UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

CIV100F and APS160F – MECHANICS

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

Tuesday, 23rd October 2018

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. El-Diraby, Tamer	5. Bruun, Edvard	Online. Seica, Michael
2. Packer, Jeffrey	6. Saxe, Shoshanna	
3. Seica, Michael	7. Mercan, Oya	
4. Packer, Jeffrey	8. Panesar, Daman	

CIRCLE YOUR CALCULATOR TYPE:

CASIO 991 **SHARP 520**

Notes: 1. Ensure that you have all 4 pages of the examination paper. Page 4 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 only on the page indicated at the bottom.

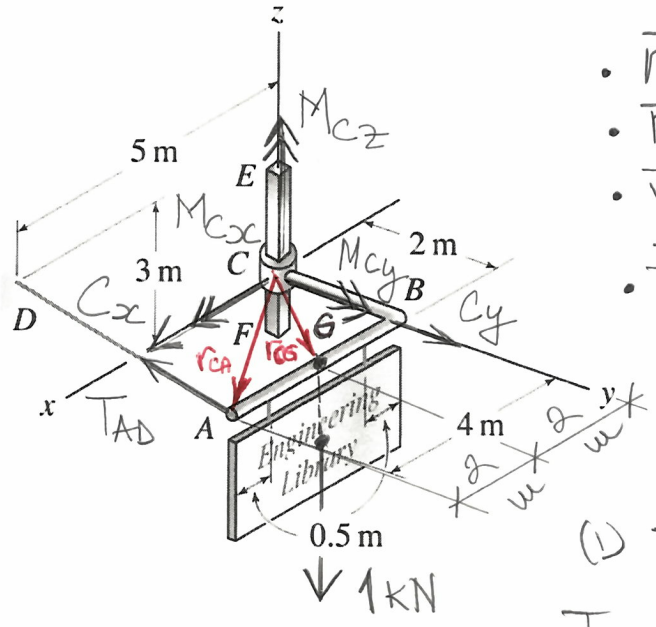
4. The only calculators permitted are listed above. Please circle your model.

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

6. Do not remove the staple.

DO NOT WRITE IN THIS SPACE.

1. Bar *EF* has a square cross-section and is fixed in space. The structure *ABC* has negligible weight and has a collar at *C* which has a square hole, that slides freely on bar *EF*. The structure *ABC* supports a uniform rectangular sign having a weight of 1 kN, acting at the centre of the sign. The vertical edges of the sign align vertically with points *A* and *B*. Determine the magnitude of the force in cable *AD* and all the reaction components at *C*.



- $\vec{r}_{CG} = 2\vec{i} + 2\vec{j}$ m
- $\vec{r}_{CA} = 4\vec{i} + 2\vec{j}$ m
- $\vec{W} = -1\vec{K}$ kN
- $\vec{T}_{AD} = T_{AD}\dfrac{1\vec{i} - 2\vec{j} + 3\vec{K}}{\sqrt{1^2+(-2)^2+3^2}} = T_{AD}\dfrac{1\vec{i} - 2\vec{j} + 3\vec{K}}{\sqrt{14}}$

(1) $\Sigma\vec{F} = 0$

$\dfrac{T_{AD}}{\sqrt{14}} + C_x = 0$ (x-axis)

$\dfrac{-2T_{AD}}{\sqrt{14}} + C_y = 0$ (y-axis) $\quad \dfrac{3T_{AD}}{\sqrt{14}} - 1 = 0$ (z-axis)

$\therefore T_{AD} = \dfrac{\sqrt{14}}{3} = 1.247$ kN; $C_x = -1/3 = -0.333$ kN

$C_y = 2/3 = 0.667$ kN

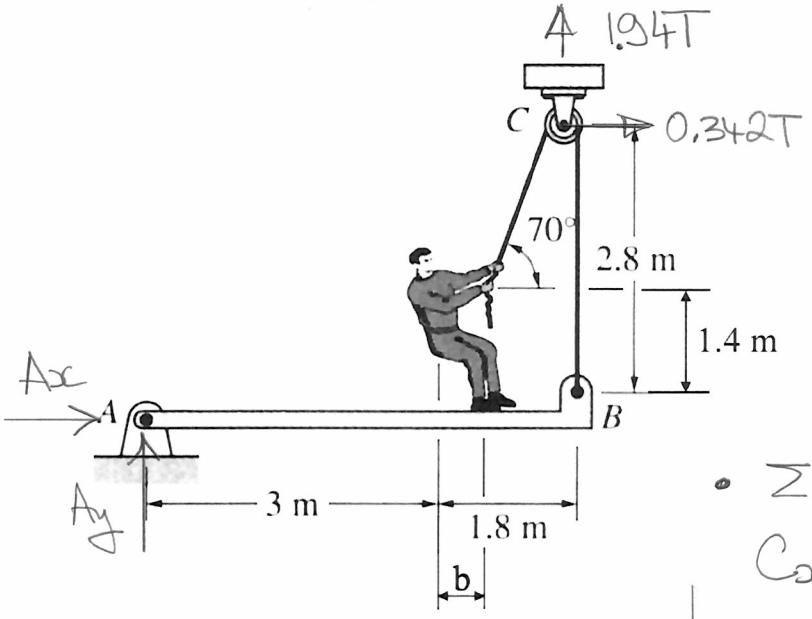
(2) $\Sigma\vec{M}_C = 0$ $\quad \vec{T}_{AD} = \frac{1}{3}\vec{i} - \frac{2}{3}\vec{j} + 1\vec{K}$ kN

