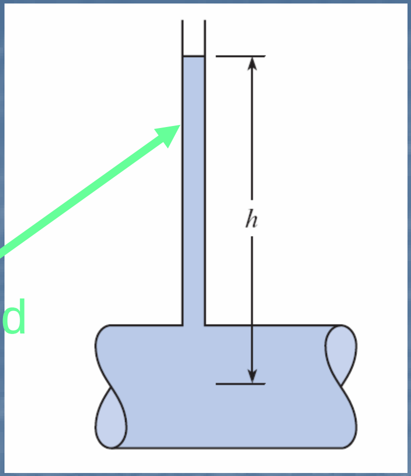
Fluid Statics

PRESSURE MEASURMENTS

Simple Manometer: It is useful for

1. Measuring high pressures
2. Measuring gas pressures

Piezometer attached to a tube



Simple Manometer

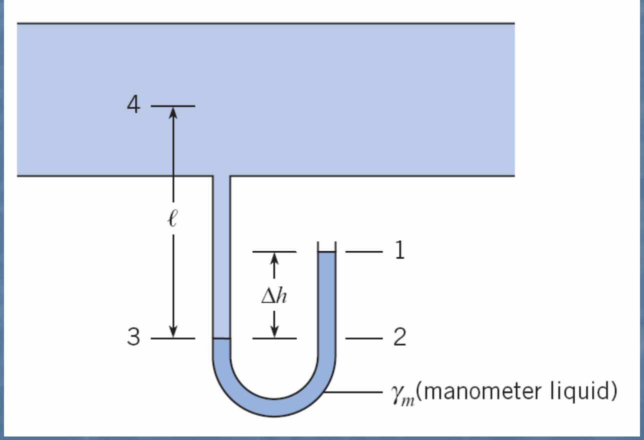
Manometer Equation

$$p = \rho g h = \gamma h$$

$$p_4 = p_1 + \gamma_m \Delta h - \gamma_w l$$

$$p_f = p_i + \sum_{down} (\gamma h) - \sum_{up} (\gamma h)$$

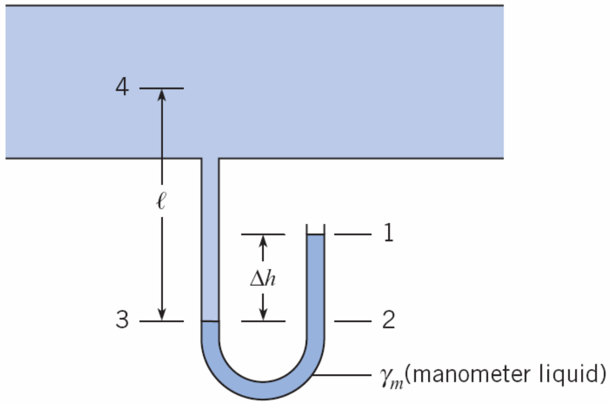
For calculating the pressure using Manometer Eqn. two terms must be known $(\gamma \,\&\, h)$



U-Tube Manometer

Example (3.7, 3.8) is an illustration

Example (3.7)



Water is the liquid in the pipe of Fig. 3.7 and mercury is the manometer fluid. If the deflection Δh is 60 cm and ℓ is 180 cm, what is the gage pressure at the center of the pipe?

Solution Since the manometer is open to the atmosphere, we know that the gage pressure at point 1, the mercury surface, is zero. Then the pressure at 2 will be

$$p_2 = p_1 + \text{change in pressure between 1 and 2} = 0 - \gamma_m \Delta h$$
$$= 0 - \gamma_m(-0.60) \qquad \text{where } \gamma_m = 133 \text{ kN/m}^3$$
$$= 79.8 \text{ kPa}$$

Point 3 is at the same elevation as point 2 and in the same fluid; therefore, $p_3 = p_2$. The next step is to evaluate Δp from 3 to 4 and to apply this to the pressure at 3:

$$\Delta p_{3\rightarrow 4} = -\gamma \times 1.80 \qquad \text{where } \gamma = 9810 \text{ N/m}^3$$
$$= -17.66 \text{ kPa}$$

