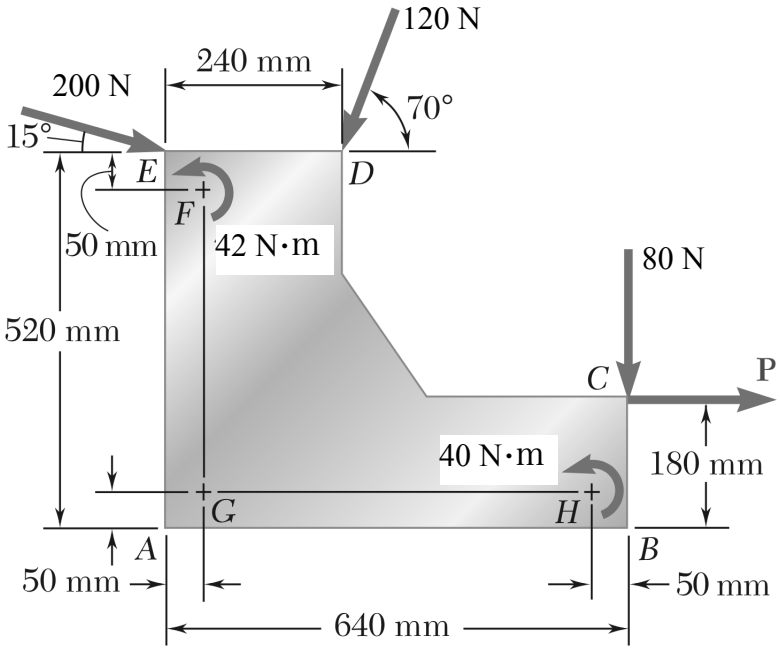
DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
CE102 ENGINEERING MECHANICS
QUIZ 1

Date: 04-02-2019 Maximum Marks: 10
Time: 09.30 pm – 10.30 pm

Read the questions carefully. Show the steps clearly and mark the final answers. Assume suitable additional data, if required, and state the same clearly. Both questions carry equal weightage.

1. A machine component is subjected to the forces and couple moments as shown in **Figure 1**. The component is to be held in place in equilibrium by a single screw that can **resist** a **force** but **not a couple moment**. For ***P*** = **60 N**, determine the location of the screw hole if it is to be located **(a) on line *FG***, and **(b) on line *GH*. Express this location with respect to point G.**



2. For a **gate width** of **2 m** into the paper, as shown in **Figure 2**, determine the force ***F*** required to hold the gate ***ABC*** at its location. Neglect the weight of the gate.

