QUIZ 1
Fall 2013-14
(Wednesday October 23, 2013)
CIVE210 – STATICS
CLOSED BOOK, 1 HR 25 MN

Name: 007 **ID#:** 007 **Sec:** 007

NOTES

- 3 PROBLEMS– 12 PAGES.
- ALL YOUR ANSWERS SHOULD BE PROVIDED ON THE QUESTION SHEETS.
- **TWO EXTRA SHEETS ARE PROVIDED AT THE END.**
- **ASK FOR ADDITIONAL SHEETS IF YOU NEED MORE SPACE.**
- SOME ANSWERS MAY REQUIRE MUCH LESS THAN THE SPACE PROVIDED.
- ***DO NOT*** USE THE BACK OF THE SHEETS FOR ANSWERS.
- *DRAFT BOOKLET WILL BE PROVIDED; BUT DO NOT USE FOR ANSWERS.*
- BOTH QUESTION SHEETS AND DRAFT BOOKLET SHOULD BE RETURNED.
- CHECK BOXES ARE TO CONFIRM THAT YOU HAVE SOLVED A QUESTION. ☑

YOUR COMMENT(S)

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

YOUR GRADE

Problem I:	30 /30
Problem II:	30 /30
Problem III:	40 /40
Bonus/Extras – Organization, Neatness, Special, ….:	___
TOTAL:	/100

Problem I: *(30 points)*

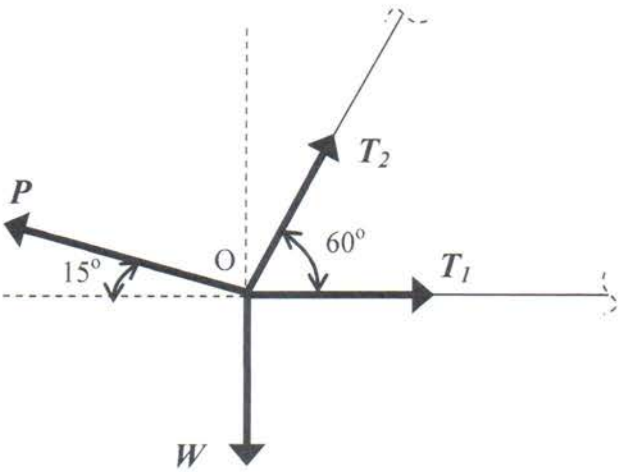


Figure I

Tick Boxes to check that you solved all questions

Referring to Figure I, the particle O is subjected to the applied loads $\boldsymbol{P}$ and $\boldsymbol{W}$ and is held in equilibrium by the cables in tension T_1 and T_2. The maximum tension that a cable can take is 1,000 lbs and it cannot take any compression.

1- Calculate the tension forces in each of the cables if P = 1,200 lbs and W = 1,000 lbs, and comment whether the system will hold the loads (your comment should be in 2 lines only; we will not read the third line and beyond). *(10 points)* ☑

2- If P is maintained at 1,200 lbs, determine the largest load W that the system can hold before it breaks. *(15 points)* ☑

3- If P is removed and W is still applied, analyze and evaluate the system (short question). *(5 points)* ☑

Calculations and/or Diagrams:

1. $\underset{\oplus\longrightarrow}{\sum F_x = 0} \Rightarrow T_1 + T_2 \cos 60 - \overset{\to 1200}{P} \cos 15 = 0$

$\Rightarrow T_1 + 0.5 T_2 = 1159.1$ ①

$\oplus\uparrow \sum F_y = 0 \Rightarrow T_2 \sin 60 + \overset{\to 1200}{P} \sin 15 - \overset{\to 1000}{W} = 0$

$\Rightarrow 0.866\, T_2 = 689.4$ ②

② $\Rightarrow$ $\boxed{T_2 = \oplus 796.1 \text{ lbs}}$ (Tension ✓)

① $\Rightarrow$ $\boxed{T_1 = \oplus 761.0 \text{ lbs}}$ (Tension ✓)

