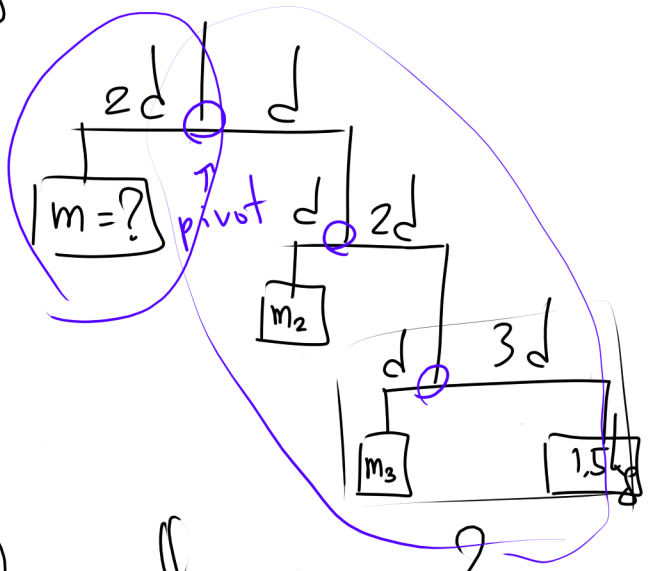
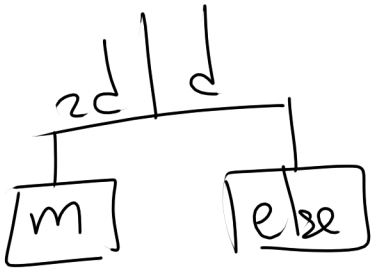
(1) Child's mobile consists of four masses supported by massless rods:



Static Equilibrium

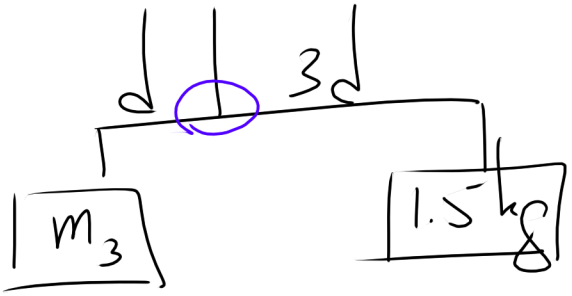
What's the mass?

Solution



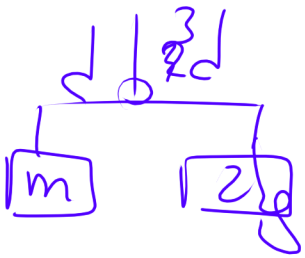
Moment's theorem

Work from bottom to top

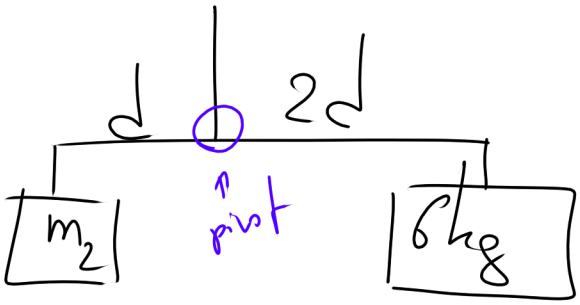


Then $m_3 = 3 \cdot 1.5 = 4.5$

Better

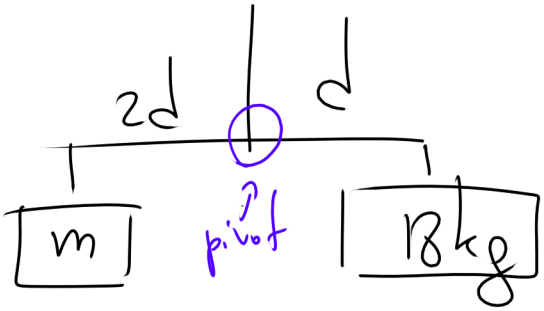


Now, let's find m_2



Then $m_2 = 12$ kg.

