UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

CIV100F – MECHANICS

Midterm Examination – Sections 1, 2, 3, 4, 5, 6, 7, 8

Saturday, 31st October 2020

Examiner: Staff in Civil Engineering

Time allowed: 1-½ hours

SURNAME: _____SEICA_____GIVEN NAME(S): _____MICHAEL_____
(Please print clearly)

STUDENT NUMBER: _____Solutions_____ DEPT. (ECE, Track One, etc.)_____

CIRCLE YOUR SECTION AND THE NAME OF YOUR INSTRUCTOR:

1. Mercan, Oya	4. Seica, Michael	7. Seica, Michael
2. Packer, Jeffrey	5. El-Diraby, Tamer	8. Seica, Michael
3. Packer, Jeffrey	6. Panesar, Daman	

CIRCLE YOUR CALCULATOR TYPE:

CASIO 991 **SHARP 520** **OTHER: _____**

Notes: 1. Ensure that you have all 5 pages of the examination paper. Page 5 is blank

2. Answer all three questions. The value of the questions is indicated below

3. If you need more space for a question, continue on the page indicated at the bottom

4. If information appears to be missing, make reasonable assumptions and state them clearly

5. The only calculators permitted are listed above. Please circle your model

6. This is a closed-book examination. No other paper will be allowed on the desk

7. Do <u>not</u> remove the staple

NAME: M. SEICA **STUDENT NO:** _____

In submitting this assessment, I confirm that my conduct during this test adheres to the Code of Behaviour on Academic Matters. I confirm that I did NOT act in such a way that would constitute cheating, misrepresentation, or unfairness, including but not limited to, using unauthorized aids and assistance, impersonating another person, and committing plagiarism. *I pledge upon my honour that I have not violated the Faculty of Applied Science & Engineering's Honour Code during this assessment.*

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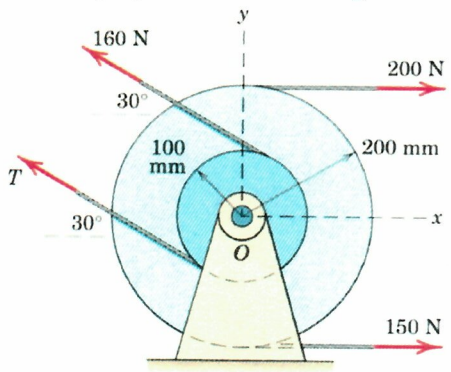
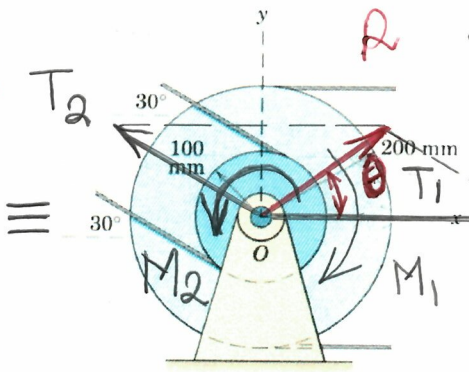
QUESTION 1a. Two grooved discs, rigidly connected to each other, are subjected to the belt tension forces as shown. If the *single* resultant force, **R**, of these applied belt forces passes through the centre of the discs, *O*, determine the magnitude and direction of **R**.



A.



B.