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{K} \\ 4 & 2 & 0 \\ 1/3 & -2/3 & 1 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{K} \\ 2 & 2 & 0 \\ 0 & 0 & -1 \end{vmatrix} + \vec{M}_C = 0$$

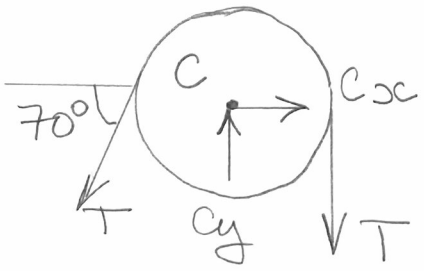
$$2\vec{i} - 4\vec{j} - \frac{10}{3}\vec{K} - 2\vec{i} + 2\vec{j} + M_x\vec{i} + M_y\vec{j} + M_z\vec{K} = 0$$

$$\begin{cases} 2 - 2 + M_x = 0 \\ -4 + 2 + M_y = 0 \\ -\frac{10}{3} + M_z = 0 \end{cases} \quad \therefore \quad \begin{aligned} M_x &= 0.00 \text{ kNm} \\ M_y &= 2.00 \text{ kNm} \\ M_z &= \frac{10}{3} = 3.33 \text{ kNm} \end{aligned}$$

2. A man supports himself and the uniform, horizontal beam *AB*, having a rough surface, by pulling on the rope with a force T. The mass of the man is 90 kg and that of the beam is 5.2 kg/m. The total weight of the beam acts at the mid-span of the beam. Compute the tension, T, in the rope and the reaction force components at the pin at *A*. In addition, calculate the distance *b*, locating the man's feet, and determine the forces exerted on the man by the beam.



(1) FBD of Pulley



- $\Sigma F_x = 0$

$C_x - T\cos 70° = 0 \quad C_x = 0.342T$

- $\Sigma F_y = 0$

$C_y - T - T\sin 70° = 0 \quad C_y = 1.94T$

(2) FBD of Man on Beam

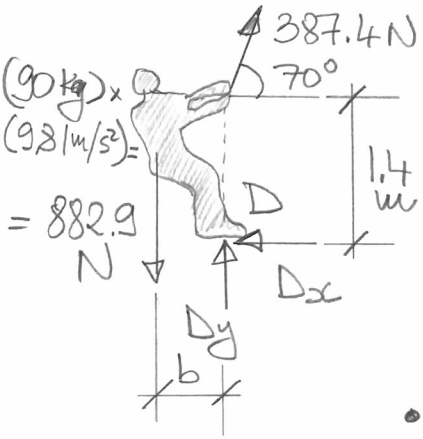
- $\Sigma M_A = 0$

$(1.94T)(4.8\,m) - (0.342T)(2.8\,m) - (90kg)(9.81\,m/s^2)(3m) -$
$-(5.2kg/m)(9.81\,m/s^2)(4.8m)(2.4m) = 0 \quad \therefore T = 387.4N$

- $\Sigma F_x = 0 \quad (0.342)(387.4N) + Ax = 0 \quad \therefore A_x = 132.5N \leftarrow$

- $\Sigma F_y = 0 \quad (1.94)(387.4N) - (90kg)(9.81\,m/s^2) -$
$-(5.2kg/m)(9.81\,m/s^2)(4.8\,m) + Ay = 0 \quad \therefore A_y = 376.2N \uparrow$

