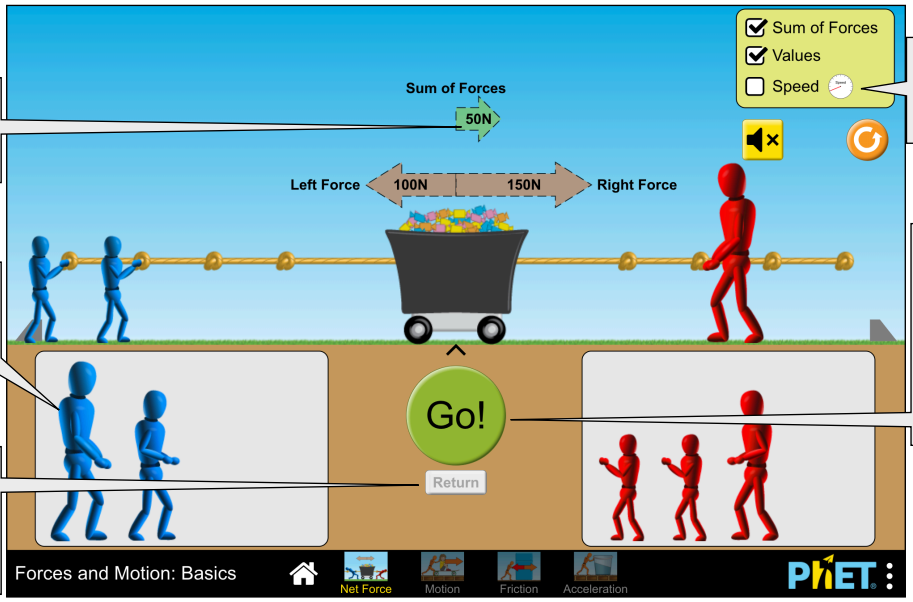
PhET Tips for Teachers

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

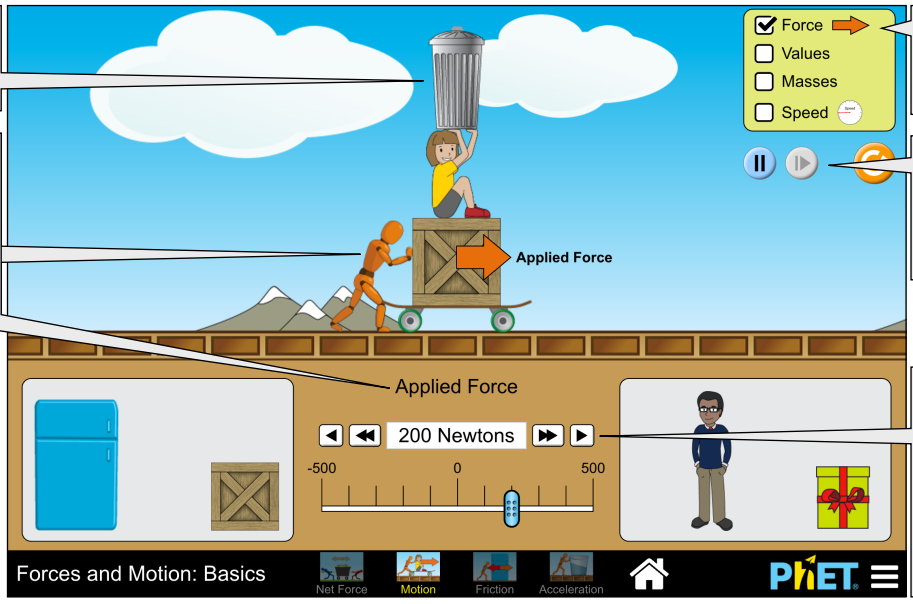
RETURN the cart to its starting position

