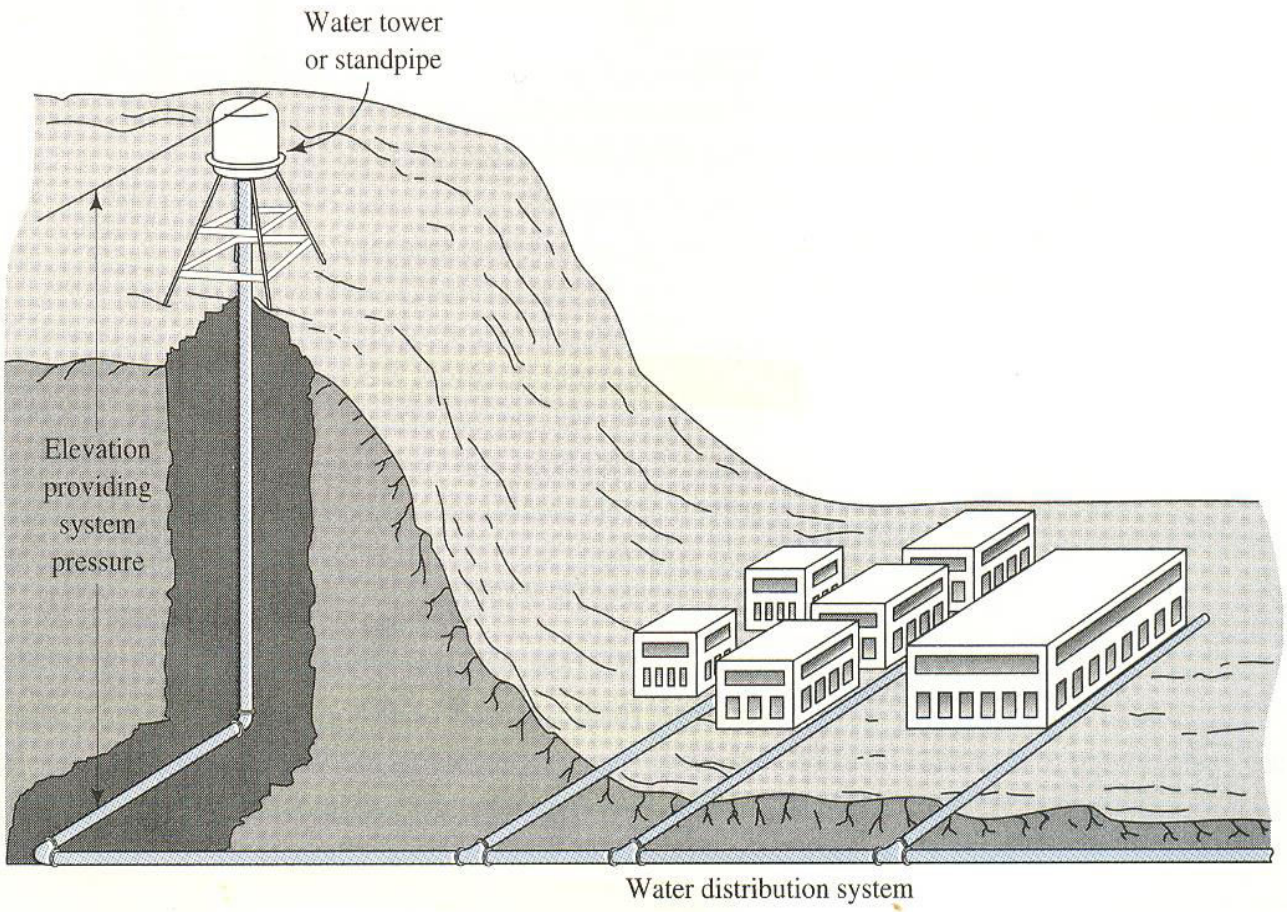
