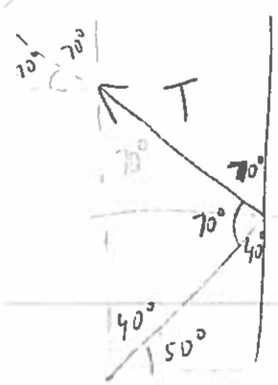
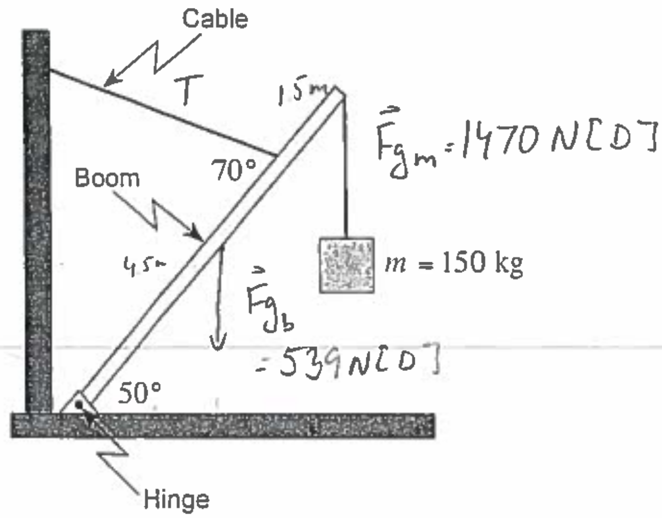
KEY

$T = 1600\,N$

- A uniform 6.0 m-long boom has a mass of 55 kg. It is kept in position by a restraining cable attached three-quarters of the way along the boom.





What is the tension in this cable when the boom supports a 150 kg mass as shown? **(7 marks)**

$\vec{\tau}_b = (539)(3.0)(\cos 50^\circ)$

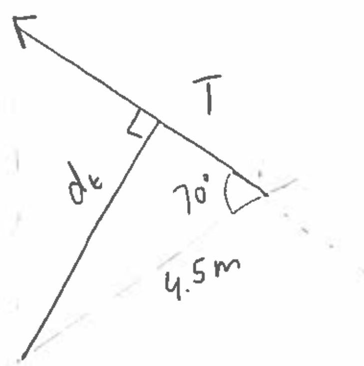
$\doteq 1039.3876\ N\,m\ [CW]$

$\vec{\tau}_m = (1470)(6.0)(\cos 50^\circ)$

$= 5669.3867\ N\cdot m\ [CW]$

$\vec{\tau}_T = \| \vec{\tau}_b + \vec{\tau}_m \|$

$= 6708.7744\ N\cdot m\ [CCW]$



$\vec{\tau}_T = T \cdot d_T$

$T = \dfrac{\vec{\tau}_T}{d_T}$

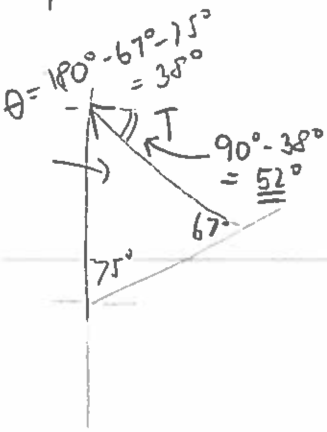
$T = \dfrac{6708.7744}{(4.5)(\sin 70^\circ)}$

