SOLUTIONS TERM TEST #1

Wherever necessary a FBD must be drawn.

STRAIGHT EDGE IS REQUIRED.
UNDERLINE YOUR ANSWERS.

COMMENTS:

Question#1

1. In <u>many cases</u>, the FBDs were not labeled correctly. The labels of all forces MUST match the labels used in the equilibrium equations.
2. A FBD is a representation of the FORCES acting on the particle. Therefore, it is necessary to convert mass to a force. <u>Never mix mass and force in the FBD</u>.
3. When writing the equilibrium equations, indicate which equilibrium equation you are writing and ALWAYS equate the left hand side of equation to zero.
4. After writing the equilibrium equations SIMPLIFY before solving.

Question#2 (This question was <u>Poorly Done</u>)

1. Need to draw the forces acting at O.
2. Tension in the same cord remains constant. Therefore, the instant the cable breaks, $T_{OA} = T_{OB} = 1000$ N. The directions of T_{OA} and T_{OB} were given. Putting T_{OA} and T_{OB} "tip to tail" and closing the figure gave the graphical solution for T_{OC} since $R = 0$ (Point O in equilibrium).

Question#3

1. Necessary to calculate R_X, R_Y and M_{RA}. Some people only calculated M_{RA}.
2. Could use Principle of Transmissibility and apply 400 N and 600 N force at D.

If you scored 7 or less on a problem it is probably because you are missing an important concept. Review the following solutions and if you still don't understand something then come and see me.

QUESTION 1

Two masses are suspended from cables as shown in the figure. Determine the tension in each cable (cables *AB*, *BC* and *CD*) and the mass *m* that is suspended at *C* if the system is in equilibrium in the configuration shown.

Use g = 9.8 m/sec^2

MARKING:

CORRECT FBDS – 4 marks
CORRECT EQUILIBRIUM EQUATIONS – 4 marks
CORRECT SOLUTION TO EQUATIONS – 2 marks
10 marks

