CONCORDIA UNIVERSITY

ENCS Faculty, BCEE Department.

ENGR 242/4 L: Statics, Winter 2017

Instructor: Dr C. Rajalingham

Friday, February 10, 2017 **Test 1** 18:15 – 19:25

Instructions:

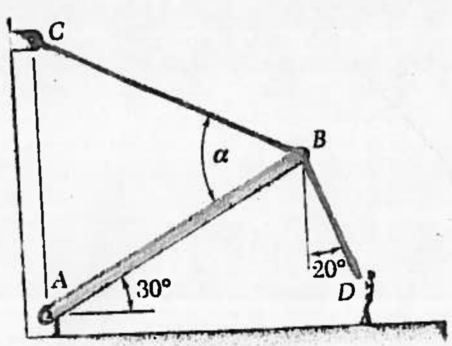
1. Answer all questions. Start you answer to each question on a fresh page.
2. This test is closed book. Crib sheet or similar formula sheet will not be permitted.
3. Explain every important step of your solution. Draw the necessary figures.
4. ENCS Faculty approved Sharp EL 531 or Casio FX-300 MS calculator is permitted.
5. You should not keep cell phone or similar electronic device on you or near you.
6. Return the answer-book only. You can take the question paper with you.

Question 1:

Boom AB, which is hinged at A, is supported by cable BC. Here $\alpha = 60°$. At the end B, the force exerted by the boom is directed along the boom. A man pulls the cable BD with a force P.

(a) Determine the tension in cable BC, when P =400 N.

(b) If the maximum allowable tension in cable BC is 600 N, determine the maximum safe value of the force P.



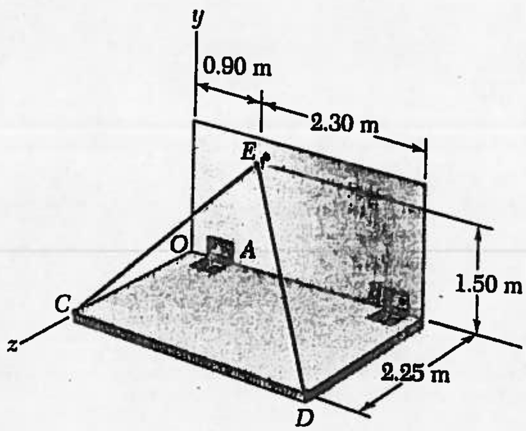
Question 2:

The rectangular platform is hinged at A and B and supported by two cables CE and DE. The tension in cable DE is 710 N.

(a) Express the force $\vec{F}$ exerted by cable DE at point D in vector notation.

(b) Determine the moment of the Force $\vec{F}$ applied at point D about the point C.

(c) Determine the moment of the force $\vec{F}$ applied at point D about axis AB.

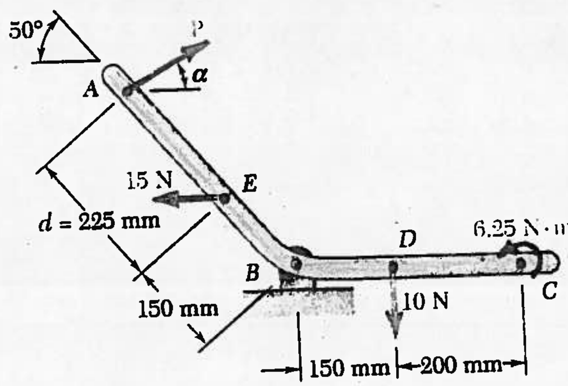


Question 3:

Three forces and a couple act on crank ABC. Here, P = 10 N. The force P acts in the direction perpendicular to AB. This force-couple system can be reduced to a force R at point B and a couple M_B.

(a) Determine the magnitude and direction of the equivalent force at B. Show the direction of this force unambiguously in a sketch.

(b) The force-couple system can be further reduced a single force. The line of action of this resultant intersects the line AB at G. Determine the distance of G from B. Show the position of G clearly on a sketch.



