PhET Tips for Teachers — Forces and Motion: Basics

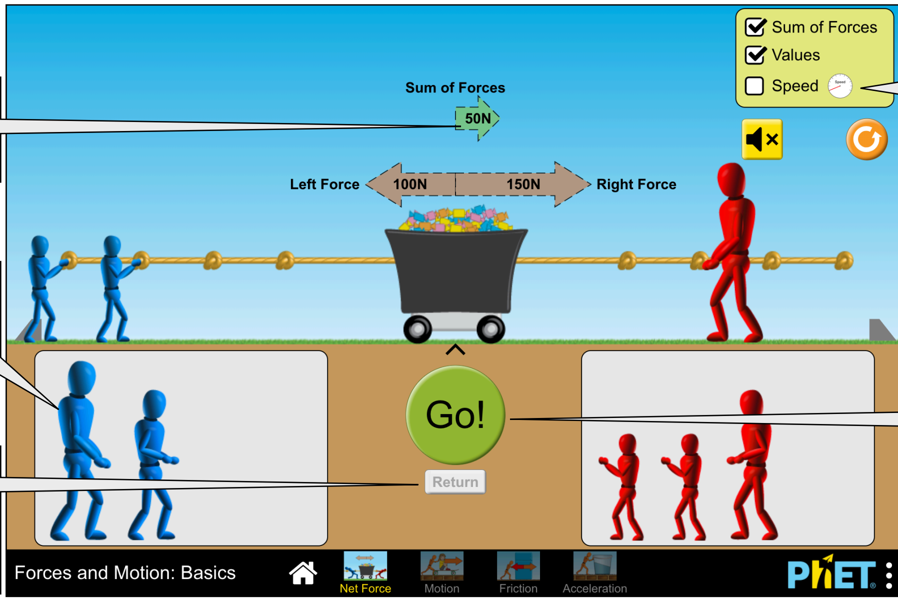
Net Force Screen

Investigate the difference between balanced and unbalanced forces as pullers compete in a tug-of-war for a cart of candy.

SEE the forces in the system

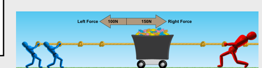
DRAG pullers onto the rope

RETURN the cart to its starting position



MEASURE the speed of the cart

PRESS Go! to see the tug-of-war

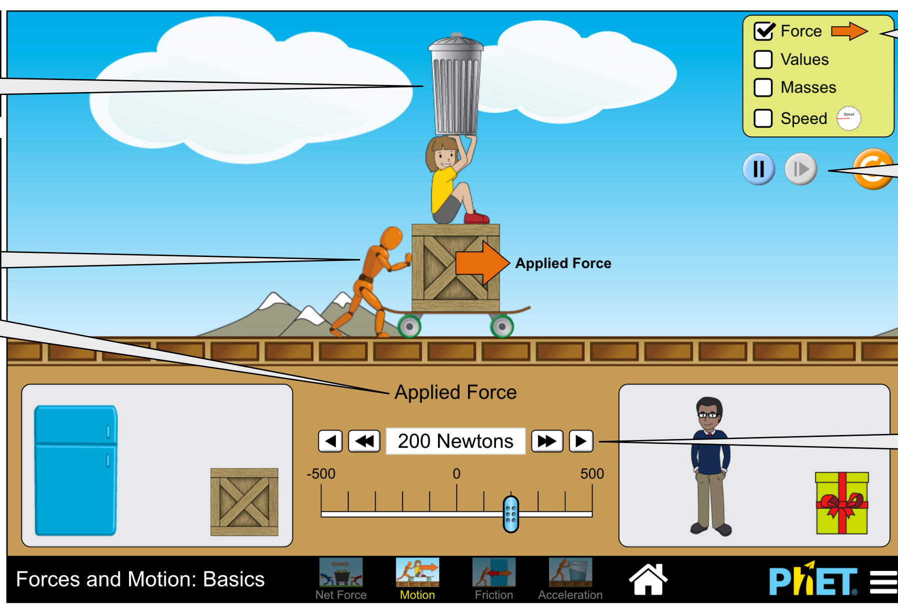


Motion Screen

Explore the forces at work when pushing a refrigerator, crate, or person. Create an applied force and see how it makes objects move.

