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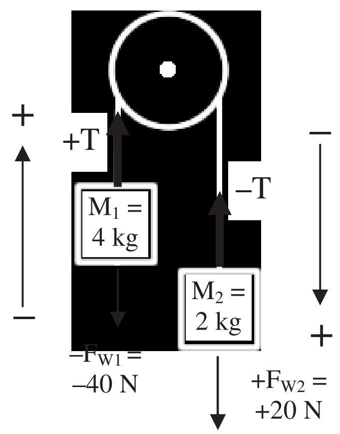
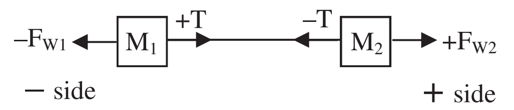
Connected Objects and Ramps

Connected Objects

When objects are connected they have the same acceleration and the shared force of whatever connects them. Yet for $\Sigma F = ma$, they are still individual objects.



Step 1– Use a common positive direction. Since they are connected, they will move the same direction at the same time. *We will always choose right as positive.*



It may help to think of the system straightened out. You can then easily see the positives and negatives.

Step 2 – Write $\Sigma F = ma$ for <u>each object in the direction of motion</u>.

For M_1	For M_2
$\Sigma F_1 = m_1a_1$	$\Sigma F_2 = m_2a_2$
$T - F_{W1} = m_1a_1$	$F_{W2} - T = m_2a_2$
$\mathbf{T - 40 = 4a_1}$	$\mathbf{20 - T = 2a_2}$

$T - 40 = 4a$ $\qquad$ $20 - T = 2a$

I choose to solve for this T because it is +

$T = 4a + 40 \longrightarrow 20 - (4a + 40) = 2a$

Substitute into other equation.

$20 - 4a - 40 = 2a$

$-20 = 6a$

$\mathbf{a = -3.33\ m/s^2}$

The – means to the left.

Finding T would now be easy!

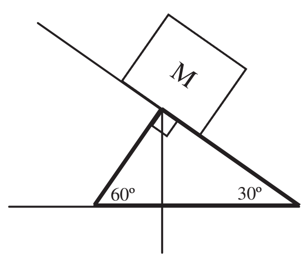
Step 3 – Identify what is equal in the system. Here the a's are equal (they move together) and the T's are equal (since T is constant in a rope).

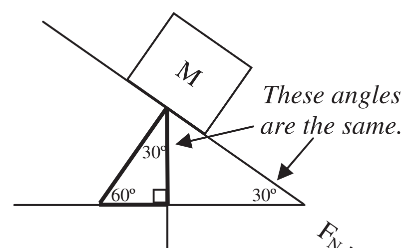
Step 4 – Solve for one variable in one equation and substitute it into the other equation and solve. It doesn't matter which equation you start with, except you must use both equations. If you solve for the wrong variable (you need T and you solved for a), just calculate the other variable as well.

Objects on Ramps

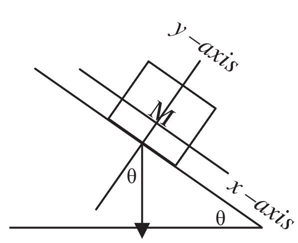
Objects on ramp follow Newton's Laws and friction just as any other object. The only trick is to understand the geometry and trigonometry of this special case.

If you know that all of the angles of a triangle add up to 180°, then proving which angles are the same is relatively easy.

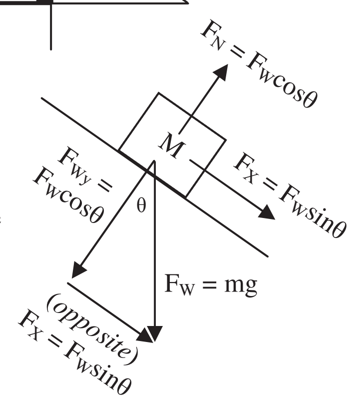




To simplify the math, we actually tilt the axis so that x is along the ramp. This way we only have to resolve one vector: weight.



