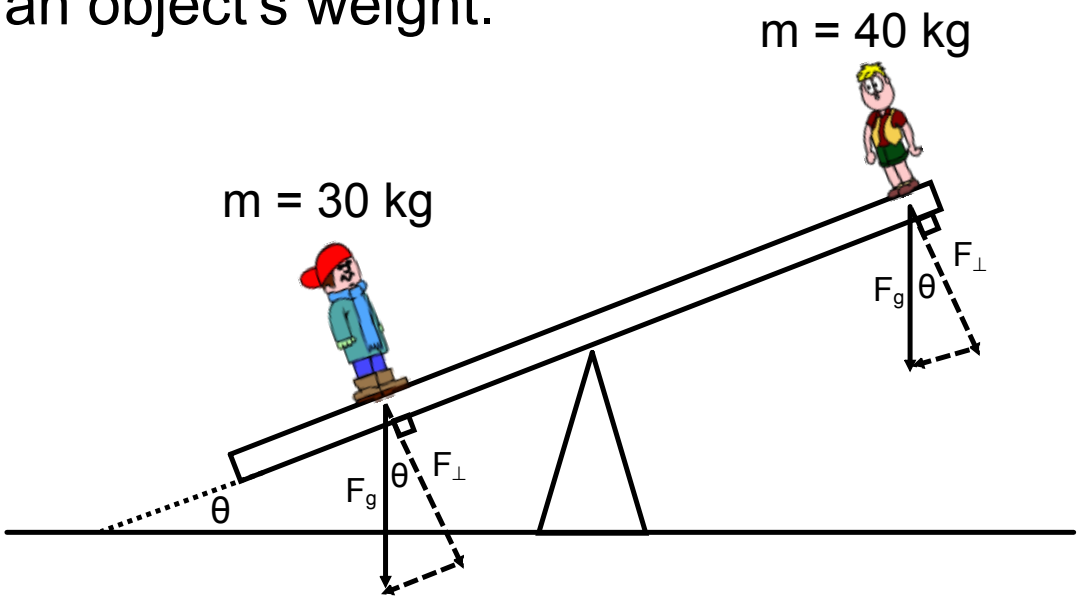
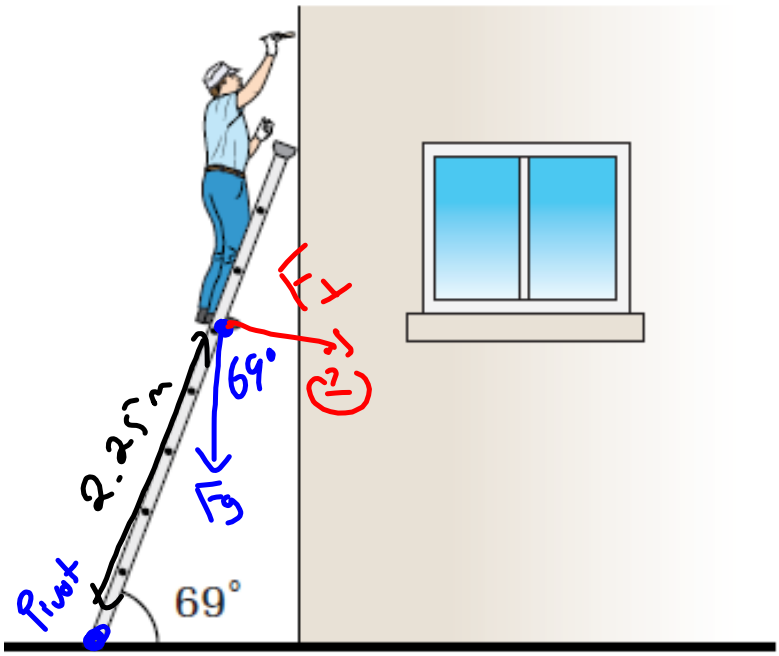
Angled Beam & Torque

Like the incline plane questions earlier, if the beam is inclined the trig functions for component calculations switch. This mainly occurs for problems in which the force acting on the beam is an object's weight.



Example: A 64 kg painter is standing 2.25 m of the distance up a ladder that is 3.0 m long. If the ladder makes an angle of 69° with the ground, what torque does the painter's weight exert on the ladder? (5.1×10^2 Nm, CW)



$$\tau = r F_\perp$$

$$= -(2.25)(64)(9.8)\cos 69^\circ$$

$$= -510 \text{ Nm}$$

Torque Review

Grade: 12

Subject: Physics 122

Date: 2014

1 An object can rotate even if the net force adds to zero.

True

False

2 Translational motion is the angular motion around one point.

True

False

3 Objects rotate about a(n) _____.

A Equilibrium point

B Force applied point

C lever arm point

D pivot point

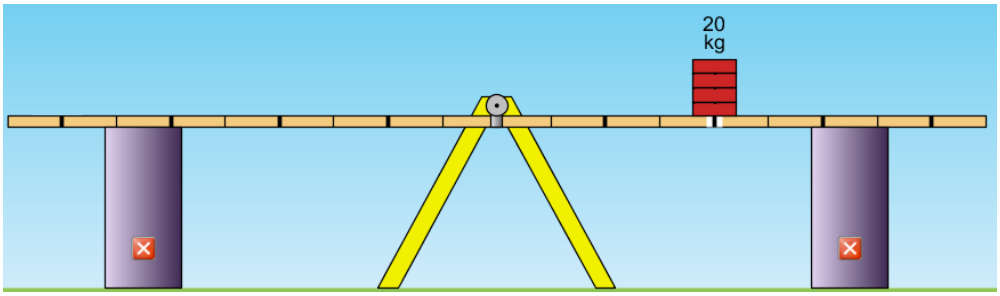
4 What statement best describes what will happen when the supports are removed?