(3) FBD of Man



- $\Sigma M_D = 0$

$(90kg)(9.81\,m/s^2) - (0.342)(387.4N)(1.4\,m) = 0$

$\therefore b = 0.210\,m$

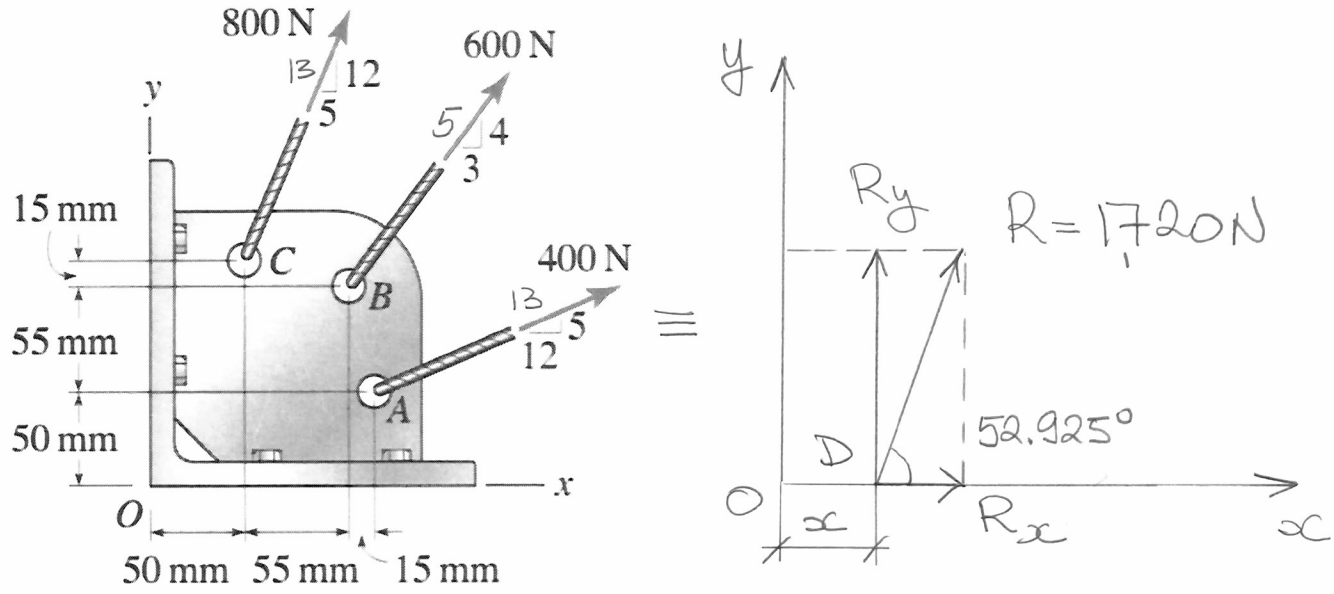
- $\Sigma F_x = 0$

$(0.342)(387.4N) - Dx = 0 \quad \therefore D_x = 132.5N \leftarrow$

- $\Sigma F_x = 0$

$Dy - (90kg)(9.81\,m/s^2) + (0.94)(387.4N) = 0 \quad \therefore D_y = 518.7N \uparrow$

3. The bracket illustrated is subjected to three cable forces, as indicated. Determine an equivalent force system consisting of a *single* resultant force and determine the x-coordinate of the point where its line of action intersect the x-axis.



- For equivalency: (1) $\Sigma F' = \Sigma F''(R)$

(2) $\Sigma M'_O = \Sigma M''_O$

(1) $\Sigma F_x = (800N)\left(\frac{5}{13}\right) + (600N)\left(\frac{3}{5}\right) + (400N)\left(\frac{12}{13}\right) = 1,036.93N$

$\Sigma F_y = (800N)\left(\frac{12}{13}\right) + (600N)\left(\frac{4}{5}\right) + (400N)\left(\frac{5}{13}\right) = 1,372.31N$

$R = \sqrt{(1,036.93)^2 + (1,372.31)^2} = \underline{1,720N}$

$\theta = \tan^{-1}\frac{1372.31}{1,036.93} = 52.925^\circ$

(2) $\Sigma M'_O = (800N)\left(\frac{12}{13}\right)(50mm) - (800N)\left(\frac{5}{13}\right)(120mm) +$

$+ (600N)\left(\frac{4}{5}\right)(105mm) - (600N)\left(\frac{3}{5}\right)(105mm) +$

$+ (400N)\left(\frac{5}{13}\right)(120mm) - (400N)\left(\frac{12}{13}\right)(50mm) = 12,600 N\,mm$

$\Sigma M''_O = (1,720N)(\sin 52.925^\circ)(x) = 1,372.297(x)$ N mm

$12,600 N\,mm = 1,372.297(x) N\,mm$

$\therefore \underline{x = 9.18\,mm}$ and $\underline{D(9.18, 0)\,mm}$