STACK up to three objects

APPLY a force by dragging the pusher or using the controls



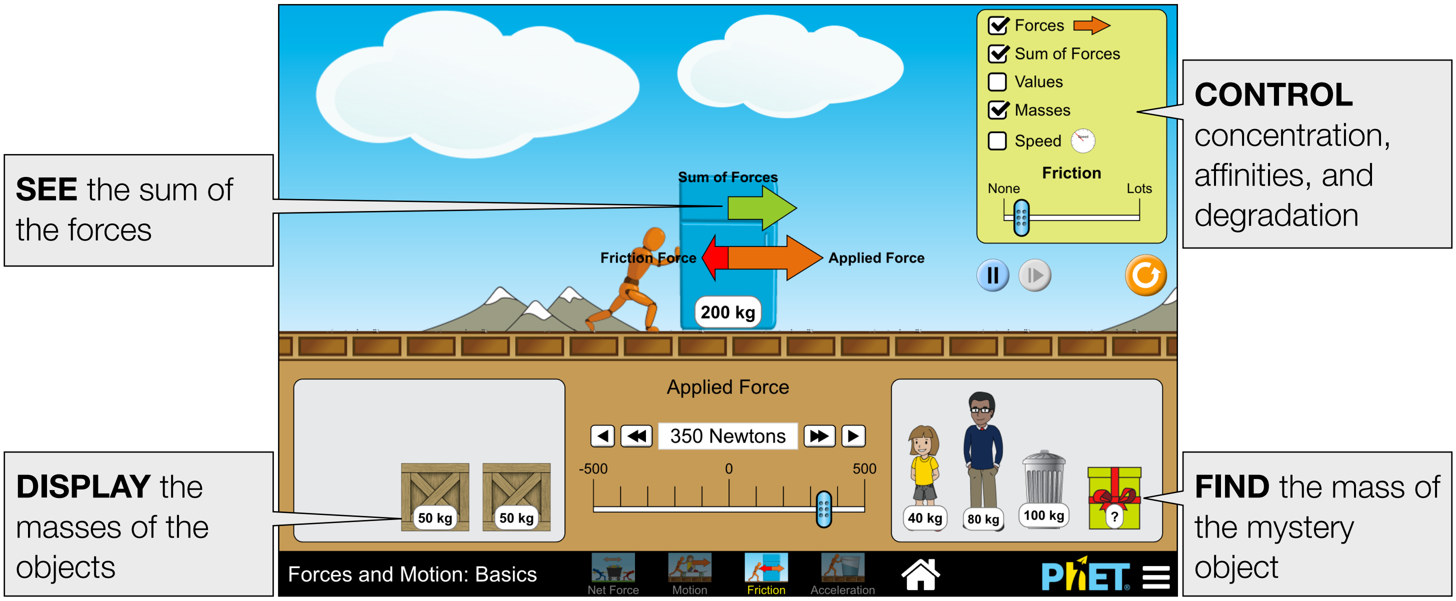
VIEW the applied force

PAUSE and step through the motion

APPLY a force in increments of 1 N (single arrow) or 50 N (double arrow)

