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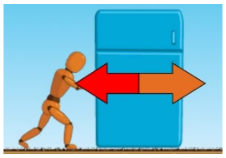


P20 Unit B: Friction Investigation

Name: Key!

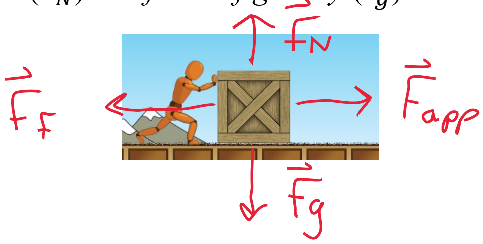
Date: ____________

Find the animation to use when working through this investigation at https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html or by Googling "phet forces and motion".

Part A: Static Friction

1. Turn on the *Forces* and *Sum of Forces, Values* and *Masses* buttons.

2. Try taking the stick man and pushing gently on the crate so it stays at rest. Draw out the free body diagram of the forces at work. Use the labels *applied force* ($\vec{F}_{app}$) as well as *force of static friction* ($\vec{F}_{Fstatic}$) *normal force* ($\vec{F}_N$) and *force of gravity* ($\vec{F}_g$).



Questions:

a) When an object has forces acting on it, but is at rest, we say the object is in static equilibrium. *(Hint: think back to the name of a lesson earlier in this unit!)*

b) Does this type of friction stay at the same magnitude, or does it change? Explain.

The mag. of $\vec{F}_{Fstatic}$ always equals the mag of $\vec{F}_{app}$.

3. Figure out how much force is needed to get *just* get the box moving. What's the largest force the box can withstand before it moves? You might need to do some trial and error to figure it out.

4. Repeat the process from above with other objects of different mass. Record your findings on a data table like the one below. Make a graph of $\vec{F}_{Fstatic}$ vs. *m. (You can also make the graph on your calculator using the instructions in the back of your lab manual, or graph using some online computer software.*

Force of Static Friction, $\vec{F}_{Fstatic}$ (N)	mass of object, *m* (kg)	Normal Force $\vec{F}_{Fstatic}$ (N)
94	50×9.81 =	491
75	40×9.81 =	392
150	80	785
188	100	981
225	120	1177

$\vec{F}_g = \vec{F}_N$ (just opposite direction)

Question: $\vec{F}_g = m\vec{g}$

In this animation, to get the force of friction on an object, I need to multiply the normal force by 0.19.

(This number is called the coefficient due to friction, or μ.)

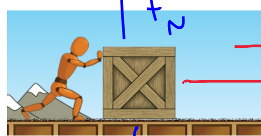
Think of $F_F = \mu F_N$

$\frac{94N}{491N} = 0.19$

Part B: Kinetic Friction

1. Make sure the speed button is checked so the speedometer is showing. Place any mass on the ground and have the stick man push it until it moves. Draw out the free body diagram of the forces at work. Use the labels *applied force* ($\vec{F}_{app}$) as well as *force of kinetic friction* ($\vec{F}_{Fkinetic}$) *normal force* ($\vec{F}_N$), *force of gravity* ($\vec{F}_g$) and *net force* ($\vec{F}_{net}$).

$\vec{F}_N$ $\vec{F}_{net}$ $\vec{F}_F$ $\vec{F}_{app}$



$\vec{F}_g$

Questions:

a) Does the force of kinetic friction depend on the magnitude of the applied force? No

b) What kind of motion (uniform/accelerated) does the object have when it starts moving?

c) Get the object moving, then suddenly stop pushing it. Does the force of kinetic friction stop when the applied force stops? No, it stops when the object stops moving.

Application Questions:

1. Find a way to determine the mass of the present. Explain your procedure.

The wooden crate can withstand 94 N of applied force before moving. It has a mass of 50kg. The present also can withstand 94N of force before moving, so it has a mass of 50kg

2. Turn up the friction slider to "Lots". Determine the new coefficient of static friction (μ_{static}) and the new coefficient of kinetic friction ($\mu_{kinetic}$) for the trash can.

for the 50kg box:

$\vec{F}_g = mg$

$\vec{F}_g = (50kg)(-9.81m/s^2)$

$= -490.5N$

$\vec{F}_N = +490.5N$.

$\vec{F}_F$ needed to just overcome

$\vec{F}_{F\,static} = 188N$

(at "lots" friction)

$\vec{F}_F = \mu \vec{F}_N$

$188N = \mu(490.5N)$

$\mu = \underline{0.38}$

3. Rest the animation, check all the boxes, keep the friction slider in the middle. Place the crate on the ground and push until the stick man lets go. Determine the displacement of the box before it comes to rest.

$m = 50kg$

$\vec{v}_1 = 40m/s$ (when box gets launched)

$\vec{v}_f = 0m/s$ (when box stops).

$\vec{F}_F = -94N$

① $\vec{F} = m\vec{a}$

$-94N = (50kg)\vec{a}$

$\vec{a} = -1.88m/s^2$

② $\vec{v}_f^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\vec{d}$

$(0m/s)^2 = (40m/s)^2 + 2(-1.88m/s^2)\vec{d}$

$\vec{d} = \underline{426m}$