A The beam will rotate.

B The beam will experience negative torque.

C The beam will experience positive torque.

D The beam will not rotate.



5 What statement best describes what will happen when the supports are removed?

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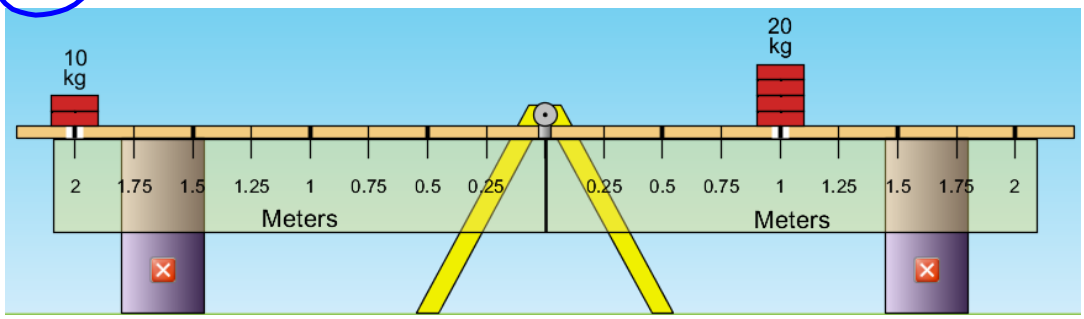
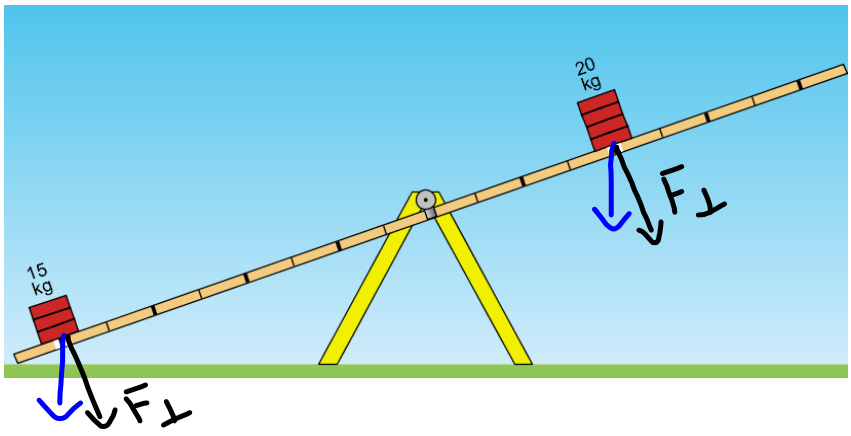


6 In the image below, what trig function must be used to determine the force of gravity perpendicular to the beam?

A sin

B cos

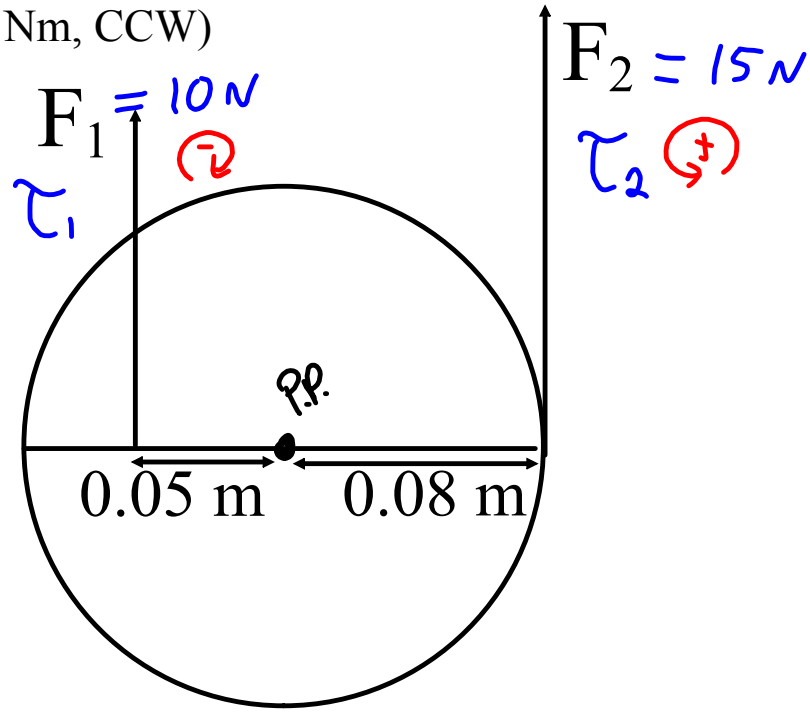
C tan



Net Torque

Just as net force sometimes plays a part in a problem, so does net torque. Net torque is the vector sum of all torques.

