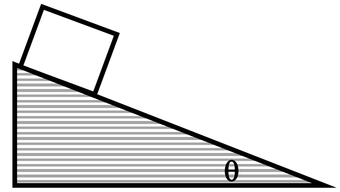
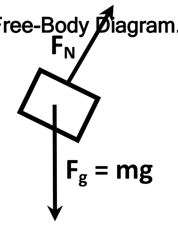
If You Are So Inclined...

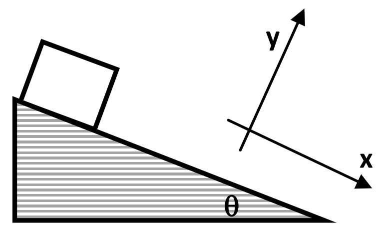


A 20-kg box is placed on a frictionless incline. What is the acceleration of the box down the incline?

This problem is not especially different from any other problem involving Newton's Laws. So, we're going to approach it like any other problem, and just point out the important points when we reach them:

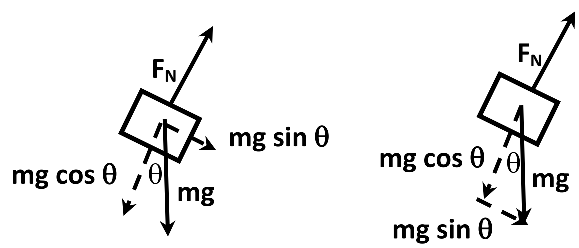
Step 1: Draw a representative Free-Body Diagram.





Step 2: Establish a coordinate system. The motion (or impending motion) should be aligned with an axis. For our problem, we'll need to rotate the x- and y-axes.

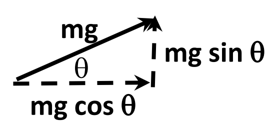
Step 3: Resolve all forces into components that are either parallel or perpendicular to the motion of the object. In our problem, as will be the case for most objects moving along an incline, the force of gravity must be broken down into components that are aligned with the rotated axes:



Both of these are acceptable ways of showing the components.

The component of the force of gravity that is responsible for the box accelerating **down** the incline is **mg sin θ,** and the component of the force of gravity that pushes the box **into** the incline is **mg cos θ.** That is:

$$F_{g\parallel} = mg \sin\theta$$
$$F_{g\perp} = mg \cos\theta$$



Step 4: Apply Newton's Second Law (ΣF = ma). Since the box is moving PARALLEL to the incline, we know that the summation of the forces perpendicular to the incline is ZERO. That is:

$$\Sigma F_{\perp} = 0$$

$$\Sigma F_{\perp} = F_N - mg \cos\theta = 0$$

And the summation of the forces parallel to the incline is equal to the mass the mass times the acceleration. That is:

$$\Sigma F_{\parallel} = ma$$

$$\Sigma F_{\parallel} = mg \sin\theta = ma$$

$$mg \sin\theta = ma$$

$$a = g \sin\theta$$

Problem 1: A duck (m = 2.5 kg) slides down a waterslide (assume frictionless), that has an angle of inclination of 40 degrees, relative to the horizontal.

(a) Draw the free-body diagram.

(b) Solve for each of the following forces:
   i. F_g
   ii. F_N

(c) What is the acceleration of the duck?

(d) Assuming the duck started from rest, how fast will the duck be traveling after it's slid 15 m?

Problem 2: A skier (m=35 kg) is skiing down a slope that has an angle of inclination of 32 degrees, relative to the horizontal. The coefficient of kinetic friction between the skis and the snow is 0.11.

(a) Draw the free-body diagram for the skier.

(b) Solve for each of the following forces:
   i. F_g
   ii. F_N
   iii. F_f
   iv. ΣF

(c) What is the acceleration of the skier?