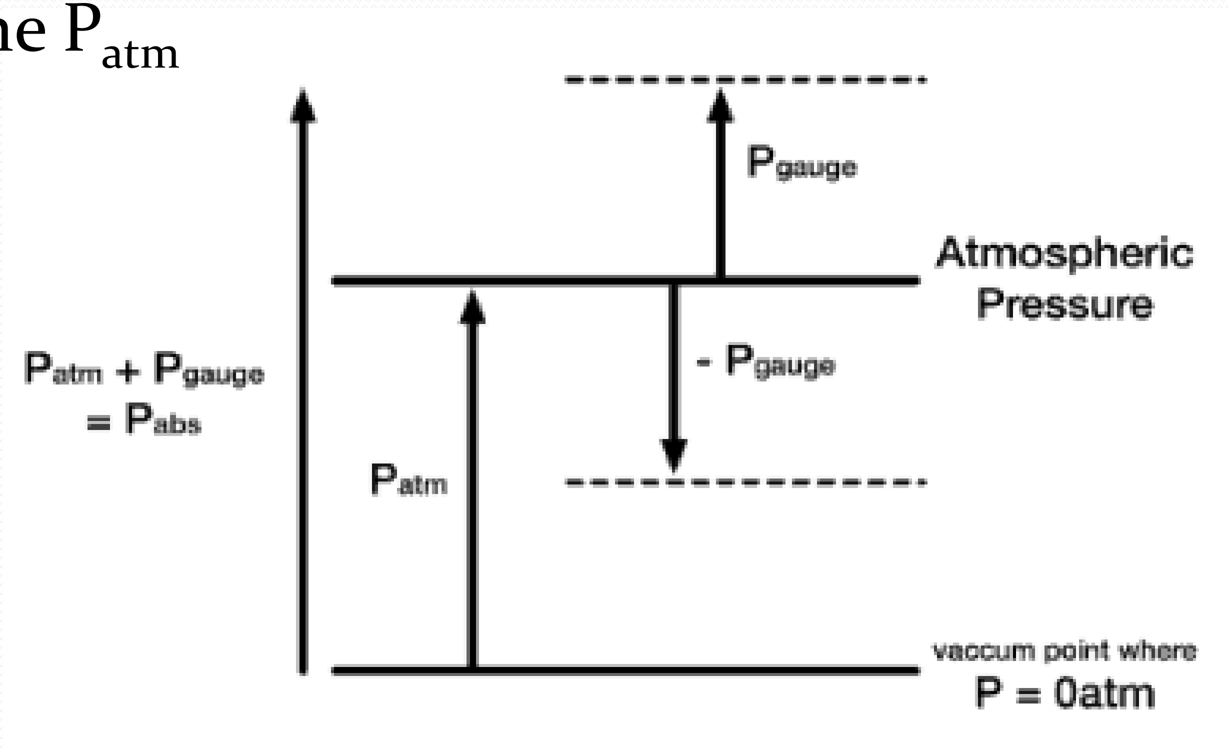
Applied hydraulics water pressure and pressure forces

Ms Hala rawabdeh

Absolute and gauge pressure

P_{abs} : related to the vacuum,

P_{gauge} : related the P_{atm}



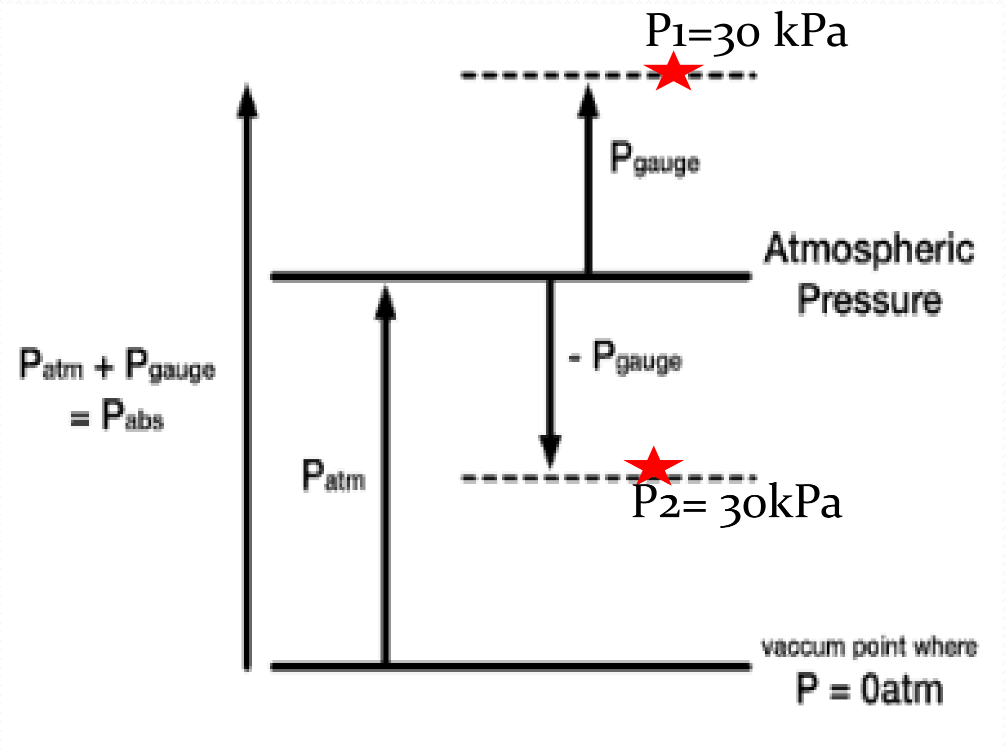
Ex:

$P1_{abs}$ = 101.4+30= 131.4 kPa

$P1_{gauge}$ = 30 kPa

$P2_{abs}$ = 101.4-30= 71.4 kPa

$P2_{gauge}$ = - 30 kPa



Pressure

Pressure between two points

X-axis $\leftarrow - \quad + \rightarrow$

$$\sum F_x = P_B A - P_A A - W \sin\theta = 0$$

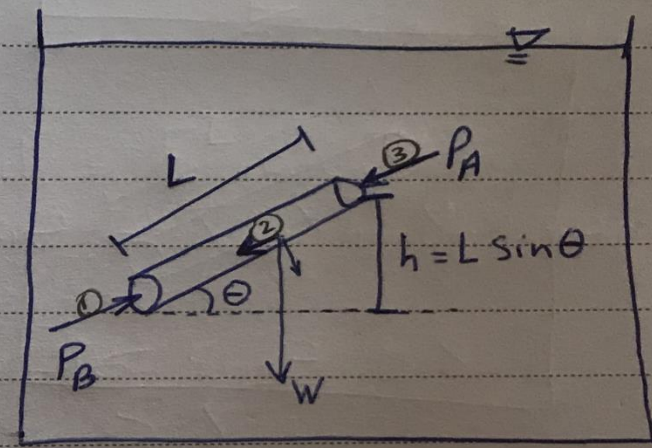
$$\therefore W = \forall \gamma = A L \gamma$$

$$\sum F_x = P_B A - P_A A - A L \gamma \sin\theta = 0$$

$$P_B - P_A = L \gamma \sin\theta$$

$$\therefore h = L \sin\theta$$

$$\boxed{P_B - P_A = \gamma h}$$



- If two points at same elevation h=o and $P_A=P_B$
- If point A at atmosphere

$$P_B = \gamma h + P_A$$

$$= \gamma h + P_{atm}$$

$$P_{abs} = P + P_{atm}$$

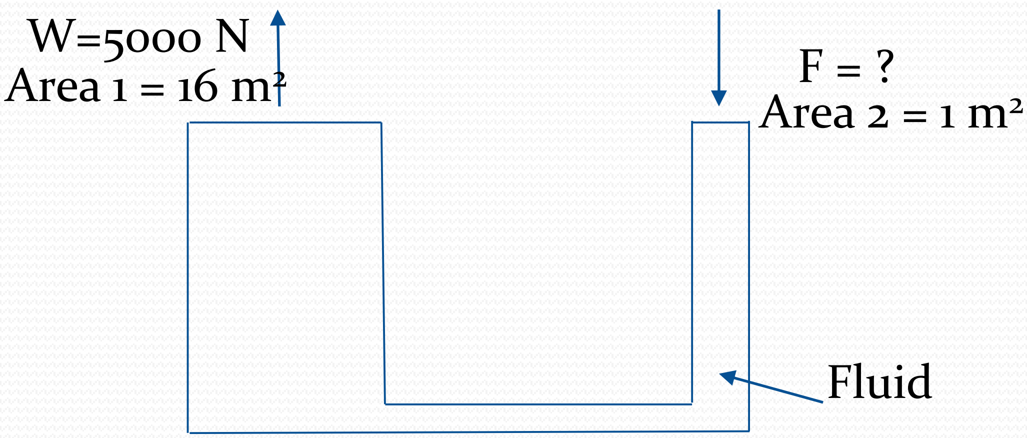
$$P_{gauge} = P_{abs} - P_{atm}$$

so $P = \gamma h$

Pressure

- Pascal law: ”Pressure applied at any point in *a liquid* is transmitted equally and undiminished in all direction to every other point in the liquid “

Application: Hydraulic jack



$P_1 = P_2$

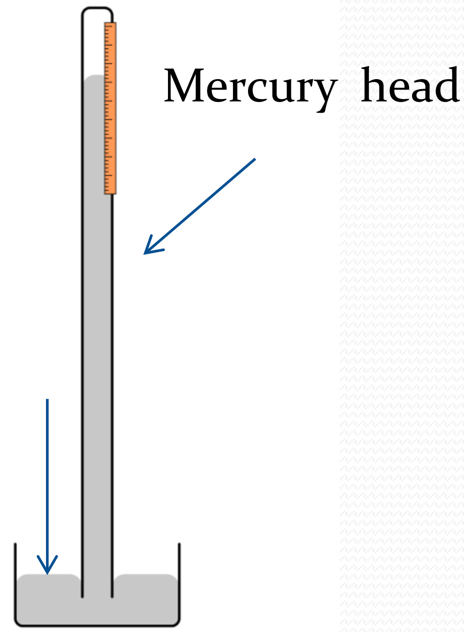
$$\frac{W}{A_1} = \frac{F}{A_2}$$

$$\frac{5000}{16} = \frac{?}{1}$$

F=312.5 N

Pressure

Atmospheric Pressure: Torricelli experiment



Atmospheric pressure

$$P_{atm} = \gamma_{Hg} h_{Hg}$$

$$\gamma_{Hg} = 13.6 \; x \; \gamma_{water}$$

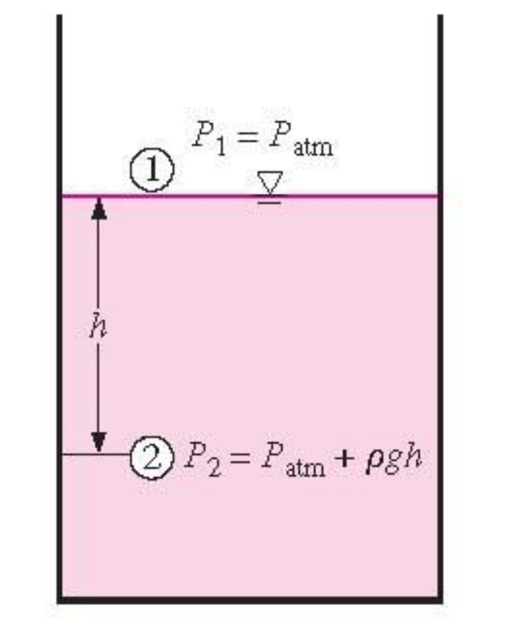
$$P_{atm} = 13.6 \; x \; 9810 \; x \; 0.759 \approx 101325 \; pa$$