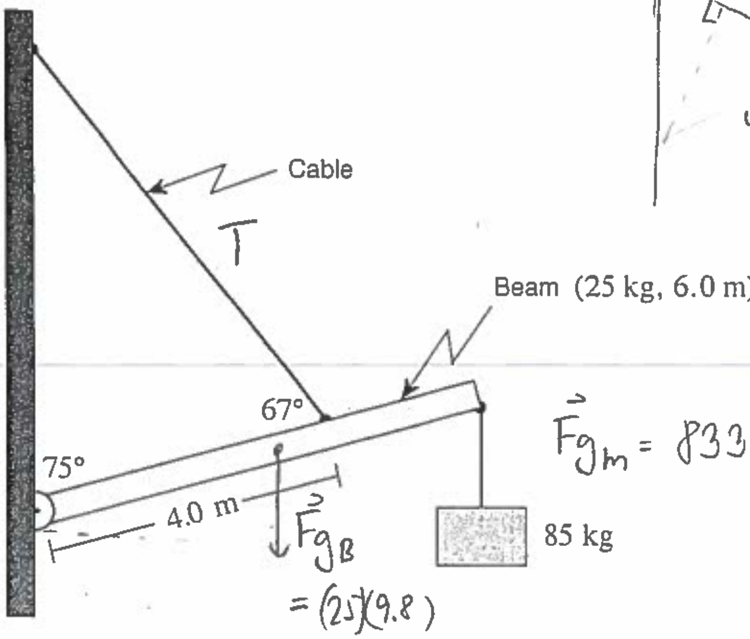
$T = 1586.5174\ N$

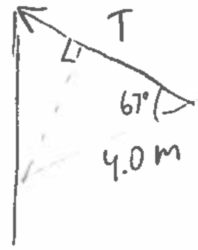
S: Tension in the cable is $1.6 \times 10^3\ N[L\,20^\circ U]$.

2. A 6.0 m uniform beam of mass 25 kg is suspended by a cable as shown. An 85 kg object hangs from one end.

$T = 1500\,N$





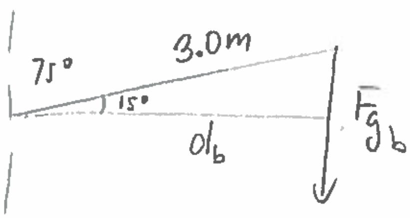


$\vec{F}_{g_m} = 833\,N\,[D]$

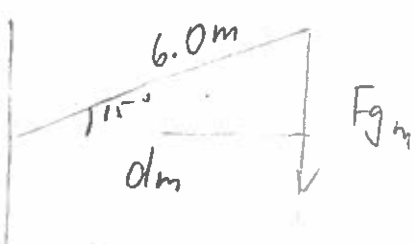
$\vec{F}_{g_B} = (25)(9.8) \doteq 245\,N\,[D]$

What is the tension in the cable? **(7 marks)**

$\vec{\tau}_B = (245)(3.0)(\cos 15°)$
$\doteq 709.9555\ N\cdot m\ [cw]$



$\vec{\tau}_m = (833)(6.0)(\cos 15°)$
$= 4827.6973\ N\cdot m\ [cw]$



$\vec{\tau}_T = \| \vec{\tau}_B + \vec{\tau}_m \|$
$\doteq 5537.6523\ N\cdot m\ [ccw]$

$T = \dfrac{\vec{\tau}_T}{d_T}$

$T = \dfrac{\vec{\tau}_T}{(4.0)(\sin 67°)}$

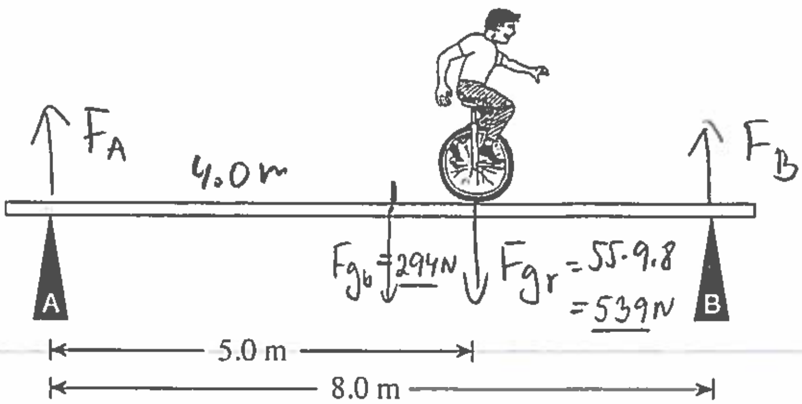
$T \doteq 1503.9716\ N$

S: The tension in the cable is $1.5 \times 10^3\ N\ [L\ 52°\ U]$

4. A circus performer on a unicycle of total mass 55 kg rides across a uniform 30 kg beam. The supports are placed equal distances from the ends of the beam.

$F_A = 350N$

$F_B = 480N$



a) When he is at the position shown, determine the forces exerted by the supports on the beam.

(5 marks)

Scenario 1: pivot at A

$\vec{\tau}_b = (294)(4.0)$ [cw]

$= 1176$ Nm [cw]

$\vec{\tau}_r = (539)(5.0)$ [cw]

$= 2695$ N·m [cw]

$\vec{\tau}_{F_B} = \| \vec{\tau}_r + \vec{\tau}_b \|$

$= 3871$ N·m [ccw]

$F_B = \dfrac{\tau_{FB}}{d_{FB}}$

$= \dfrac{3871}{8.0}$

$= 483.875$ N

$\vec{F} = 4.8 \times 10^2$ N [U]

Scenario 2: pivot at B

$\vec{\tau}_b = (294)(4.0)$ [ccw]