Comment: T_1 & T_2 are tensile forces and < max 1000 lbs ✓

System can hold (Additional Safety $= \frac{1000}{796.1} = 1.26$ or 26% above

Calculations and/or Diagrams (cont'd):

2. $P = 1200$ lbs $W_{max} = ?$

Case 1: Set $T_2 = (+)1000$ lbs (max tension)

① ⇒ $T_1 = (+)659.1$ lb (<1000)

② ⇒ $W = 1000 \sin 60 + 1200 \sin 15 = 1176.6$ lbs

Case 2: Set $T_1 = +1000$ lbs

① ⇒ $T_2 = 318.2$ lbs (<1000)

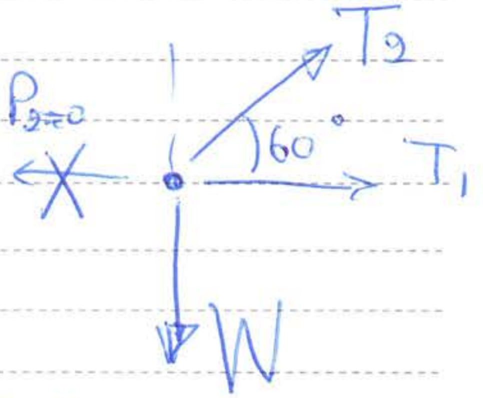
② ⇒ $W = 318.2 \sin 60 + 1200 \sin 15 = 586.1$ lbs.

So $\boxed{W_{max} = 1176.6 \text{ lbs}}$ with $T_2 = 1000$ lbs

$T_1 = 659.1$ lbs

(If $W > 1176.6$ say $W = 1200$ lbs then $T_2 = 1027 > 1000$ [illegible])

3.



$\Sigma F_x = 0$ $\xrightarrow{+}$ ⇒ $T_1 + T_2 \cos 60 = 0$

⇒ $T_1 = -0.5 T_2$ (≠ signs)

⇒ So one cable will be under tension and other under compression

$(+\uparrow)$ $\Sigma F_y = 0$ $T_2 \sin 60 = W$

⇒ $T_2 = (+)W/\sin 60$ (tension)

+ $T_2 < 0$ X

Cable cannot hold compression.

$\boxed{\text{System Cannot hold}}$ (unless $W = 0$! then $T_1 = T_2 = 0$)

Problem II: *(30 points)*

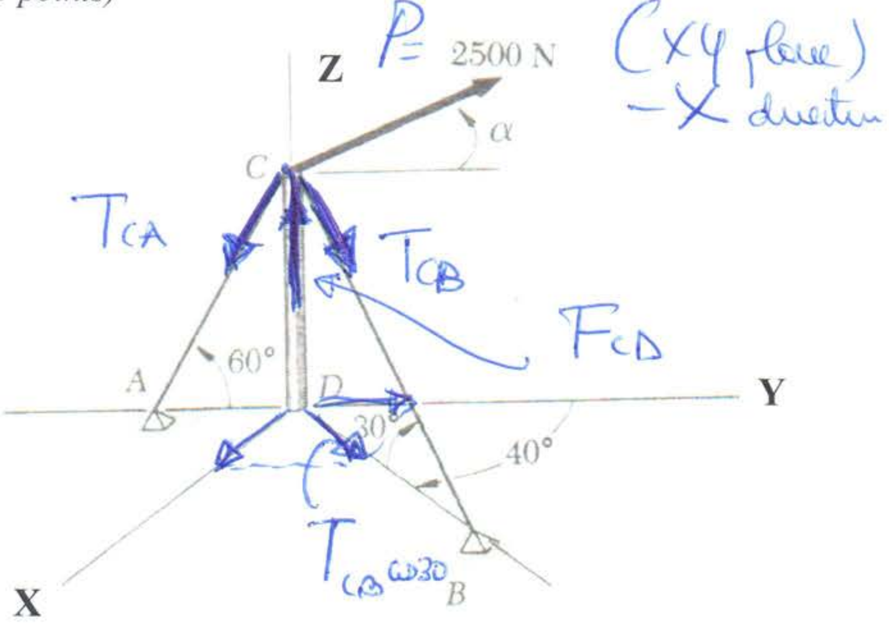


Figure II

As shown in Figure II, the two cables AC and BC are attached to top of the vertical pole DC where a horizontal force of 2,500 N is applied in the direction opposite to the X axis (so α = ☑ 90°). Given that the force in the pole DC is vertical, compute the tension forces in the cables. *(30 points)*