Water head = 10.33 m

Pressure

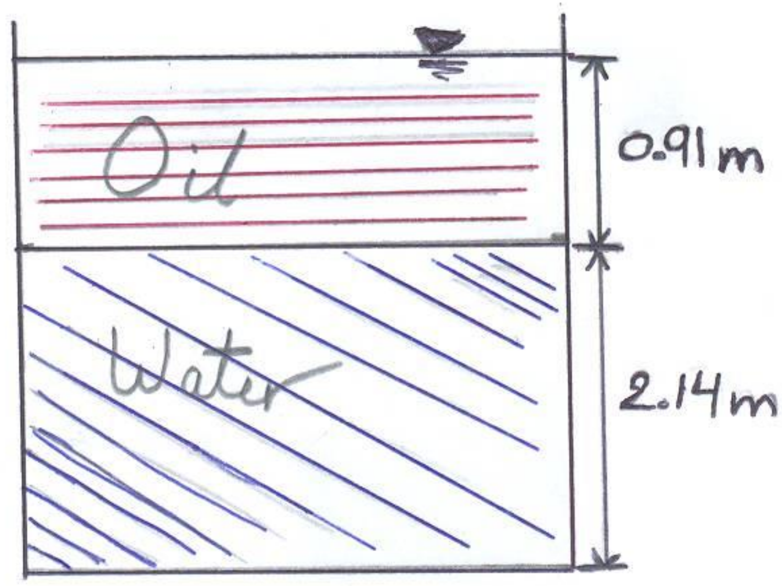
Depth variation

$P_2 = P_1 + \gamma h$



- **Oil with a specific gravity of 0.80 is 0.91 m deep in an open tank which is otherwise filled with water. If the tank is 3.05 m deep, what is the pressure at the bottom of the tank?**

Answer: 28.135 kPa



Equal pressure

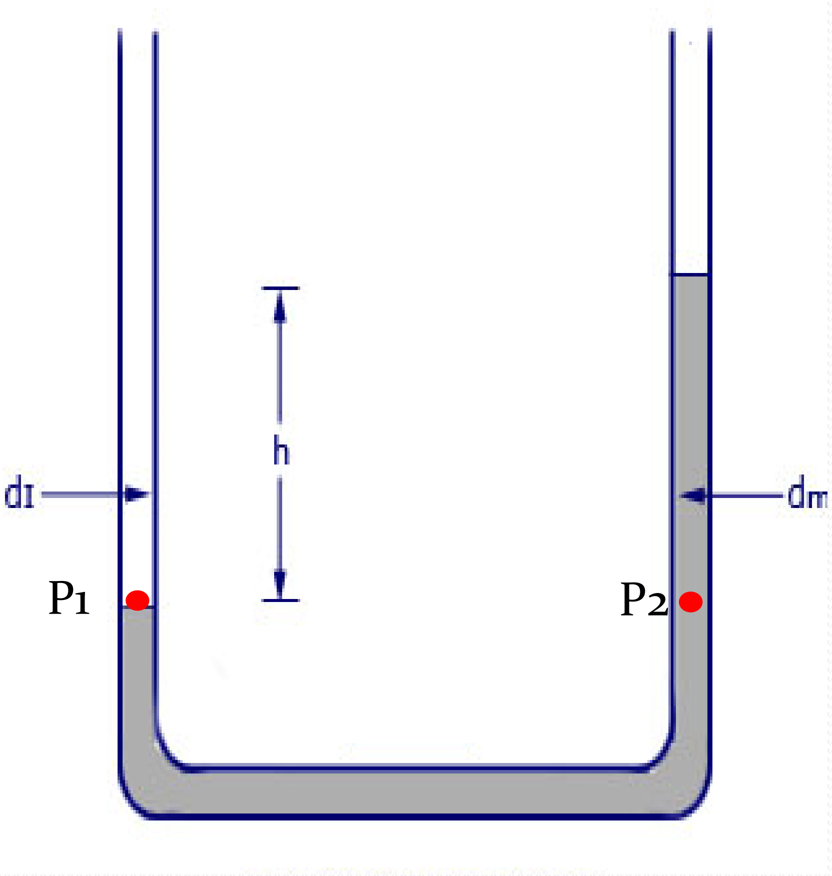
$P_1 = P_2$

If the points on the surface be

1. in the same liquid
2. Same elevation
3. The liquid containing the points be connected