R

$\Sigma F^A = \Sigma F^B$

$T_1 = 200 + 150 = 350\,N \rightarrow$

$T_2 = (160 + T)\,N \nwarrow$

$\Sigma M_O^A = \Sigma M_O^B$

$M_1 = -(200)(0.2) + (150)(0.2) = 10\,Nm \circlearrowleft$

$M_2 = (160)(0.1) - (T)(0.1) = (16 - 0.1T)\,Nm$ But $M_1 + M_2 = 0$

$-10 + 16 - 0.1T = 0 \quad \therefore T = 60.0\,N$ and $T_2 = 160 + 60 = 220\,N$

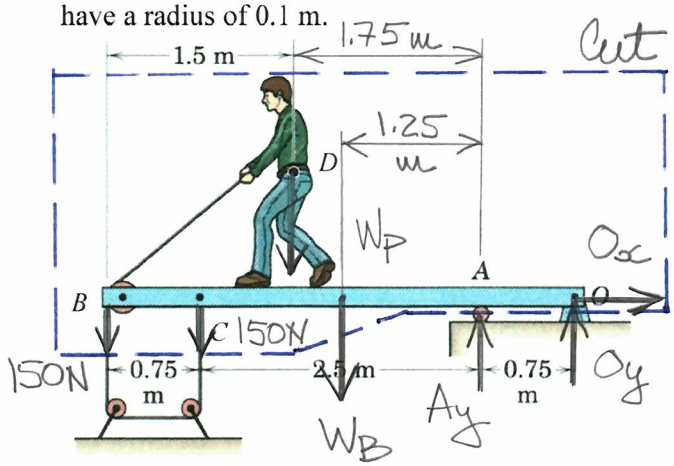
$T_{2x} = 220\cos 30^\circ = 190.5\,N$

$T_{2y} = 220 \sin 30^\circ = 110\,N$

$\therefore R = \sqrt{(350 - 190.5)^2 + (110^2)} = 193.7\,N$

$\theta = \tan^{-1}[110/(350 - 190.5)] = 34.6^\circ$

QUESTION 1b. The uniform beam has a mass of 100 kg and its weight acts at the centre of the beam. To test the beam, the person having a mass of 50 kg acting at *D* exerts a pull of 150 N on the rope rigged as shown around the three frictionless pulleys. Determine the force supported by the pin at *O*. All pulleys have a radius of 0.1 m.



$W_B = (100)(9.81) = 981\,N$

$W_P = (50)(9.81) = 490.5\,N$

$\Sigma M_A = 0$

$(150)(3.25) + (150)(2.5) + (490.5)(1.75) + (981)(1.25) - O_y(0.75) = 0 \quad \therefore O_y = 3{,}930\,N \downarrow$

$\Sigma F_x = 0 \quad \therefore O_x = 0$

$\therefore$ Total force at O:

$R_O = \sqrt{0^2 + 3930^2} = 3{,}930\,N \downarrow$

Use additional pages, if necessary…

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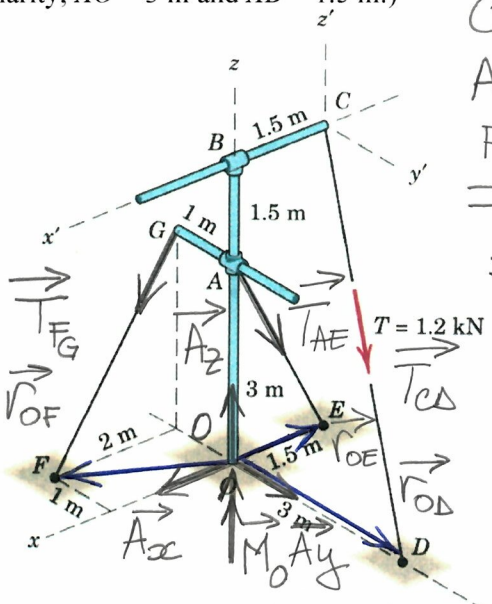
QUESTION 2. The rigid pole, *OB*, and horizontal cross-arm assembly is supported by the three cables shown. The pole is supported at the base *O* by a special ball-and-socket support which allows rotations only around the *x*- and *y*-axes. A turnbuckle at *D* is tightened until it induces a tension force in cable *CD*, having a magnitude of 1.2 kN. Determine the magnitude of the tension forces in cables *AE* and *GF*. Also, determine the reaction components at the base of the pole. The entire pole has a mass of 500 kg. (For clarity, $AO = 3$ m and $AB = 1.5$ m.)