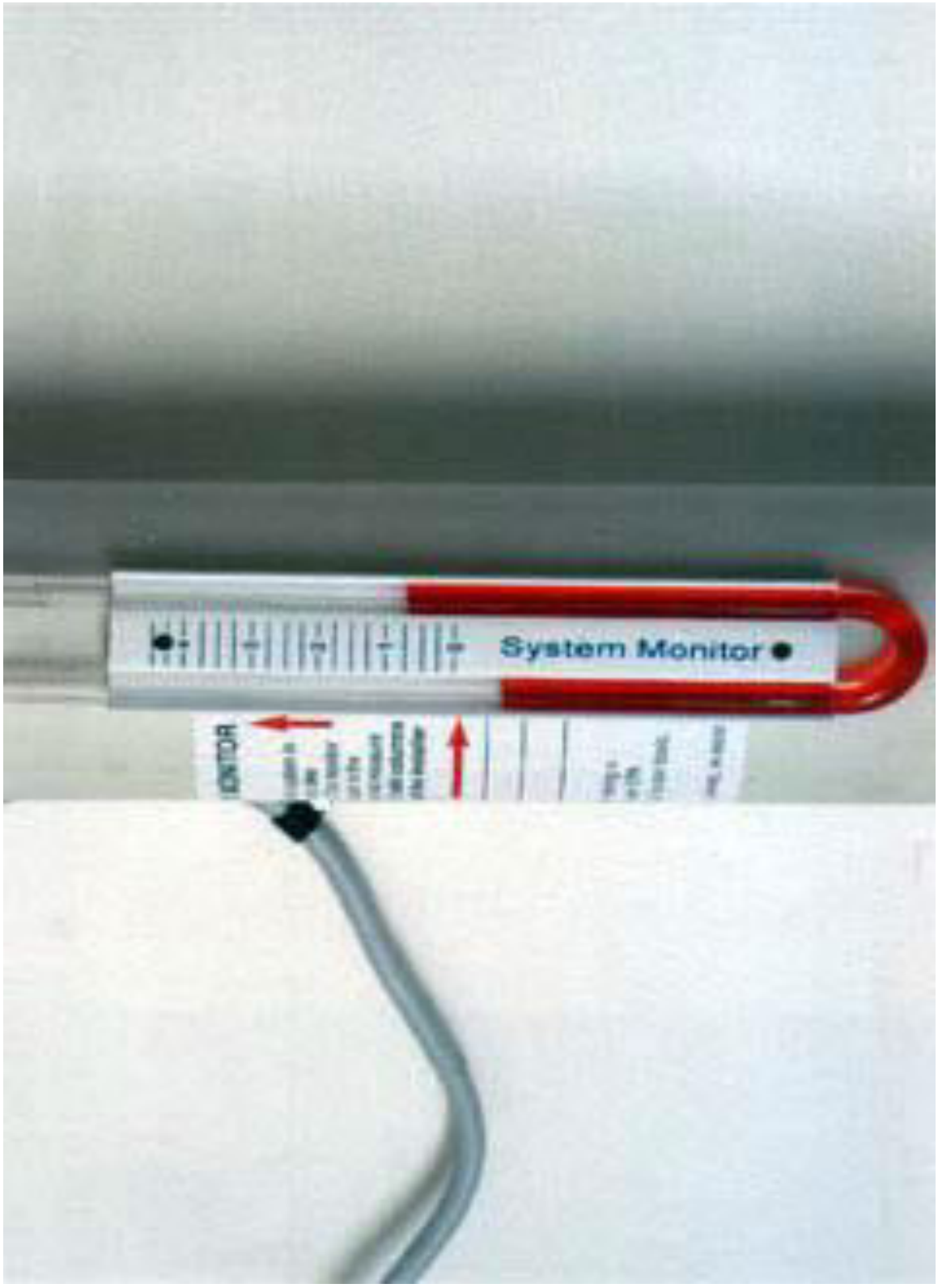