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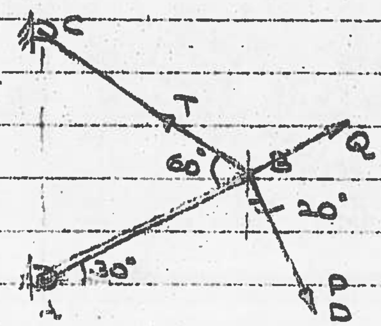
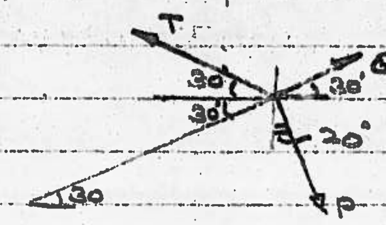
Test #1 : Solution

(1)

(10)

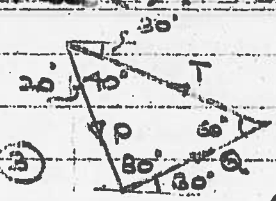


Step (1) : Mark forces at B.



(3)

Step (2) : Method (1) : Force Polygon Method.



(3)

$\therefore \dfrac{T}{\sin 80^\circ} = \dfrac{Q}{\sin 40} = \dfrac{P}{\sin 60}$ (2)

(a) $P = 400$ N. (1) $T = \dfrac{400 \times \sin 80^\circ}{\sin 60^\circ} = 454.9$ N

(b) $T < 600$ N (1) $P < \dfrac{600}{\sin 80} \times \sin 60$

$\therefore P < 527.6$ N.

Method (2) : Resolution Method.

$\rightarrow$ $(-T\cos 30^\circ + Q\cos 30^\circ + P\sin 20 = 0)\ \sin 30^\circ$

(3) $\uparrow$ $(T\sin 30^\circ + Q\sin 30^\circ - P\cos 20 = 0)\ \cos 30$

$\therefore 2T\sin 30\cos 30 - P(\cos 20\cos 30 + \sin 20\sin 30) = 0$

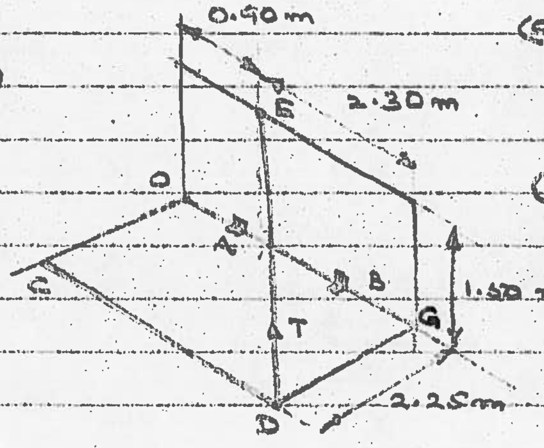
(2) $\therefore T\sin 60 = P\cos 10$

(a) $P = 400$ N (1) $T = \dfrac{400 \times \cos 10}{\sin 60} = 454.9$ N

(b) $T < 600$ N (1) $P < \dfrac{600 \times \sin 60}{\cos 10} = 527.6$ N

(2)

10



(a) Draw the figure.

$E = (0.90,\ 1.50,\ 0)$

$D = (3.20,\ 0,\ 2.25)$

(2) $\therefore E/D = (-2.30,\ 1.50,\ -2.25)$

(1) $r_{E/D} = \sqrt{2.30^2 + 1.35^2 + 2.25^2} = 3.55\ m$

$$\therefore \vec{T} = 710\ \frac{(-2.30\vec{i} + 1.50\vec{j} - 2.25\vec{k})}{3.55}$$

(1) $= -460\vec{i} + 300\vec{j} - 450\vec{k}$ N

$T = 710$ N.

