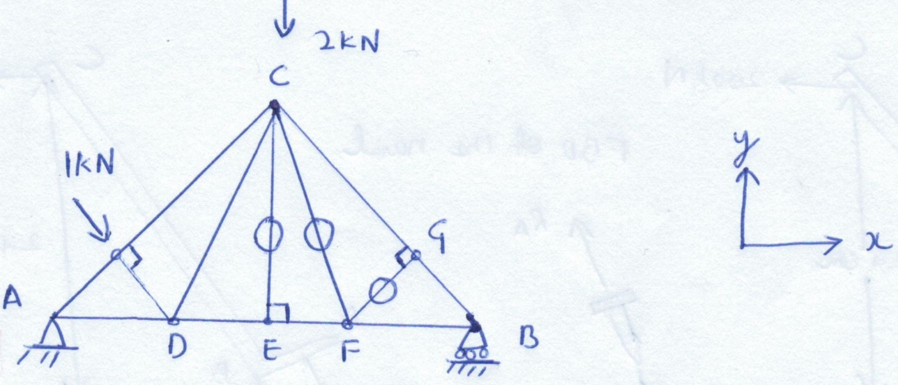
ME-101 Quiz-1 Solutions

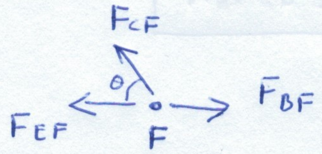
1(a)



→ Members DE & EF are Collinear and no external force (Vertical) is acting at point E. Therefore, CE is a Zero force member. — 1 mark

→ Similarly, GF is a zero force member (CG & GB are collinear) — 1 mark

→ If GF is a zero force member, then CF is also a zero force member. Consider the Joint F — 1 mark

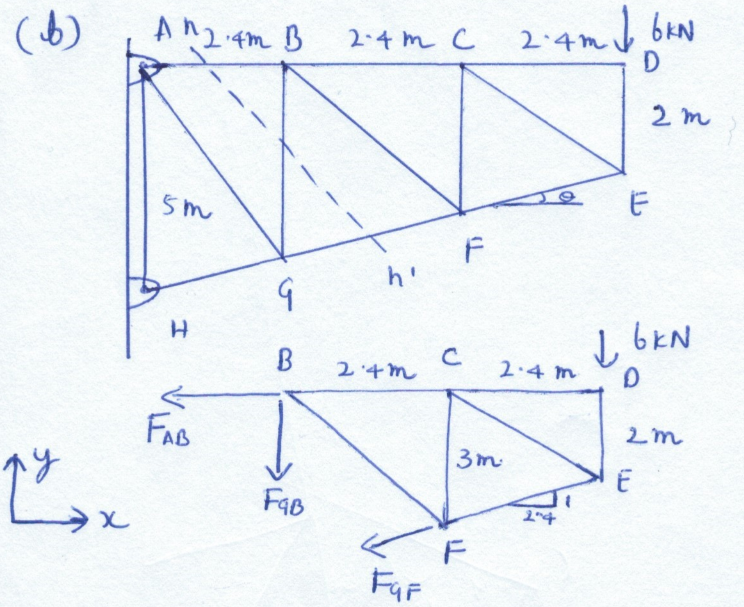


$\Sigma F_y = 0 \Rightarrow F_{CF} \sin\theta = 0$

$\Downarrow$

$(F_{CF} = 0)$

(b)



By inspection, CF = 3 m, BG = 4 m

Considering the right part of the section

$\tan\theta = (1/2.4) \Rightarrow \theta = 22.62^\circ$

— 2 marks

For find F_{GF}, use $\Sigma M_B = 0$ $\quad \cos(\theta) F_{GF} (4) - 6\times 4.8 = 0 \Rightarrow F_{GF} = -7.8$ kN — 1 mark

For find F_{AB}. use $\Sigma M_G = 0$ $\quad F_{AB}(4) - 6 \times 4.8 = 0 \Rightarrow F_{AB} = 7.2$ kN — 1 mark

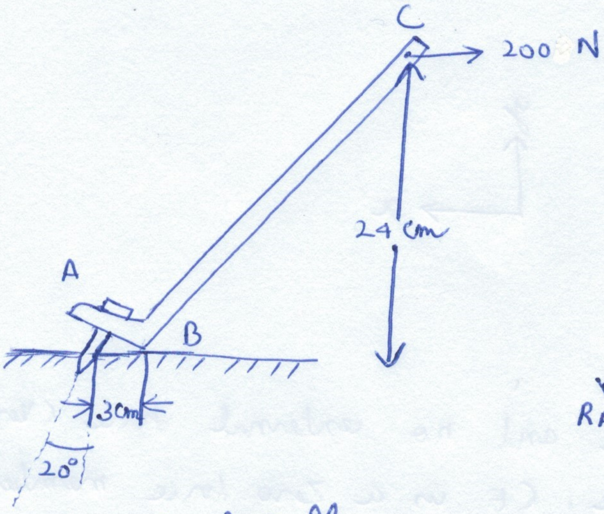
For find F_{GB}, use $\Sigma F_y = 0$ $\quad -F_{GB} - 6\text{ kN} - F_{GF}\sin\theta = 0 \Rightarrow F_{GB} = -3$ kN — 1 mark