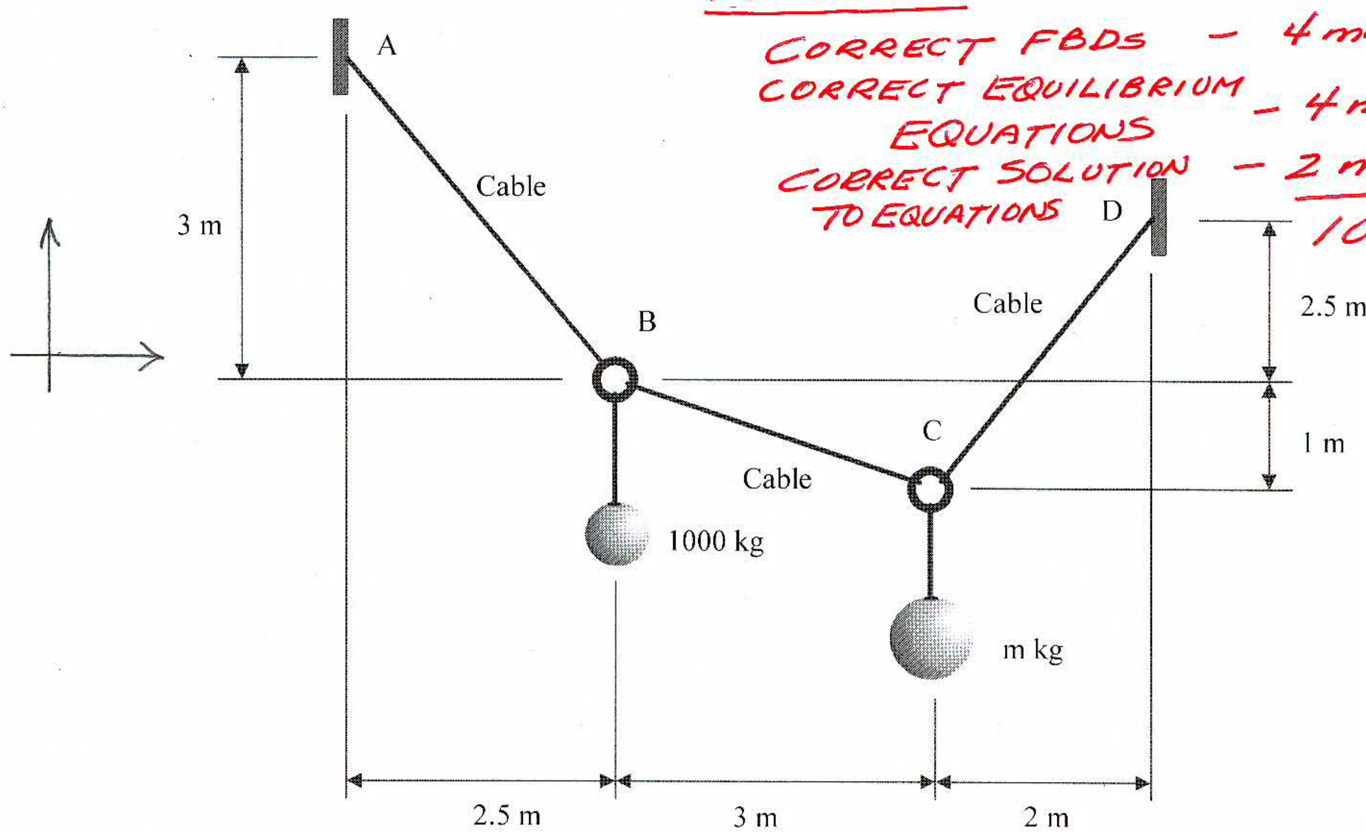
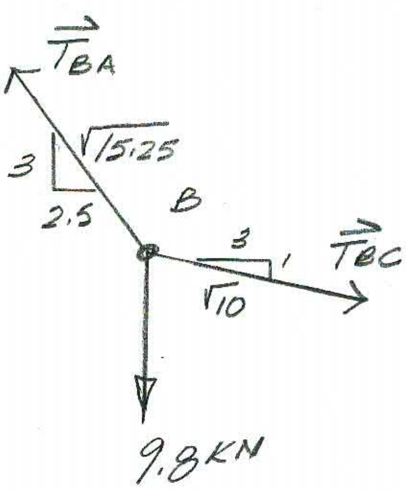
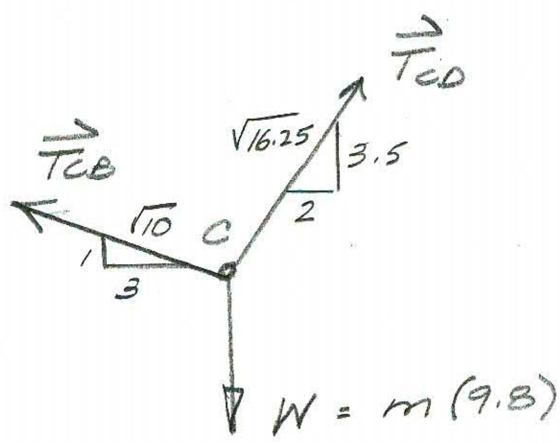


Figure 1



FBD AT B



FBD AT C

FROM FBD AT B

$\Sigma F_x = 0 \qquad -\frac{2.5}{\sqrt{15.25}} T_{BA} + \frac{3}{\sqrt{10}} T_{BC} = 0 \quad (1)$

$\Sigma F_y = 0 \qquad \frac{3}{\sqrt{15.25}} T_{BA} - \frac{1}{\sqrt{10}} T_{BC} - 9.8 = 0 \quad (2)$

FROM (1) $\quad T_{BC} = \frac{\sqrt{10}}{3}\left(\frac{2.5}{\sqrt{15.25}}\right) = 0.6748\, T_{BA}$

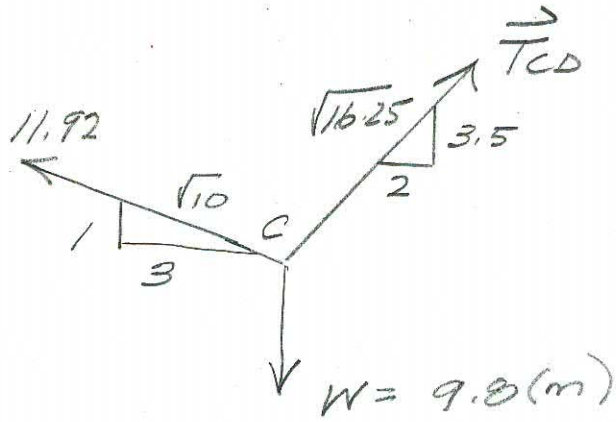
Substitute in (2)