Example: Two forces act on the cylinder as shown in the diagram below. If $F_1 = 10$ N and $F_2 = 15$ N, what is the net torque on the cylinder? (0.70 Nm, CCW)



$\tau_{net} = \sum \tau_{torques}$

$\tau_{net} = \tau_1 + \tau_2$

$= -(0.05)(10) + (0.08)(15)$

$= -0.5 + 1.2$

$\tau_{net} = +0.7$ Nm

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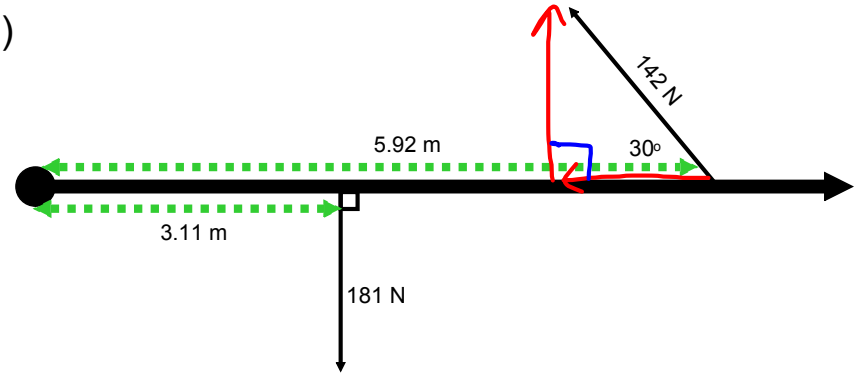
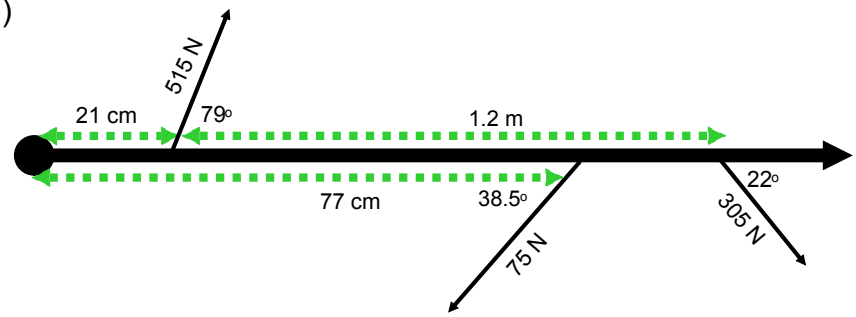
Net Torque Practice

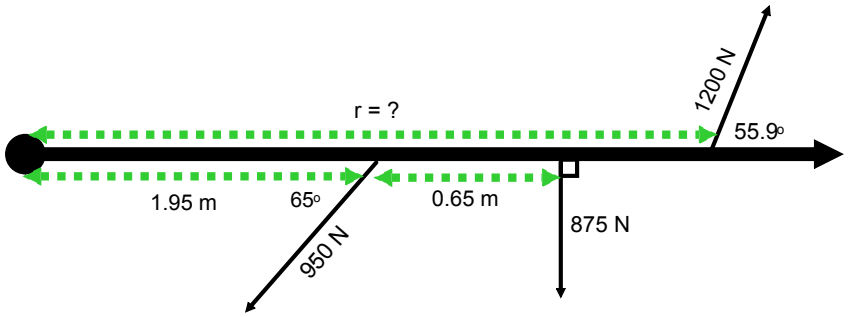
#1)



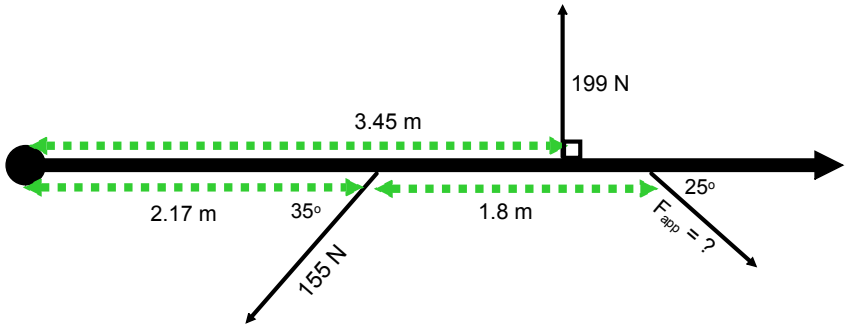
#2)