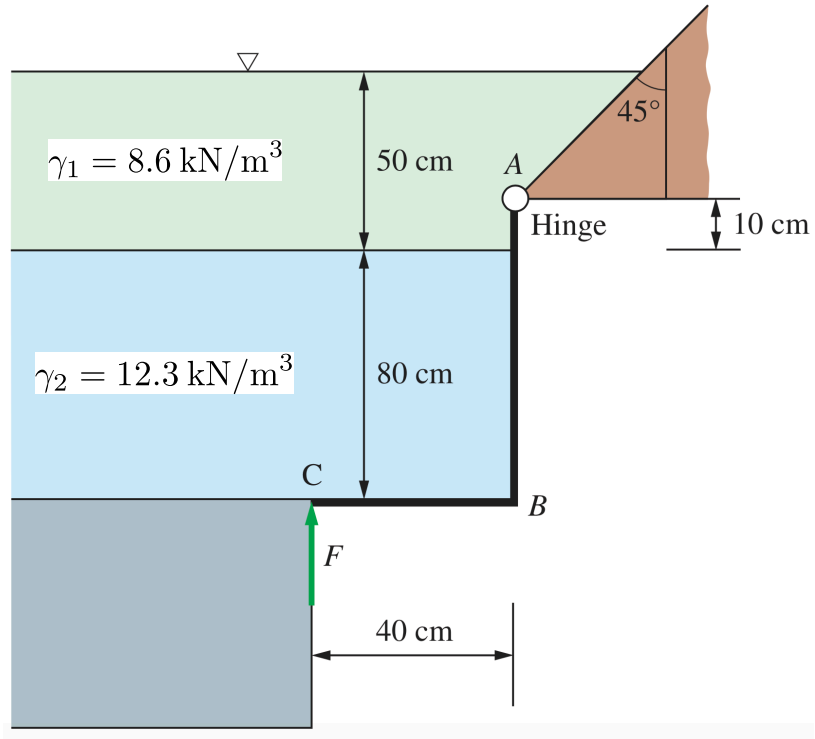
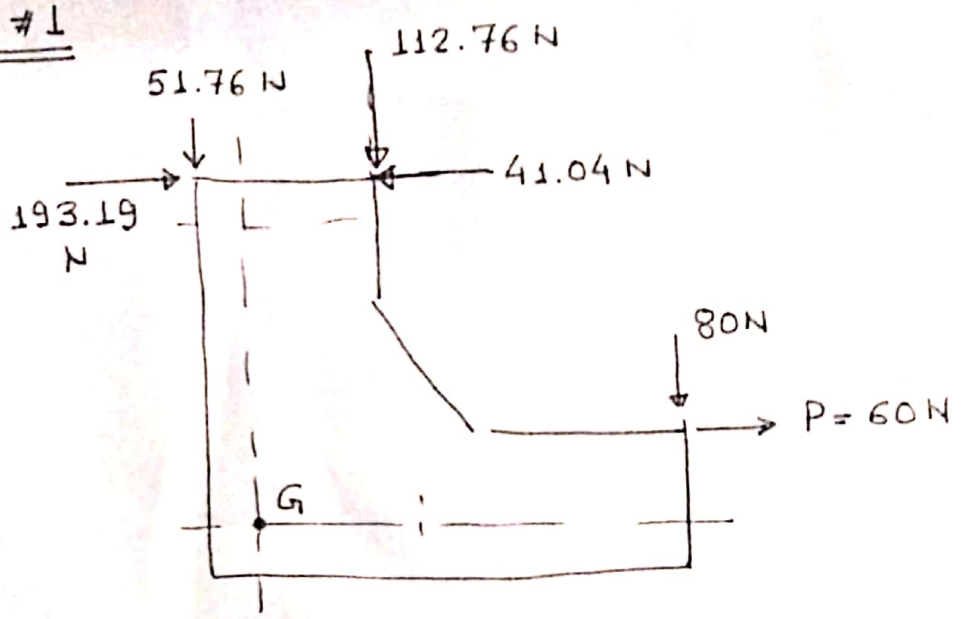


Figure 2

Solution by Prof. A. Goyal

Q#1



Forces transferred to G

$\xrightarrow{+} F_x \quad +193.19 + 60 - 41.04 = 212.15 \text{ N} \rightarrow$

$+\downarrow F_y \quad +51.76 + 112.76 + 80 = 244.52 \text{ N} \downarrow$

$\overset{+}{\circlearrowleft} M_G \quad +42 \text{ N-m} + 40 \text{ N-m} - 80 \text{ N} \times 0.59 \text{ m} - 60 \text{ N} \times 0.13 \text{ m}$

$(-193.19 \text{ N} + 41.04) \times 0.47 \text{ m} - 112.76 \text{ N} \times 0.19 \text{ m}$

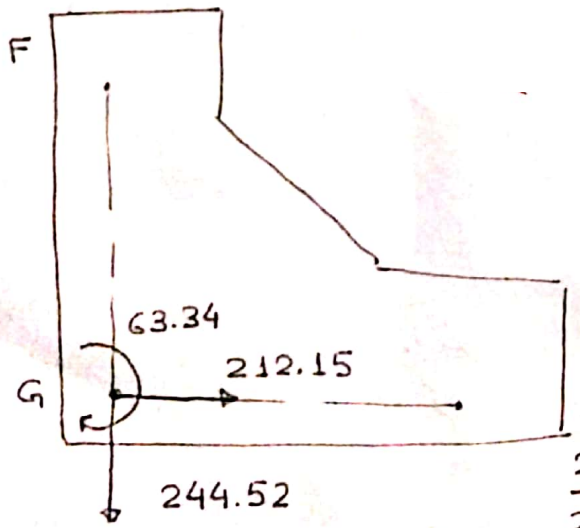
$+ 51.76 \text{ N} \times 0.05 \text{ m}$

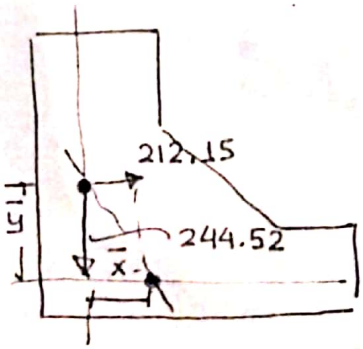
$= 84.588 - 47.2 - 7.8 - 71.51 - 21.42 \text{ N-m}$

