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, 27th October 2015

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. Panesar, Daman	Online. Seica, Michael
2. El-Diraby, Tamer	6. Grasselli, Giovanni	
3. Packer, Jeffrey	7. Grasselli, Giovanni	
4. Xia, Kaiwen	8. Kamaleddine, Fouad	

CIRCLE YOUR CALCULATOR TYPE:

CASIO 991 **SHARP 520**

Notes: 1. Ensure that you have all 5 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. No other paper will be accepted for marking or allowed on the desk.

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

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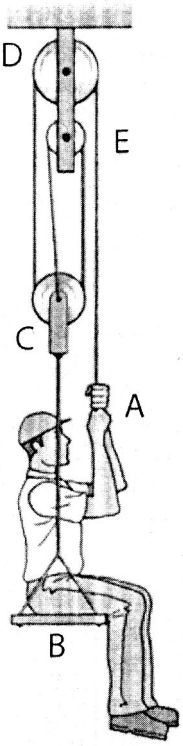
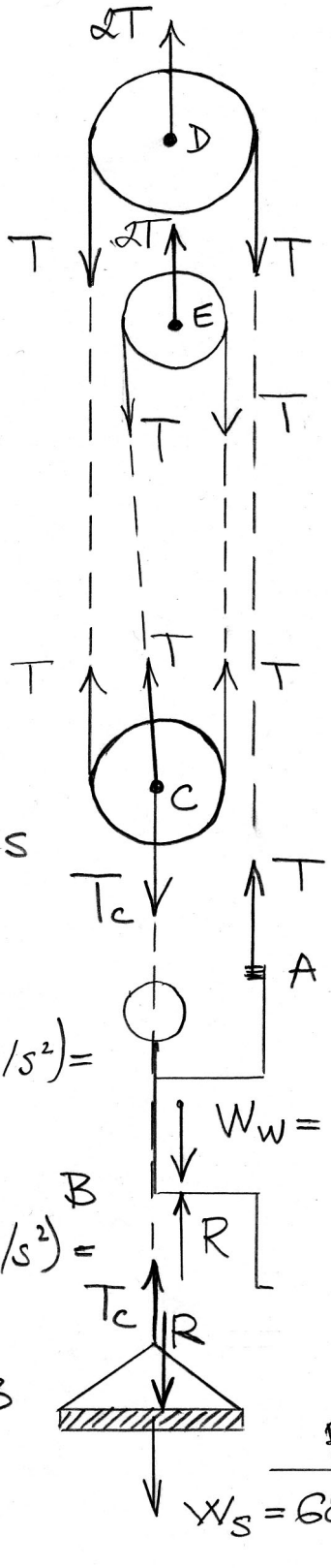
1. A worker having a mass of 80 kg supports himself in the boatswain's chair by means of the cable and pulley system shown. If the seat has a mass of 7 kg, determine the tension force, T, which the worker must exert with his hands on the cable at *A* in order that he is in equilibrium. What force, R, does the worker exert on the chair? Neglect the mass of the cable and pulleys.





Assume all cables are vertical.

- For worker:

$W_w = (80\,kg)(9.81\,m/s^2) = 784.8N.$

- For seat:

$W_s = (7kg)(9.81\,m/s^2) = 68.7N.$

- Pulley at D:

$\Sigma F_y = 0$

$-T - T + 2T = 0$

- Pulley at E:

$\Sigma F_y = 0$

$-T - T + 2T = 0$

- Pulley at C:

$\Sigma F_y = 0$

$T + T + T - T_c = 0$

$\therefore T_c = 3T \downarrow$

- FBD of Worker:

$\Sigma F_y = 0$

$T + R - 784.8N = 0$

$R = 784.8N - T$

- FBD of Seat:

$\Sigma F_y = 0$

$3T - R - 68.7N = 0$

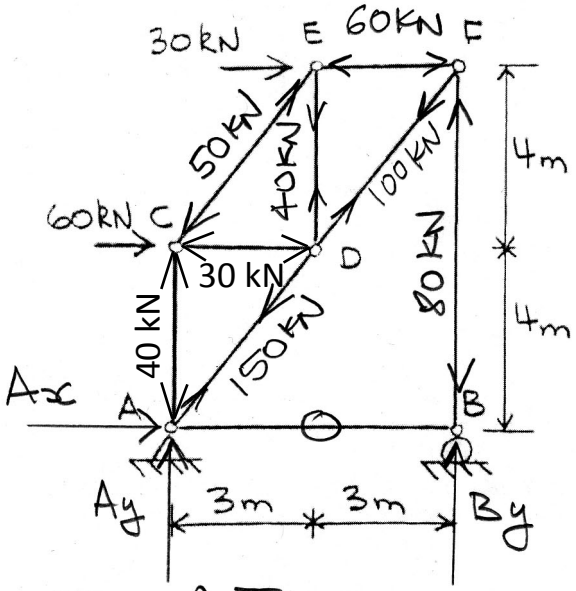
$3T - 784.8N + T - 68.7N = 0$

$\therefore T = 213N$

$R = 784.8N - 213.4N$

$\therefore R = 571N$

2. Determine the forces in all members of the truss below. Show you final answers on a similar sketch of the truss and indicate if the members are in tension or compression.



FBD of Truss

• Truss reaction forces:

$\Sigma F_x = 0 \quad A_x + 30kN + 60kN = 0$

$\therefore A_x = -90kN = 90kN \leftarrow$

$\Sigma M_B = 0 \quad -A_y(6m) - (30kN)(8m) - (60kN)(4m) = 0$

$\therefore A_y = -80kN = 80kN \downarrow$

$\Sigma M_A = 0 \quad B_y(6m) - (30kN)(8m) - (60kN)(4m) = 0$

$\therefore B_y = 80kN \uparrow$

Check: $\Sigma F_y = 0 \quad -80kN + 80kN = 0$ ✓

• Truss Member Forces: $F_{AB} = 0$ and $F_{BF} = 80kN\ (C)$ (by insp.)

(1) Joint F

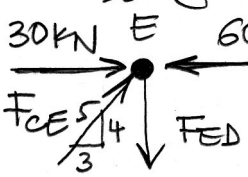
$\Sigma F_y = 0 \quad 80kN - \frac{4}{5}F_{FD} = 0$

$\therefore F_{FD} = 100kN\ (T)$

$\Sigma F_x = 0 \quad F_{EF} - \frac{3}{5}(100kN) = 0$

$\therefore F_{EF} = 60kN\ (C)$

(2) Joint E



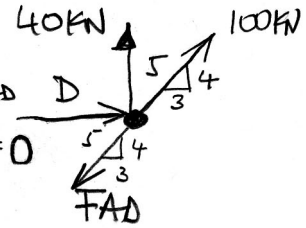
$\Sigma F_x = 0 \quad 30kN - 60kN + \frac{3}{5}F_{CE} = 0$

$\therefore F_{CE} = 50kN\ (C)$

$\Sigma F_y = 0 \quad \frac{4}{5}(50kN) - F_{ED} = 0$

$\therefore F_{ED} = 40kN\ (T)$

(3) Joint D



$\Sigma F_y = 0$

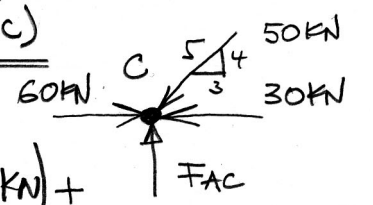
$40kN + \left(\frac{4}{5}\right)(100kN - F_{AD}) = 0$

$\therefore F_{AD} = 150kN\ (T)$

$\Sigma F_x = 0 \quad F_{CD} + \left(\frac{3}{5}\right)(100kN - 150kN) = 0$

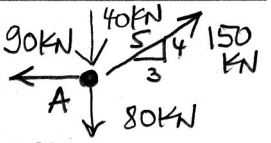
$\therefore F_{CD} = 30kN\ (C)$

(4) Joint C



$\Sigma F_y = 0 \quad -\frac{4}{5}(50kN) + F_{AC} = 0 \quad \therefore F_{AC} = 40kN\ (C)$

(5) Joint A – Check!