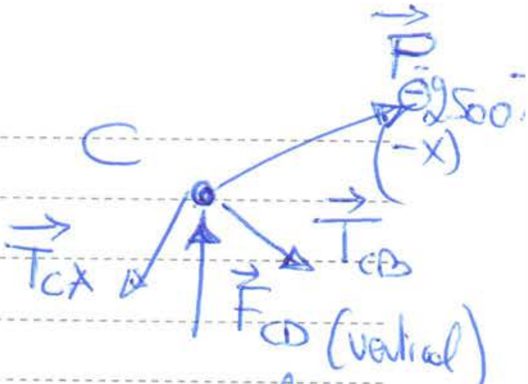
Calculations and/or Diagrams:

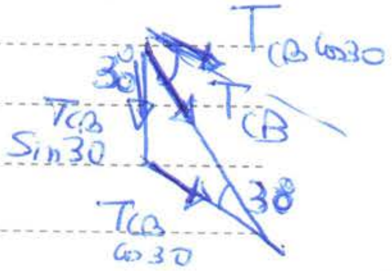
$\vec{P} = -2500\,\vec{i}$ (−X)

$\vec{F}_{CD} = F_{CD}\,\vec{k}$ (vertical ↑ assumed upward)

$\vec{T}_{CA} = 0\,\vec{i} - T_{CA}\cos 60\,\vec{j} - T_{CA}\sin 60\,\vec{k}$

$\vec{T}_{CB} = T_{CB}\cos 30\sin 40\,\vec{i} + T_{CB}\cos 30\cos 40\,\vec{j} - T_{CB}\sin 30\,\vec{k}$





$\sum \vec{F} = \vec{0}$
- $\sum F_x = 0$ ①
- $\sum F_y = 0$ ②
- $\sum F_z = 0$ ③

Calculations and/or Diagrams (cont'd):

① $\Sigma F_x = 0 \Rightarrow T_{CB} \cos 30 \sin 40 - 2500 = 0$ ①

② $\Sigma F_y = 0 \Rightarrow -T_{CA} \cos 60 + T_{CB} \cos 30 \cos 40 = 0$ ②

③ $\Sigma F_z = 0 \Rightarrow -T_{CA} \sin 60 - T_{CB} \sin 30 + F_{CD} = 0$ ③

Solution: ① $\Rightarrow$ $T_{CB} = ⊕4491.1$ N (Tension cable ✓)

② $\Rightarrow$ $T_{CA} = ⊕5959.1$ N (〃 ✓)

Additional ③ $\Rightarrow$ $F_{CD} = +7406.1$ N (as assumed ✓)