$P_1 = P_2$

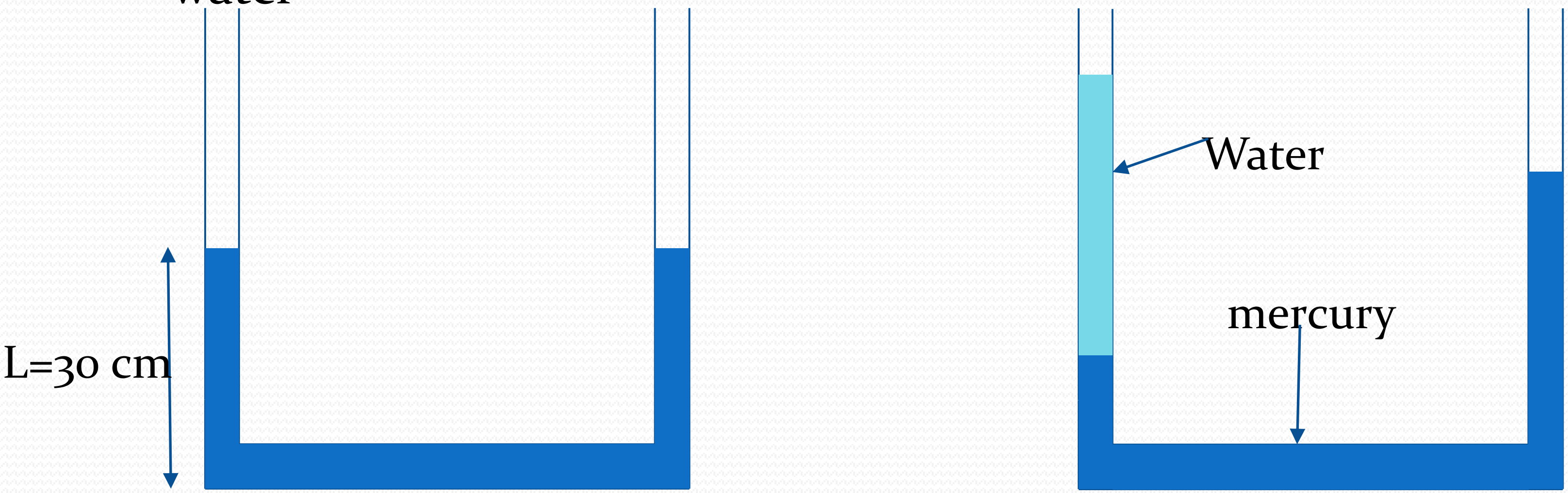
$P_{atm} = P_{atm} + \gamma h$



Manometer

Example: If water was added to one side of the manometer below until the height of water column reaches 40 cm. Both sides of the manometer are open to atmosphere. SG of Hg = 13.6

1. Determine the rise of mercury in the other side of the manometer.
2. The difference between the mercury height before and after adding water



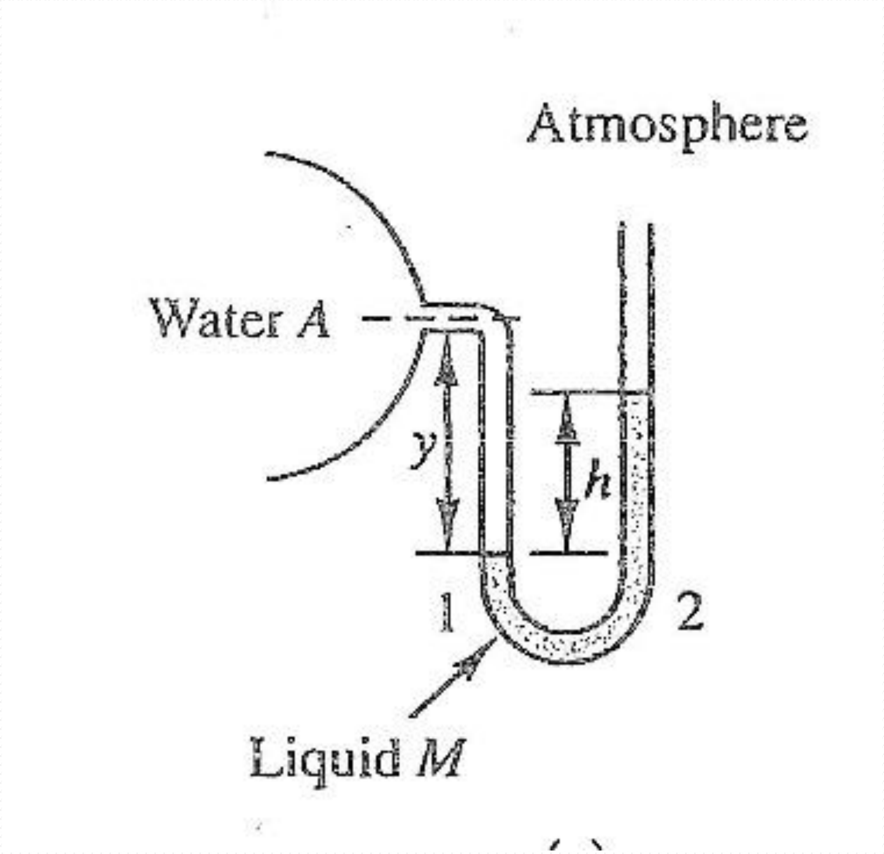
Answer 1. hm = 2.94 cm

2. The difference in hm = 1.47 cm

- للفرع التاني الحل من قاع المانوميتر

13.6*9810 (30- الانخفاضh) +water =13.6*9810(30+ الارتفاعh)

