GNG 1105 A

ENGINEERING MECHANICS

Mid-term Exam | Page 1 of 1

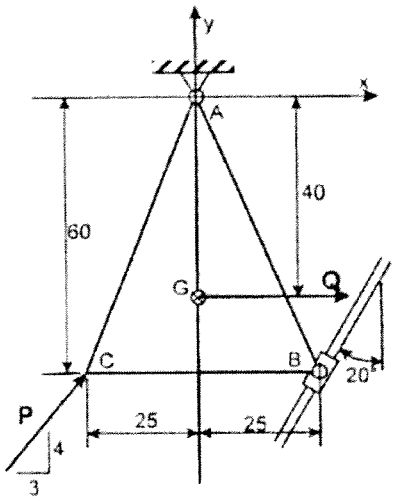
October 24, 2013 | Prof. A. Skaff

Times: 80 minutes

Closed book Examination. Only non- programmable calculators are allowed.

1- (15 marks)

The steel plate shown is supported by a frictionless pin joint at A and a frictionless slide at B. A force P= 50 N acts at C, and another force Q= 10 N acts at G. Determine all reactions at points A and B. All dimensions are in mm.

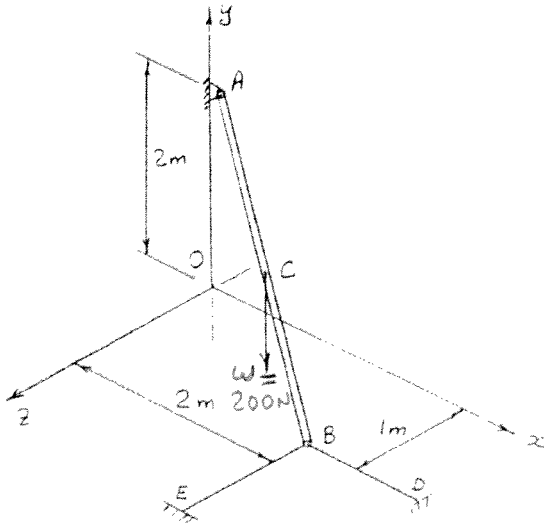


2- (15 marks)

A 3m rod AB is supported by a ball and socket joint at A. The weight of this rod is 200N and acts at its mid-point C.
This rod is being held in equilibrium by 2 cables BD & BE which lie in the x-z plane as shown. BD is parallel to the x-axis and BE is parallel to the z-axis.

a) Draw the FBD of rod AB.

b) Determine the tension in cables BD and BE.



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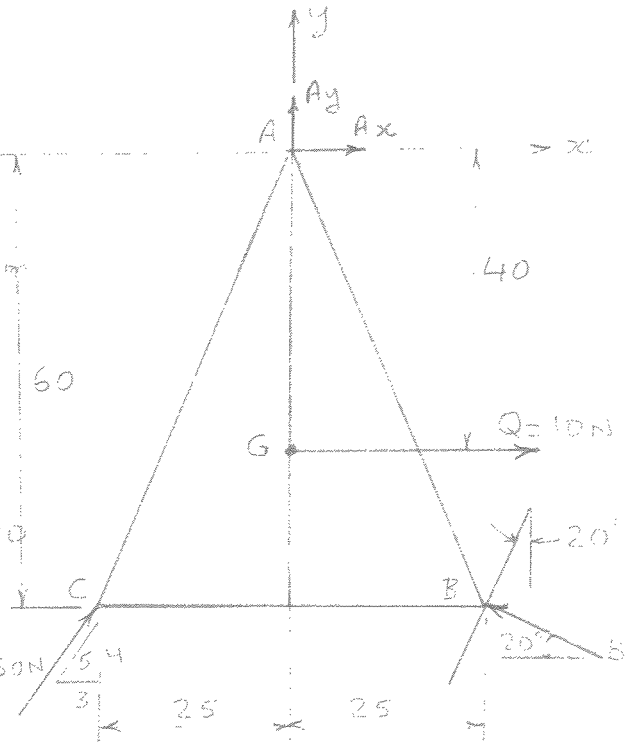
SOLUTIONS

1- FBD- plate



$+\circlearrowleft \Sigma M_A = 0$

$P \times \frac{3}{5} \times 60\,mm - P \times \frac{4}{5} \times 25\,mm + Q \times 40\,mm$

$+ B\sin 20^\circ \times 25\,mm - B\cos 20^\circ \times 60\,mm = 0$

$50 \times \frac{3}{5} \times 60 - 50 \times \frac{4}{5} \times 25 + 10 \times 40$