FIGURE 3.8 Use of a water tower or a standpipe to maintain water system pressure.

The Supply point should be higher than the receiving points to allow pressure to be maintained by gravity.

Manometers

- Instrument to measure pressure.
- Simplest kind – U tube manometer
- One end – open to the atmosphere
- Other end – connected to the fluid whose pressure is to be measured
- Contains liquid (gage fluid)– whose deflection indicates the pressure
- Gage liquid – should not mix with the other liquid


System Monitor

- Procedure for measurement:
- Start from the point which is exposed to atmosphere, and move towards the point at which the pressure is desired.
- If you move down in the fluid, pressure increases; and vice versa.

Problem :Compute the pressure at A?

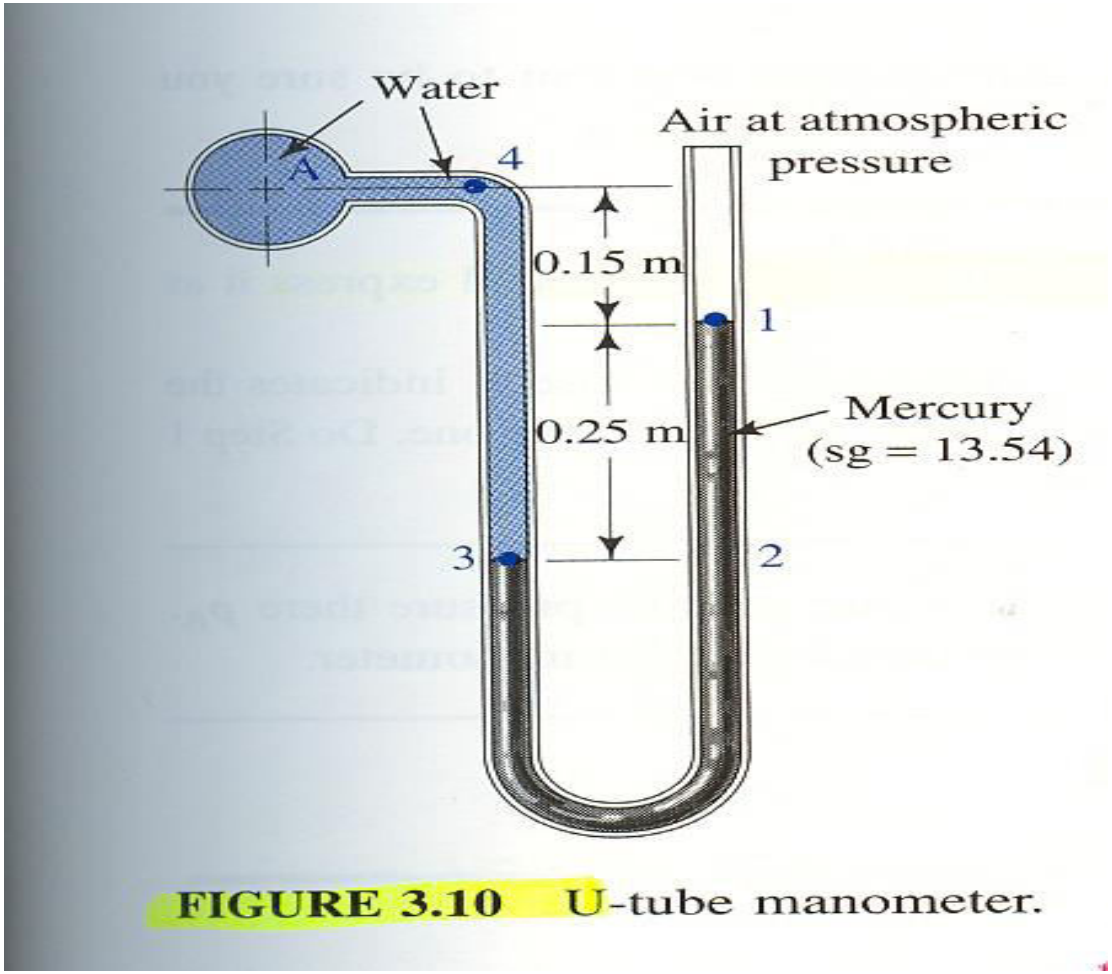


FIGURE 3.10 U-tube manometer.

