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 2022
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	5. Seica, Michael	Online. Seica, Michael
2. Packer, Jeffrey	6. Packer, Jeffrey	
3. Bu, Xiao	7. Salehin, Mohammad	
4. Tao, Junjie	8. Seica, Michael	

CIRCLE YOUR CALCULATOR TYPE:

CASIO FX-991 **SHARP EL-W516**

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 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

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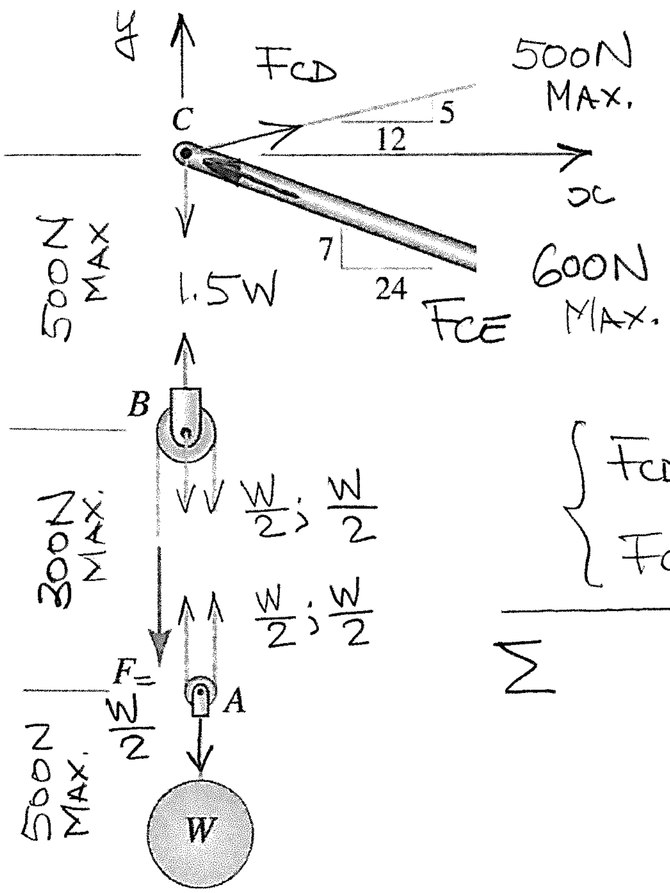
1. The hoist shown is used in a machine shop to position heavy workpieces in a lathe. If the cable between pulleys *A* and *B* can support a force of 300 N, all other cables can support a force of 500 N and bar *CE* can support an axial force of 600 N, determine the largest weight, W, that can be lifted.



At C: $\Sigma F_x = 0$

$\Sigma F_y = 0$

$$\begin{cases} F_{CD}\frac{12}{13} - F_{CE}\frac{24}{25} = 0 & (\times 5) \\ F_{CD}\frac{5}{13} + F_{CE}\frac{7}{25} = 1.5W & (\times 12) \end{cases}$$

$$\begin{cases} F_{CD}\frac{60}{13} - F_{CE}\frac{120}{25} = 0 & (\times(-1)) \\ F_{CD}\frac{60}{13} + F_{CE}\frac{84}{25} = 18W \end{cases}$$

$$\Sigma \quad / \quad F_{CE}\frac{204}{25} = 18W$$

$\therefore F_{CE} = 2.206W$ (C)

$F_{CD} = 2.294W$ (T)

(1) $W \le 500N$ (Lower cable)

(2) $\frac{W}{2} \le 300N$; $W \le 600N$ (Cable between A-B)

(3) $1.5W \le 500N$; $W \le 333N$ (Cable BC)

(4) $2.206W \le 600N$; $W \le 272N$ (Bar CE)

(5) $2.294W \le 500N$; $\underline{\underline{W \le 218N}}$ (Cable CD)

Lowest value governs.