Finally,



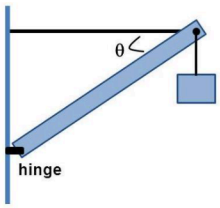
Then $m = 9$ kg.

↑ Correct Answer.

(2)

QUESTION 3

A 3 m long uniformly dense cantilever with a mass of 250 kg is attached to a hinge and also held in place by a steel cable that is attached to the far end of the cantilever at an angle of θ = 30° with respect to the cantilever as shown in the figure.

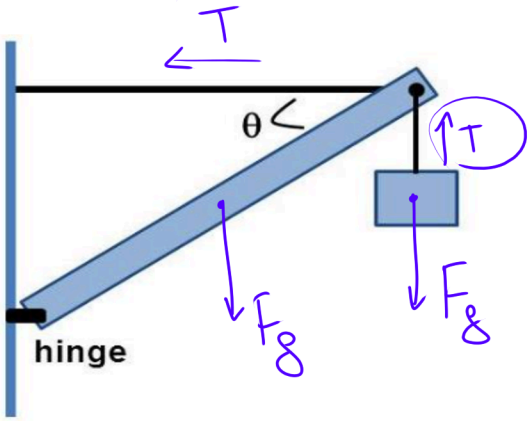


A 25 kg mass also hangs from the far end of the cantilever. What is the tension (in N) in the cable?

Let $m_A = 250$ cantilever

Let $m_B = 25$ block

Solution



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As the system is in a static equilibrium:

$$\sum_i (F_x)_i = 0 \quad \text{and} \quad \sum_i (F_y)_i = 0$$

$\Rightarrow$

normal force exerted by the hinge on cantilever

$$\sum_i (F_x)_i = n_x - T\cos 30^\circ = 0$$

$$\Rightarrow n_x = T\cos 30^\circ$$

$$\sum_i (F_y)_i = n_y + T\sin 30^\circ - m_A g - m_B g = 0$$

Notice that

$$\sum_i \tau_i = 0$$

Then

center of mass

$$TL\sin(180^\circ - 30^\circ) - m_B g L - m_A g\left(\frac{L}{2}\right) = 0$$

$$\Rightarrow T\sin 30^\circ - m_B g - \frac{m_A g}{2} = 0$$

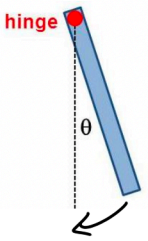
$$\Rightarrow T = \frac{g\left(m_B + \frac{m_A}{2}\right)}{\sin 30^\circ}$$

$$= 2940\ N$$

$$= 2.94\ kN$$

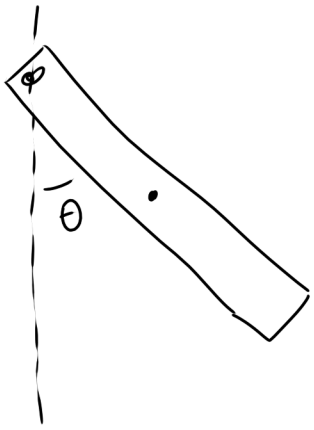
↑ Answer

(3) A physical pendulum is made using a uniformly dense rod with a mass of 1.5 kg and a length of 0.75 m pivots around a frictionless hinge at one end of the rod. What is the work (in J) done by the gravitational torque as the rod swings from $\theta = 15°$ to $\theta = 0°$?



Solution

work → $W = -\Delta U_g$ ← change in potential



$\frac{L}{2}\cos\theta = h$

Potential $= mgh$

m: Do we know it? Yes!

g: Do we know it? Yes!

h: Do we know it?

$$U_g = -mg\left(\frac{L}{2}\right)\cos\theta$$

$$\Rightarrow W = mg\left(\frac{L}{2}\right)(\cos\theta_f - \cos\theta_i)$$

$$= 1.5\,\text{kg} \cdot 9.8\,\text{m s}^{-2} \cdot \frac{0.75\,\text{m}}{2}(\cos 0° - \cos 15°)$$

$$= 0.19\,\text{J}$$

↖ Answer.