- $\gamma m = 9.81 \times 13.54 = 132.8$ kN/m3
- $P1 = 0$
- $P2 = 0.25 \times 132.8 = 33.2$ kN/m2
- $P3 = P2 = 33.2$ kN/m2
- $P4 = P3 – 0.4 \times 9.81 = P3 - 3.92 = 29.28$ kN/m2
- Answer = Pa = 29.28 kN/m2 = 29.28kPa

Problem :

Determine the difference in pressure between points A and B

Specific wt of water = 62.4 lb/ft3.

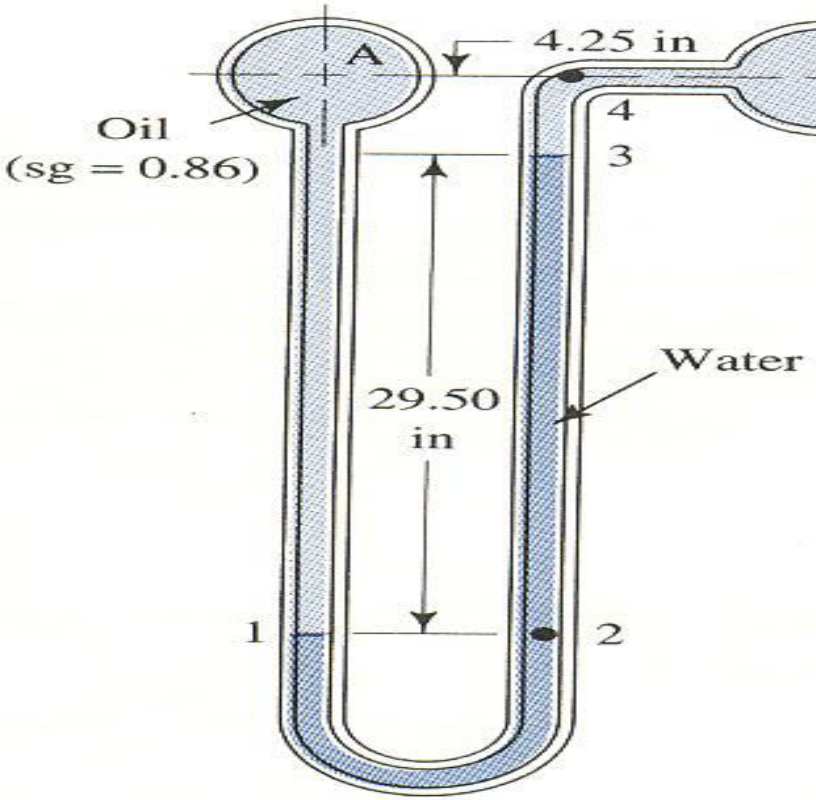


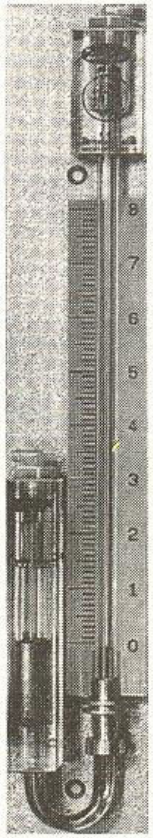
FIGURE 3.11 Differential manometer.

- $P1 = Pa + 33.75 \times \gamma o$
- $P1 = P2$
- $P3 = P1 - 29.5 \times \gamma w$
- $P4 = P3 - 4.25 \times \gamma o$
- $Pb = P4 = Pa + 33.75 \times \gamma o - 29.5 \times \gamma w - 4.25 \times \gamma o$
- Or
- $Pb - Pa = 33.75 \times \gamma o - 29.5 \times \gamma w - 4.25 \times \gamma o$
- $= 29.5\ \gamma o - 29.5 \times \gamma w$
- $= 29.5(\gamma o - \gamma w)$
- $\gamma o = 0.86 \times 62.4 = 53.7$ lb/ft3
- $Pb\text{-}Pa = 29.5$ in x $(53.7 - 62.4)$ lb/ft3
- $= 29.5$ in x $(-8.7$ lb/ft3$) \times (1$ ft3/ 1728 in3$)$
- Answer : **$Pb - Pa = -0.15$ lb/in2**

