UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

CIV100S – MECHANICS

Midterm Examination

Friday, 8th March 2024

Examiner: Prof. Michael Seica

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:

INDICATE YOUR CALCULATOR TYPE:

☐ **CASIO FX-991** ☐ **SHARP EL-W516/520** ☐ **OTHER: _____**

Notes: 1. Ensure that you have all 8 pages of the examination paper. Page 8 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 indicate your model

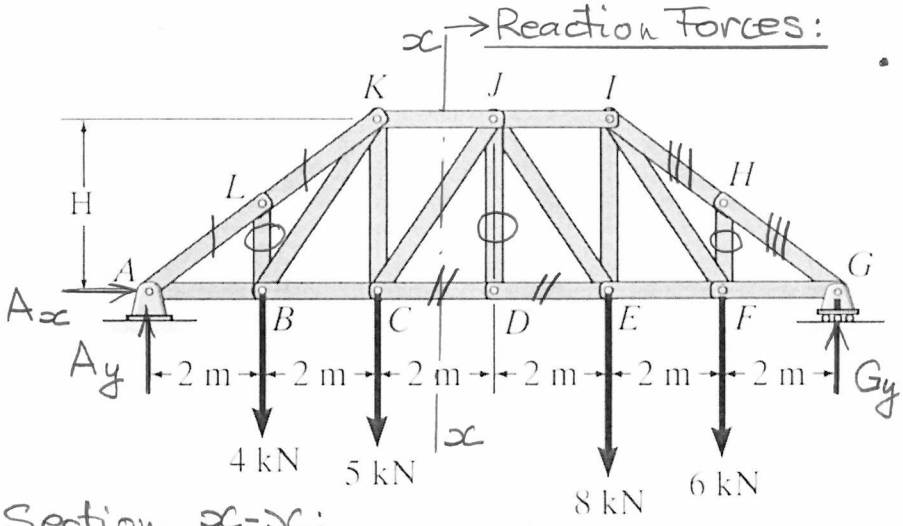
6. This is a closed-book examination. No other paper will be allowed on the desk

7. Turn OFF all electronic equipment and place it in your bag

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

NAME: M. SEICA

1. A truss in a pedestrian bridge has a height H = 3 m and is loaded as shown. Determine the force in members *JK*, *CJ*, *DE*, *EF* and *FI*, and indicate whether the members are in tension or compression.



→ Reaction Forces:

• $\Sigma M_G = 0$

$-A_y(12) + (4)(10) +$

$+ (5)(8) + (8)(4) + (6)(2) = 0$

$\therefore A_y = 10.33\,kN \uparrow$

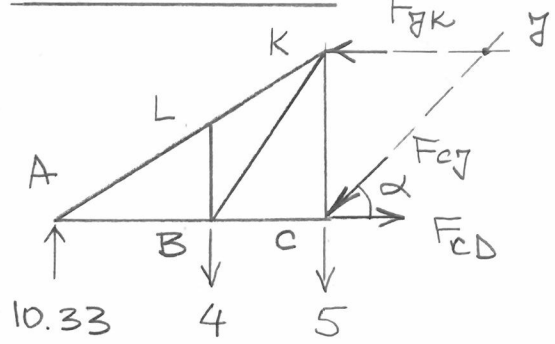
• $\Sigma F_y = 0$

$G_y + 10.33 - 4 - 5 -$

$-8 + 6 = 0$

$\therefore G_y = 12.67\,kN \uparrow$

→ Section x-x:



$\alpha = \tan^{-1} 3/2 = 56.3°$

• $\Sigma M_C = 0$

$-(10.33)(4) + (4)(2) + F_{JK}(3) = 0$

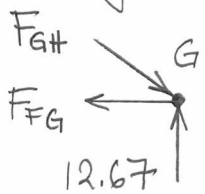
$\therefore F_{JK} = 11.11\,kN\,(C)$

• $\Sigma M_J = 0$

$-(10.33)(6) + (4)(4) + (5)(2) + F_{CD}(3) = 0 \quad \therefore F_{CD} = F_{DE} = 12.00\,kN\,(T)$

• $\Sigma F_y = 0$ $10.33 - 4 - 5 - F_{CJ} \sin 56.3° = 0 \quad \therefore F_{CJ} = 1.600\,kN\,(C)$

→ Joint G:



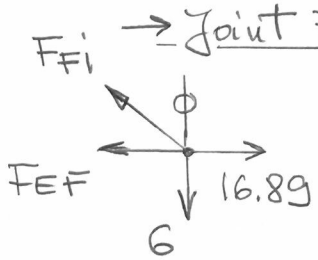
• $\Sigma F_y = 0$ $12.67 - F_{GH}(3/5) = 0$

$\therefore F_{GH} = 21.12\,kN\,(C)$

• $\Sigma F_x = 0$ $(21.12)(4/5) - F_{FG} = 0$

$\therefore F_{FG} = 16.89\,kN\,(T)$

→ Joint F:



• $\Sigma F_y = 0$ $F_{FI} \sin 56.3° - 6 = 0$

$\therefore F_{FI} = 7.21\,kN\,(T)$

• $\Sigma F_x = 0$ $16.89 - F_{EF} -$

$- 7.21 \cos 56.3 = 0$

$\therefore F_{EF} = 12.89\,kN\,(T)$

Solution can be continued on Page 3

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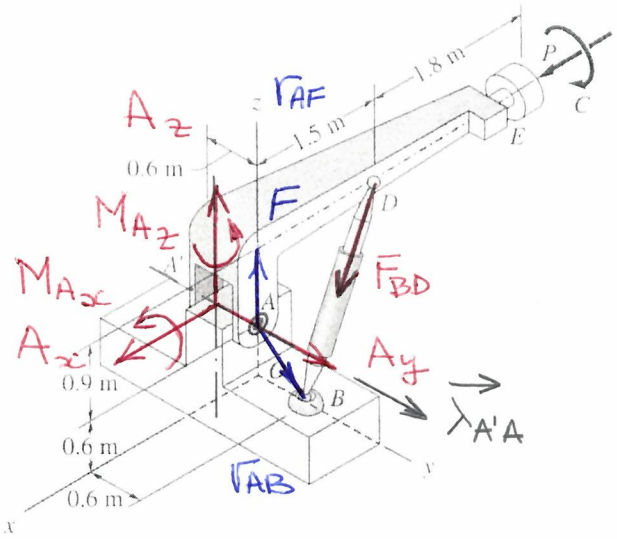
2. The arm *ADE* of the boring machine is attached to a rigid support by pins at *A* and *A'* (not visible). *DE* is parallel to the *x*-axis. The arm is also supported by the hydraulic cylinder *BD* which has a ball-and-socket joint at each end. The applied loading consists of a force $P = 6.2$ kN and a couple $C = 4.8$ kNm, both acting at the boring tool *E*. Neglecting the weight of the members, determine the force in the cylinder *BD* (provide both the magnitude and the Cartesian vector expression).



$$\vec{F}_{BD} = F_{BD}\,\frac{-1.5\vec{i} - 0.6\vec{j} + 1.5\vec{k}}{\sqrt{4.86}}$$

$$\vec{P} = 6.2\vec{i}\ \text{kN}$$

$$\vec{C} = -4.8\vec{i}\ \text{kN m}$$

$$\vec{\lambda}_{A'A} = 1\vec{j}$$

$$\vec{r}_{AF} = 0.9\vec{k}\ \text{m}$$

$$\vec{r}_{AB} = 0.6\vec{j} - 0.6\vec{k}\ \text{m}$$

- $\Sigma M_{A'A} = 0$:

$$\begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 0.9 \\ 6.2 & 0 & 0 \end{vmatrix} + \frac{F_{BD}}{\sqrt{4.86}} \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0.6 & -0.6 \\ -1.5 & -0.6 & 1.5 \end{vmatrix} = 0$$

$$(-1)(0-(0.9)(6.2)) + \frac{F_{BD}}{\sqrt{4.86}}(-1)\big((-0.6)(-1.5) - (0)(1.5)\big) = 0$$

$$\therefore F_{BD} = -13.7\ \text{kN} = \underline{13.70\ \text{kN (C)}}$$

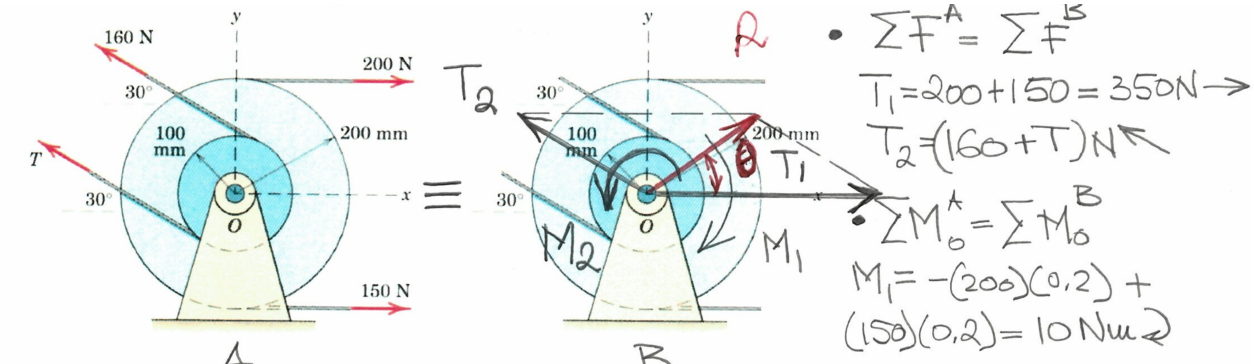
$$\vec{F}_{BD} = \frac{-13.7}{\sqrt{4.86}}(-1.5\vec{i} - 0.6\vec{j} + 1.5\vec{k}) =$$

$$= \underline{9.3\vec{i} + 3.72\vec{j} - 9.3\vec{k}\ \text{kN}}$$

Solution can be continued on Page 5

NAME: _____

3a. 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**. (7 mks)



$R = T_2$

$\Sigma F_x^A = \Sigma F_x^B$

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

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

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

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

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

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

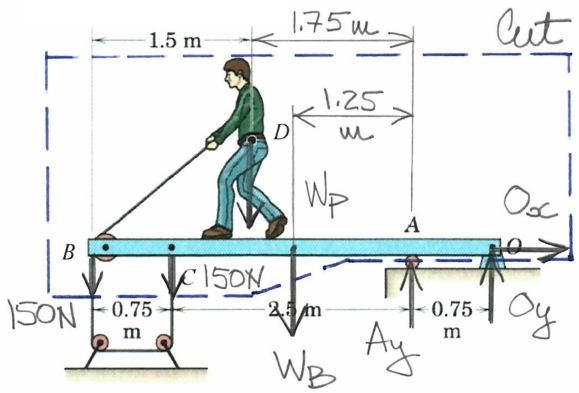
$T_{2x} = 220\cos 30^\circ = 190.5\,N$

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

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

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

3b. 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. (4 mks)



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

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

$\Sigma M_A = 0$

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

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

$\therefore$ Total force at O:

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

Solution can be continued on Page 7