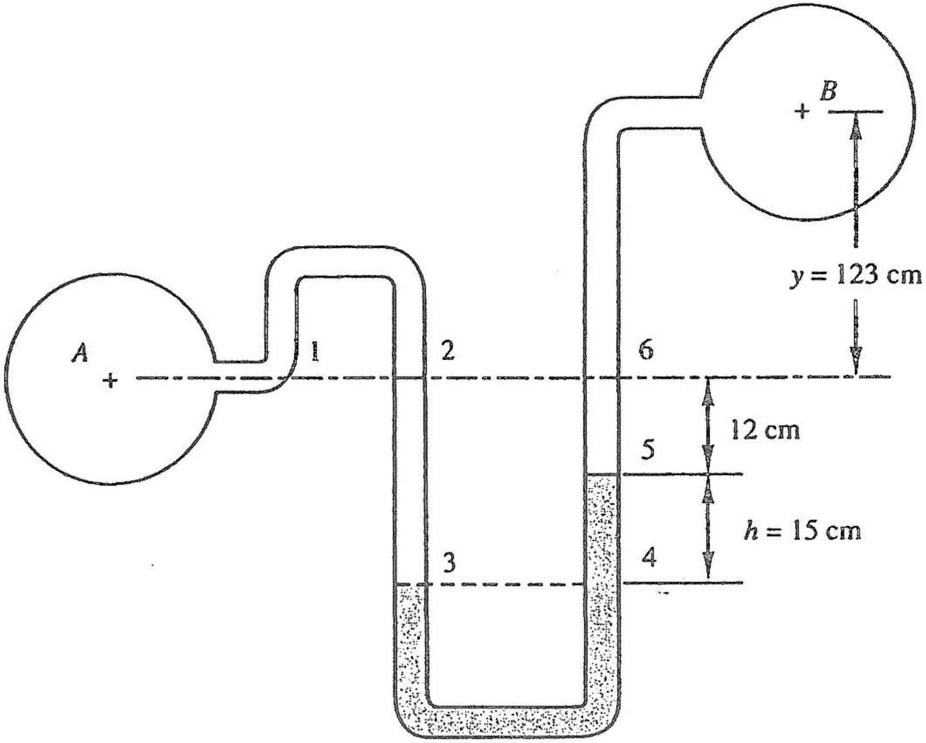
Manometer



$$P_A + \gamma_w \cdot y = P_{atm} + \gamma_m \cdot h$$

Manometer

- Example



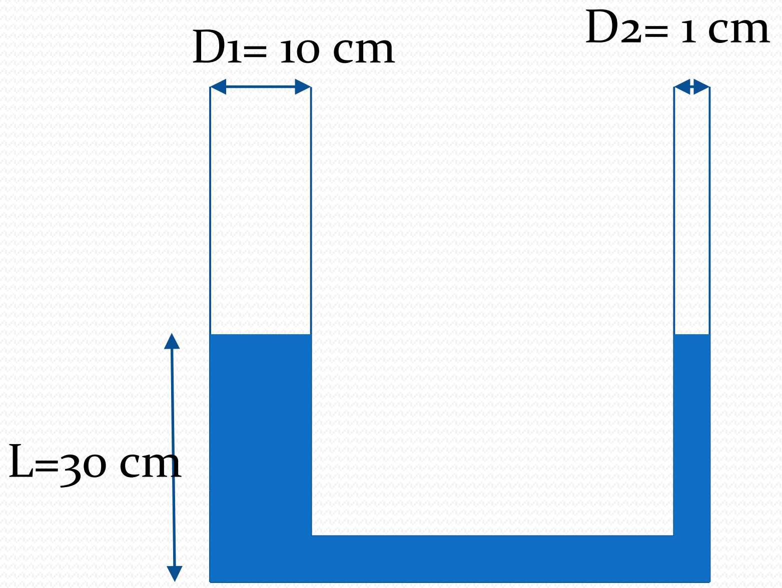
Determine the pressure difference between A and B

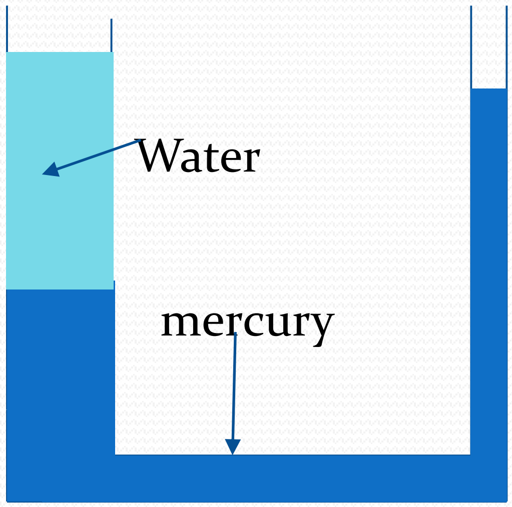
Mercury specific gravity = 13.6

Answer:
ΔP = 30607.2 Pascal

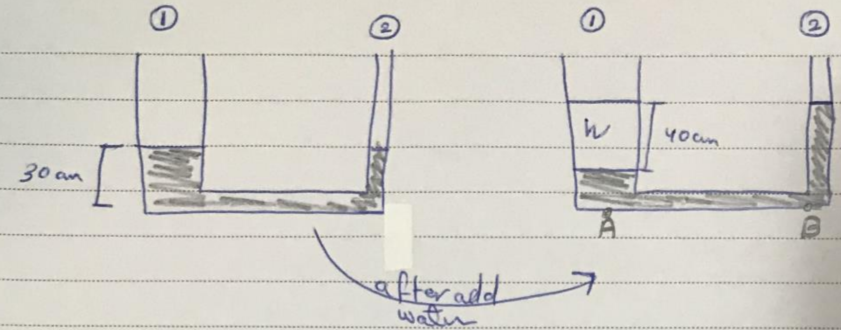
Manometer

Example: If water was added to one side of the manometer below until the height of water column reaches 40 cm. Both sides of the manometer are open to atmosphere. SG of Hg = 13.6 . Determine the mercury height in two side after adding water(down and rise)