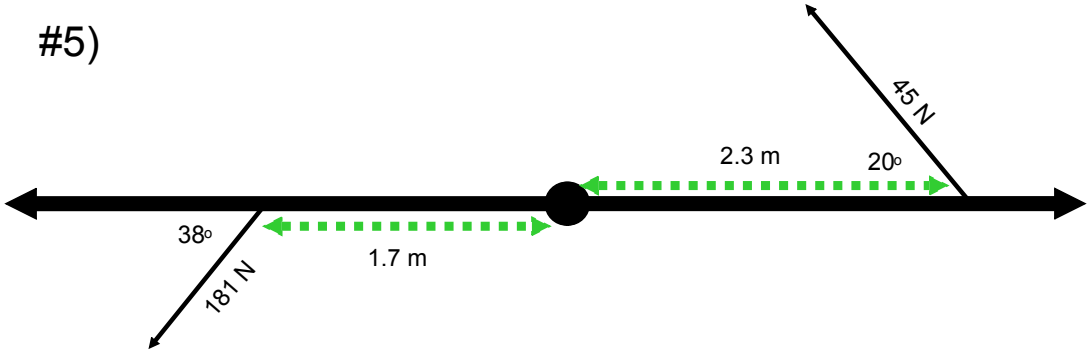
#3) τ_{net} = 0 Nm



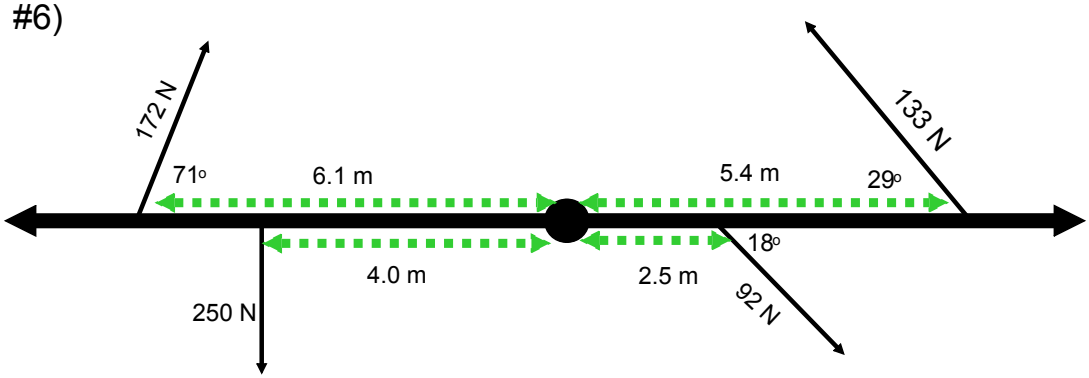
#4) τ_{net} = 0 Nm



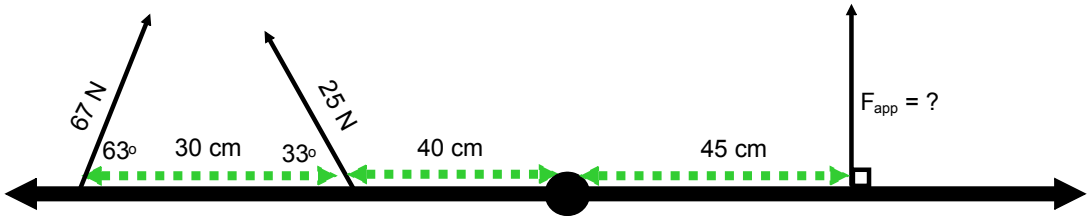
#5)



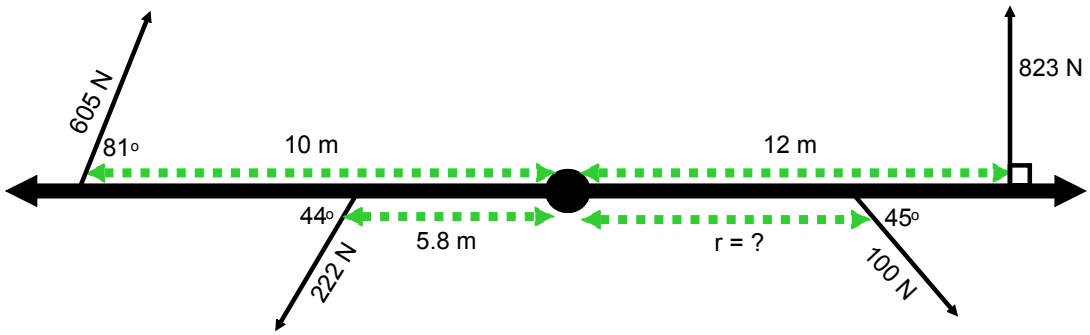
#6)



