UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

CIV100F – MECHANICS

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

Saturday, 30th October 2021

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. Seica, Michael	4. Seica, Michael	7. Seica, Michael
2. Mercan, Oya	5. El-Diraby, Tamer	8. Packer, Jeffrey
3. Packer, Jeffrey	6. Panesar, Daman	9. Seica, Michael

CIRCLE YOUR CALCULATOR TYPE:

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

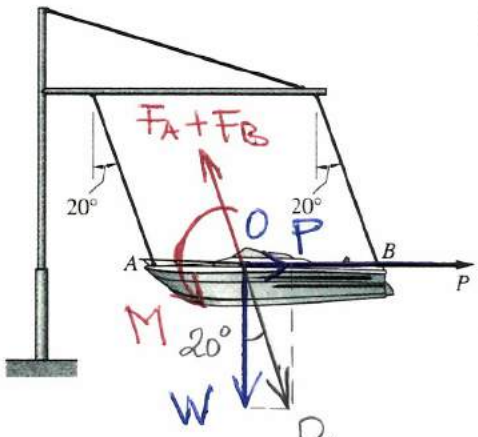
Notes:
1. **Ensure that you have all 5 pages of the examination paper. Page 5 is blank**
2. **Answer all three questions. The value of the questions is indicated below**
3. **If you need more space for a question, continue on the page indicated at the bottom**
4. **If information appears to be missing, 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.*

SIGNATURE: X

QUESTION 1A. The 1,800 kg boat is suspended from the horizontal beam by two parallel cables of equal length. Calculate the force P required to hold the boat in the position shown.



Since $F_A \parallel F_B$, move them to O, where the weight of the boat acts, and sum them up into a single resultant force, $F_A + F_B$. For equilibrium:

$R = F_A + F_B$, or

$\Sigma F_x = 0 \quad P - (F_A+F_B)(\sin 20°) = 0$

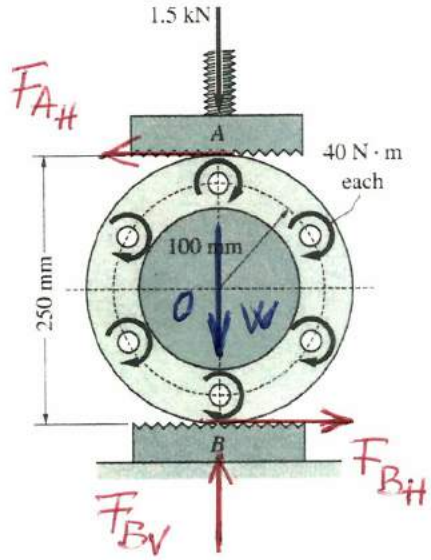
$\Sigma F_y = 0 \quad (F_A+F_B)(\cos 20°) - 17.658 = 0$

$\therefore F_A + F_B = 18.791\,kN$ and $\underline{P = 6.43\,kN}$

$W = (1800)(9.81)(10^{-3})$

$= 17.658\,kN$

QUESTION 1B. The circular flange of a pipe is clamped between two rough surfaces by the vertical 1.5 kN force in the screw jack at *A*. An automatic drilling machine exerts the 40 Nm torques shown as it simultaneously drills six holes in the flange. If the mass of the flange is 12 kg, compute the magnitude of the total forces which act on the flange during the drilling operation.



For equilibrium:

$\Sigma F_x = 0 \quad -F_{AH} + F_{BH} = 0 \quad \therefore F_{AH} = F_{BH}$

$\Sigma F_y = 0 \quad F_{BV} - 1500 - 117.72 = 0$

$\therefore F_{BV} = 1617.72\,N$

$\Sigma M_O = 0 \quad F_{AH}(0.25) - (40)(6) = 0$

$\therefore F_{AH} = F_{BH} = 960\,N$

$F_A = \sqrt{1500^2 + 960^2} = 1{,}781\,N$

$F_B = \sqrt{1617.72^2 + 960^2} = 1{,}881\,N$

$W = (12)(9.81)$

$= 117.72\,N$

Use additional pages, if necessary…

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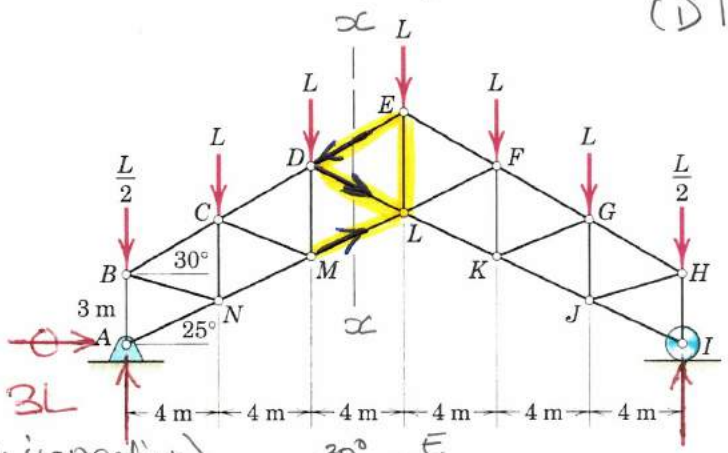
QUESTION 2. Determine the force in members *DE*, *EL*, *FL* and *LM* of the truss, and indicate if the members are in tension or compression.



