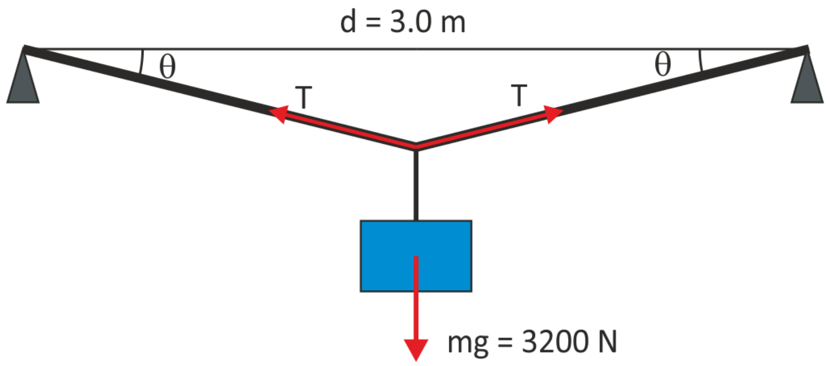
Answer on Question #39583, Physics, Mechanics | Kinematics | Dynamics

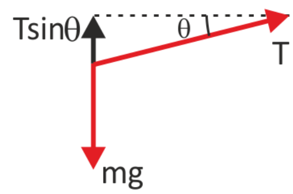
a) A massless rope is stretched horizontally between two supports that are 3.0 m apart. When an object of weight 3200 N is hung at the center of the rope, the rope is observed to sag by 50 cm. Calculate the tension in the rope.

b) A ball of mass 5.0X10^-2 Kg starting from rest, falls a height of 4.0 m and then collides with the ground. The ball bounces up to a height of 2.0 m. The collision with the ground takes place over a time 4.0X10^-1 S Determine (i) the momentum of the ball immediately before the collision, (ii) the momentum of the ball immediately after the collision and (iii) the average force of the ground on the ball.

Solution:

We have three forces acting on the object being hung at the center of the rope, as you can see in the diagram below. Since the rope is assumed massless, tension is uniform throughout the rope and the rope exerts two forces of equal magnitude on both the left and right side of the object.





To find the horizontal and vertical components of the two tension forces on either side, we must first know the angle θ.

$$\tan\theta = \frac{s}{d/2} = \frac{0.5}{1.5} = 0.3333$$

$$\theta = \arctan\left(\frac{1}{3}\right) = 0.321751 \text{ rad} = 18.43°$$

We can split up the tension forces using trigonometry. The horizontal components are always T*cos(θ) and the vertical components are T*sin(θ).

For y direction:

$$T\sin\theta + T\sin\theta = mg$$

$$2T\sin\theta = mg$$

$$T = \frac{mg}{2\sin\theta} = \frac{3200}{2\cdot\sin 18.43°} = 5061 \text{ N}$$

b) Given:

m = 0.05 kg

h1 = 4 m

h2 = 2 m

t = 0.4 s

(i) the momentum of the ball immediately before the collision

The velocity of the ball before it hits the ground using the conservation of energy

Kinetic energy = Potential energy

$$\frac{mv^2}{2} = mgh_1$$

Thus the momentum of the ball is

$$p_1 = -mv = -m\sqrt{2gh_1} = -0.05\sqrt{2 \cdot 9.8 \cdot 4} = -0.443 \text{ kg} \cdot \text{m/s}$$

Note that we chose the positive direction to be up.

(ii) the momentum of the ball immediately after the collision

We use the conservation of energy to find

$$mgh_2 = \frac{mv_2^2}{2}$$

$$p_2 = mv_2 = m\sqrt{2gh_2} = 0.05\sqrt{2 \cdot 9.8 \cdot 2} = 0.313 \text{ kg} \cdot \text{m/s}$$

(iii) the average force of the ground on the ball

The average force is

$$F = \frac{\Delta p}{\Delta t} = \frac{p_2 - p_1}{\Delta t} = \frac{0.313 + 0.443}{0.4} = 1.89\ N$$

Answer. a) T = 5061 N,

b) (i) p_1 = -0.443 kgm/s, (ii) p_2 = 0.313 kgm/s, F = 1.89 N.