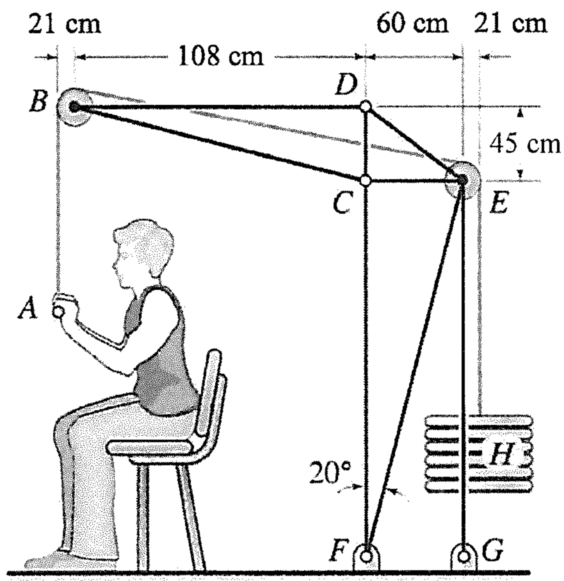
$\therefore$ Cable CD will fail for $\underline{\underline{W_{max} = 218N}}$

Solution can be continued on Page 3

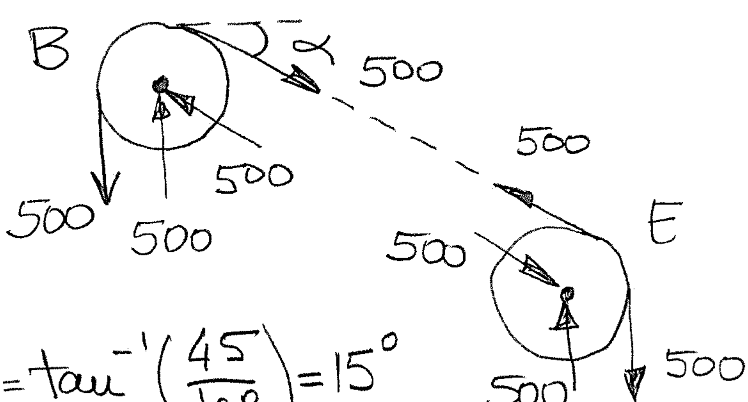
Question 1 can be continued on this page.

Solution can be continued on Page 8

2. In the exercise machine shown, the stack of weights at *H* weighs 500 N. If cable segment *AB* is vertical, determine the force supported by each member of the machine.

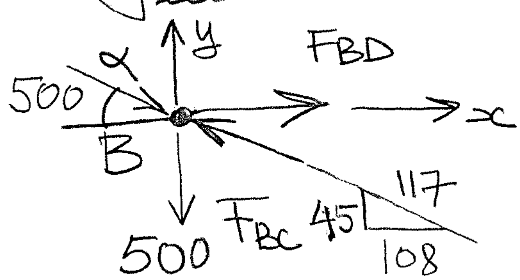


- Force in cable = 500N
- Pulley reaction forces at B and E:



$\alpha = \tan^{-1}\left(\frac{45}{168}\right) = 15^\circ$

- Joint B



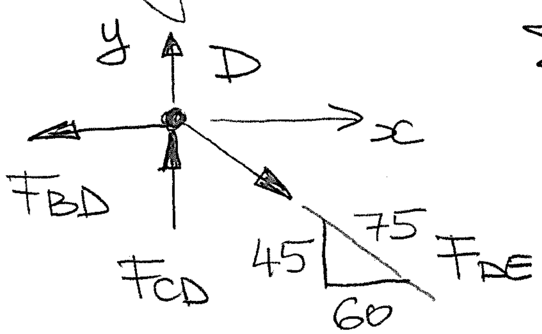
$\Sigma F_y = 0: -500 - (500)\sin 15^\circ + F_{BC}\frac{45}{117} = 0$