Then

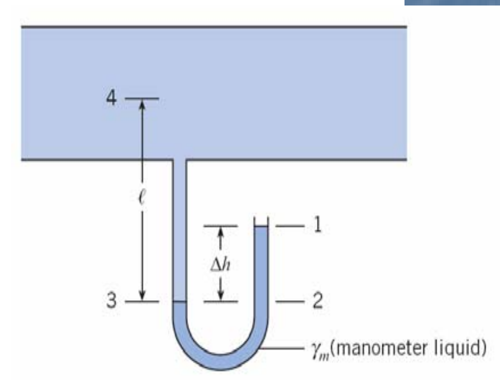
$$p_4 = p_3 - 17.66 \text{ kPa} = 62.1 \text{ kPa gage}$$

Example (3.8)

Air at 20°C is the fluid in the pipe of Fig. 3.7, and water is the manometer fluid. If the deflection Δh is 70 cm and ℓ is 140 cm, what is the gage pressure in the pipe? Also compute this pressure by neglecting the pressure change due to the 140-cm column of air. Assume standard atmospheric pressure.

Solution The specific weight of air is found from Eq. (3.12), which requires that the air pressure be known. Therefore, the air pressure at the bottom of the 70-cm column is first calculated:

$$p_{\text{air}} = 9790\ \text{N/m}^3 \times 0.70\ \text{m} = 6853\ \text{Pa gage}$$



Then the absolute air pressure is given as

$$p_{\text{air}} = 6853\ \text{Pa} + 101{,}300\ \text{Pa} = 108.15\ \text{kPa}$$

Then $$\rho_{\text{air}} = \frac{p}{RT} = \frac{108{,}150\ \text{N/m}^2}{287\ \text{J/kg K} \times (20 + 273)\ \text{K}} = 1.286\ \text{kg/m}^3$$

or $$\gamma_{\text{air}} = 1.286\ \text{kg/m}^3 \times 9.81\ \text{m/s}^2 = 12.62\ \text{N/m}^3$$

Now compute the gage pressure in the pipe:

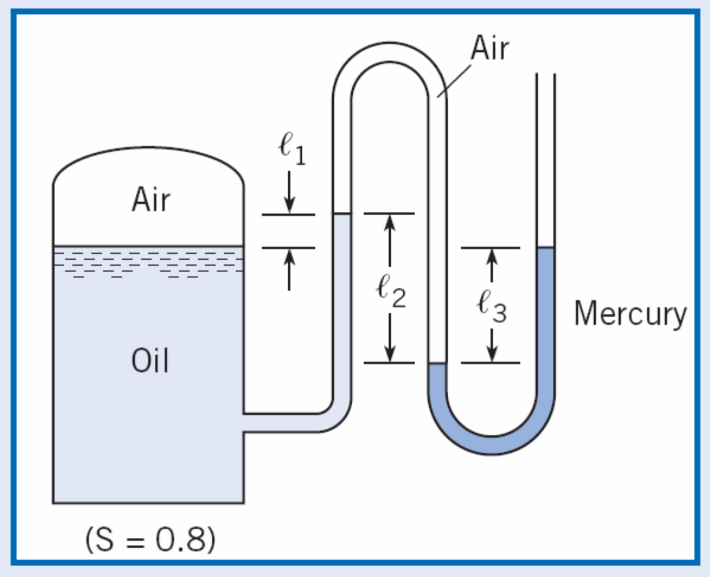
$$p_{\text{pipe}} = 6853\ \text{Pa} - 1.4\ \text{m} \times 12.62\ \text{N/m}^3 = 6835\ \text{Pa} \quad \triangleleft$$

If the effect of the air column is neglected, the gage pressure in the pipe is

$$p_{\text{pipe}} = 9790\ \text{N/m}^3 \times 0.70\ \text{m} = 6853\text{Pa} \quad \triangleleft$$

