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, 1st November 2016

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. Saxe, Shoshanna	5. Miglietta, Paola	Online. Seica, Michael
2. El-Diraby, Tamer	6. Ruggiero, David	
3. Grasselli, Giovanni	7. Ruggiero, David	
4. Bruun, Edvard	8. Kamaleddine, Fouad	

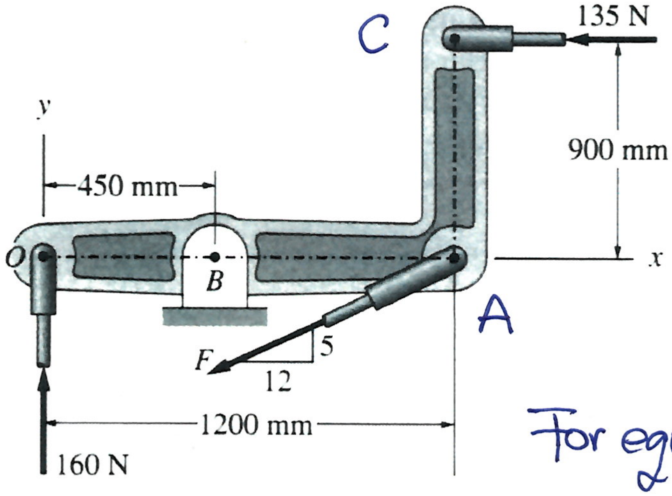
CIRCLE YOUR CALCULATOR TYPE:

CASIO 991 **SHARP 520**

Notes:
1. **Ensure that you have all five sheets 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, please use the back of the preceding question. In all cases, please indicate clearly where your calculations are continued.**
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.**

NAME: M. SEICA

1. The single resultant force of the three forces applied to the bracket is a force R which passes through point B. Determine the magnitude of forces R and F, and the direction of R.



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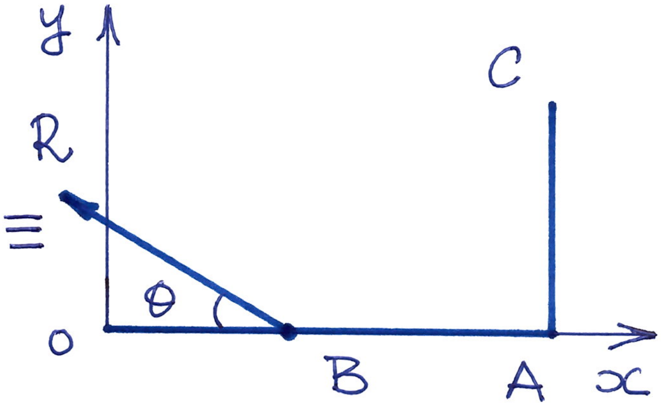

For equivalency: $\begin{cases} \Sigma F' = \Sigma F'' \\ \Sigma M'_B = \Sigma M''_B \end{cases}$

Since the single resultant force (i.e. $M=0$) passes through point B, it is convenient to sum the moments about B.

$$\Sigma M'_B = (135N)(0.9m) - F(5/13)(0.75m) - (160N)(0.45m) =$$

$$= 0 = \Sigma M''_B \qquad \therefore \underline{\underline{F = 171.6\,N}}$$

Then,

$$\Sigma F'_x = -135N - (171.6N)(12/13) = -293.4N = 293.4N \leftarrow = \Sigma F''_x$$

$$\Sigma F'_y = 160N - (171.6N)(5/13) = +94.0N = 94.0N \uparrow = \Sigma F''_y$$

$$\therefore R = \sqrt{(-293.4N)^2 + (94.0N)^2} = \underline{\underline{308\,N}}$$