$\therefore F_{BC} = 1{,}636\,N\ (C)$

$\Sigma F_x = 0: F_{BD} + (500)\cos 15^\circ - F_{BC}\frac{108}{117} = 0$

$\therefore F_{BD} = 1{,}028\,N\ (T)$

- Joint D



$\Sigma F_x = 0: -F_{BD} + F_{DE}\frac{60}{75} = 0$

$\therefore F_{DE} = 1{,}285\,N\ (T)$

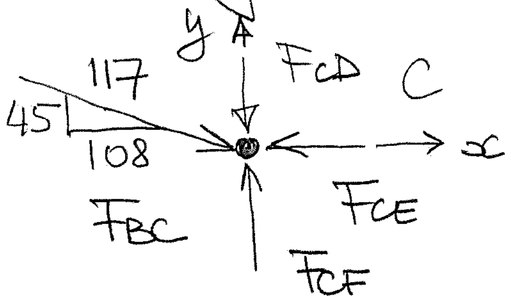
$\Sigma F_y = 0: F_{CD} - F_{DE}\frac{45}{75} = 0$

$\therefore F_{CD} = 771\,N\ (C)$

Solution can be continued on Page 5

Question 2 can be continued on this page.

• Joint C



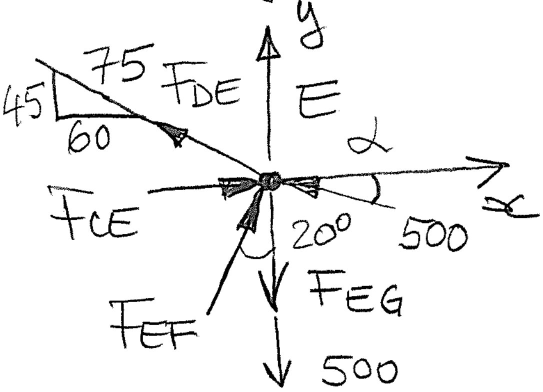
$\Sigma F_x = 0$: $F_{BC} \frac{108}{117} - F_{CE} = 0$

$\therefore$ $F_{CE} = 1{,}511$ N (C)

$\Sigma F_y = 0$: $F_{CF} - F_{CD} - F_{BC} \frac{45}{117} = 0$

$\therefore$ $F_{CF} = 1{,}400$ N (C)

• Joint E



$\Sigma F_x = 0$:

$F_{CE} - F_{DE} \frac{60}{75} + F_{EF} \sin 20^\circ - (500)\cos 15^\circ = 0$

$\therefore$ $F_{EF} = 0$ N

(Cannot be determined by inspection)

$\Sigma F_y = 0$:

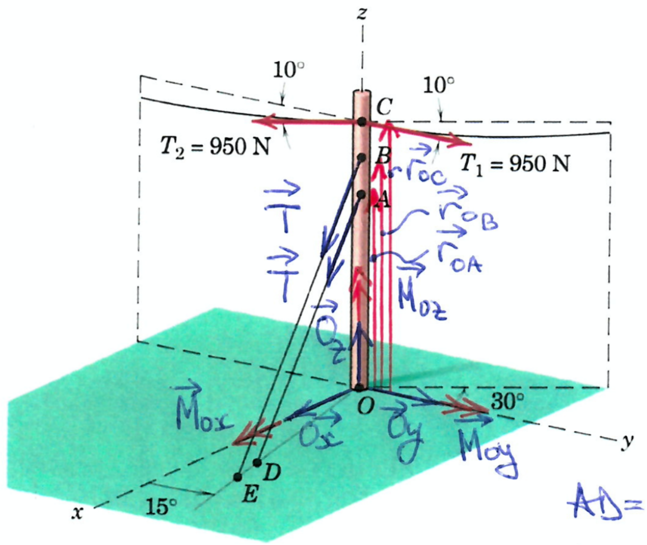
$F_{EF} \cos 20^\circ + F_{DE} \frac{45}{75} + (500)\sin 15^\circ - F_{EG} - 500 = 0$

$\therefore$ $F_{EG} = 400$ N (T)

NOTE: This is a cantilever truss, so the reaction forces at F and G do not need to be calculated.

Solution can be continued on Page 8

3. The vertical plane containing the utility cable turns 30º at the vertical pole *OC*, which is fixed at the base, at *O*. The magnitude of both tension forces, T_1 and T_2, is 950 N. In order to prevent long-term leaning of the pole, guy wires *AD* and *BE* are utilized. If the two guy wires are adjusted so as to carry equal tension forces, *T*, which together reduce the moment at *O* to zero, determine the magnitude of the horizontal reaction force at *O*. Also, determine the required magnitude of *T*. Neglect the mass of the pole.