$CD = \sqrt{1.5^2 + 3^2 + (-4.5)^2} = 5.612$ m

$AE = \sqrt{(-1.5)^2 + 0^2 + (-3)^2} = 3.354$ m

$FG = \sqrt{(2)^2 + 0^2 + (-3)^2} = 3.6056$ m

$\vec{T}_{CD} = (1.2)(0.2673\vec{i} + 0.5345\vec{j} - 0.8018\vec{k})$ kN

$\vec{T}_{AE} = T_{AE}(-0.4472\vec{i} - 0.8944\vec{k})$ kN

$\vec{T}_{FG} = T_{FG}(0.5547\vec{i} - 0.8321\vec{k})$ kN

$\vec{r}_{OD} = 3\vec{j}$ m; $\vec{r}_{OE} = -1.5\vec{i}$ m;

$\vec{r}_{OF} = 2\vec{i} - 1\vec{j}$ m

$\Sigma \vec{M}_O = 0$ $\vec{r}_{OD} \times \vec{T}_{CD} + \vec{r}_{OE} \times \vec{T}_{AE} + \vec{r}_{OF} \times \vec{T}_{FG} + \vec{M}_{O_z} = 0$

$$\vec{r}_{OD} \times \vec{T}_{CD} = (1.2)\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 3 & 0 \\ 0.2673 & 0.5345 & -0.8018 \end{vmatrix} = -2.8865\vec{i} - 0.9623\vec{k} \text{ kNm}$$

$$\vec{r}_{OE} \times \vec{T}_{AE} = T_{AE}\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -1.5 & 0 & 0 \\ -0.4472 & 0 & -0.8944 \end{vmatrix} = -(1.3416\vec{j})T_{AE} \text{ kNm}$$

$$\vec{r}_{OF} \times \vec{T}_{FG} = T_{FG}\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 2 & -1 & 0 \\ 0.5547 & 0 & -0.8321 \end{vmatrix} = (0.8321\vec{i} + 1.6642\vec{j} + 0.5547\vec{k})T_{FG} \text{ kNm}$$

$\Sigma M_{O_x} = 0$ $-2.8865 + 0.8321\,T_{FG} = 0$ $\therefore T_{FG} = 3.47$ kN

$\Sigma M_{O_y} = 0$ $-1.3416\,T_{AE} + 1.6642\,T_{FG} = 0$ $\therefore T_{AE} = 4.30$ kN

$\Sigma M_{O_z} = 0$ $M_O - 0.9623 + 0.5547\,T_{FG} = 0$

$\therefore M_O = 0.962$ kNm

Use additional pages, if necessary…

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QUESTION 2 (CONT. 'A)

$$\Sigma \vec{F} = 0$$

$$\Sigma F_x = 0 \quad (1.2)(0.2673) - (0.4472)T_{AE} + (0.5547)T_{FG} + O_x = 0$$

$$\therefore \underline{O_x = -0.320\,KN}$$

$$\Sigma F_y = 0 \quad (1.2)(0.5345) + O_y = 0 \quad \therefore \underline{O_y = -0.641\,KN}$$

$$\Sigma F_z = 0 \quad -(1.2)(0.8018) - (0.8944)T_{AE} - (0.8321)T_{FG} -$$

$$(500)(9.81)(10^{-3}) + O_z = 0 \quad \therefore \underline{O_z = 12.60\,KN}$$

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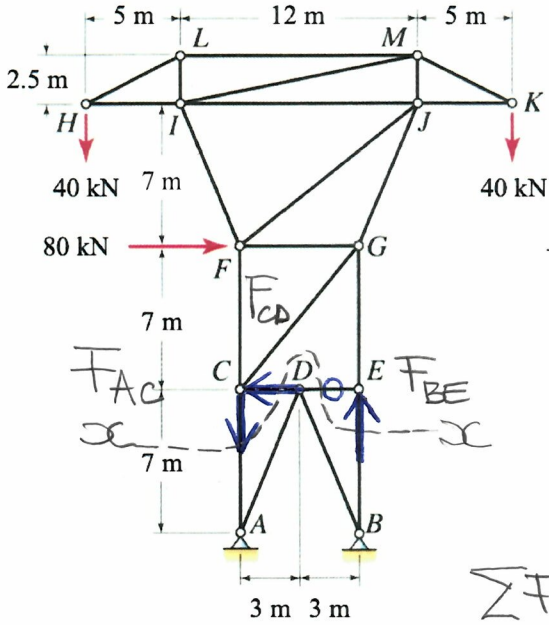
QUESTION 3. The electric power-transmission tower supports two wires that apply a 40 kN vertical force each, while the 80 kN horizontal force represents wind loading during a storm. The tower is attached to the foundations at *A* and *B* by pin supports. Determine the reaction force components at the supports *A* and *B*. Also, determine the force in the four members which emanate from joint *D* and the force in members *CF*, *CG* and *EG*, and indicate if the members are in tension or compression.



