Chapter N5: Statics

N5.1: Forces from Motion

This chapter explores further the idea that if we know how an object moves we can figure out stuff about the forces acting on that object.

N5.2: Introduction to Statics

Specifically, in this chapter we will consider objects at rest. Since such objects aren't moving, we know that $\vec{a} = 0$. By Newton's second law, the next *external* force acting on an object at rest must be zero.

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 \cdots = 0 \; . \qquad (1)$$

Examples:

1. A 3kg object hangs from a string.
2. A 50 kg box rests on an inclined plane as shown. Find the normal force and the frictional force acting on the box if $\theta = 37$ degrees.

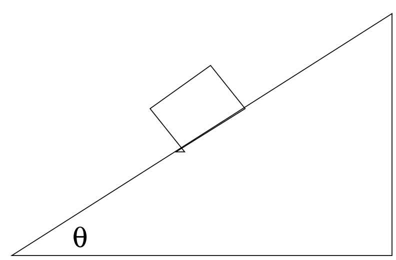


Figure 1:

N5.3 Statics Problems Involving Torque

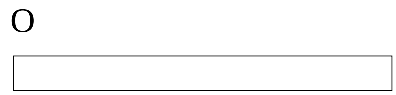
Recall that the torque τ about a point O acting on an object is given by:

$$\vec{\tau} = \vec{r} \times \vec{F} \; , \qquad (2)$$

where $\vec{F}$ is the force acting on the object and $\vec{r}$ is a vector that point from O to the point where the force acts on the object.

Example:

What is the torque about O exerted by the weight of the rod shown below? The rod has a mass of 70 kg and is 2 meters long?



In statics problems, the total external torque on the object must also be zero. (If it wasn't zero, the object would be rotationally accelerating.) Thus,

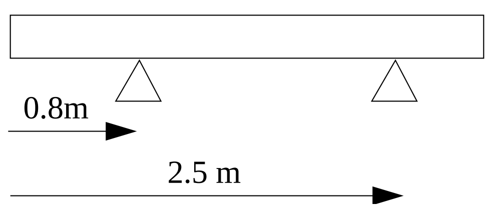
$$\vec{\tau_1} + \vec{\tau_2} + \vec{\tau_3} + \cdots = 0 \; . \tag{3}$$

Note that the above equation doesn't say anything about the point 0 about which we compute the torque. This is because 0 doesn't matter. If the object isn't rotating, it's torque about *any* point is zero. Thus, we are free to choose any convenient point for O.

Equations (1) and (3) apply to any object at rest. These two equations can be used together to solve many, many different sorts of problems.

Example:

A uniform plank rests on two supports as shown. What are the magnitudes of the normal forces that each support exerts on the plank? The mass of the plank is 125 kg and it is 3 meters long.



Practice:

1. A 50 kg box hangs from a rope. If a horizonal, 100 N force is applied to the box, what angle does the rope make with the vertical?
2. A 25 kg sign is hung from a single rope as shown. Determine the tension in the rope if $\theta = 37$ degrees and $\phi = 45$ degrees.
3. A 30 kg sign is attached to a wall with a hinge and then suspended with a rope as shown. The sign is 1.5 meters long; the angle $\theta = 37$ degrees. Find the tension in the cord and the force that the hinge exerts on the sign.

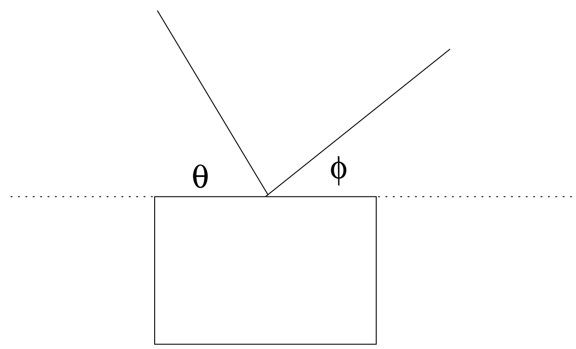


Figure 2:

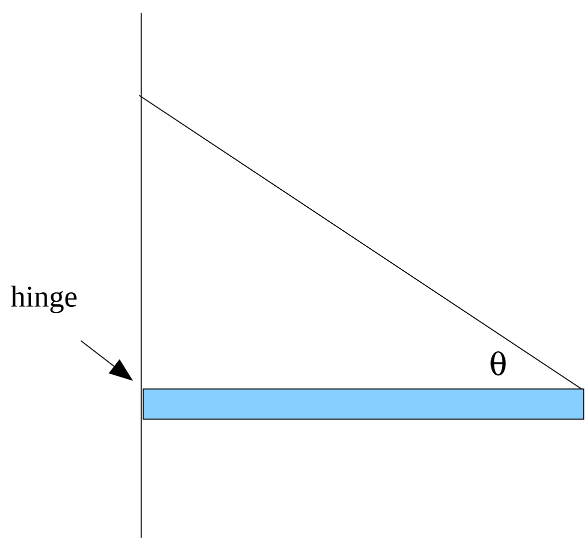


Figure 3: