# Model answer

## Midterm exam. In Fluid mechanics (MPE171) 2015-2016

**Question (1)** **The viscosity of oil (1) is three times of viscosity of oil (2) ($\mu_1=3\mu_2$). When the force F required to pull the plate at velocity V=40 cm/s is 30 N per unit area. Calculate the viscosity of each oil. (shown in Fig. 1)**

**Given:** V=0.4 m/s, F= 30 N, A=1 m², $\mu_1=3\mu_2$
$y_1$=0.5 cm , $y_2$=0.7 cm
**Required:** $\mu_1$ and $\mu_2$

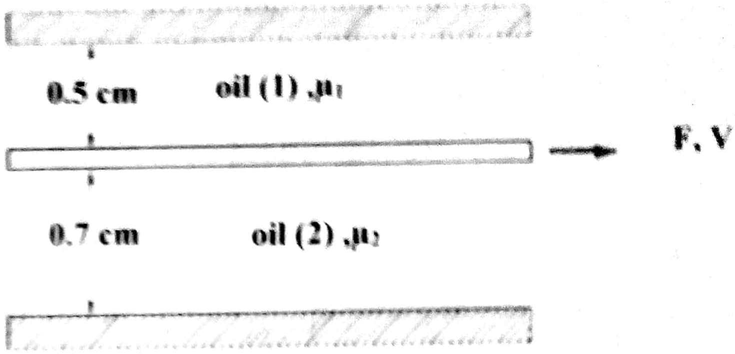



Fig. 1

**Solution:**

$$F = F_1 + F_2 = \mu_1 A \frac{V}{y_1} + \mu_2 A \frac{V}{y_2}$$

$$30 = 3\mu_2 \frac{0.4}{0.5 \times 10^{-2}} + \mu_2 \frac{0.4}{0.7 \times 10^{-2}}$$

$$\therefore \mu_2 = 0.1\ Pa.s$$

and $\mu_1 = 3\mu_2 = 0.3\ 02\ Pa.s$

**Question (2) :** In Fig. 2 the water and gasoline surfaces are open to the atmosphere and at the same elevation. What is the height h of the third liquid in the right leg

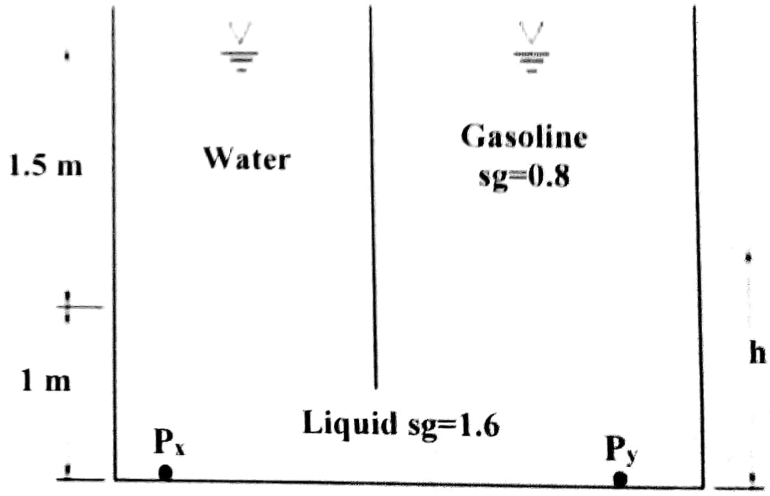



Fig. 2

$$P_x = P_y$$

$$\rho_L g \times 1 + \rho_w g \times 1.5 = \rho_L g \times h + \rho_G g \times (2.5 - h)$$

$$1600 x g \times 1 + 1000 x g \times 1.5 = 1600 x g \times h + 800 x g \times (2.5 - h)$$

h= 1.375 m

**Question (3) :** Calculate all the forces on the gate (3 m width) and the location of their line of action. Calculate the minimum force F necessary to keep the gate closed. (shown in Fig. 3)