(a) By inspection: $F_{DE} = 0$; and $F_{EG} = F_{BE} =$ see below $= 133.3\,kN\,(C)$

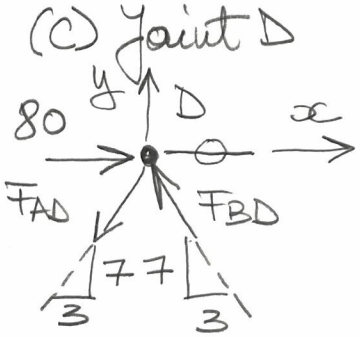
(b) cut along x-x, use top FBD.

$\sum M_C = 0 \quad (40)(8) - (80)(7) - (40)(14) + F_{BE}(6) = 0 \quad \therefore F_{BE} = 133.3\,kN\,(C)$

$\sum M_E = 0 \quad (40)(14) - (80)(7) - (40)(8) + F_{AC}(6) = 0 \quad \therefore F_{AC} = 53.3\,kN\,(T)$

$\sum F_x = 0 \quad 80 - F_{CD} = 0 \quad \therefore F_{CD} = 80.0\,kN\,(C)$

(c) Joint D

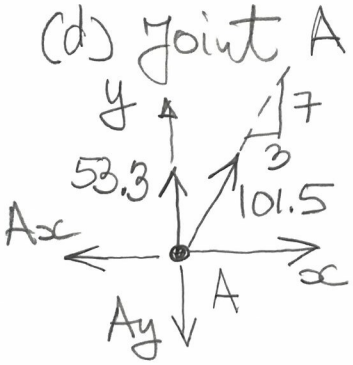


$\sum F_y = 0 \quad F_{AD} = F_{BD}$

$\sum F_x = 0 \quad 80 - F_{AD}\frac{3}{\sqrt{58}} - F_{BD}\frac{3}{\sqrt{58}} = 0$

$\therefore F_{AD} = 101.5\,kN\,(T) \qquad F_{BD} = 101.5\,kN\,(C)$

(d) Joint A



$\sum F_x = 0 \quad -A_x + 101.5\frac{3}{\sqrt{58}} = 0 \quad \therefore A_x = 40.0\,kN \leftarrow$

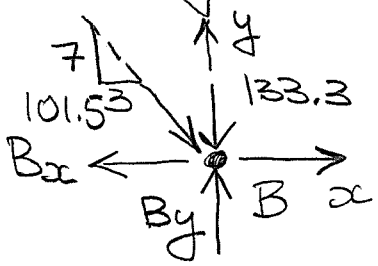
$\sum F_y = 0 \quad -A_y + 53.3 + 101.5\frac{7}{\sqrt{58}} = 0$

$\therefore A_y = 146.7\,kN \downarrow$

Use additional pages, if necessary… →

QUESTION 3 (CONT'D)

(e) Joint B



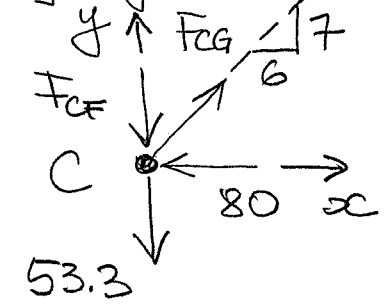
$\Sigma F_x = 0 \quad -B_x + 101.5 \frac{3}{\sqrt{58}} = 0$

$\therefore B_x = 40.0\,KN \leftarrow$

$\Sigma F_y = 0 \quad B_y - 133.3 - 101.5 \frac{7}{\sqrt{58}} = 0$

$\therefore B_y = 227\,KN \uparrow$

(f) Joint C



$\Sigma F_x = 0 \quad -80 + F_{CG} \frac{6}{\sqrt{85}} = 0$

$\therefore F_{CG} = 122.9\,KN\,(T)$

$\Sigma F_y = 0 \quad -F_{CF} - 53.3 + F_{CG} \frac{7}{\sqrt{85}} = 0$

$\therefore F_{CF} = 40.0\,KN\,(C)$