(b) $\vec{M}_C = \vec{r}_{D/C} \times \vec{T}$ $\qquad \vec{r}_{D/C} = 3.20\vec{i}$ (1)

$$\therefore \vec{M}_C = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 3.2 & 0 & 0 \\ -460 & 300 & -450 \end{vmatrix} \quad (1)$$

$$= \begin{vmatrix} 0 & 0 \\ 300 & -450 \end{vmatrix}\vec{i} - \begin{vmatrix} 3.2 & 0 \\ -460 & -450 \end{vmatrix}\vec{j} + \begin{vmatrix} 3.2 & 0 \\ -460 & 300 \end{vmatrix}\vec{k}$$

$= 0\vec{i} + 1440\vec{j} + 960\vec{k}$ Nm (1)

(c) Note O & C are convenient points on axis AB.

$\vec{M}_O = \vec{r}_{D/O} \times \vec{T}$ $\qquad r_{D/O} = 3.2\vec{i} + 0\vec{j} + 2.25\vec{k}$ (1)

$$\therefore \vec{M}_O = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 3.2 & 0 & 2.25 \\ -460 & 300 & -450 \end{vmatrix}$$

$$= \begin{vmatrix} 0 & 2.25 \\ 300 & -450 \end{vmatrix}\vec{i} - \begin{vmatrix} 3.2 & 2.25 \\ -460 & -450 \end{vmatrix}\vec{j} + \begin{vmatrix} 3.2 & 0 \\ -460 & 300 \end{vmatrix}\vec{k}$$

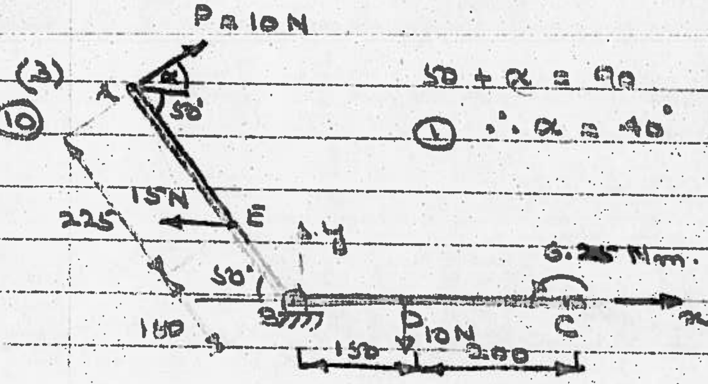
$= -675\vec{i} + 405\vec{j} + 960\vec{k}$ Nm (1)

Axis: $\vec{\lambda}_{axis} = \vec{i}$

$\therefore M_{axis} = \vec{M}_O \cdot \vec{i} = -675$ Nm

$\vec{M}_{axis} = M_{axis}\vec{\lambda} = -675\vec{i}$ Nm. (1)

(3) 10



$50 + \alpha = 90$

1 $\therefore \alpha = 40°$

Draw the figure.

(a)

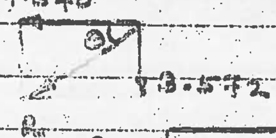
$\rightarrow$ $R_x = P\cos\alpha - 15$

1 $= -7.340$ N.

$\uparrow$ $R_y = P\sin\alpha - 10$

1 $= -3.572$ N.

$\vec{R}$:



1 $R = \sqrt{7.340^2 + 3.572^2}$

$= 8.163$ N.

1 $\tan\theta = \dfrac{3.572}{7.340}$

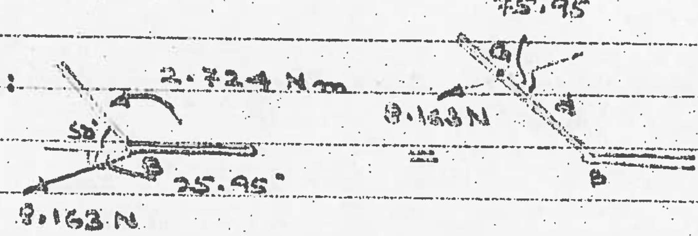
$\theta = 25.95°$

(b): CCW B $M_B = -(P)(0.375) + (15)(0.150\sin 50°)$

3 $= (10)(0.150) + 6.25$

$= 2.724$ Nm.

Equivalent system:



B $2.724 = (8.163)(d\sin 75.95°)$

2 $\therefore d = \dfrac{2.724}{(8.163)(\sin 75.95°)}$

$= 0.3440$ m.