$\frac{3}{\sqrt{15.25}} T_{BA} - \frac{1}{\sqrt{10}}\left(0.6748\, T_{BA}\right) = 9.8$

$0.5548\, T_{BA} = 9.8 \qquad T_{BA} = 17.66\,kN$

$\therefore\ T_{BC} = 0.6748(17.66) = 11.92^{kN}$

FROM FBC AT C



$$\Sigma F_x = 0 \qquad \frac{3}{\sqrt{10}}(11.92) - \frac{2}{\sqrt{16.25}}\,T_{CD} = 0$$

$$T_{CD} = \frac{\sqrt{16.25}}{2}\left(\frac{3}{\sqrt{10}}\right)(11.92)$$

$$T_{CD} = 22.79^{kN}$$

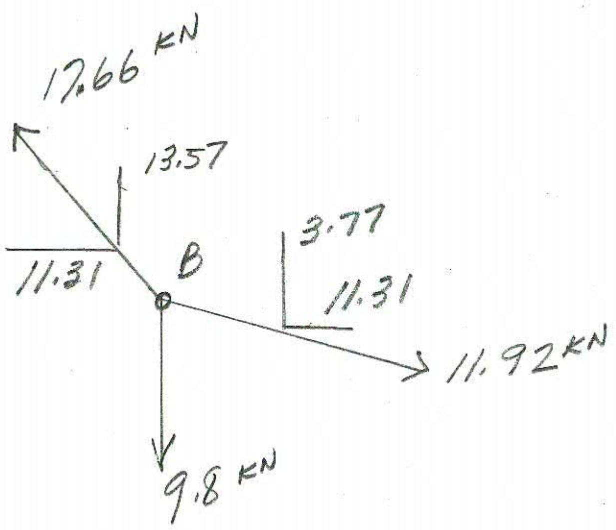
$$\Sigma F_y = 0$$

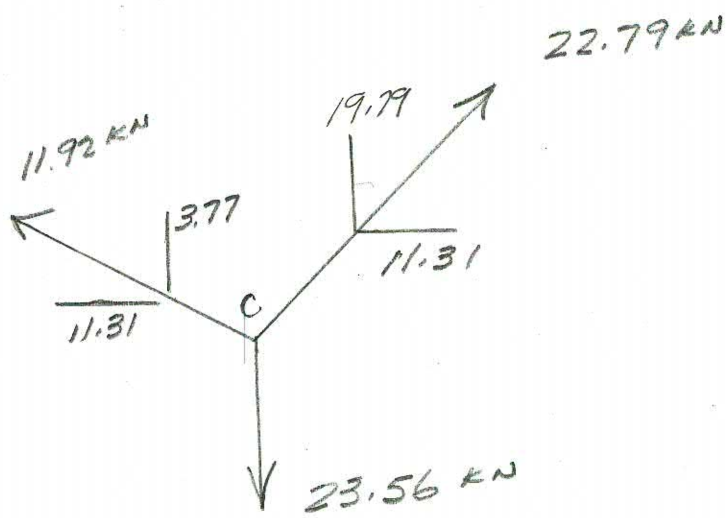
$$\frac{1}{\sqrt{10}}(11.92) + \frac{3.5}{\sqrt{16.25}}(22.79) - W = 0$$

$$W = 23.56^{kN} = 23560\ N$$

$$W = 9.8m \quad \therefore\ m = \frac{23560}{9.8}$$

$$m = 2403.7\ kg$$





$\Sigma F_x = 0$

$-11.31 + 11.31 = 0$ ✓

$\Sigma F_y = 0$

$13.57 - 3.77 - 9.8 = 0$ ✓

$0 = 0$

checks

$\Sigma F_x = 0$

$-11.31 + 11.31 = 0$ ✓

$\Sigma F_y = 0$

$3.77 + 19.79 - 23.56 = 0$

$0 = 0$

checks

QUESTION 2

A tugboat is pulling a barge with a *80 m* long cable in the configuration shown in the figure. The cable is attached to the barge at *A* and wraps around a frictionless pulley and is attached to the tugboat at *B*. (Neglect the radius of the pulley.) The pulley is attached to the dock by the rope *OC*. The cable breaks when the tension in the cable reaches *1000N*.