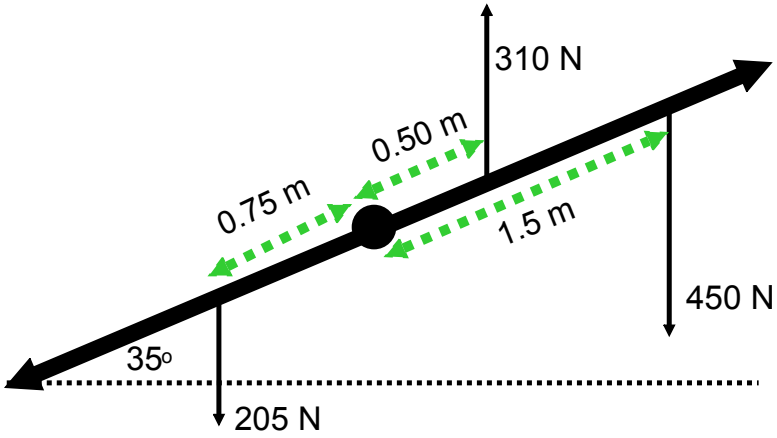
#7) τ_{net} = 0 Nm



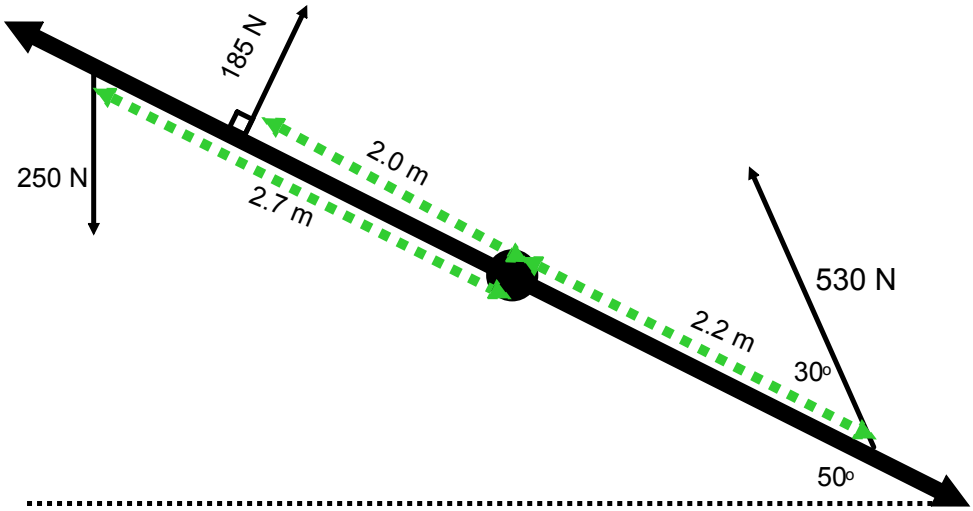
#8) τ_{net} = 0 Nm



#9) All forces are perpendicular to the horizontal dashed line.

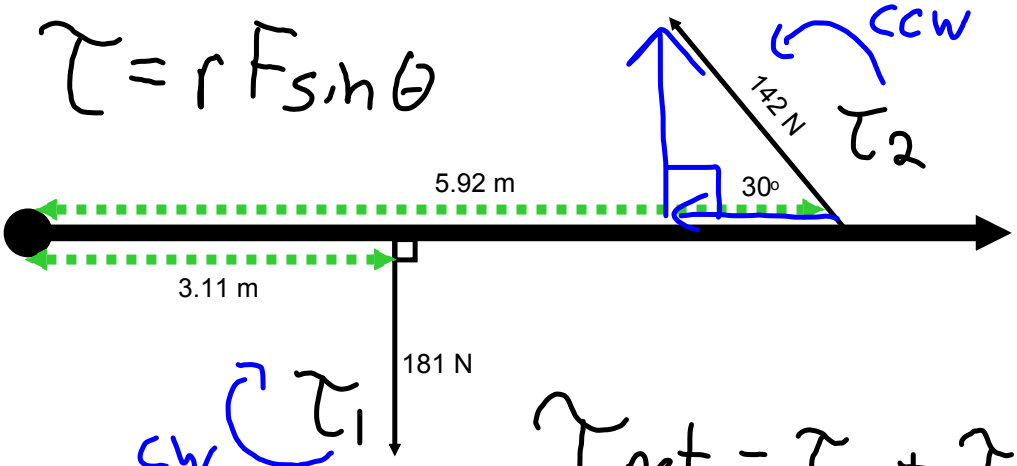


#10) Unless indicated, all forces are perpendicular to the horizontal dashed line.



Net Torque Practice - Solutions

#1) $\tau = rF\sin\theta$



$\tau_{net} = \tau_1 + \tau_2$

$\tau_1 = -(3.11\text{m})(181)\sin 90°$

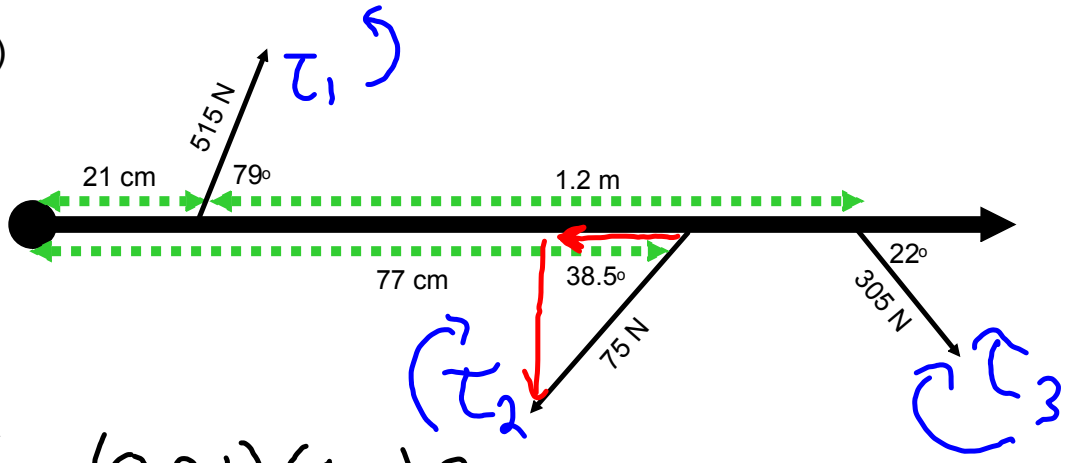
$= -563\ \text{Nm}$

$\tau_2 = 420\ \text{Nm} \Leftarrow (5.92\text{m})(142)\sin 30°$

$\tau_{net} = -563\ \text{Nm} + 420\ \text{Nm}$

$= -143\ \text{Nm}$ or $143\ \text{Nm}$ [cw]

