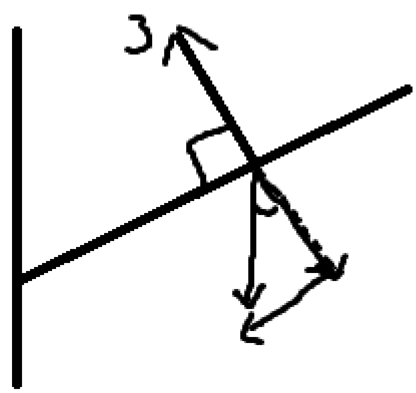
Multiple Choice Answers

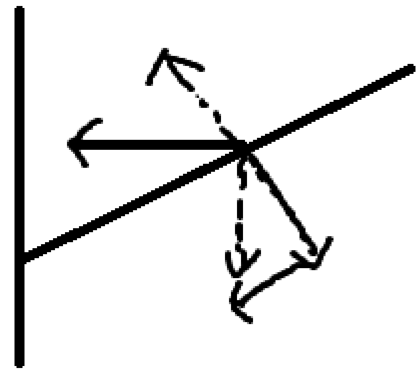
1. C

   Reason: Point P is the center of mass for the beam. To find the minimum force required consider vertical and horizontal forces, that is options 1 and 3. Torque is defined as Force * displacement, the force is **perpendicular** to the beam.

   In the left picture, this is great for applying torque, it directly targets the perpendicular.

   In the right picture, the horizontal force is insufficient compared to the first case.





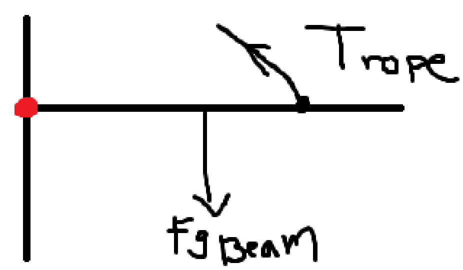
2. C

   Reason:

(1) Full body diagram shows the tension in the rope holding up the beam.

(2) Set up the standard torque equation

   Net torque is 0 because this is at static equilibrium



$T_{CW} = T_{CCW}$

The clockwise torque with respect to the pivot point (red dot) is just the F_{G_BEAM}

The counterclockwise torque is tension by the rope. Specifically the vertical component.

Therefore we have:

$F_{G\_BEAM}(1.5m) = T_{rope}$ (Plug in)

$F_{G\_BEAM}(1.5m) = T_{rope}\sin(32)$ (Vertical Torque component)

$m_{Beam}\ g\ (1.5m) = T_{rope} \sin(32)$ (F=mg, simplify)

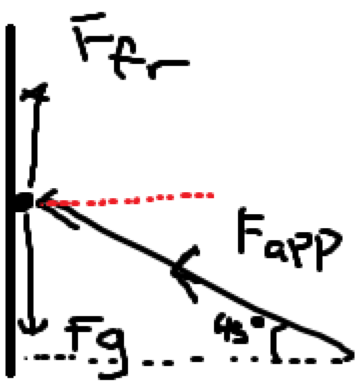
$(16.0kg)\ (9.8\ m/s^2)(1.5m) = T_{rope} \sin(32)$ (Plug numbers in)

$$T_{rope} = \frac{(16.0kg)\ (9.8\ m/s^2)(1.5m)}{sin(32)} \sim 197\ N = 200N$$

3. D

Reason:

(1) Full body diagram



(2) Look at the vertical components applied. Force of friction, force of gravity but also the vertical applied force from the hand

(3) How do we calculate friction? Look at the red dotted line, that's perpendicular to the wall and remember the formula for friction Ffr = Fn * u , where u is the coefficient of friction. In this case our perpendicular force is simply the Fapp,x or just simply the horizontal force of Fapp.

(4) Let's set up the equation for the vertical components first.

$F_{fr} + F_{applied,y} = F_g$

(5) Let's simplify this equation

$F_{fr} + (75N)\sin(45) = m(9.8\ m/s^2)$

(6) Now let's get the friction by balancing the horizontal component as explained earlier.