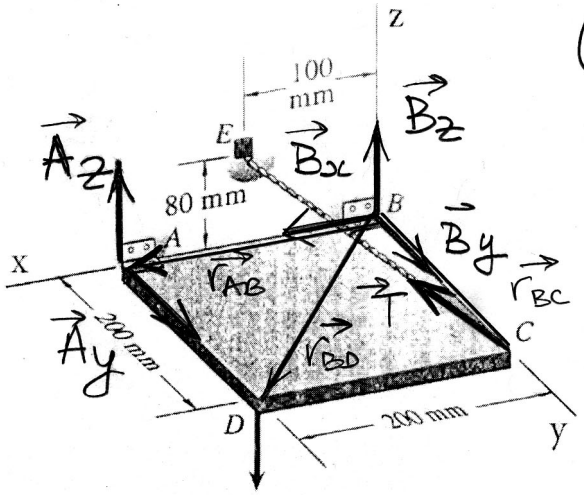
$\Sigma F_x = 0$

$-90kN + \left(\frac{3}{5}\right)(150kN) = 0$ OK

$\Sigma F_y = 0$

$\left(\frac{4}{5}\right)(150kN) - 40kN - 80kN = 0$ OK

3. The plate shown is supported by hinges at *A* and *B*, and by the cable *CE*. The axes of the two hinges are aligned along the *x*-axis and the hinge at *A* is modified so that it can slide freely in the direction of the *x*-axis. Determine the magnitude and indicate the direction of the reaction force components at the hinges and the magnitude of the force in the cable. Neglect the mass of the plate.



(a) $\sum \vec{M}_B = 0$ and (b) $\sum \vec{F} = 0$

$\vec{W} = -400\vec{k}$ N; $\vec{r}_{BC} = 0.2\vec{j}$ m

$\vec{r}_{AB} = 0.2\vec{i}$ m; $\vec{r}_{BD} = 0.2\vec{i} + 0.2\vec{j}$ m

$$\vec{T} = T\frac{0.1\vec{i} - 0.2\vec{j} + 0.08\vec{k}}{\sqrt{(0.1)^2 + (-0.2)^2 + (0.08)^2}} =$$

$$T(0.421\vec{i} - 0.842\vec{j} + 0.337\vec{k})$$

(a) $$\sum \vec{M}_B = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0.2 & 0 \\ 0.421T & -0.842T & 0.337T \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0.2 & 0 & 0 \\ 0 & A_y & A_z \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0.2 & 0.2 & 0 \\ 0 & 0 & -400 \end{vmatrix} = 0$$

$$\sum \vec{M}_B = (0.0674T - 80)\vec{i} + (-0.2A_z + 80)\vec{j} + (-0.0842T + 0.2A_y)\vec{k} = 0$$

(i) $\sum M_x = 0$ $0.0674T - 80 = 0$ $\therefore$ $T = 1{,}187\text{N (T)}$

(ii) $\sum M_y = 0$ $-0.2A_z + 80 = 0$ $\therefore$ $A_z = 400\text{N} \uparrow$

(iii) $\sum M_z = 0$ $(-0.0842)(1187) + 0.2A_y = 0$ $\therefore$ $A_y = 500\text{N} \searrow$

(b) $\sum \vec{F} = 0$

$\sum F_x = 0$ $B_x + (0.421)(1{,}187\text{N}) = 0$ $\therefore$ $B_x = -500 = 500\text{N} \rightarrow$

$\sum F_y = 0$ $500\text{N} + B_y - (0.842)(1{,}187\text{N}) = 0$ $\therefore$ $B_y = 500\text{N} \searrow$

$\sum F_z = 0$ $400\text{N} + B_z + (0.337)(1{,}187\text{N}) - 400\text{N} = 0$

$\therefore$ $B_z = -400 = 400\text{N} \downarrow$