$= -63.34 \text{ N-m} \circlearrowright$

Line FG: $\bar{y} = \frac{63.34}{212.15} \simeq +298.5 \text{ mm}$

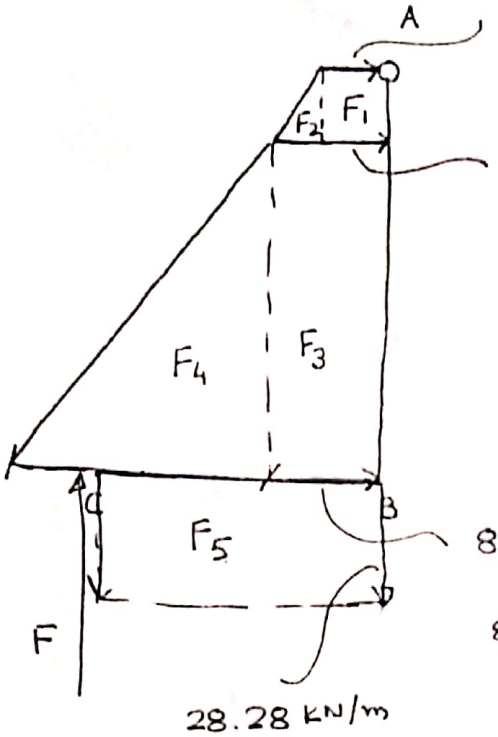
Line GH: $\bar{x} = \frac{63.34}{244.52} \simeq 259 \text{ mm}$





$\frac{259}{298.5} = \frac{\bar{x}}{\bar{y}} = \frac{212.15}{244.52}$ OK

Q # 2

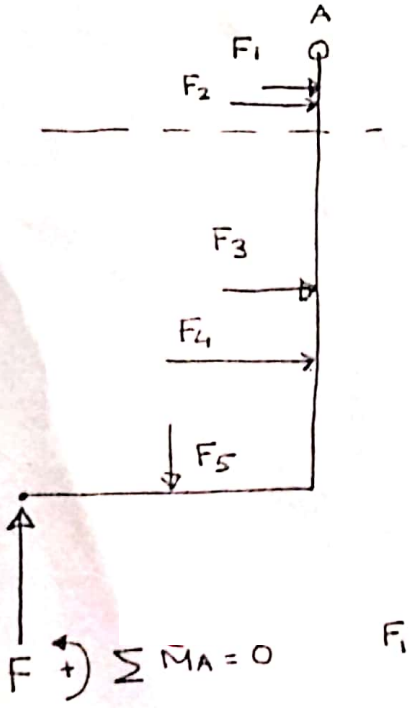


$8.6 \frac{KN}{m^3} \times 2m \times 0.4m = 6.88 \text{ KN/m}$

$8.6 \frac{KN}{m^3} \times 2m \times 0.5m = 8.6 \text{ KN/m}$

$8.6 \text{ KN/m} + 12.3 \frac{KN}{m^3} \times 2m \times 0.8m = 28.28 \text{ KN/m}$

$8.6 \text{ KN/m} + 19.68 \text{ KN/m}$



$F_1 = 6.88 \frac{KN}{m} \times 0.1m = 0.688 \text{ KN}$ $\quad x_1 = 0.05 m$

$F_2 = \frac{1}{2} \times (8.6 - 6.88) \frac{KN}{m} \times 0.1m = 0.086 \text{ KN}$ $\quad x_2 = 0.1 \times \frac{2}{3} = 0.0667 m$

$F_3 = 8.6 \frac{KN}{m} \times 0.8 m = 6.88 \text{ KN}$ $\quad x_3 = 0.4 + 0.1 = 0.5 m$

$F_4 = \frac{1}{2} \times 19.68 \frac{KN}{m} \times 0.8 = 7.872 \text{ KN}$ $\quad x_4 = \frac{2}{3}(0.8) + 0.1 = 0.6333$

$F_5 = 28.28 \frac{KN}{m} \times 0.4m = 11.312 \text{ KN}$ $\quad y_5 = 0.2 m$

$+) \sum M_A = 0$

$F_1 x_1 + F_2 x_2 + F_3 x_3 + F_4 x_4 + F_5 y_5 - F \times 0.4m = 0$

$0.0344 + 0.0057 + 3.44 + 4.985 + 2.262 - F \times 0.4m = 0$

$10.727 \text{ KN-m} - F \times 0.4m = 0$

$F = 26.82 \text{ KN}$