Determine the tension in the rope *OC* and the angle θ at the instant the cable breaks.

a) By means of a graphical solution (state the scale that you are using),
b) By trigonometry (using sine and/or cosine rules) and
c) By rectangular components.

MARKING:
a) 3 marks
b) 3 marks
c) 4 marks.

10 marks

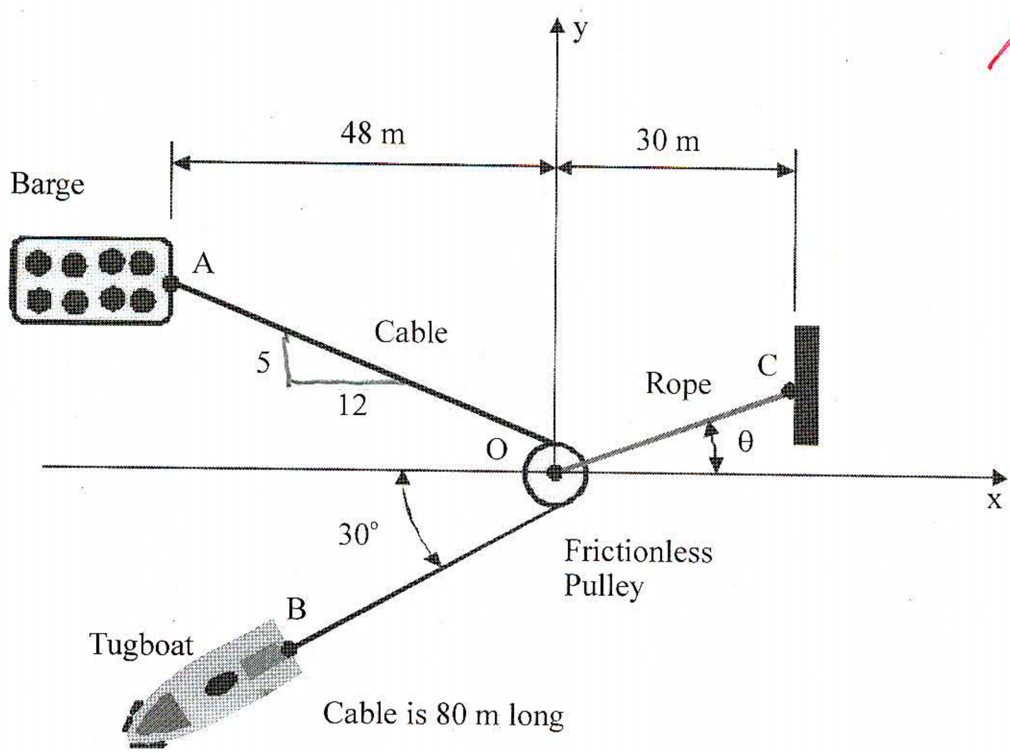
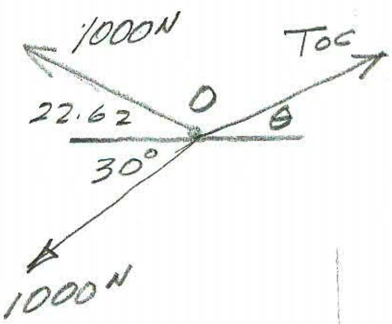