Pole is under compression

Problem III: *(40 points)*

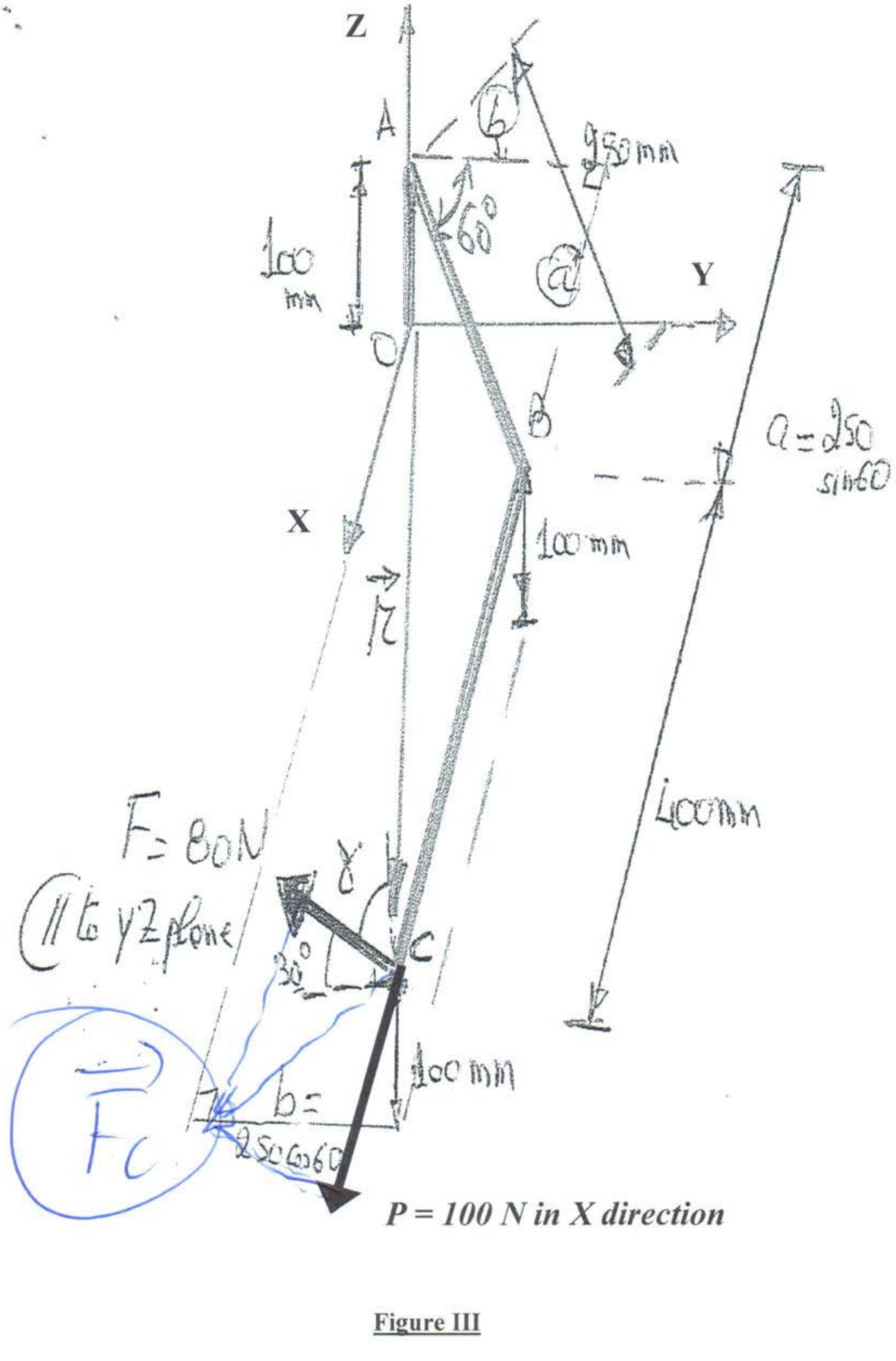


Figure III

The rigid pipe system is subjected to the forces ***P*** and ***F*** at point C as shown in Figure III.

1. Compute the moment at point O from the forces applied and express in Cartesian vector form; then compute its magnitude and direction. (20 points). ☑
2. Determine the component of this moment about an axis extending between points A and B. Express the result as Cartesian vector. *(10 points)* ☑
3. Using a scalar approach, compute the moment at point O in the Z direction and compare with question 1. *(10 points)* ☑

Calculations and/or Diagrams:

Coordinats

$$A\begin{pmatrix}0\\0\\100\end{pmatrix} \quad B\begin{pmatrix}250\sin 60\\250\cos 60\\100\end{pmatrix} \quad C\begin{pmatrix}250\sin 60+400\\250\cos 60\\100\end{pmatrix}$$

$$A\begin{pmatrix}0\\0\\100\end{pmatrix} \quad B\begin{pmatrix}216.5\\125\\100\end{pmatrix} \quad C\begin{pmatrix}616.5\\125\\100\end{pmatrix}$$