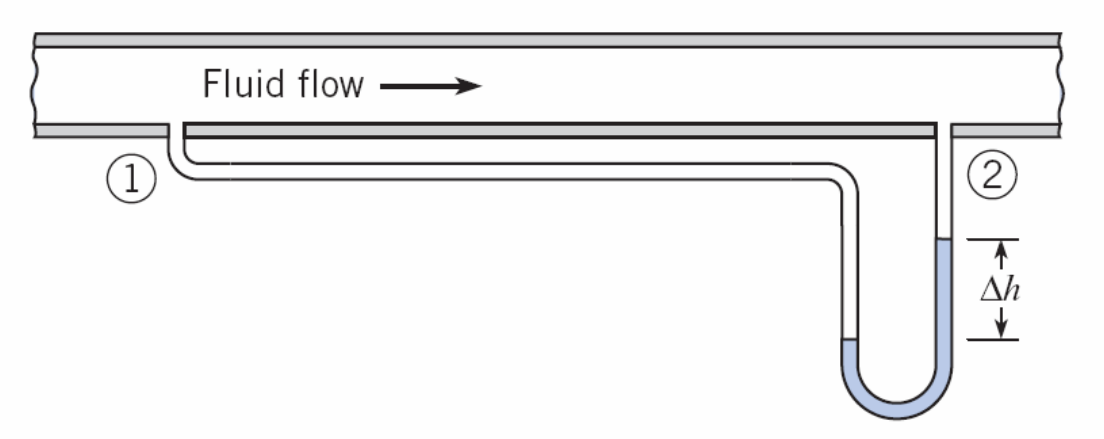
Fluid Statics

Example (3.9) is an illustration where The column of air is neglected

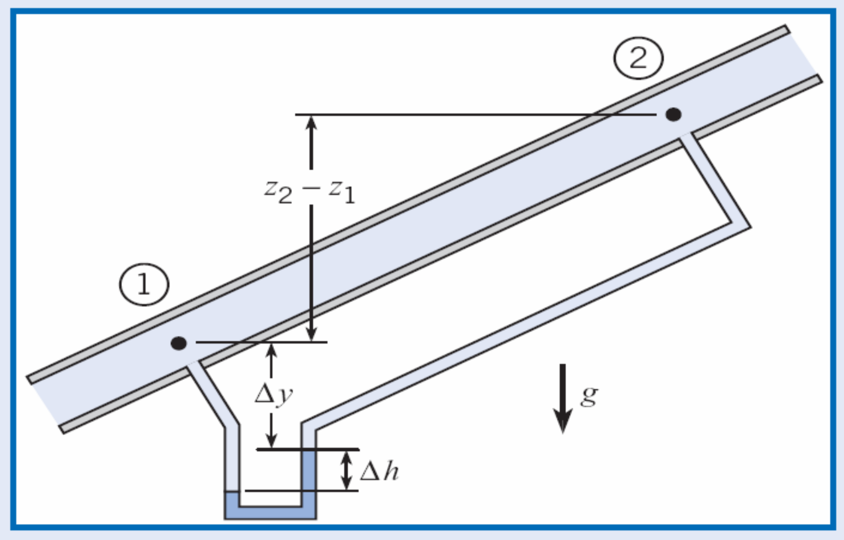


Differential Manometer

$$p_1 - p_2 = (\gamma_m - \gamma_f)\Delta h$$



Fluid Statics



Required

1. Piezometric Pressure (1-2).
2. Piezometric Head(1-2).

Piezometric Pressure (1-2) =

$$p_{z_2} - p_{z_1} = (p_2 + \gamma_w z_2) - (p_1 + \gamma_w z_1)$$

Piezometric Head (1-2) $h_2 - h_1 = \dfrac{p_{z_2} - p_{z_1}}{\gamma_w}$

$$p_2 = p_1 + \gamma_w(\Delta y + \Delta h) - (\gamma_m \Delta h) - \gamma_w(\Delta y + z_2 - z_1)$$