Answer: h_2=2.91 cm, h1 = 0.029 cm



$$\forall_{1m}\,(\text{down}) = \forall_{2m}\,(\text{rise})$$

$$A_1 h_1 = A_2 h_2$$

$$\frac{\pi}{4} D_1^2 h_1 = \frac{\pi}{4} D_2^2 h_2 \Rightarrow 100 h_1 = 1 h_2 \Rightarrow \boxed{h_1 = 0.01\, h_2} \quad \text{--- (1)}$$

$$P_A = P_B$$

$$\text{atm} + \gamma_w (h_w) + \gamma_w\, 13.6\, (30 - h_1) = \text{atm} + \gamma_w\, 13.6\, (30 + h_2)$$

$$40 + 408 - 13.6 h_1 = 408 + 13.6 h_2$$

$$\boxed{40 - 13.6 h_1 = 13.6 h_2} \quad \text{--- (2)}$$

(1) & (2)

$$40 - 13.6(0.01 h_2) = 13.6 h_2$$

$$40 - 0.136 h_2 = 13.6 h_2$$

$$+0.136 h_2 \qquad +0.136 h_2$$

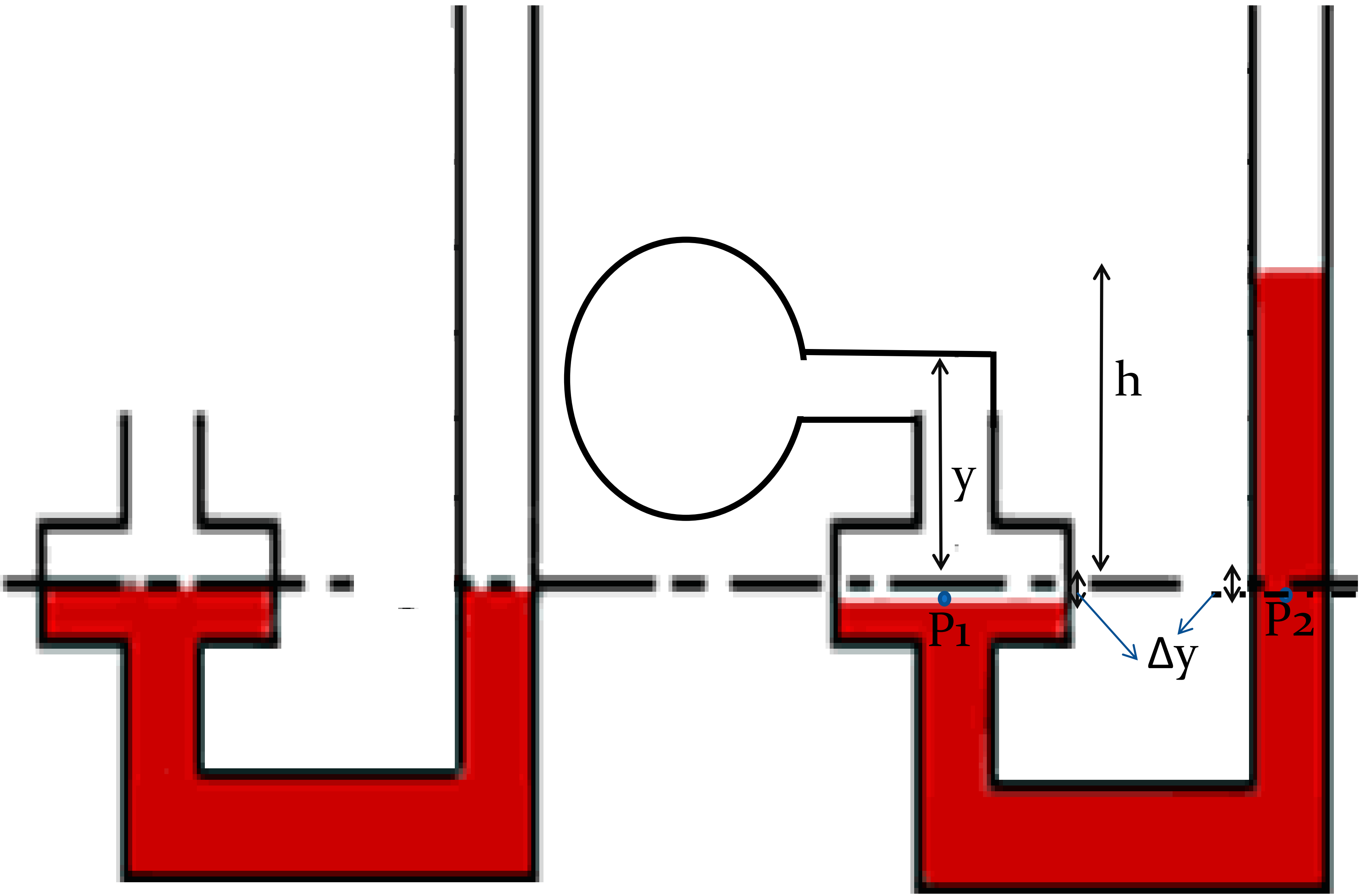
$$40 = 13.736 h_2$$

$$\therefore \boxed{h_2 = 2.91\,\text{cm}}$$

$$h_1 = 0.01 \times 2.91 \Rightarrow \boxed{h_1 = 0.029}$$

Manometer

- Manometers require readings of liquid levels at two points. However, we can create a single reading manometer by adding larger reservoir.


