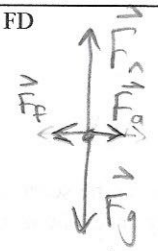
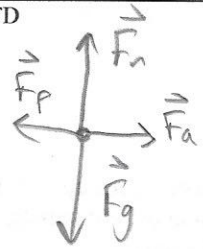
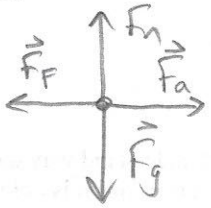
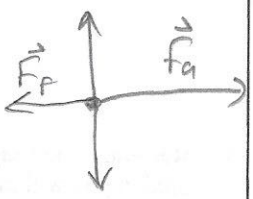
SPH3U: Friction

Pianos are very hard to move. A strong person pushes a piano with a large force and it still doesn't move. Why not?

A: The Types of Friction

At the front of the class your teacher has a fairly heavy object attached to a ***Newton scale***. Watch as your teacher will gradually exert a larger force on the object until it starts to move.

1. **Represent.** For each situation below draw a force diagram for the object. Compare the size of the horizontal forces that may be involved in a particular situation.

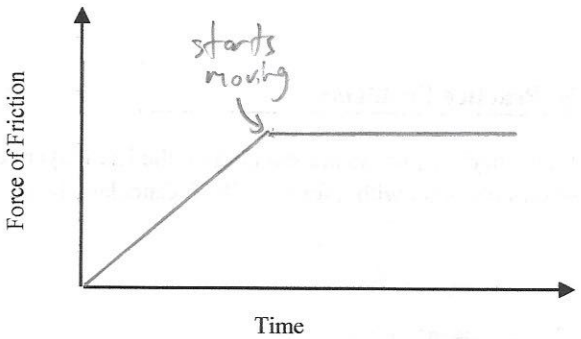
(A) Your teacher is not pulling on the object	(B) Your teacher is gently pulling, but it is not yet moving	(C) Your teacher is pulling hard, but it is not yet moving	(D) Your teacher is pulling and it is now moving at a constant velocity	(E) Your teacher is pulling even harder and it is now accelerating
FD 	FD 	FD 	FD 	FD 
Compare:	Compare:	Compare:	Compare:	Compare:

2. **Reason.** In which situations above is the force of friction present? What evidence is there? Explain.

B, C, D → need balanced forces for no acceleration

E → there is friction, but evidence less clear

3. **Describe.** What happens to the size of the friction force when the object begins to move? Draw a graph of force of friction vs time.



Friction is a contact force that occurs when two objects that are pressed together try to slide against one another. If the surfaces are sliding relative to one another we call the force *kinetic friction* (F_{fk}). If the two surfaces are not slipping we call the force *static friction* (F_{fs}).

4. **Describe.** Label the force diagrams above with the appropriate type of friction.

5. **Reason.** What would happen to the size of the force of static friction if we pulled a bit harder and the object still did not move? Explain.

static friction force would grow

The size of the force of static friction can take a range of values depending on what is happening in the particular situation. $0 < F_{fs} \leq F_{fs\,max}$. There is a maximum possible value for the force of static friction which occurs just before the objects begin to slip. This maximum value is usually greater than the force of kinetic friction.

B: Kinetic Friction and the Normal Force

We will use an online simulation to try to answer the following question:
How does the size of the force of kinetic friction depend on how hard the objects are pressing against one another?

1. **Reason.** Which force represents how hard the two objects are pressing against one another? How could we find the magnitude of this force in the case of a book with a mass of 0.5 kg? Show your calculation.

Normal force: $F_{net} = mg$

$F_{net} = (0.5)(-9.8) = -4.9\ N$ or $(0.5)(-10) = -5\ N$

2. **Design**. Visit the friction simulation at the following link:
https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html
You need to configure a variety of masses, and exert enough force on the masses to make them move. You will need to calculate the normal force on your masses, and the simulation will tell you the force of friction that exists.
Note: once you have selected how much friction your surface has (somewhere between None → Lots), do not change your friction.