#2)



$\tau_1 = (0.21)(515)\sin 79$

$= 106 \text{ Nm}$

$\tau_2 = -(0.77)(75)\sin 38.5°$

$= -35.9 \text{ Nm}$

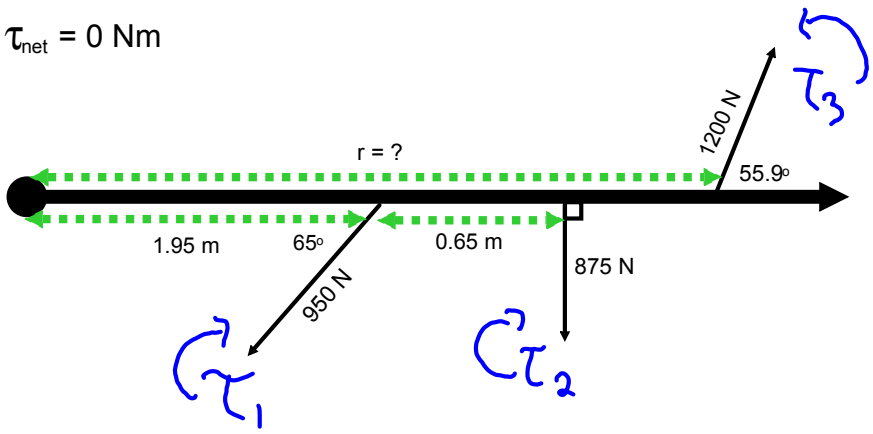
$\tau_3 = -(1.2+0.21)(305)(\sin 22°)$

$= -161 \text{ Nm}$

$\tau_{net} = \tau_1 + \tau_2 + \tau_3 = 106 \text{ Nm} - 35.9 \text{ Nm} - 161 \text{ Nm}$

$\boxed{\tau_{net} = -90.9 \text{ Nm or } 90.9 \text{ Nm [cw]}}$

#3) $\tau_{net} = 0$ Nm



$\tau_1 = -(1.95)(950)\sin 65°$

$= -1679$ Nm

$\tau_2 = -(1.95+0.65)(875)\sin 90°$

$= -2275$ Nm

$\tau_3 = +r(1200)\sin 55.9°$

$= 994r$

$\tau_{net} = \tau_1 + \tau_2 + \tau_3$

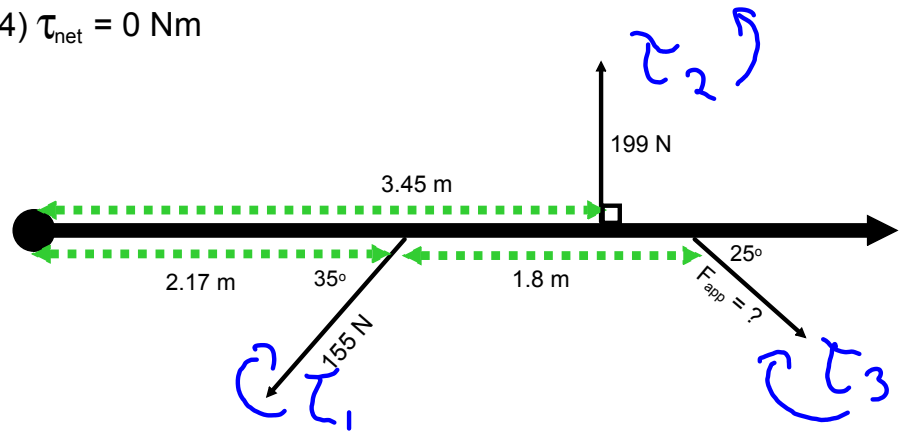
$0 = -1679\text{ Nm} - 2275\text{ Nm} + (994\text{ N})r$