$+ B\sin 20^\circ \times 25 - B\cos 20^\circ \times 60 = 0$

$1800 - 1000 + 400 + 8.55B - 56.38B = 0$

$47.83B = 1200$

$\therefore B = 25.1\ N$ ANS. $P = 50N$

$\rightarrow \Sigma F_x = 0$

$P \times \frac{3}{5} - B\cos 20^\circ + A_x + Q = 0$

$50 \times \frac{3}{5} - 25.1\cos 20^\circ + A_x + 10 = 0$

$\therefore A_x = 23.6 - 30 - 10 = -16.4\ N$, i.e. $A_x = 16.4\ N \leftarrow$

$+\uparrow \Sigma F_y = 0$

$A_y + P \times \frac{4}{5} + B\sin 20^\circ = 0$

$A_y + 50 \times \frac{4}{5} + 25.1\sin 20^\circ = 0$

$\therefore A_y = -48.6\ N$, i.e. $A_y = 48.6\ N \downarrow$

$A = \sqrt{(16.4)^2 + (48.6)^2} = 51.28\ N$

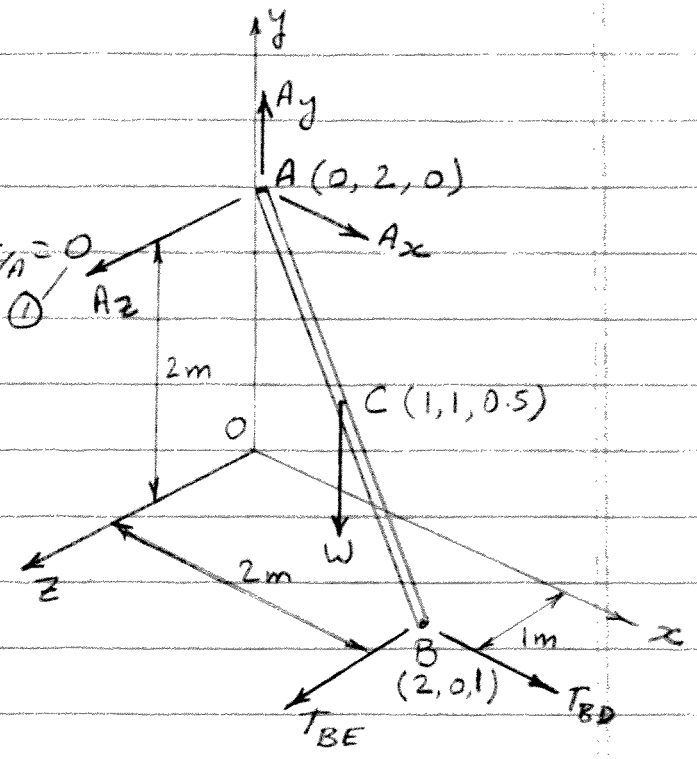
$\alpha = \tan^{-1}\frac{48.6}{16.4} = 71.35^\circ$

$\therefore A = 51.3\ N$ at 71.35° ANS

3.

a) FBD – Rod AB

See diagram.



b) $\Sigma M_A = 0$

$$\bar{T}_{BE} \times \bar{r}_{B/A} + \bar{T}_{BD} \times \bar{r}_{B/A} + W \times \bar{r}_{C/A} = 0 \quad (1)$$

Where, $\bar{T}_{BE} = T_{BE}\bar{k}$

$\bar{T}_{BD} = T_{BD}\bar{i}$

$\bar{r}_{B/A} = 2\bar{i} - 2\bar{j} + 1\bar{k}$

$\bar{r}_{C/A} = 1\bar{i} - 1\bar{j} + 0.5\bar{k}$

$W = -200\bar{j}$

Insert in (1):

$$T_{BE}\bar{k}(2\bar{i} - 2\bar{j} + 1\bar{k}) + T_{BD}\bar{i}(2\bar{i} - 2\bar{j} + 1\bar{k}) - 200\bar{j}(1\bar{i} - 1\bar{j} + 0.5\bar{k}) = 0$$

$$2T_{BE}\bar{j} + 2T_{BE}\bar{i} - 2T_{BD}\bar{k} - T_{BD}\bar{j} + 200\bar{k} - 100\bar{i} = 0$$

Equate the Coefficients of $\bar{i}$, $\bar{j}$ and $\bar{k}$ to Zero:

($\bar{i}$): $2T_{BE} - 100 = 0$; $\therefore T_{BE} = \frac{100}{2} = \underline{\underline{50N}}$ ANS.

($\bar{j}$): $2T_{BE} - T_{BD} = 0$

$2 \times 50 - T_{BD} = 0$; $\therefore T_{BD} = \underline{\underline{100\,N}}$ ANS.

($\bar{k}$): $-2T_{BD} + 200 = 0$; $\therefore T_{BD} = 100\,N$ ✓ check.

– End –

Another Method

3.)
$$\begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 0 & 0 & T_{BE} \\ 2 & -2 & +1 \end{vmatrix} + \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ T_{BD} & 0 & 0 \\ 2 & -2 & 1 \end{vmatrix} + \begin{vmatrix} \bar{i} & \bar{j} & \bar{k} \\ 0 & -200 & 0 \\ 1 & -1 & 0.5 \end{vmatrix} = 0$$

$$\left(+2T_{BE}\bar{i} + 2T_{BE}\bar{j}\right) + \left(-T_{BD}\bar{j} - 2T_{BD}\bar{k}\right) + \left(-200\times 0.5\bar{i} + 200\bar{k}\right) = 0$$

$$2T_{BE}\bar{i} + 2T_{BE}\bar{j} - T_{BD}\bar{j} - 2T_{BD}\bar{k} - 100\bar{i} + 200\bar{k} = 0$$

Equate $\bar{i}$, $\bar{j}$ & $\bar{k}$ to zero:

(I): $2T_{BE} - 100 = 0$; $\therefore T_{BE} = \frac{100}{2} = \underline{\underline{50\ N}}$ ANS.

(j): $2T_{BE} - T_{BD} = 0$;

$2\times 50 - T_{BD} = 0$; $\therefore T_{BD} = \underline{\underline{100\ N}}$ ANS.

(k): $-2T_{BD} + 200 = 0$; $\therefore T_{BD} = \frac{200}{2} = 100\ N$ ✓ Check.