(mm or change to m)

Forces

$$\vec{F}\begin{pmatrix}0\\-80\cos 30 \text{ or } 80\cos 150\\+80\sin 30 \text{ or } 80\sin 150\end{pmatrix} \qquad \vec{P}\begin{pmatrix}100\\0\\0\end{pmatrix}$$

$$\vec{F_c} = \vec{F} + \vec{P} \Rightarrow \vec{F_c}\begin{pmatrix}100\\-69.3\\40\end{pmatrix} = 100\vec{i} - 69.3\vec{j} + 40\vec{k}$$

$$1.\quad \underset{\text{Forces}}{\vec{M}_O} = \vec{M}_{F/O} + \vec{M}_{P/O} = \vec{M}_{F_c/O}$$

$$\vec{M}_O = \vec{r}_{OC} \times \vec{F_c}$$

Vector

$$\vec{M_O} = \begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\616.5 & 125 & 100\\100 & -69.3 & 40\end{vmatrix} = \boxed{\underset{(M_{Ox})}{11930\vec{i}} - \underset{(M_{Oy})}{14660\vec{j}} - \underset{(M_{Oz})}{55223\vec{k}} = \vec{M_O}}$$

Magnitud

$$|\vec{M_O}| = \sqrt{M_{Ox}^2 + M_{Oy}^2 + M_{Oz}^2} = 58368 \text{ Nmm}$$

$$\boxed{|\vec{M_O}| = 58.4 \text{ Nm}}$$

Directn

$$\cos\alpha = \frac{11930}{|\vec{M_O}|} \Rightarrow \qquad \alpha = 78.2^\circ$$

$$\cos\beta = \frac{-14660}{|\vec{M_O}|} \Rightarrow \qquad \beta = 104.5^\circ$$

$$\cos\gamma = \frac{-55223}{|\vec{M_O}|} \Rightarrow \qquad \gamma = 161.1^\circ$$

Calculations and/or Diagrams (cont'd):

2. $A \rightarrow B$ $\quad \vec{u}_{AB} = ?$

$$\vec{u}_{AB} = \frac{\vec{AB}}{|\vec{AB}|} = \frac{216.5\vec{i} + 125\vec{j} + 0\vec{k}}{\underbrace{\sqrt{216.5^2 + 125^2 + 0^2}}_{250}}$$

$$= 0.866\,\vec{i} + 0.5\,\vec{j}$$

(Shortcut ☺ = Since AB is in XY plane

$u_{AB}(x) = \cos 60 = \sqrt{3}/2 = 0.866$ $\quad u_{AB}(y) = \cos 60 = 1/2 = 0.5$)

$$\vec{M}_{O/AB} = \left(\vec{M}_O \cdot \vec{u}_{AB}\right)\vec{u}_{AB}$$

$$= \left[11930 \times 0.866 + (-14660) \times 0.5\right]\vec{u}_{AB}$$

$$= 3001\,\vec{u}_{AB} = \boxed{2599\,\vec{i} - 1501\,\vec{j} = \vec{M}_{O/AB}}$$

3. Scalar $M_{O/z}$

Due to $\vec{P}$ (X direction) $\quad M_{O/\textcircled{z}} = -\overset{\textcircled{x}}{100}\,\overset{\text{arm}\,\textcircled{y}}{\left(\begin{matrix}250\cos 60\\ or\ 125\end{matrix}\right)}$

$= -12500\ N_{mm}$

Due to $\vec{F}$ $\left(\begin{matrix}F_x = 0\\ |F_y| = |-69.3|\\ \cancel{F_z}\ //\ to\ z\end{matrix}\right)$ $\quad M_{O/\textcircled{z}} = -\overset{\textcircled{y}}{69.3} \times (616.5)$

$= -42723\ N_{mm}$

$M_{O/z} = -55223$ ($\Rightarrow$ opposite to +z)

$\vec{M}_{O/z} = -55223\,\vec{k}$ (Same as Questi