$3954\text{ Nm} = (994\text{ N})r$

$\frac{3954\text{ Nm}}{994\text{ N}} = r$

$\boxed{3.98\text{ m} = r}$

#4) $\tau_{net} = 0$ Nm



$\tau_1 = (2.17)(155)\sin 35°$

$= -193$ Nm

$\tau_2 = (3.45)(199)\sin 90°$

$= 687$ Nm

$\tau_3 = -(2.17 + 1.8)F \sin 25°$

$= -1.68F$

$\tau_{net} = \tau_1 + \tau_2 + \tau_3$

$0 = -193\text{ Nm} + 687\text{ Nm} - 1.68F$

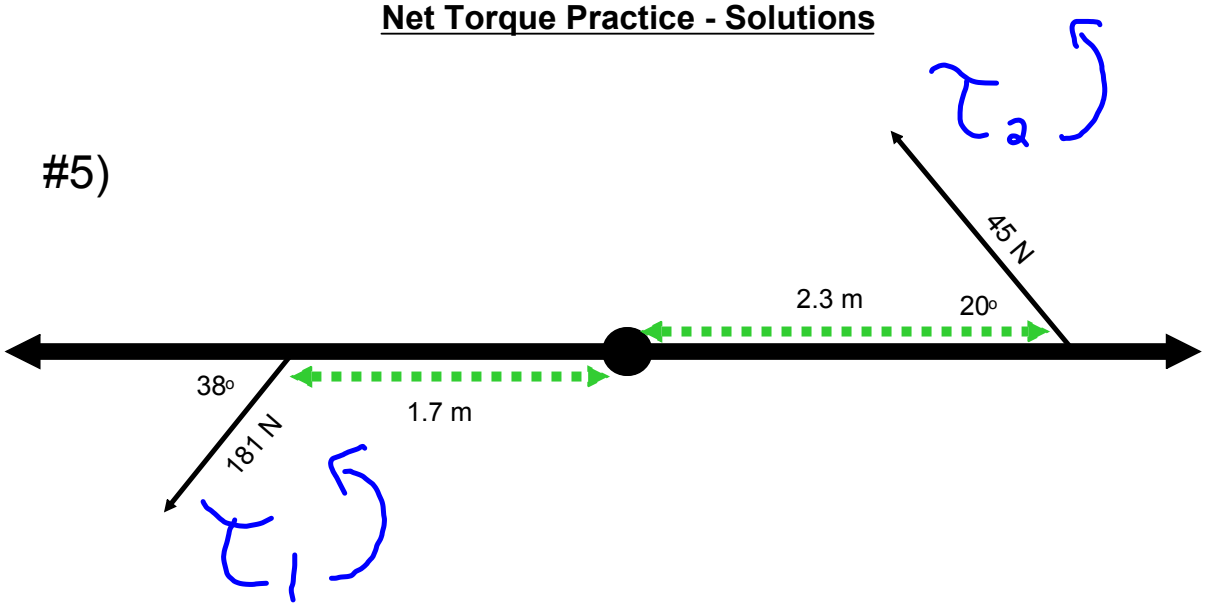
$-494 = -1.68F$

$\frac{-494\text{ Nm}}{-1.68\text{ m}} = F$

$294\text{ N} = F$

Net Torque Practice - Solutions

#5)



$\tau_1 = (1.7)(181)\sin 38°$

$= 189\ Nm$

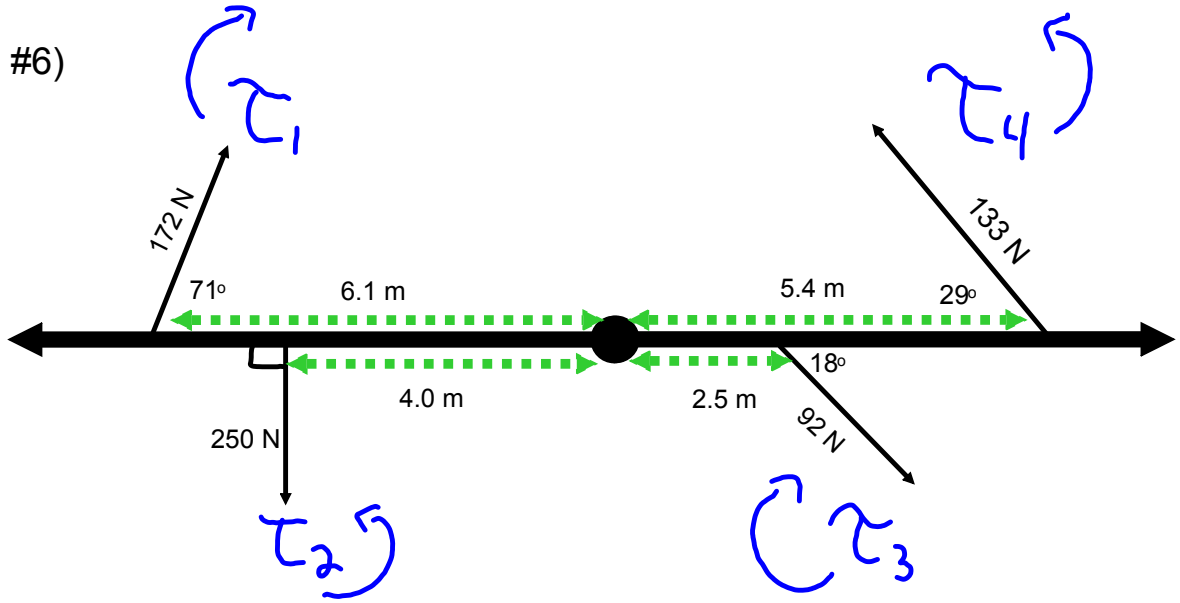
$\tau_2 = (2.3)(45)\sin 20°$

$= 35.4\ Nm$

$\tau_{net} = 189\ Nm + 35.4\ Nm$

$= 224\ Nm\ [ccw]$

#6)