$$\theta = \tan^{-1}\frac{94.0N}{293.4N} = \underline{\underline{17.76^\circ}}$$

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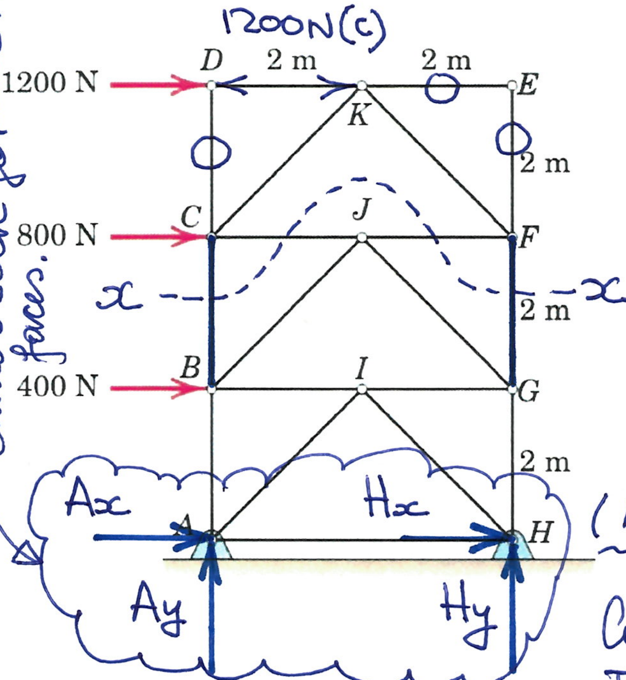
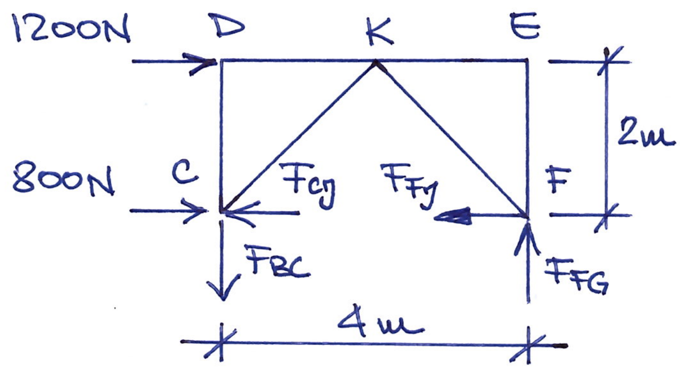
Externally statically indeterminate. Cannot solve for all reaction forces.

2. The truss illustrated is held in place by pin supports at joints *A* and *H*. Determine the forces in members *BC* and *FG* of the truss which is loaded as shown. Indicate whether the two members are in tension or compression.





FBD of Truss Above Cut x-x

(I) Method A: Using the Method of Sections

Cut along x-x and use the top FBD. See diagram above. The cut goes through four members with unknown forces but sum of moments at F and C will eliminate each three unknowns.

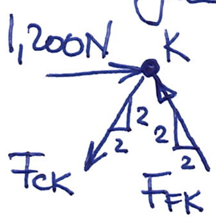
$$\Sigma M_F = 0 \quad F_{BC}(4m) - (1{,}200N)(2m) = 0 \quad \therefore \underline{\underline{F_{BC} = 600N\ (T)}}$$

$$\Sigma M_C = 0 \quad F_{FG}(4m) - (1{,}200N)(2m) = 0 \quad \therefore \underline{\underline{F_{FG} = 600N\ (C)}}$$

(II) Method B: Using the Method of Joints

Recognize that $F_{CD} = F_{EK} = F_{EF} = 0$ and $F_{DK} = 1{,}200N\,(C)$ (by inspection)