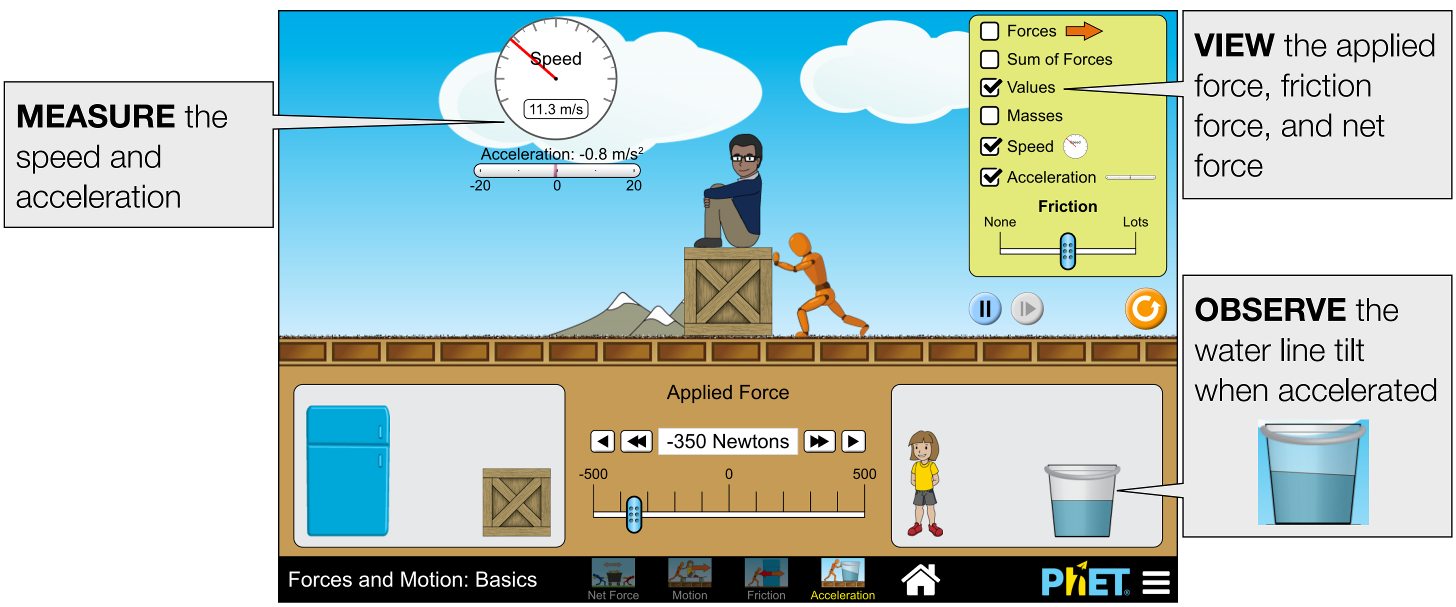
Friction Screen

Create an applied force to push various objects, and adjust the amount of the amount of friction and see how it affects their motion.



Acceleration Screen

Investigate the relationship between the net force, acceleration, and speed.



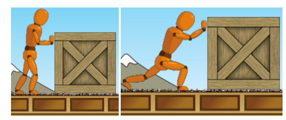
Insights into Student Use

- Whenever there is a net force, the cart on the Net Force screen will accelerate. If more pullers are added after the motion is started, students may have to run some tests to understand that the motion was already happening. This might be a great teaching moment around "An object at rest stays at rest and an object in motion stays in motion unless acted upon by an external force."
- Students may have some difficulty understanding why adding mass in the frictionless environment doesn't change the motion.

Model Simplifications

- The pullers and pushers are used to embody the applied force, but are somewhat “magical” as they don’t require friction between the ground and their feet to apply a force. One could also imagine the pullers and pushers being propelled in a way does not require pushing against the ground, such as rocket power or by an electromagnetic rail in the ground (like a maglev train).
- The size of the pullers on the Net Force screen is proportional to the amount of force they apply (small = 50 N, medium = 100 N, large = 150 N) and the game of tug-of-war will end when the cart hits the stopper on the ground.

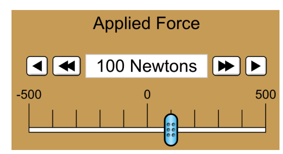
- The purpose of the skateboard on the Motion screen is to indicate that the system is frictionless. Changing mass does not affect the speed of the objects. We assume that an object dropped on an already moving object is in the same reference frame so that they are already both moving the same speed.
- The Friction slider on the Friction and Acceleration screen controls the coefficient of static friction. When overcoming the static threshold, the object begins to move, and the magnitude of the frictional force reduces by 25% to simulate that the coefficient of kinetic friction is less than the coefficient of static friction.
- The pusher is meant to help students make sense of how force is applied. As the applied force increases, the pusher leans forward. The maximum speed the pusher can reach is 20.0 m/s. At this point the pusher will fall, and the applied force slider will disable to prevent acceleration in the direction of motion.



- If the mass of the object or applied force acting on the object is changed while the sim is paused, the acceleration in the system will not change until the sim is unpaused.