$\tau_1 = -(6.1)(172)\sin 71°$

$= -992\ Nm$

$\tau_2 = (4.0)(250)\sin 90°$

$= 1000\ Nm$

$\tau_3 = -(2.5)(92)\sin 18°$

$= -71.1\ Nm$

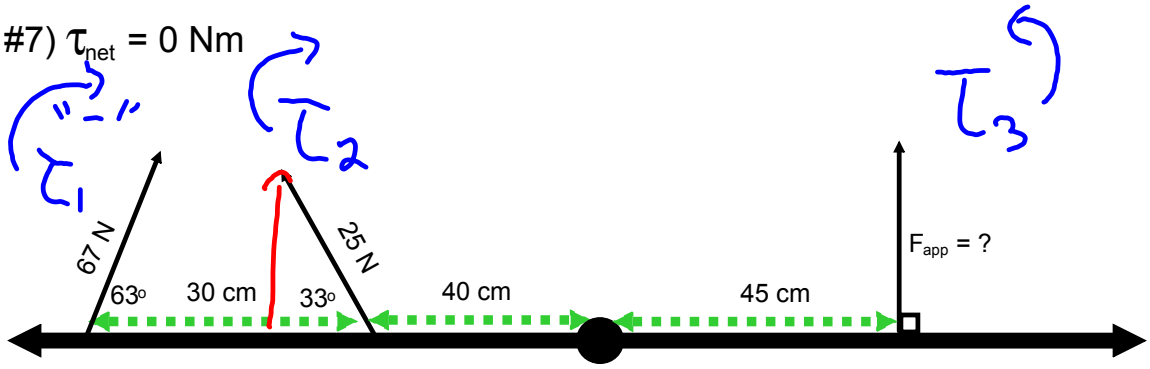
$\tau_4 = (5.4)(133)\sin 29°$

$= 348\ Nm$

$\tau_{net} = -992\ Nm + 1000\ Nm - 71\ Nm + 348\ Nm$

$= 285\ Nm$ or $285\ Nm\ [ccw]$

#7) $\tau_{net} = 0$ Nm



$$\tau_1 = -(0.30 + 0.40)(67)\sin 63^\circ$$

$$= -41.8 \text{ Nm}$$

$$\tau_2 = -(0.40)(25)\sin 33^\circ$$

$$= -5.45 \text{ Nm}$$

$$\tau_3 = (0.45\text{m})(F)\sin 90^\circ$$

$$= 0.45F$$

$$\tau_{net} = \tau_1 + \tau_2 + \tau_3$$

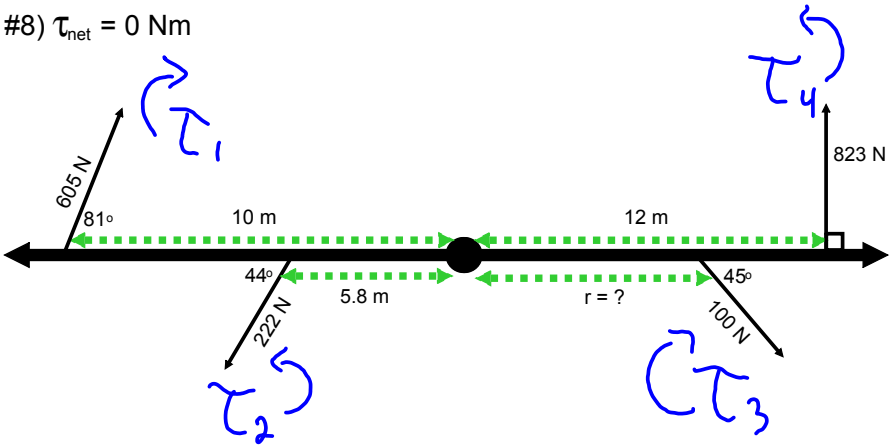
$$0 = -41.8 \text{ Nm} - 5.45 \text{ Nm} + 0.45F$$

$$47.25 \text{ Nm} = 0.45F$$

$$\frac{47.25 \text{ Nm}}{0.45 \text{ m}} = F$$

$$\boxed{105 \text{ N} = F}$$

#8) $\tau_{net} = 0$ Nm



$\tau_1 = -(10)(605)\sin 81°$

$= -5976$ Nm

$\tau_2 = (5.8)(222)\sin 44°$

$= 894$ Nm

$\tau_3 = -r(100)\sin 45°$

$= -70.7r$

$\tau_4 = (12)(823)\sin 90°$

$= 9876$ Nm

$\tau_{net} = \tau_1 + \tau_2 + \tau_3 + \tau_4$

$0 = -5976\text{ Nm} + 894\text{ Nm} - 70.7r + 9876\text{ Nm}$

$0 = 4794\text{ Nm} - 70.7r$

$-4794\text{ Nm} = -70.7r$

$\frac{-4794\text{ Nm}}{-70.7\text{ N}} = r$

$\boxed{67.8\text{ m} = r}$

Attachments

balancing-act_en.jar