GNG 1105 A

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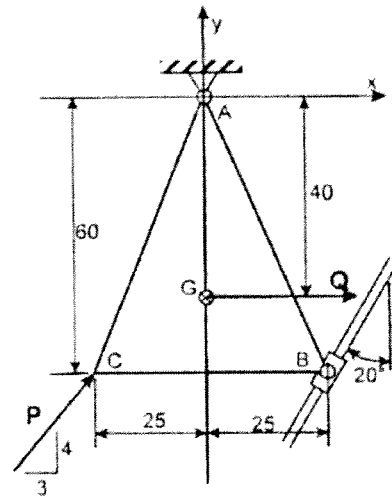
Closed book Examination. Only non- programmable calculators are allowed.

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
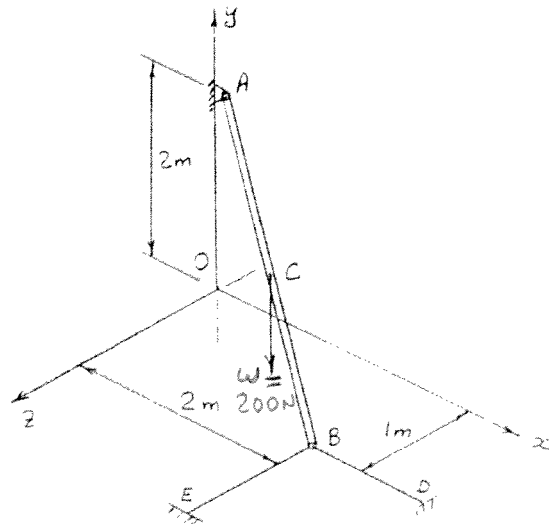points A and B. All dimensions are
in mm.

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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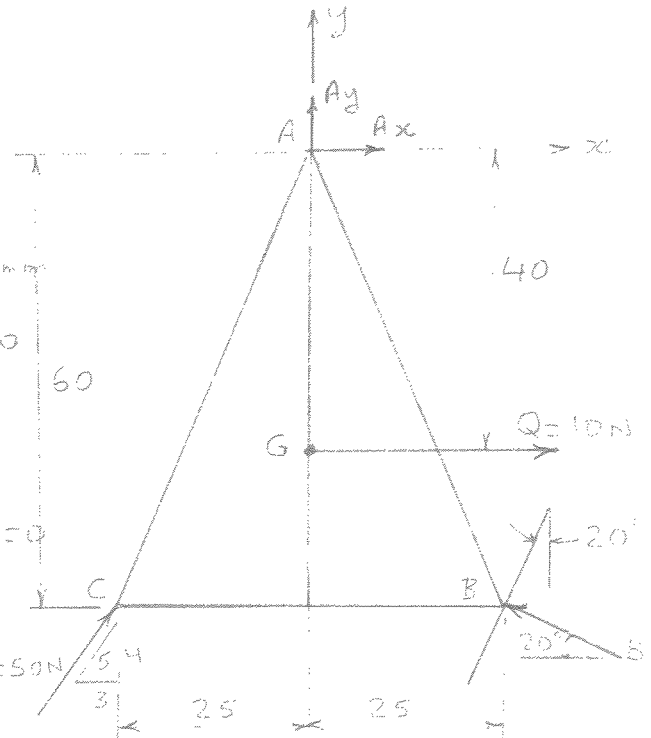
ENGINEERING MECHANICS

Mid_term Exam   Oct 24, 2013

SOLUTIONS

1. FBD_ plate

$+)\Sigma M_A = 0$

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

$+ B \sin 20° \times 25mm - B \cos 20° \times 60mm = 0$

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

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

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

$47.83 B = 1200$

$\therefore \underline{B = 25.1 N}$

ANS. P=50N

$\rightarrow \Sigma F_x = 0$

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

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

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

$+\uparrow \Sigma F_y = 0$

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

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

$\therefore A_y = -40 - 8.61 = -48.6N, \therefore A_y = 48.6N \downarrow$

$A = \sqrt{(16.4)^2 + (48.6)^2} = 51.29N$

$\alpha = \tan^{-1} \frac{48.6}{16.4} = 71.35°$
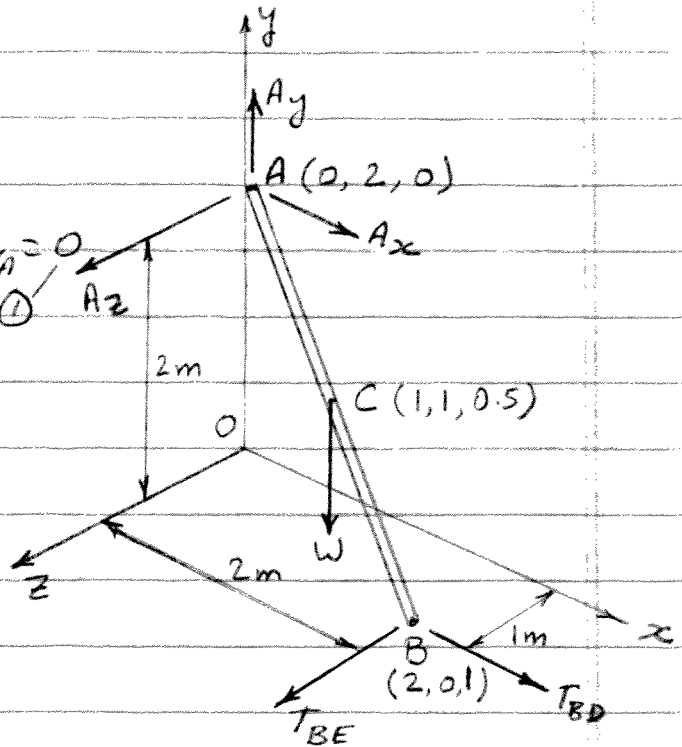
$\therefore A = 51.3N$ ANS

3.

a) FBD _ Rod AB
   See diagram.

b) $\Sigma M_A = 0$

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

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

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

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

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

$W = -200\bar{j}$

[Diagram: Coordinate axes with y up, z and x. Points labeled A (0,2,0) with forces A_y, A_x, A_z; C (1,1,0.5); B (2,0,1) with forces T_{BE} and T_{BD}; W force; dimensions 2m, 2m, 1m; O origin.]

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:

$\textcircled{$\bar{i}$}$: $2T_{BE} - 100 = 0$; $\qquad \therefore T_{BE} = \dfrac{100}{2} = \underline{\underline{50N}}$ $\qquad$ ANS.

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

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

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

_ End _

Another Method

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

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

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

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

$\overline{i}$: $2T_{BE} - 100 = 0$; $\therefore T_{BE} = \dfrac{100}{2} = \underline{\underline{50 \text{ N}}}$ ANS.

$\overline{j}$: $2T_{BE} - T_{BD} = 0$;
$2 \times 50 - T_{BD} = 0$; $\therefore T_{BD} = \underline{\underline{100 \text{ N}}}$ ANS.

$\overline{k}$: $-2T_{BD} + 200 = 0$; $\therefore T_{BD} = \dfrac{200}{2} = 100 \text{ N}$ ✓ check.