Complex Controls

If an applied force is created by using the slider or dragging the pusher, the force will return to zero upon release. To apply a sustained force, use the arrow buttons next to the readout. The single arrow button adjusts the force by 1N, and the double arrow adjusts the force by 50 N.



Suggestions for Use

Sample Challenge Prompts

- What factors determine which team of pullers will win in a game of tug-of-war? When the cart moves are the forces balanced or unbalanced?
- In a frictionless environment, use the applied force slider to push an object. Predict what the net force on the object will be once the pusher lets go. What happens to the net force and the speed when the pusher lets go? What happens to the speed if you add another object?
- Once an object is in motion, what can you do to slow it down or stop it?
- How do the friction force and applied force compare before and after the object is in motion? Are these forces balanced or unbalanced? Predict the net force.
- Determine the mass of the mystery item.
- Investigate the relationship between the acceleration, net force, and mass.

Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Forces and Motion: Basics, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:
https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_all.html?locale=es&screens=1,2&initialScreen=2

Query Parameter and Description	Example Links

`screens` - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center.	`screens=1`
	
	`screens=2,1`

`initialScreen` - opens the sim directly to the specified screen, bypassing the home screen.	`initialScreen=1` `initialScreen=3`
`locale` - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`

See all published activities for Forces and Motion: Basics here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

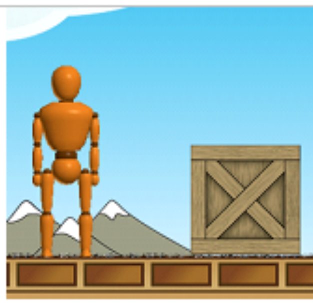
Name: ______________________________ Date: __________

Coefficients of Friction

Purpose: Determine the coefficient of static and kinetic friction using a computer simulation between a crate and the ground

Use the link below, then click on the program called Friction

http://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html

		
Sam not pushing	**Sam pushing but box not moving**	**Sam pushing and box moving**

Materials: Chromebooks

Pre Lab questions:

1) Compare and contrast static and kinetic friction
2) How can the maximum static friction be determined? Be sure to include Newton's second law in your answer
3) How can the kinetic force of friction between two surfaces be determined? Be sure to include Newton's second law in your answer

Procedure:

1) Using the answer from pre lab question 2 you should be able to slowly increase the force until the crate begins to move. Utilize the speedometer tool on the side
2) Then, using your answer to pre lab question 3 you should be able to reduce the force until the crate reaches a constant speed to determine the kinetic friction
3) Increase the mass added by varying the objects placed on top of the crate. You can place up to two on top at a time
4) Using the total mass column, determine the normal force for each trial.

Data: Mass of crate (kg): _________________

Trial #	Mass Added (added to block) (kg)	Total Mass (block + masses) (kg)	F_{Normal} (acting on the block) (N)	Force of Static Friction (N)	Force of Kinetic Friction (N)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

Calculations:
1) Show 1 sample calculation for the Normal Force.
2) Show a sample calculation for Newtons second law for the static and kinetic force of friction

Graph: You may do by hand or on sheets.
1) 0,0 is a data point on the graph (make sure you include it by not putting in any "breaks" in either axis).
2) Create two Force of Friction Vs. Normal Force graphs from the data (static vs normal and kinetic vs normal). You can use the same page for both sets of data if doing it by hand.
3) Draw a best fit line for each graph. Remember a best fit line is a "graphical average," not simply a line connecting the first and last data point.
4) For each graph, **pick two points on the best fit line** (these should not be data points) and find the slope of each best fit line. Make sure you identify on the graph which pairs of data points were used for the calculation of slope. Show this work right on the graph.
5) Include the full equation for each line
6) Make sure it is clear which graph is kinetic and which is static.

7) Label all parts of the graph.

Questions:

1) Explain why 0,0 is a data point on the graph even though you did not “measure it.”
2) What is the significance of the slope of the lines?
3) Which is larger the coefficient of static friction or the coefficient of kinetic friction? Why? How do your graphs show this?
4) What is the effect of surface area on the force of friction?
5) Reopen the program and place the unknown “gift” on top of the crate. Using either of your calculated coefficients of friction, determine the mass of the gift