$= 1176$ N·m [ccw]

$\vec{\tau}_r = (539)(3.0)$ [ccw]

$= 1617$ N·m [ccw]

$\vec{\tau}_{FA} = \| \vec{\tau}_r + \vec{\tau}_b \|$

$= 2793$ N·m [cw]

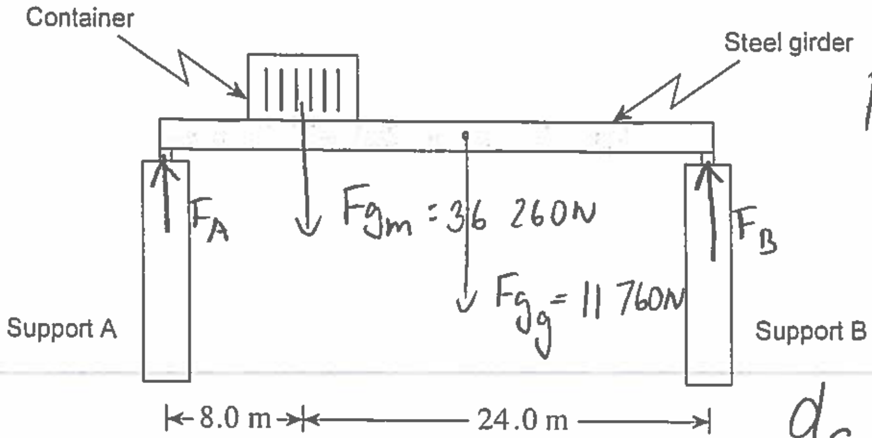
$F_A = \dfrac{\vec{\tau}_{FA}}{d_{FA}}$

$= \dfrac{2793}{8.0}$

$= 349.125$ N

$\vec{F} = 3.5 \times 10^2$ N [U]

3. A uniform 1 200 kg steel girder is supported horizontally at its endpoints as shown in the diagram.



$F_A = 3.31 \times 10^4 N$

$d_G = 24.0 + 8.0$
$= 32.0 m$

What are the upward forces at the girder end points when it is bearing a 3 700 kg shipping container 8.0 m from support A?

(7 marks)

Scenario 1: Pivot point at A

$\vec{\tau}_m = (36\ 260)(8.0)$ [CW]

$= 290\ 080$ N·m [CW]

$\vec{\tau}_G = (11\ 760)(16.0)$ [CW]

$= 188\ 160$ N·m [CW]

$\vec{\tau}_{F_B} = \| \vec{\tau}_m + \vec{\tau}_G \|$

$= 478\ 240$ N m [CCW]

$F_B = \frac{\tau_{FB}}{d_{FB}}$

$= \frac{478\ 240}{(24 + 8)}$

$= 14\ 945$ N

$\vec{F}_B = 1.5 \times 10^4$ N [up]

Scenario 2: Pivot at B

$\vec{\tau}_m = (36\ 260)(24)$ [CCW]

$= 870\ 240$ N·m [CCW]

$\vec{\tau}_G = (11\ 760)(16.0)$ [CCW]

$= 188\ 160$ N·m [CCW]

$\vec{\tau}_{F_A} = \| \vec{\tau}_G + \vec{\tau}_M \|$

$= 1\ 058\ 400$ N·m [CW]

$F_A = \frac{\vec{\tau}_{FA}}{d_{F_A}}$

$= \frac{1\ 058\ 400}{32}$

$\vec{F}_A = 33\ 075$ N [up]

$\vec{F} = 3.3 \times 10^4$ N [up]

b) As the performer moves toward the right the force exerted by support B will

- ☐ remain the same.
- ☑ increase.
- ☐ decrease.

(Check one response.) **(1 mark)**

c) Using principles of physics, explain your answer to b). **(3 marks)**

Pivot at A: to analyze F_B.

As the rider moves closer to point B the distance between the rider and point A increases, thus $d_r \uparrow$ and makes $\vec{\tau}_{FB} \uparrow$.* With $\vec{\tau}_{FB} \uparrow$ $F_B \uparrow$. **

* $\vec{\tau}_{FB} \uparrow$ because it needs to cancel out a greater $\Sigma\vec{\tau}$ in cw direction. As $d_r \uparrow$ $\vec{\tau}_r \uparrow$ and $\|\vec{\tau}_r + \vec{\tau}_b\| \uparrow$.

** $\vec{\tau}_{FB} \uparrow$ leads to $F_B \uparrow$ because d_B does not change (it stays 8.0 m).

ANSWER:

a) force A: __________

force B: __________