• Joint K



$\Sigma F_y = 0$

$F_{FK}(2/2\sqrt{2}) - F_{CK}(2/2\sqrt{2}) = 0$

$\therefore F_{CK} = F_{FK}$

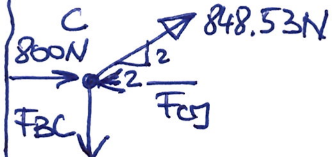
$\Sigma F_x = 0$

$1200N - F_{CK}(2/2\sqrt{2}) - F_{FK}(2/2\sqrt{2}) = 0$

$\therefore F_{CK} = 848.53N\ (T)$

$F_{FK} = 848.53N\ (C)$

• Joint C

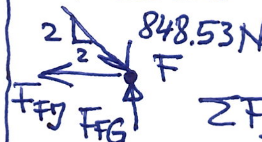


$\Sigma F_y = 0$

$848.53(2/\sqrt{2}) - F_{BC} = 0$

$\therefore \underline{\underline{F_{BC} = 600N\ (T)}}$

• Joint F



$\Sigma F_y = 0$

$F_{FG} - 848.53N(2/2\sqrt{2}) = 0$

$\therefore \underline{\underline{F_{FG} = 600N\ (C)}}$

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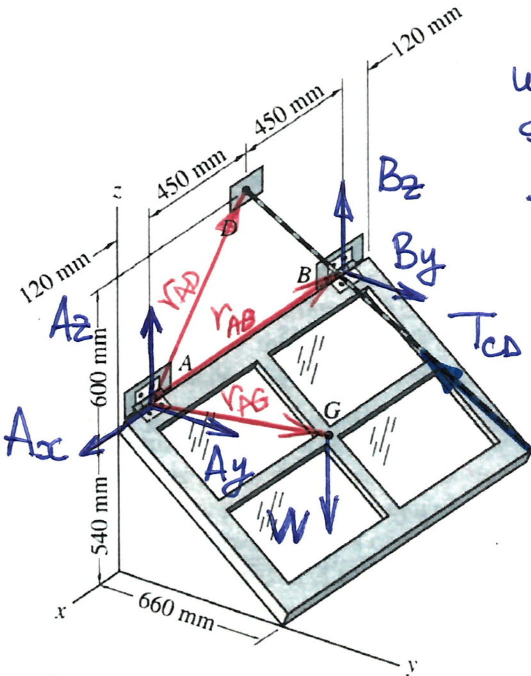
3. The window below has a mass of 20 kg, which acts at the geometric centre of the window, at *G*. The window is attached at A and B by two hinges which can be idealized as ball-and-socket supports. Find all forces acting on the window when it is held open in the position shown by the rope attached to it at *C*. The hinge at *B* has been modified to allow translation along its own axis of rotation.



Summing moments about line AB would solve for T_{CD}, but we need to solve for all unknowns, so...

$$\sum \vec{M}_A = 0 \quad (\vec{r}_{AD} \times \vec{T}_{CD}) + (\vec{r}_{AB} \times \vec{F}_B) + (\vec{r}_{AG} \times \vec{W}) = 0$$

$$\vec{T}_{CD} = T_{CD}\,\frac{0.57\vec{i} - 0.66\vec{j} + 1.14\vec{k}}{\sqrt{(0.57)^2 + (0.66)^2 + (1.14)^2}} = \frac{T_{CD}}{1.435}\left(0.57\vec{i} - 0.66\vec{j} + 1.14\vec{k}\right)$$

$$\vec{F}_B = B_y\vec{j} + B_z\vec{k}$$

$$\vec{W} = -(20\,\text{kg})(9.81\,\text{m/s}^2)\vec{k} = -196.2\vec{k}\ \text{N}$$

$\vec{r}_{AD} = -0.45\vec{i} + 0.6\vec{k}$ m; $\vec{r}_{AB} = -0.9\vec{i}$ m; $\vec{r}_{AG} = -0.45\vec{i} + 0.33\vec{j} - 0.27\vec{k}$ m.

- $\sum \vec{M}_A = 0$

$$\frac{T_{CD}}{1.435}\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -0.45 & 0 & 0.6 \\ 0.57 & -0.66 & 1.14 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -0.9 & 0 & 0 \\ 0 & B_y & B_z \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -0.45 & 0.33 & -0.27 \\ 0 & 0 & -196.2 \end{vmatrix} = 0$$

$$\begin{cases} 0.2759\,T_{CD} - 64.746 = 0 \\ 0.5958\,T_{CD} - 0.9B_z - 88.29 = 0 \\ 0.2069\,T_{CD} - 0.9B_y = 0 \end{cases}$$

$\therefore T_{CD} = 234.62\text{N} = \underline{\underline{234.6\text{N (T)}}}$

$B_z = 57.225\text{N} = \underline{\underline{57.2\text{N}}}$

$B_y = 53.955\text{N} = \underline{\underline{54.0\text{N}}}$

- $\sum \vec{F} = 0$

$$\left(A_x + \frac{0.57T_{CD}}{1.435}\right)\vec{i} + \left(A_y + B_y - \frac{0.66T_{CD}}{1.435}\right)\vec{j} + \left(A_z + B_z + \frac{1.14T_{CD}}{1.435} - 196.2\right)\vec{k} = 0$$

$\therefore A_x = -93.195\text{N} = \underline{\underline{-93.2\text{N}}}$

$A_y = 53.955\text{N} = \underline{\underline{54.0\text{N}}}$

$A_z = 67.035\text{N} = \underline{\underline{67.0\text{N}}}$