UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

CIV100S – MECHANICS

Midterm Examination

Wednesday, 5th March 2025

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:

1. Seica, Michael	4. -	7. -
2. -	5. -	8. -
3. -	6. -	9. -

INDICATE YOUR CALCULATOR TYPE:

☐ **CASIO FX-991** ☐ **SHARP EL-W516** ☐ **SHARP EL-520**

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

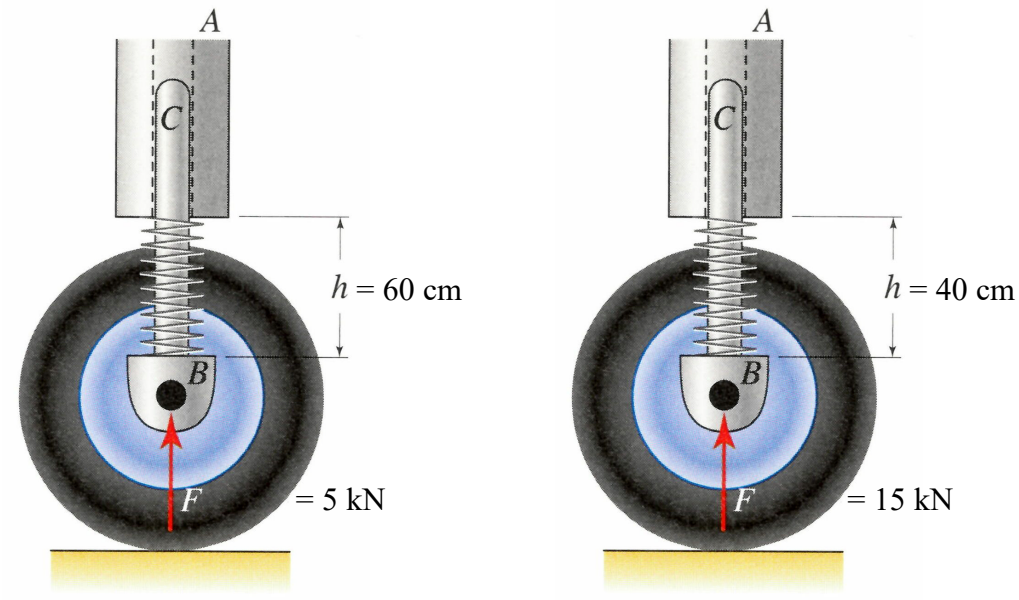
7. Turn OFF all electronic equipment and place it in your bag

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

---

1. The suspension for the landing gear of an airplane is shown. The wheel is attached to rod *BC*, which can slide vertically without friction in housing *A* that is fixed to the fuselage of the aircraft. The spring is pre-compressed so that it does not undergo additional shortening until the force supported by the landing gear, *F*, is sufficiently large. Furthermore, if the force *F* exceeds a limit value, the suspension *'bottoms out'* and cannot deflect further. Determine the spring constant, *k*, and the unstretched length of the spring, *l*, if:

- $h = 60$ cm, for $F \leq 5{,}000$ N; and
- $h = 40$ cm, for $F \geq 15{,}000$ N.



Condition A Condition B

For Cond. A: $F_A = 5$ kN; $h_A = l - \Delta y_A = 60$ cm $\rightarrow \Delta y_A = l - 60$

For Cond. B: $F_B = 15$ kN; $h_B = l - \Delta y_B = 40$ cm $\rightarrow \Delta y_B = l - 40$

But $F = k\Delta y$, so: $5 = k(l-60) \rightarrow k = 5/(l-60)$ (A)

$15 = k(l-40) \rightarrow k = 15/(l-40)$ (B)

Hence, $\frac{l-60}{5} = \frac{l-40}{15} \rightarrow 3l - 180 = l - 40$

$\therefore l = 140/2 = 70$ cm $= 0.7$ m

Then substitute l into (A) or (B)

$\therefore k = \frac{5}{70-60} = 0.5$ kN/cm

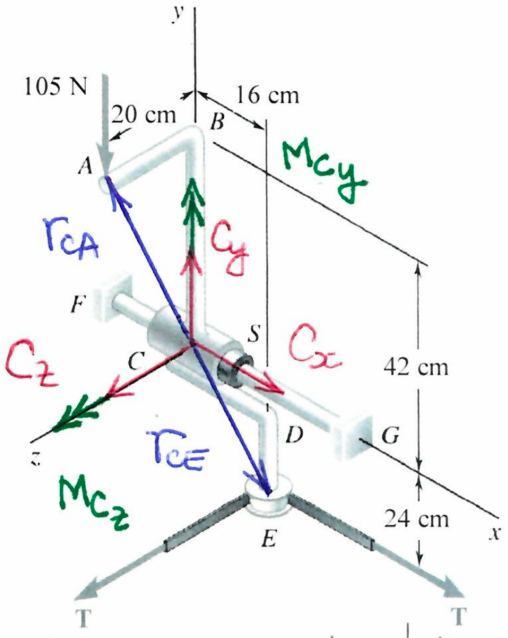
$= 50{,}000$ N/m

Solution can be continued on Page 3

2. The assembly shown is used to control the tension *T* in a tape that passes around a frictionless pulley at *E*. Rods *ABC* and *CDE* are rigidly connected through welding to collar *C*. *AB* is parallel to the *z*-axis, *BC* and *DE* are parallel to the *y*-axis, and *CD* is parallel to the *x*-axis. The collar can rotate *only* about shaft *FG* and its motion along the shaft is prevented by a washer, *S*. *F* and *G* are fixed supports for the shaft. Given the loading and configuration shown, determine:

(a) The tension *T* in the tape; and

(b) The Cartesian expression for the reaction force at *C* and its magnitude.