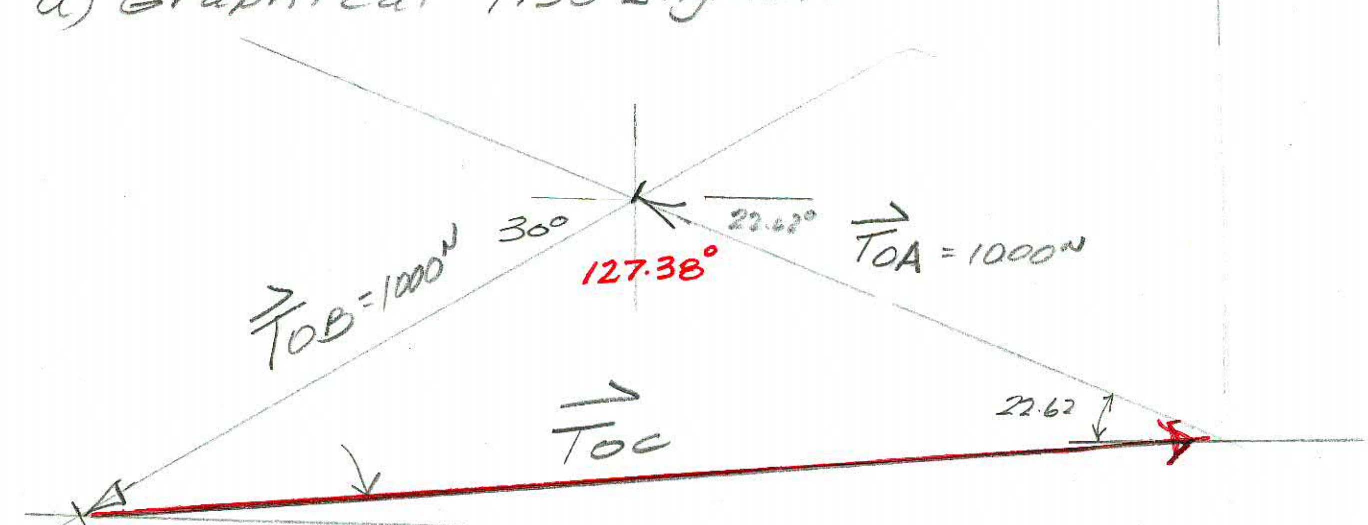
Figure 2



$\tan\theta = \frac{5}{12}$

$\Rightarrow \theta = 22.62°$

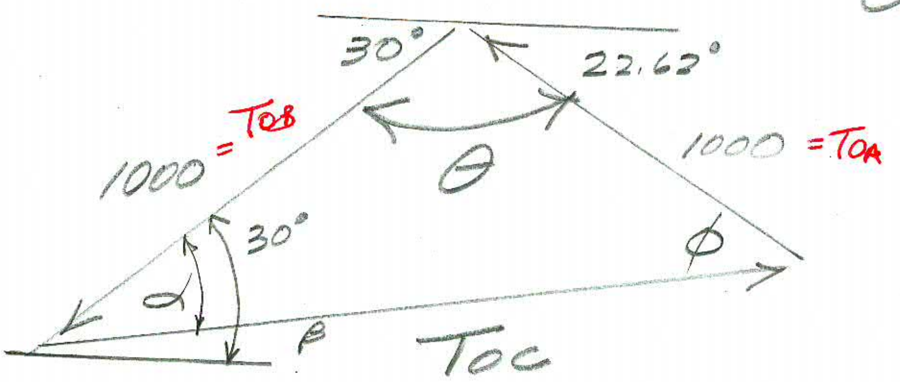
a) Graphical 1:30 Engineer's



$T_{OC} \approx 1780^N$

$\theta \approx 5°$

b) TRIG SOLN



$\theta = 180 - 30° - 22.62°$

$\theta = 127.38°$

OR $\alpha = \phi$ isoceles $\triangle$

$= \dfrac{180 - 127.38}{2} = 26.31$

Cosine Rule:

$T_{OC}^2 = 1000^2 + 1000^2 - 2(1000)(1000)\cos 127.38°$

$\dfrac{1000}{\sin 26.31} = \dfrac{T_{OC}}{\sin 127.38}$

$T_{OC} = 1792.82$

$T_{OC} = 1792.81^N$

Sine Rule:

$\dfrac{1792.81}{\sin 127.38°} = \dfrac{1000}{\sin\alpha} = \dfrac{1000}{\sin\phi}$