**Gate A-B**

$h_{c1} = 1m$ , $A = 6\ m^2$

$F_1 = \rho\ g\ h_{c1}\ A = 1000 \times 9.81 \times 1 \times 6 = 58860N$

$I = bh^3/12 = 3 \times 2^3/12 = 2\ m^4$

$h_{p1} = h_{c1} + I/(Ah_{c1}) = 1 + 2/(6 \times 1) = 1.333\ m$

**Gate B-C**

$h_{c2} = 2m$, $A = 6\ m^2$

$F_2 = \rho\ g\ h_{c2}\ A = 1000 \times 9.81 \times 2 \times 6 = 117720N$

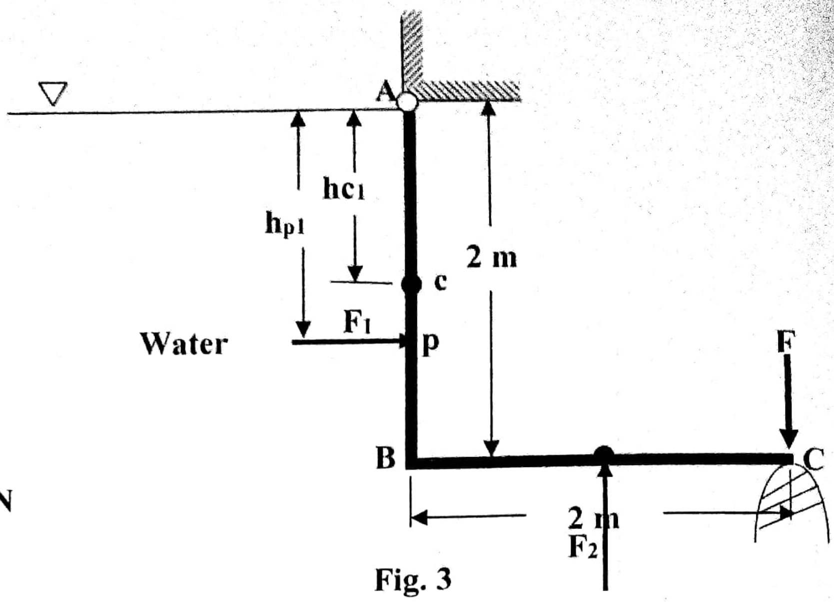



Fig. 3

$$\sum_A M = 0$$

$F \times 2 - F_2 \times 1 - F_1 \times h_{p1} = 0$

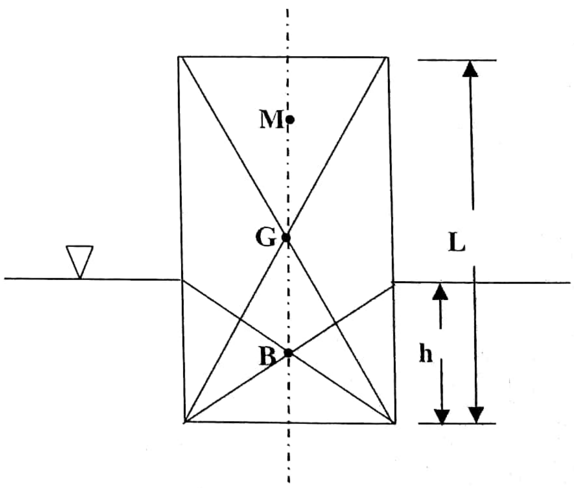
$F \times 2 - 117720 - 58860 \times 1.3333 = 0$

$F = 98090\ N = 98.09\ kN$

**Question (4) :** . Consider a homogeneous right circular cylinder of length L, diameter D, and specific gravity sg, floating in water . Show that the body will be stable with its axis vertical if:

$$\frac{D}{L} \geq \sqrt{8 \times sg(1 - sg)}$$

$\overline{BM} \geq \overline{BG}$ ....................(1)




$W = F_B$

$\rho_b\ g\ V = \rho_f\ g\ V_s$

$\rho_b\ g\ A\ L = \rho_f\ g\ A\ h$

$$h = \frac{\rho_b}{\rho_f} L = sg\ L$$

$$\overline{BG} = \frac{L}{2} - \frac{h}{2} = \frac{L}{2} - \frac{sgL}{2} = \frac{L}{2}(1 - sg) \quad \text{....................(2)}$$

$$\overline{BM} = \frac{I}{V_s} = \frac{\frac{\pi}{64} D^4}{\frac{\pi}{4} D^2 h} = \frac{D^2}{16 \times sgL} \text{........................(3)}$$

**From (2) and (3) substitute in (1)**

$$\frac{D^2}{16\ \times s.gL} \geq \frac{L}{2}(1 - sg)$$

$$\frac{D^2}{L^2} \geq 8\ sg(1 - sg)$$

$$\therefore \frac{D}{L} \geq \sqrt{8\ s.g(s.g - 1)}$$