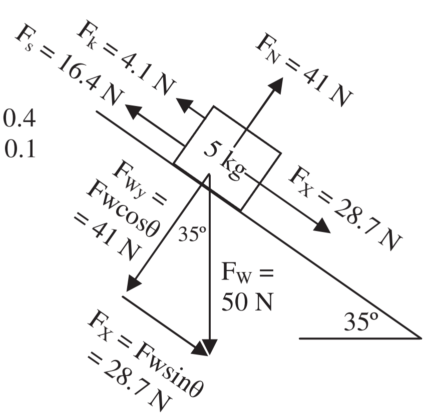
The x-direction force pulling the object down the ramp is a component of the weight, but due to the angle given, $F_{Wx} = F_W\sin\theta$ and $F_N = F_W\cos\theta$



With F_N, calculating Fs and Fk is easy. Then deciding if the object will slide or not and its acceleration is also an easy matter.

$\mu_s = 0.4$

$\mu_k = 0.1$



Example: *A 5 kg mass is on a 35º ramp. $\mu_s = 0.4$ and $\mu_k = 0.1$.*
A) Will the mass slide?
B) If so, what is its acceleration?

Calculating Friction:

$F_s = \mu_sF_N$	$F_k = \mu_kF_N$
$F_s = 0.4(41)$	$F_s = 0.1(41)$
$F_s = 16.4$ N	$F_s = 4.1$ N

A) Since 28.7 N > 16.4 N it slides.
B) Find acceleration:

$\Sigma F_X = ma$ $\qquad$ $24.6 = 5a$

$28.7 - 4.1 = 5a$ $\qquad$ $a = 4.92\ m/s^2$

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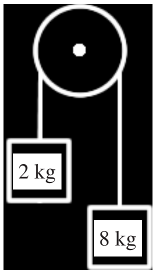
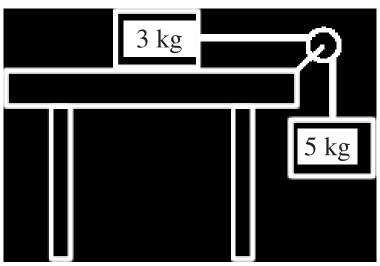


1. Using the pulley system at the left to answer the following.
   A. What is equal in this system?
   B. Draw the positive direction for both masses.
   C. Positive or negative?

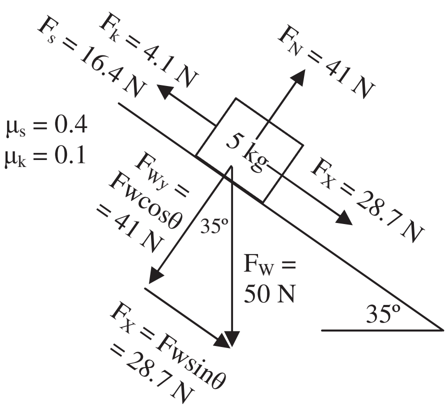
1. ____	Up for the 2 kg mass?	4. ___	F_W for the 8 kg mass?
2. ____	Up for the 8 kg mass?	5. __	T for the 8 kg mass?
3. ____	F_W for the 2 kg mass?	6. __	T for the 2 kg mass?

   D. Write the Newton's Second Law equations for both masses.
   <u>2 kg mass</u>: <u>8 kg mass:</u>

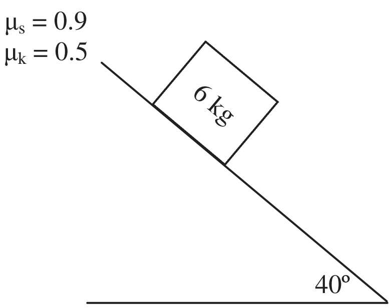
   E. Find the acceleration of the system.



2. Find the tension in the rope between the 3 kg and 5 kg objects. Assume no friction.



3. A 5 kg object is on a 35º ramp. If $\mu_s = 0.4$ and $\mu_k = 0.1$ figure out whether it will slide or not. If it does slide, find the object's acceleration down the ramp.
   A. Why is the F_x the sin instead of cosine?
   B. How is 41 N calculated?
   C. Why is the normal force 41 N?
   D. How is 16.4 N calculated?
   E. Will the object slide (prove it)?
   F. Find the acceleration of the object.



4. A. Fill in the diagram at the right with all of the appropriate information.
   B. Will the object slide or not?
   C. If it will slide, find its acceleration. If it doesn't slide, find the additional force necessary to start it sliding.