$\sin\alpha = \dfrac{1000 \sin 127.38°}{1792.81}$

$\alpha = 26.31°$

$\beta = 30 - 26.31 = 3.69°$

$\vec{T}_{OC} = 1792.81^N \measuredangle 3.69°$

c) $\Sigma F_x = 0$ Equilibrium at instant cable breaks

$-1000\cos 22.62 - 1000\cos 30° + T_{OC}\cos\beta = 0$

$\Sigma F_y = 0$

$1000\sin 22.62 - 1000\sin 30° + T_{OC}\sin\beta = 0$

$T_{OC}\cos\beta = 1789.10$

$T_{OC}\sin\beta = 115.382$

$\dfrac{T_{OC}\sin\beta}{T_{OC}\cos\beta} = \dfrac{115.382}{1789.10}$ $\tan\beta = 6.449 \times 10^{-2}$

$\beta = 3.69°$

$\therefore T_{OC} = \dfrac{1789.10}{\cos 3.69°} = 1792.81^N$

QUESTION 3

A building with a semicircular arch roof having a radius of *5 m* has *400 N* and *600 N* loads applied to the roof as shown in the figure. There is also a *100 N.m* clockwise couple-moment acting on the roof. There is a distributed wind pressure load and a distributed hydrostatic pressure load. For the given loading:

Determine the equivalent force-couple at point *A*.