$\vec{F}_A = -105\vec{j}\ N$

$\vec{T} = T\vec{i} + T\vec{k}$

$\vec{r}_{CA} = 0.42\vec{j} + 0.2\vec{k}\ m$

$\vec{r}_{CE} = 0.16\vec{i} - 0.24\vec{j}\ m$

$\bullet\ \Sigma \vec{M}_C = 0$

$(\vec{r}_{CA} \times \vec{F}_A) + (\vec{r}_{CE} \times \vec{T}) + \vec{M}_C = 0$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0.42 & 0.20 \\ 0 & -105 & 0 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0.16 & -0.24 & 0 \\ T & 0 & T \end{vmatrix} + M_{cy}\vec{j} + M_{cz}\vec{k} = 0$$

$21\vec{i} - 0.24T\vec{i} - 0.16T\vec{j} + 0.24T\vec{k} + M_{cy}\vec{j} + M_{cz}\vec{k} = 0$

$\therefore 21\vec{i} - 0.24T\vec{i} = 0 \rightarrow \underline{T = 87.5\ N}$

$\bullet\ \Sigma \vec{F} = 0$

$\Sigma F_x = 0 \quad C_x + T = 0 \quad C_x = -87.5\ N$

$\Sigma F_y = 0 \quad C_y - 105 = 0 \quad C_y = 105\ N$

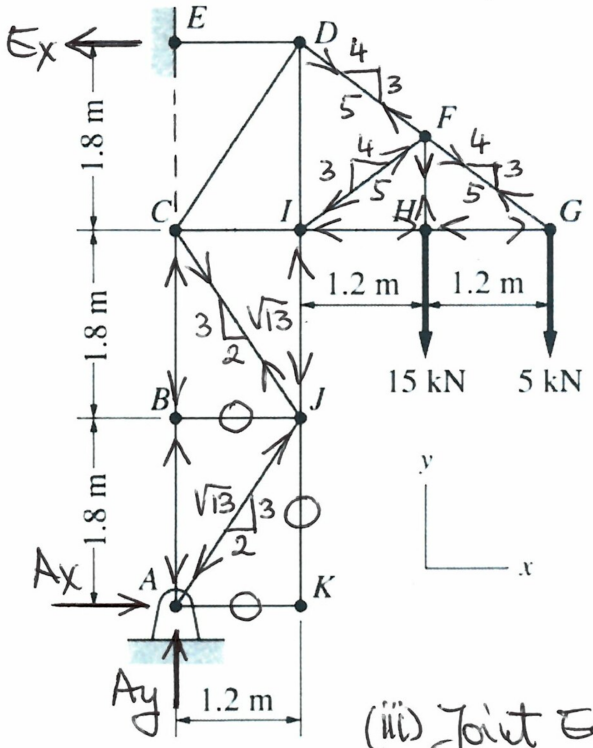
$\Sigma F_z = 0 \quad C_z + T = 0 \quad C_z = -87.5\ N$

$\therefore \underline{\vec{C} = -87.5\vec{i} + 105.0\vec{j} - 87.5\vec{k}\ N}$

$\underline{C = \sqrt{(-87.5)^2 + (105.0)^2 + (-87.5)^2} = 162.3\ N}$

Solution can be continued on Page 5

3. For the truss loaded as illustrated, determine the force in members *BC*, *CJ*, *DF*, *FH*, *HI* and state if the members are in tension or compression. Also, indicate zero-force members, if there are any.



(i) By inspection: $F_{AK} = F_{JK} = F_{BJ} = 0$

$F_{BC} = F_{AB}$; $F_{HI} = F_{GH}$; $\underline{F_{FH} = 15.00\,kN(T)}$

(ii) Reaction forces

$\Sigma M_E = 0 \quad A_x(5.4) - (15)(2.4) - (5)(3.6) = 0$

$\therefore A_x = 10\,kN \rightarrow$

$\Sigma F_y = 0 \quad A_y - 15 - 5 = 0 \therefore A_y = 20\,kN \uparrow$

(iii) Joint Equilibrium

- Joint A: $\Sigma F_x = 0 \quad 10 - F_{AJ}\left(\frac{2}{\sqrt{13}}\right) = 0 \therefore F_{AJ} = 18.03\,kN(C)$

  $\Sigma F_y = 0 \quad -F_{AB} + 20 - 18.03\left(\frac{3}{\sqrt{13}}\right) = 0 \therefore \underline{F_{AB} = 5.00\,kN(C) = F_{BC}}$

- Joint J: $\Sigma F_x = 0 \quad 18.03\left(\frac{2}{\sqrt{13}}\right) - F_{CJ}\left(\frac{2}{\sqrt{13}}\right) = 0 \therefore \underline{F_{CJ} = 18.03\,kN(T)}$

- Joint G: $\Sigma F_y = 0 \quad F_{FG}\left(\frac{3}{5}\right) - 5 = 0 \therefore F_{FG} = 8.33\,kN(T)$

  $\Sigma F_x = 0 \quad F_{GH} - 8.33\left(\frac{4}{5}\right) = 0 \therefore \underline{F_{GH} = 6.67\,kN(C) = F_{HI}}$

- Joint F: $\Sigma F_x = 0 \quad 8.33\frac{4}{5} + F_{FI}\left(\frac{4}{5}\right) - F_{DF}\left(\frac{4}{5}\right) = 0 \quad F_{DF} - F_{FI} = 8.33$

  $\Sigma F_y = 0 \quad -15 - 8.33\left(\frac{3}{5}\right) + F_{FI}\left(\frac{3}{5}\right) + F_{DF}\left(\frac{3}{5}\right) = 0 \quad F_{DF} + F_{FI} = 33.33$

  $\therefore \underline{F_{DF} = 20.8\,kN(T)}$

Solution can be continued on Page 7