$F_{GF} = 7.8$ kN (C)

$F_{AB} = 7.2$ kN (T)

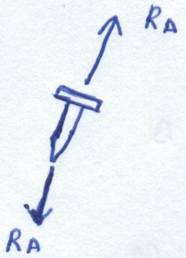
$F_{GB} = 3$ kN (C)

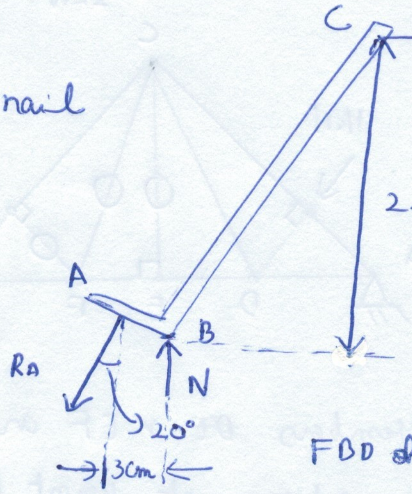
2)



Nail puller

FBD of the nail





2 marks for FBD

FBD of the nail puller

$$\Sigma M_B = 0$$

$$R_A \cos 20^\circ \times 3 = 200 \times 24$$

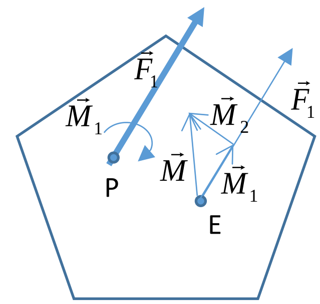
$$R_A = \frac{200 \times 24}{3 \cos 20^\circ} = \boxed{1702.68 \text{ N}}$$

- 2 marks

Solution to Question 3

Coordinates of points C(0,0,0), G(0,0,70), E (250,0,70), D(250,0,0), H(310,60,0) and J(190,30,0)

Unit vector along EH =



$$\hat{n}_{EH} = \frac{(310-250)\hat{i}+(60-0)\hat{j}+(0-70)\hat{k}}{\sqrt{60^2+60^2+70^2}} = \frac{60\hat{i}+60\hat{j}-70\hat{k}}{110} \rightarrow 1mark$$

$$\vec{F}_1 = \frac{110}{110}\left(60\hat{i}+60\hat{j}-70\hat{k}\right) = 60\hat{i}+60\hat{j}-70\hat{k}$$

(a) $\mathrm{M_c} = \mathrm{CE}\times\vec{F}_1 = \left(250\hat{i}+70\hat{k}\right)\times\left(60\hat{i}+60\hat{j}-70\hat{k}\right) = -4200\hat{i}+21700\hat{j}+15000\hat{k}\ \text{Nmm} \ \rightarrow 1\ \text{mark}$

(b) $\mathrm{M}_{CG} = CG.\,\mathrm{M_c} = \hat{k}.\left(-4200\hat{i}+21700\hat{j}+15000\hat{k}\right) = 15\times 10^3\,\text{Nmm} = 15\ \text{kNmm} \rightarrow 1mark$

(c) $\hat{n}_{EJ} = \dfrac{(190-250)\hat{i}+(30-0)\hat{j}+(0-70)\hat{k}}{\sqrt{60^2+30^2+70^2}} = \dfrac{-60\hat{i}+30\hat{j}-70\hat{k}}{97} \rightarrow 1mark$

$$\vec{M} = \frac{30}{97}\left(-60\hat{i}+30\hat{j}-70\hat{k}\right) = -18.56\hat{i}+9.28\hat{j}-21.65\hat{k}$$

M can be divided two components M_1 and M_2

M_1= The component of M along EH=$\vec{M}.\hat{n}_{EH} = (-60\times18.56+60\times9.28+(-70)\times(-21.65))/110 = 8.715 \rightarrow 1mark$

M_2= The component of M perpendicular to EH

Now the wrench can be formed with force $\vec{F}_1$ and couple M_1 at a position away from point E and parallel to line EH

As the wrench is intersecting XZ plane at point P, so the coordinate of point P can be taken as $(x_1, 0, z_1)$

$$M = M_1 + (PE)\times\vec{F}_1 = 8.715\left(\frac{60\hat{i}+60\hat{j}-70\hat{k}}{110}\right) + \left((x_1-250)\hat{i}+(0-0)\hat{j}+(z_1-70)\hat{k}\right)\times\left(60\hat{i}+60\hat{j}-70\hat{k}\right) \rightarrow 2marks$$

$$\Rightarrow -18.56\hat{i}+9.28\hat{j}-21.65\hat{k} = 4.75\hat{i}+4.75\hat{j}-5.55\hat{k}+(x_1-250)60\hat{k}+(x_1-250)(70)\hat{j}+(z_1-70)60\hat{j} - 60(z_1-70)\hat{i}$$

Equating ith component

$-18.56 = 4.75+4200-60z_1 \Rightarrow z_1 = 70.39mm \rightarrow 0.5marks$

Equating kth component

-21.65=-5.55-15000+60$x_1 \Rightarrow x_1 = 249.73 \rightarrow 0.5marks$

Hence, the wrench will intersect the xz plane at point (249.73, 0, 70.39) (dimensions are in mm)