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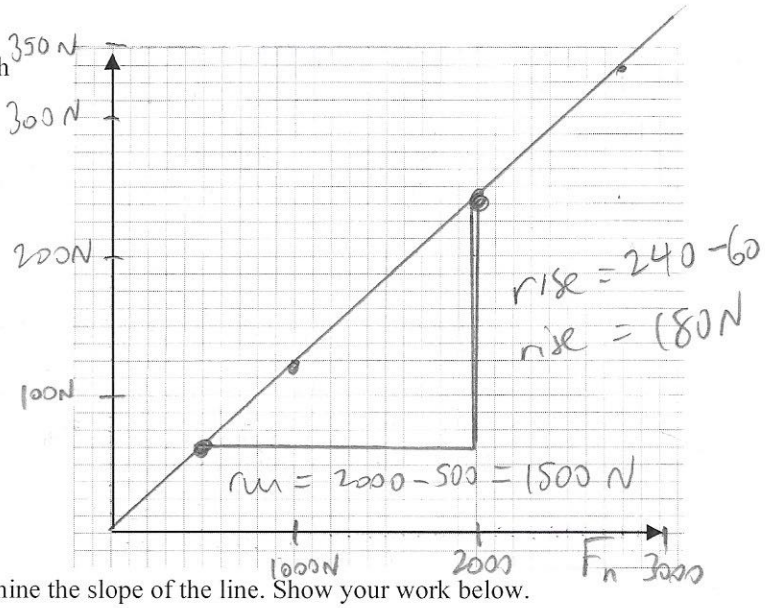
3. **Observe and Represent.** Collect data according to your procedure. Plot the data comparing the forces on the graph (F_N on the x-axis and F_f on the y-axis).

Mass (kg)	F_n (N)	F_f (N)
50	500 N	60 N
100	1000 N	120 N
200	2000	240 N
90	900 N	108 N
180	1800 N	216 N
250	2500 N	300 N
280	2800 N	336 N



4. **Analyze.** Construct a line of best-fit for your data. Determine the slope of the line. Show your work below.

$m = \frac{rise}{run} = \frac{180\ N}{1500\ N} = 0.12 = \mu_K$

5. **Interpret.** The value you found for the slope is called the *coefficient of kinetic friction* (μ_k). What characteristics of your experiment do you think affect this value? What would a smaller value for μ_k signify?

↳ surface it is sliding on → less friction
↳ material of object sliding.

6. **Analyze.** Write down an equation for the line of best fit for your graph. Use the symbols F_n, μ_k and F_{fk}.

$\vec{F}_{Fk} = \mu_K \vec{F}_n$

7. **Predict.** Make a prediction. If a 230 lb (1 kg = 2.2 lbs) basketball player wore your shoe (which may defy other laws of physics!) what would the force of kinetic friction be? Show your work.

230 lb = 104.5 kg

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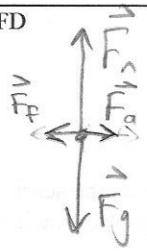
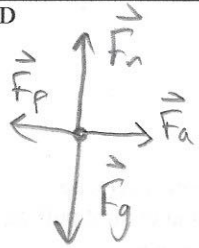
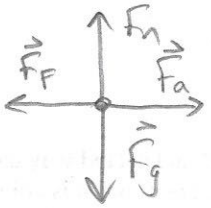
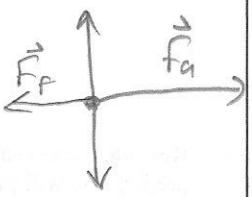
FD 	FD 	FD 	FD 	FD 
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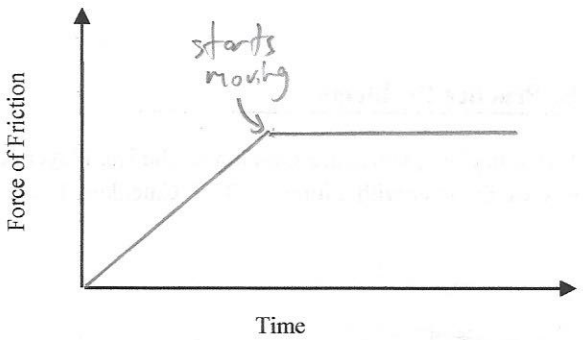

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