h
y
P1
Δy
P2

$\forall_1$ down $= \forall_2$ rise

$A_1 \, \Delta y = A_2 \, h$

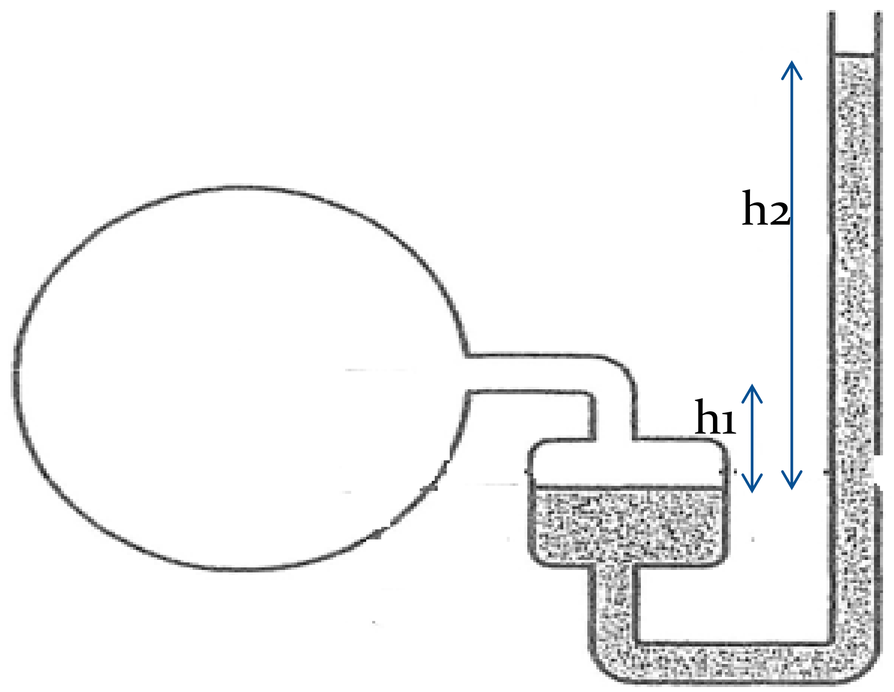
$\Delta y = \frac{A_2}{A_1} h \Rightarrow \boxed{\Delta y = \left(\frac{D_2}{D_1}\right)^2 h}$ ---- ①

$P_1 = P_2$

$P_A + \gamma_w (y + \Delta y) = \cancel{P_{atm}} + \gamma_m (h + \Delta y)$

$P_A + \gamma_w (y + \Delta y) = \gamma_m (h + \Delta y)$

- Determine the pressure in kPa in the pipe if h_1=20cm, h_2=67cm.
- Also determine the change in liquid height h_1 for a 10cm rise in h_2. if the diameter of the manometer tube is 0.5 cm and the diameter of the manometer fluid reservoir is 5cm