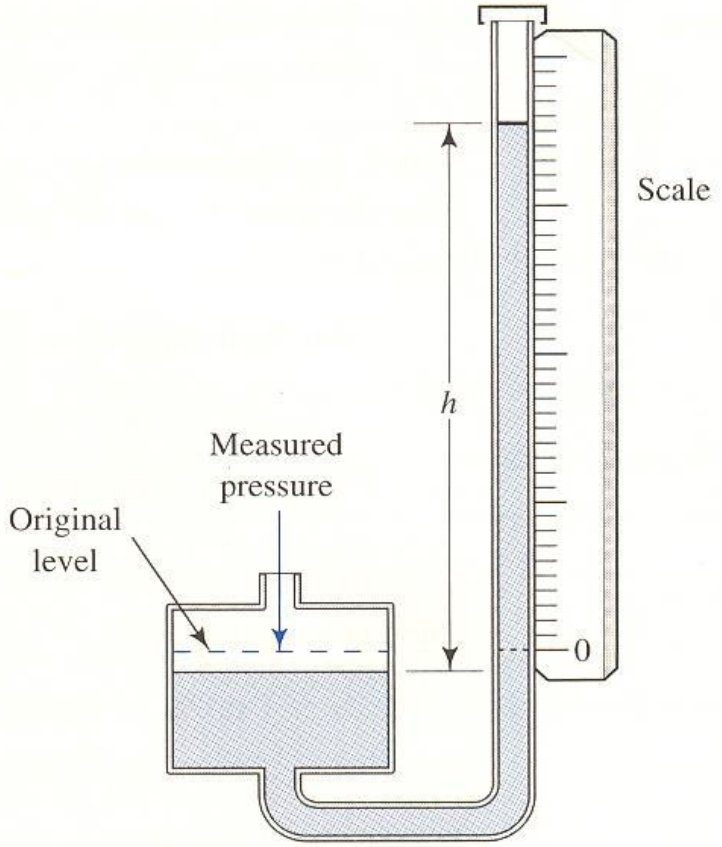
Other types of manometers

Well-type manometer

FIGURE 3.12 Well-type manometer. (Source of photo: Dwyer Instruments, Inc., Michigan City, IN)

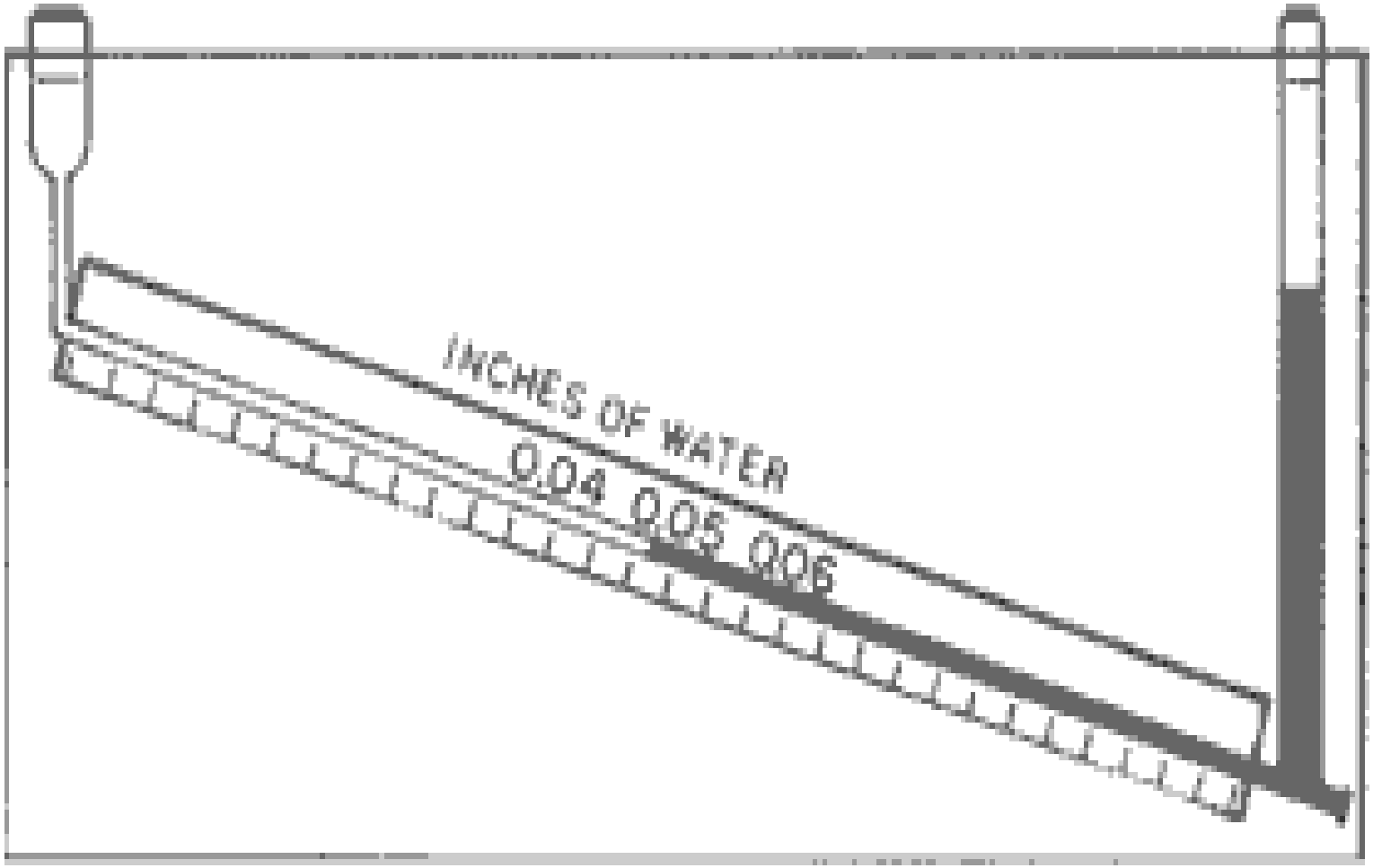


(a)



(b)

Inclined well-type manometer



Barometers

- Device for measuring atmospheric pressure.
- Filled with mercury
- Mercury filled tube is inverted in mercury bath. Mercury column drops a little – filled with mercury vapor at 0.17 Pa.
- The height of the mercury provides the atmospheric pressure

$$0 + \gamma_m h = P_{atm}$$

$$P_{atm} = \gamma_m h$$

- Mercury depth decreases 1.0 inch every 1000 ft of increase in altitude. (pressure will decrease as you go up in the atmosphere).
- Specific wt of mercury changes with temp! So adjustments with temp have to be made!

Pressure gages and transducers

Gage - Pressure sensed mechanically.

Pressure transducer – pressure measured at one point, displayed at another – pressure sensed mechanically and converted into an electrical signal.

Problems

- **Q**. A pressure gage at 19.0 ft from bottom of tank reads =13.19 psi. Another at 14 ft, reads = 15.12 psi.Compute – specific wt, density, and specific gravity of fluid in tank.

Soln. We have two known pressure points and the distance between them!

$$p_2 - p_1 = -\gamma(z_2 - z_1)$$

$(15.12 – 13.19) * 144 = \gamma * (19.0\text{-}14.0)$

Therefore $\gamma = 55.6$ lb/ft3

Remember $\gamma = \rho g$

Therefore, $\rho = 55.6/ 32.2 = 1.73$ slug/ft3

$SG = \gamma_f/ \gamma_w = 55.6/62.4 = 0.891.$

Q.A reservoir of CCl4 has mass of 500 kg and a volume of 0.315m3. Find the weight, density, specific weight and specific gravity.

Soln. m = 500 kg , g = 9.81 m/s2

W = mg = 500*9.81 = 4905 N = 4.905 kN

Density = ρ = m/V = 500/0.315 = 1587 kg/m3

Specific wt =γ = W/V = 4.905/0.315 = 15.57 kN/m3

SG = 15.57/9.81 = 1.59