$F_{fr} = F_N u$,where u is the coefficient of friction

$F_{fr} = F_{applied,x}\, u$

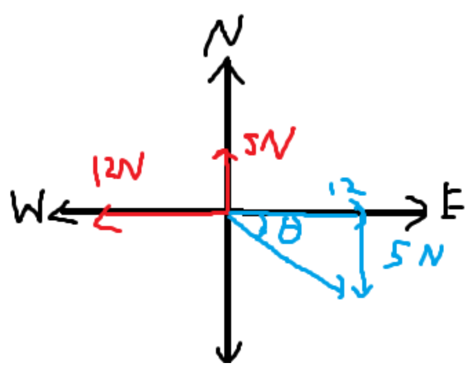
$F_{fr} = (75N)\cos(45)(0.30)$

(7) Now bring everything together

$(75N)\cos(45)(0.30) + (75N)\sin(45) = m(9.8\ m/s^2)$

m = 7.03kg

4. A



Reason:

1. Draw a typical compass
2. Label the forces in red
3. To balance out the forces, draw the forces in blue to cancel out the red forces
4. Find the angle theta, which you can do by doing

tan(5/12) = 22.61 ~ 23

Remember the convention, always label with smallest angle in triangle
Also, opposite to the angle first and then adjacent like tan.

Final answer: 23 South of East or 23 S of E

5. A

Reason:

(1) Full body diagram

You can see from the picture the child on the left side of the fulcrum is going counter clockwise and the beam & second child is going clockwise. We want equilibrium. The fulcrum is at 1.0m from the left which means that the displacement of the beam (for torque calculations) is half the beam length minus the fulcrum location

Beam displacement = (1.5m - 1m) = 0.5m

$T_{CW} = T_{CCW}$

$F_{g1} * d = F_{g\_Beam} * d + F_{g1} * d$

$m_1 g*(0.60m) = F_{g\_Beam}(0.50m) + m_2 g*d$

$(35kg)(9.8\ m/s^2)(0.60m) = (15kg)(9.8\ m/s^2)(0.50m) + (20kg)(9.8\ m/s^2)*d$

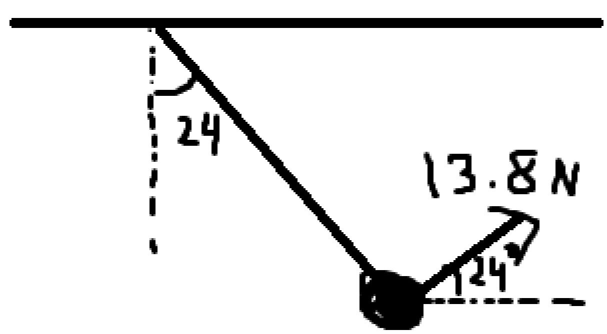
You can cancel out gravity here because it's in all the terms.

$(35kg)(0.60m) = (15kg)(0.50m) + (20kg)*d$

$d = \frac{(35kg)(0.60m) - (15kg)(0.50m)}{(20kg)} = 0.675\ m = 0.68m$

6. D

Reason:



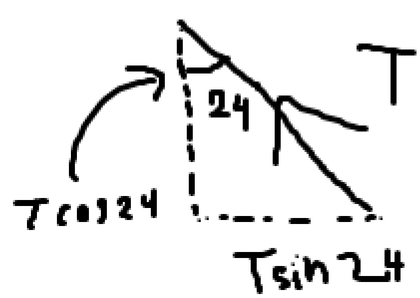
1) Full body diagram, you must calculate all the horizontal and vertical forces that are applied. This ball is at equilibrium meeting that all vertical and horizontal forces are net zero.

2) I labelled the vertical forces of the string with its tension as well.

3) Equation for the vertical forces

Vertical tension + vertical force applied = gravitational force on the ball

T*cos(24) + Fapp*sin(24) = Fg



$T*\cos(24) + (13.8N)*\sin(24) = m(9.8\ m/s^2)$

4) We don't know what the tension is but we can calculate it, by considering the horizontal forces.

Horizontal tension = horizontal force applied

T*sin(24) = Fapp,x

T*sin(24) = (13.8N)*cos(24)

$$T = \frac{(13.8N)*cos(24)}{sin(24)} = 31N$$

5) Now we know the tension, let's go plug it back into the equation we found at step (3)

$(31)*\cos(24) + (13.8N)*\sin(24) = m(9.8\ m/s^2)$

m = 3.5kg

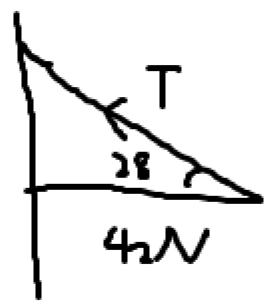
7. A

Reason: This is a standard question on torque however, the horizontal force just means the horizontal component of the tension in the string.

(1) We first find the vertical component of the string

We can use $T_{vertical}$ = (42N)*tan28

(2) Now we use the Torque equations



$$T_{CW} = T_{CCW}$$

$F_{g\_Load}\ d = T_{vertical} * d$

$m_{load}\ g * d = T_{vertical} * d$

$m_{load}\ g*(1.80m) = (42N)*\tan28* (1.30m)$

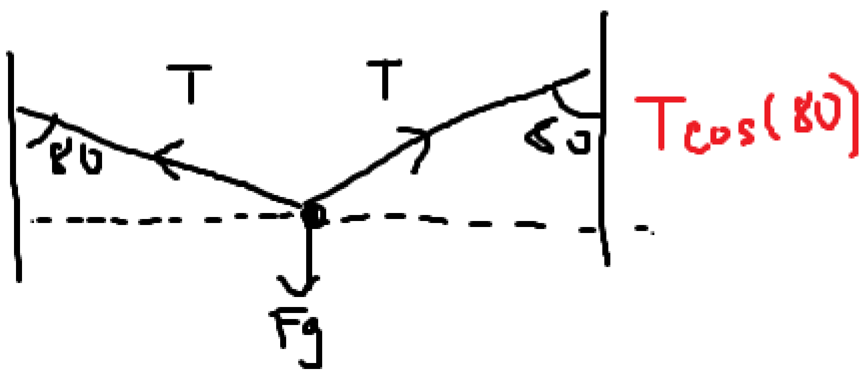
Weight = $m_{load}\ g$ = 42N)*tan28* (1.30m)/(1.80m)

=16.1N

8. C

Reason: the two tension hanging the traffic light is basically the same because the angles are the same This means we can do the following:

(1) Full body diagram



(2) The vertical forces are

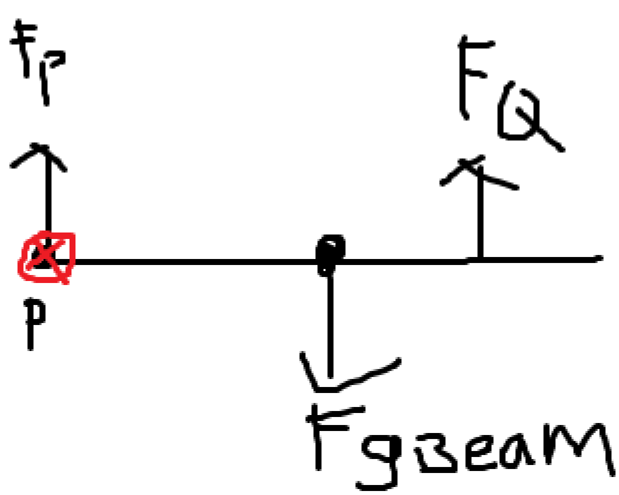
2*T*cos(80) = Fg

2*T*cos(80) = (75kg)*(9.8 m/s^2)

T = $\frac{(75kg)*(9.8\, m/s2)}{2*cos(80)}$ = 2116 N = 2100 N

9. B

Reason: Make sure that the pivot point will P. Then we will be able to find the Force Q.
note** If we make Q the pivot point then we're solving for Force at P because our displacement value is non-zero at point P and zero displacement at point Q.



$$T_{CW} = T_{CCW}$$

Fg_Beam * d = Fq *d

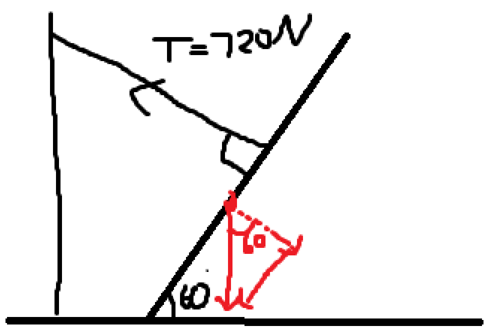
(25kg)(9.8 m/s2)* (4.0m = Fq *(6.0m)

Fq = $\frac{(25kg)(9.8\,m/s^2)*(4.0m)}{(6.0m)}$ = 163N = 160N

10. D

Reason: we are not given the displacement value but we do know the relative locations of the string and the center of mass. It's important to appropriate break the angled component to vertical and horizontal components (explained by the red diagram, you may need to review dynamics if you're not familiar)

(1) Full body Diagram



(2) The tension acts like a counter clockwise torque
Whereas, the weight of the beam acts like a clockwise torque. All of this nets zero torque.
Remembering that we need the perpendicular force for Torque.

(3) Let's first start with the torque equation

$$T_{CW} = T_{CCW}$$

The perpendicular force of the Fg will act like clockwise torque. Which is

Fg*cos(60)

The full equation is now:

Fg*cos(60) *(½ d)* = *T* (¾ *d)

Note that d will cancel out on both sides. And that's why we only need their relative values.

(4) Solve for Fg:

(5) $Fg = \frac{T*(3/4)}{cos(60)*(1/2)} = 2160N$