Answer: 1. 87.4 kPa

2. Δy=0.1 cm

$P_1 = P_2$

$P_A + h_1 \gamma_w = h_2 \gamma_m$

$P_A = 0.67 * 13.6 * 9810 - 0.2 * 9810$

$P_A = 87.4 \text{ kPa}$

$\forall_1 = \forall_2$

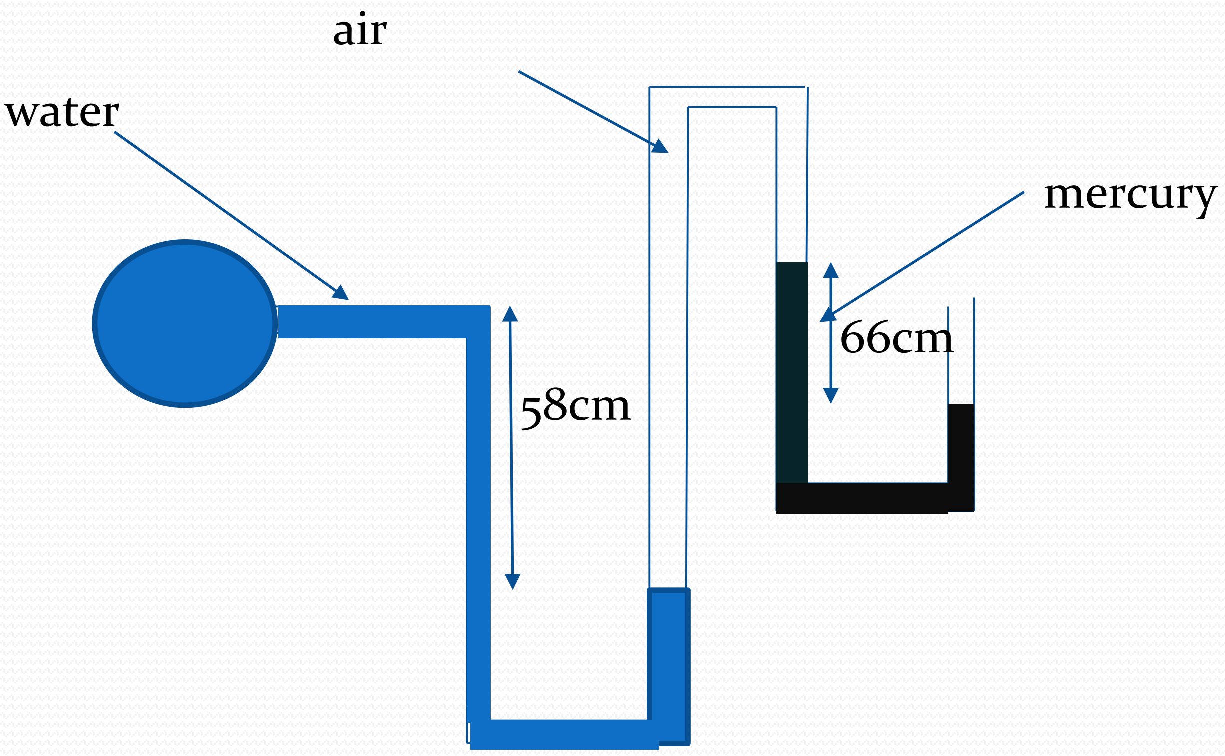
$A_1 \Delta y = A_2 * 10 \text{ cm}$

$\Delta y = \frac{0.5^2}{5^2} \times 10$

$\Delta y = 0.1 \text{ cm}$

Manometer

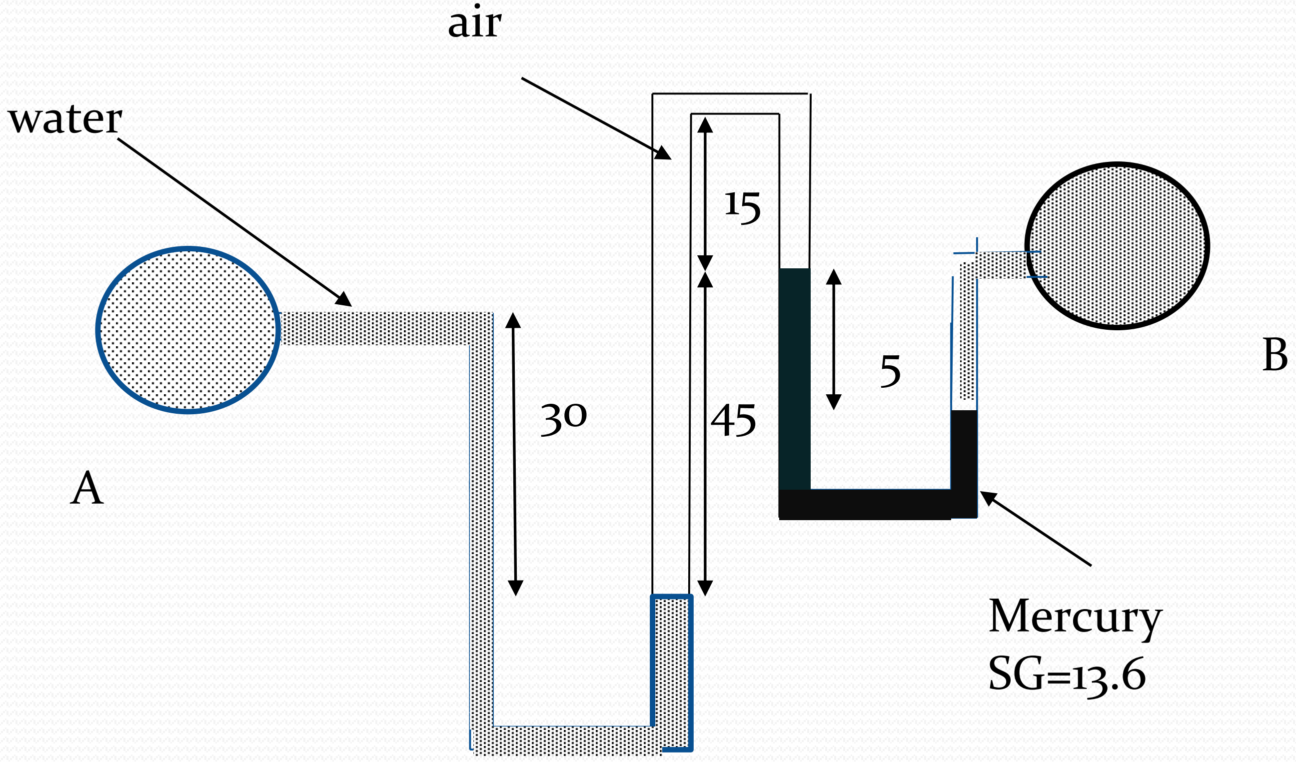
Determine the pressure in the water pipe.



Answer:
P= - 93.7 kPa

Manometer

Determine the pressure difference between points A and B.

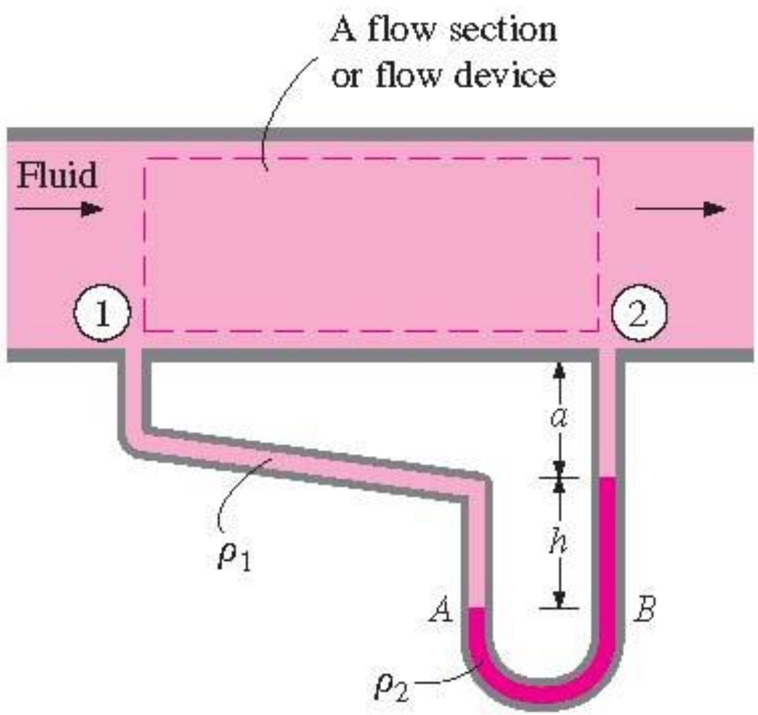


Answer:

$P_B - P_A = 912330$ *Pa*

$P_A - P_B = -912330$ *Pa*

Manometer



Determine the difference in water pressure between 1 and 2. The manometer fluid is mercury (SG=13.6). h=18 cm and a = 8 cm

Answer:
$P_1 - P_2$ =22249.08 Pa