3L

(By inspection)

(i) The truss is symetric (geometry + loading), therefore:

- $FL = DL$
- $A_y = \frac{6L}{2} = 3L$ and $A_x = 0$

(ii) Cut along x-x and analyze LHS FBD:

- $\sum M_D = 0$

$(-3L + \frac{L}{2})(8) + L(4) + LM(\cos 25^\circ)(3.89) = 0$ (C)

$\therefore LM = 4.54L$ (T)

- $\sum M_L = 0$ $(-3L + \frac{L}{2})(12) + L(8) + L(4) + DE(\cos 30^\circ)(4.33) = 0$ (d)

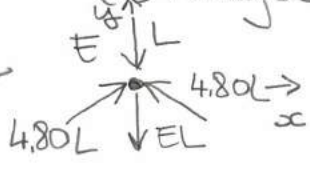
$\therefore DE = 4.80L$ (C)

- $\sum M_O = 0$ $(3L - \frac{L}{2})(27) - L(31) - L(35) - DL(\cos 26.8^\circ)(20.21) - DL(\sin 26.8^\circ)(35) = 0$

(20.21 = DS)

$\therefore DL = FL = 0.0444L$ (T)

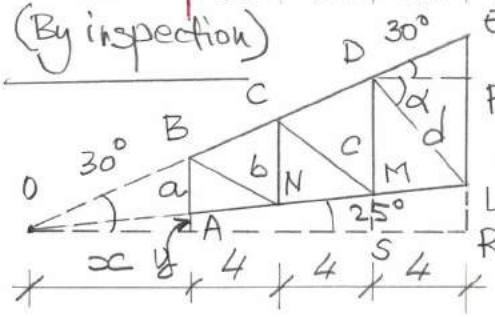
(iii) Analyze joint E



$\sum F_y = 0$

$-L + (2)(4.80L)(\sin 30^\circ) - EL = 0$

$\therefore EL = 3.80L$ (T)



$a = 3m$

$\tan 30^\circ = \frac{DS}{35}$

$DS = 20.21m$

$\tan 30^\circ = \frac{3+y}{x} = 0.57735$

$\tan 25^\circ = \frac{y}{x} = 0.46631$

$\therefore y = 0.46631x$ and $x = 27m$

Also, by similar triangles (not shown):

$\frac{3}{27} = \frac{b}{27+4} = \frac{c}{27+8} = \frac{d}{27+12}$

$b = 3.44m$; $c = 3.89m$; $d = 4.33m$

In $\triangle DEP$ $\tan 30^\circ = \frac{EP}{4}$

$EP = 2.31m$; $PL = 4.33 - 2.31 = 2.02m$

$\alpha = \tan^{-1}\frac{2.02}{4} = 26.8^\circ$ (in $\triangle DLP$)

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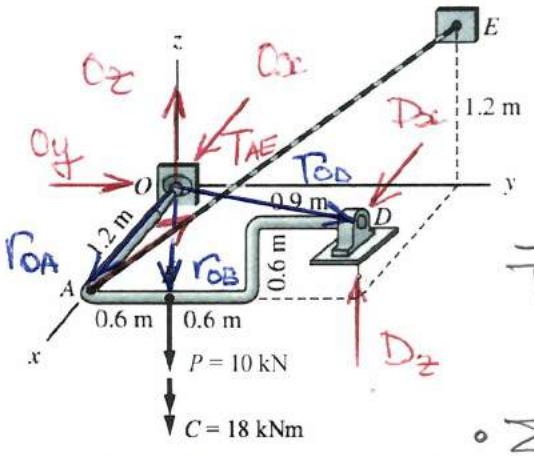
QUESTION 3. The bent bar of negligible weight is supported by a ball-and-socket joint at O, a cable connected between A and E, and a sliding bearing at D (allows free sliding of the bar in the y-direction). The bar is acted upon by force P and moment C, both vectors being parallel to the z-axis. Determine the magnitude of the total reaction force at D and the force in cable AE.



$\vec{P} = -10\vec{k}$ kN; $\vec{C} = -18\vec{k}$ kNm

$\vec{r}_{OA} = 1.2\vec{i}$ m; $\vec{r}_{OB} = 1.2\vec{i} + 0.6\vec{j}$ m

$\vec{r}_{OD} = 1.2\vec{i} + 2.1\vec{j} + 0.6\vec{k}$ m

$$\vec{T}_{AE} = T_{AE}\,\frac{-1.2\vec{i} + 2.1\vec{j} + 1.2\vec{k}}{\sqrt{(-1.2)^2 + (2.1)^2 + (1.2)^2}}$$

$\sqrt{(-1.2)^2 + (2.1)^2 + (1.2)^2} = 2.7$

$\circ\ \sum \vec{M}_O = 0$

$$\frac{T_{AE}}{2.7}\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 1.2 & 0 & 0 \\ -1.2 & 2.1 & 1.2 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 1.2 & 2.1 & 0.6 \\ D_x & 0 & D_z \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 1.2 & 0.6 & 0 \\ 0 & 0 & -10 \end{vmatrix} - 18\vec{k} = 0$$

$$\begin{cases} 2.1 D_z - 6 = 0 \\ -0.533 T_{AE} + 0.6 D_x - 1.2 D_z + 12 = 0 \\ 0.933 T_{AE} - 2.1 D_x - 18 = 0 \end{cases}$$

$\therefore D_z = 2.8571$ kN

$$\begin{cases} -0.533 T_{AE} + 0.6 D_x = -8.571 \quad | \times 3.5 \\ 0.933 T_{AE} - 2.1 D_x = 18 \end{cases}$$

$-0.9325 T_{AE} = -11.9985$

$\therefore T_{AE} = 12.87$ kN

$(0.933)(12.867) - 2.1 D_x = 18 \quad \therefore D_x = -2.8548$ kN

$\therefore R_D = \sqrt{(2.8548)^2 + (2.8571)^2} = 4.04$ kN

Use additional pages, if necessary…