MARKING.
F_1, F_2, F_3 3 marks
R_x, R_y 3 marks
M_{RA} 4 marks
10 marks

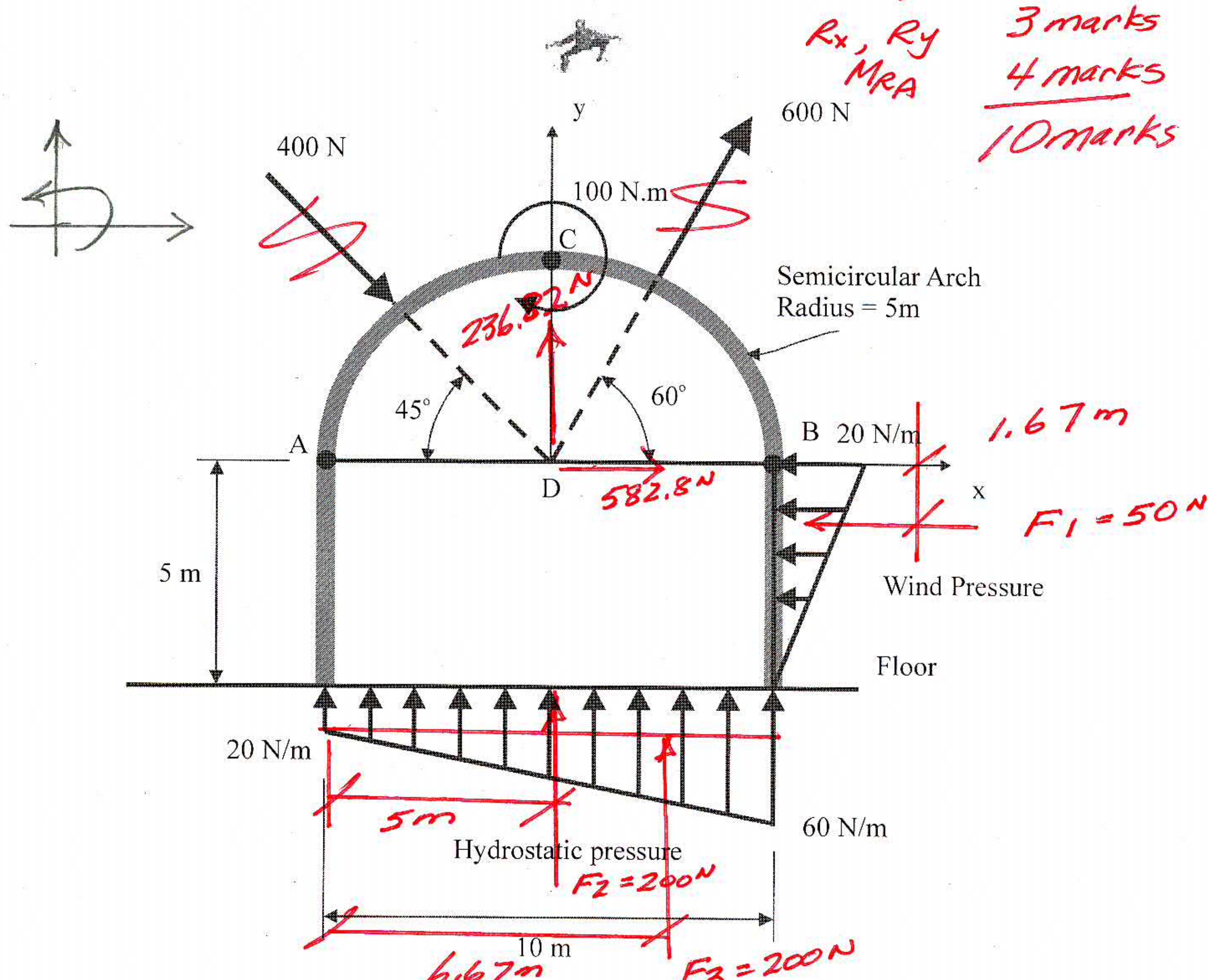


Figure 3

Distributed Loads:

Wind: $F_1 = \frac{20(5)}{2} = 50N$ @ 1.67m as shown

Hydrostatic:

$F_2 = 20(10) = 200N$ @ 5m as shown

$F_3 = \frac{(60-20)10}{2} = 200N$ @ 6.67m as shown

Applying 400N and 600N force at D by Principle of transmissibility (resolving into x and y components

$F_x = 400\cos 45° + 600\cos 60° = +582.8^N$
$= 582.8^N \rightarrow$

$F_y = -400\cos 45 + 600\sin 60° = +236.82^N$
$= 236.82N \uparrow$

$R_x = \Sigma F_x$

$= 582.8 - 50 = +532.8^N$

$\therefore \vec{R_x} = 532.8^N \rightarrow$

$R_y = \Sigma F_y$

$= +236.82 + 200 + 200 = +636.82^N$

$\therefore \vec{R_y} = 636.82^N \uparrow$

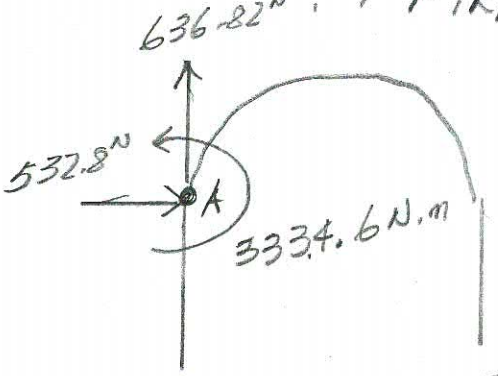
$M_{R_A} = \Sigma M_A$

$= -100 N.m + 200(5) + 200(6.67)$

$- 50(1.67) + 236.82(5)$

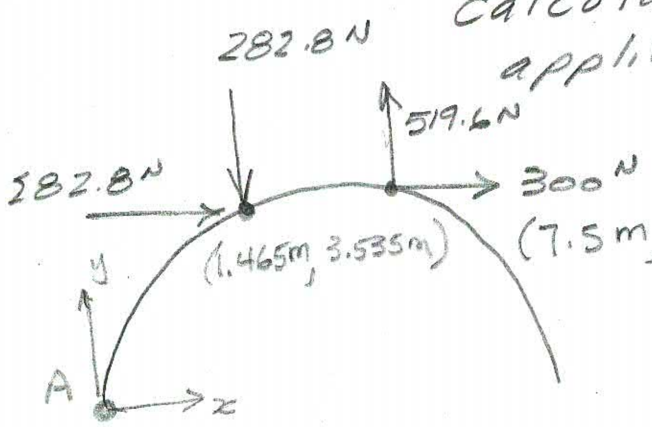
$= +3334.6\ N.m$

$\therefore \vec{M_{R_A}} = 3334.6\ N.m \circlearrowleft$



EQUIVALENT FORCE-COUPLE AT A

Alternately Apply 400N force & 600 N force as shown on the arch & calculate coordinates of application points.



Calculate moments of 400N & 600N about A using x & y coordinates of application points