• For $\vec{T}_1$:

$\cos\theta_x = \cos(90°+30°)\cos 10° = -0.49240$

$\cos\theta_y = \cos(-10°)\cos 30° = 0.85287$

$\cos\theta_z = \cos(-90°-10°) = -0.17365$

• For $\vec{T}_2$: $\cos\theta_x = \cos 90° = 0$

$\cos\theta_y = \cos(180°+10°) = -0.98481$

$\cos\theta_z = \cos(90°+10°) = -0.17365$

$\therefore \vec{T}_1 = 950(-0.4920\vec{i} + 0.85287\vec{j} - 0.17365\vec{k})\,N$

$\vec{T}_2 = 950(-0.98481\vec{j} - 0.17365\vec{k})\,N$

Dimensions: $\overline{OA}$ = 9 m $\overline{OD}$ = 8 m

$\overline{OB}$ = 11 m $\overline{OE}$ = 10 m

Dimensions: $\overline{OC}$ = 13 m

$AD = \sqrt{9^2+8^2} = 12.0416\,m$

$BE = \sqrt{11^2+10^2} = 14.8661\,m$

$\vec{r}_{OA} = 9\vec{k}\,m;\ \vec{r}_{OB} = 11\vec{k}\,m;\ \vec{r}_{OC} = 13\vec{k}\,m$

$$\vec{T}_{AD} = T\left[\frac{(8)\cos 15°}{12.0416}\vec{i} + \frac{(8)\sin 15°}{12.0416}\vec{j} - \frac{9}{12.0416}\vec{k}\right] = T(0.64173\vec{i} + 0.17195\vec{j} - 0.74741\vec{k})$$

$$\vec{T}_{BE} = T\left[\frac{(10)\cos 15°}{14.8661}\vec{i} + \frac{(10)\sin 15°}{14.8661}\vec{j} - \frac{11}{14.8661}\vec{k}\right] = T(0.64975\vec{i} + 0.1741\vec{j} - 0.73994\vec{k})$$

$$\bullet\ \sum \vec{M}_O = 0 \quad \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0 & 13 \\ -0.4924 & +0.85287 & -0.17365 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0 & 13 \\ 0 & -0.98481 & -0.17367 \end{vmatrix} +$$

$$T\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0 & 9 \\ 0.64173 & 0.17195 & -0.74741 \end{vmatrix} + T\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0 & 11 \\ 0.64975 & 0.1741 & -0.73994 \end{vmatrix} + \underbrace{M_{Ox}\vec{i} + M_{Oy}\vec{j} + M_{Oz}\vec{k}}_{\text{Must be} = 0!} = 0$$

$+1629.5\vec{i} - 6081.1\vec{j} - 3.46265T\vec{i} + 12.9223T\vec{j} = 0 \quad \therefore T = 470.6 = \underline{\underline{471\,N}}$

$$\bullet\ \sum \vec{F} = 0 \quad \underbrace{302\vec{i} + 80.92\vec{j} - 351.7\vec{k}}_{\vec{T}_{AD}},\ + \underbrace{305.8\vec{i} + 81.93\vec{j} - 348.2\vec{k}}_{\vec{T}_{BE}}\ -$$

$$\underbrace{467.8\vec{i} + 810.2\vec{j} - 165\vec{k}}_{\vec{T}_1},\ - \underbrace{935.6\vec{j} - 165\vec{k}}_{\vec{T}_2} + O_x\vec{i} + O_y\vec{j} + O_z\vec{k} = 0$$

$O_x = -140\,N;\ O_y = -37.5\,N \quad \therefore$ Horiz. react. force at $O = \sqrt{(-140)^2 + (-37.5)^2} = \underline{\underline{144.9\,N}}$

<u>Question 3</u> can be continued on this page.

Solution can be continued on Page 8