Student Worksheet: Applying Newton's Second Law
Let's work friction into our method of analyzing forces.

A block of mass *m* remains at rest on a ramp inclined at an angle θ with respect to the horizontal. The coefficient of static friction for the block-ramp interaction is μ_S.

Sketch a free-body diagram for the block.

Draw the coordinate system on the diagram.

Find an expression for the normal force acting on the block.

Find an expression for the force of static friction acting on the block that must be present for the block to remain at rest.

Find an expression for the maximum possible value the force of friction can be at a particular angle.

Choose a value for the coefficient of static friction. State that value here: μ_S =________

The angle θ can be set to any value between 0˚ and 90˚. Use the expressions you derived above, and your chosen value of μ_S to plot, as a function of θ, the following:

- the magnitude of the normal force applied by the ramp to the block
- the magnitude of the force of friction required to keep the block from sliding down the ramp
- the magnitude of the maximum possible force of friction the ramp could exert on the block in this situation

At what angle will the block start to slide down the ramp?

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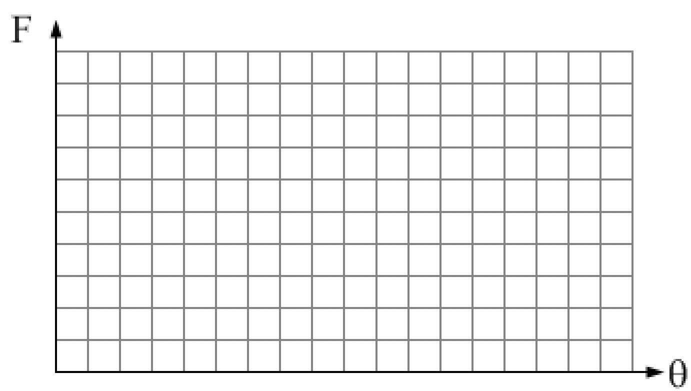
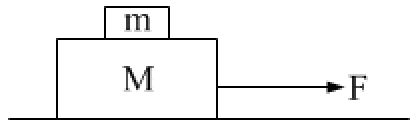


A large box of mass M sits on a horizontal surface. A small box of mass m sits on top of the large box. The coefficients of friction between all surfaces in contact are:

$\mu_k = 0.40$ and $\mu_s = 0.50$



A string of negligible mass is tied to the large box and a horizontal force F is applied to the string so that the two boxes accelerate to the right, with the small box maintaining its position on top of the large box at all times.

Draw the free-body diagram of the system consisting of the two boxes together. Label all arrows appropriately.

Draw the free-body diagram of the small box. Label all arrows appropriately.

Draw the free-body diagram of the large box. Label all arrows appropriately.

Let's say that $M = 2.0$ kg and $m = 1.0$ kg, and we'll use the approximation that $g = 10\ \text{m/s}^2$ to simplify the calculations. If the force applied to the string is $F = 21$ N then the boxes accelerate together to the right with the small box maintaining its position on top of the large box. What is the acceleration of the system?

Under the conditions specified above, what is the magnitude of the force of friction acting on the small box?