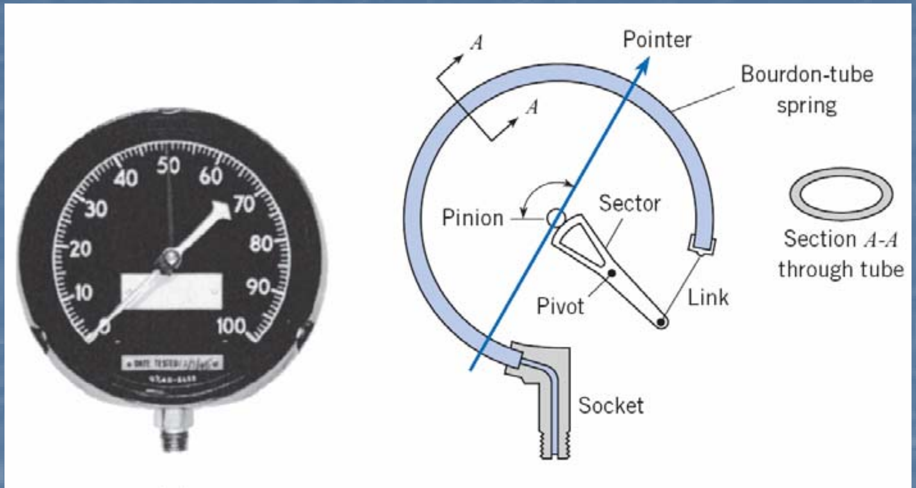
$$p_2 - p_1 = (\gamma_w \Delta h) - (\gamma_m \Delta h) - \gamma_w(z_2 + z_1)$$

Piezometric Pressure (1-2) = $(p_2 + \gamma_w z_2) - (p_1 + \gamma_w z_1) = \Delta h(\gamma_w - \gamma_m)$

Piezometric Head(1-2) = $h_2 - h_1 = \dfrac{\Delta h\,(\gamma_w - \gamma_m)}{\gamma_w}$

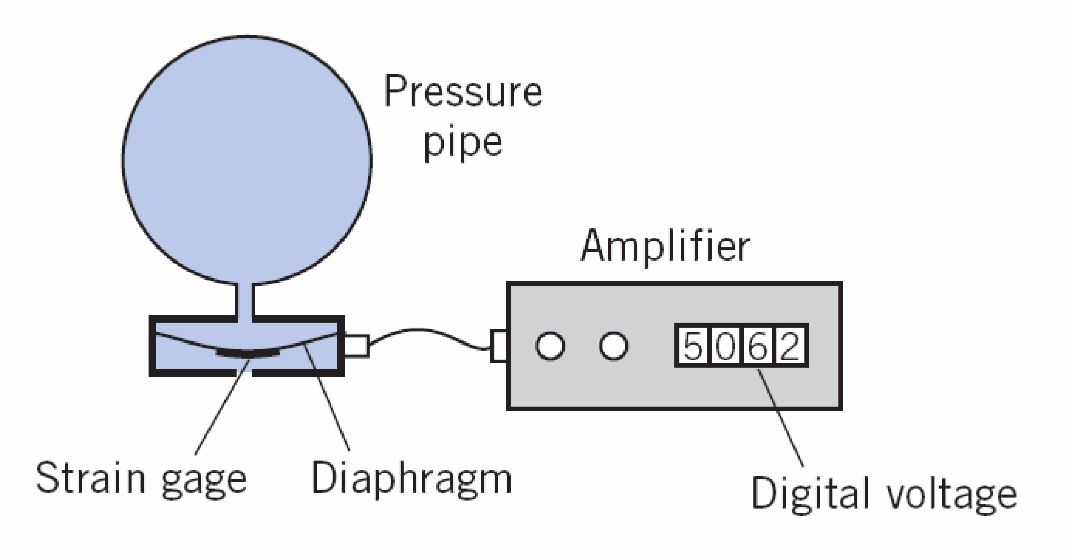
Fluid Statics

Bourdon- Tube Gauge



(a)
(b)

Pressure Transducer



END OF LECTURE (4)