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

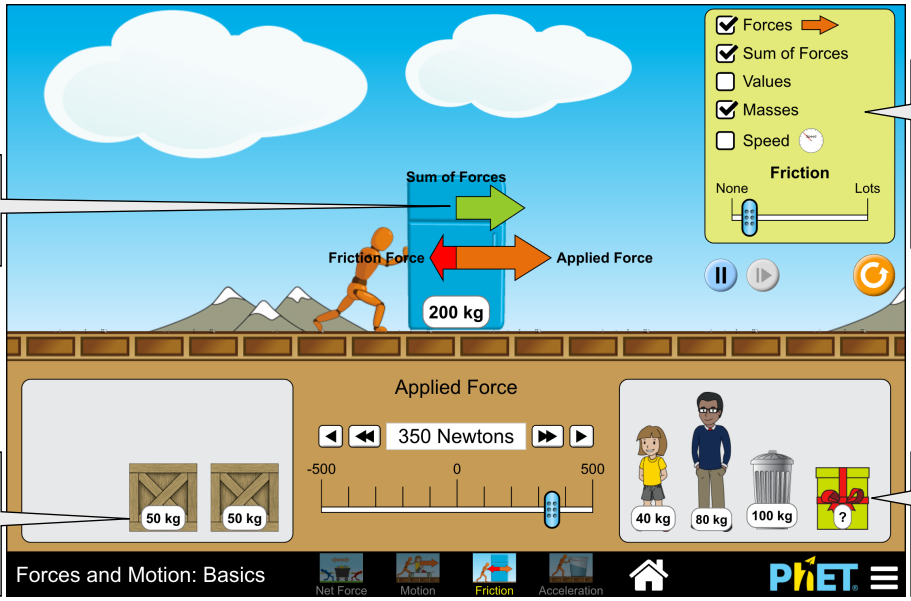
PAUSE and step through the motion

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

Rouinfar & Paul, August 2023

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.



SEE the sum of the forces

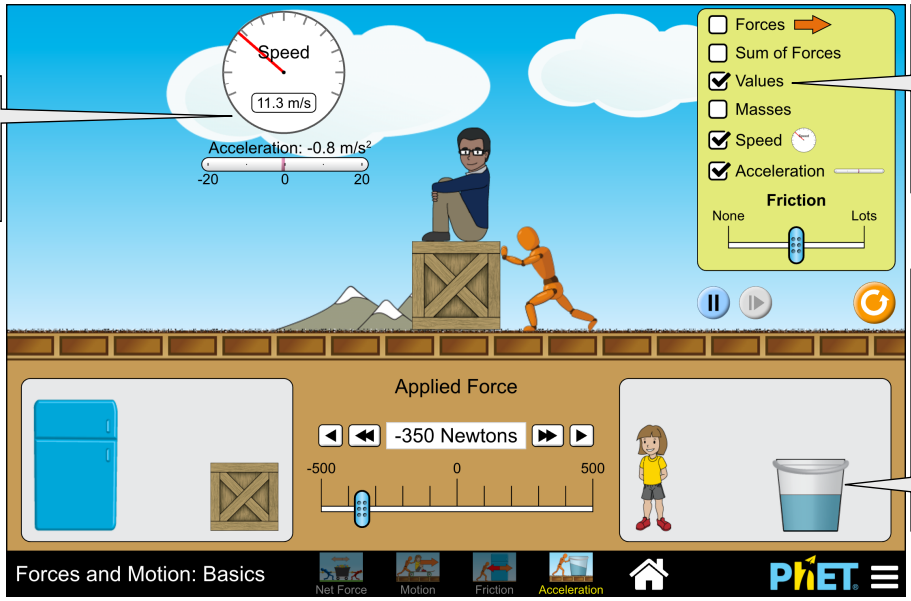
CONTROL concentration, affinities, and degradation

DISPLAY the masses of the objects

FIND the mass of the mystery object

Acceleration Screen

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



MEASURE the speed and acceleration

VIEW the applied force, friction force, and net force

OBSERVE the water line tilt when accelerated

Insights into Student Use

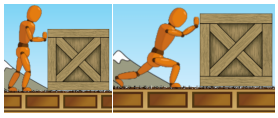
- Whenever there is a net force, the cart on the Net Force screen will accelerate. If more pullers are added after the motion is started, students may have to run some tests to understand that the motion was already happening. This might be a great teaching moment around “An object at rest stays at rest 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.

Rouinfar & Paul, August 2023

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.

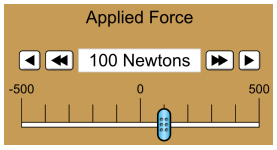
- The purpose of the skateboard on the Motion screen is to indicate that the system is frictionless. Changing mass does not affect the speed of the objects. We assume that an object dropped on an already moving object is in the same reference frame so that they are already both moving the same speed.
- 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 _____ PhET Simulation - Forces and Motion: Basics

Learning Target: I will explore the relationship of forces and motion by using an interactive PhET simulation.

Standard: NGSS MS-PS-2-2

Finding the simulation: Navigate to the website for the Simulation by clicking the link:
https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html

OR use a search engine to find "PhET Simulation Forces and Motion Basics

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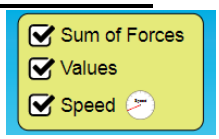
Explore the computer simulation to find answers to the questions.

Net Force Section – enable measurement functions by checking boxes in top corner



1. Explore the program by placing red and blue figures on the rope to simulate a tug of war
    a. Which figure can pull with the most force?

    b. What is the exact measurement of force that each figure can pull the rope?
        i. Small –
        ii. Medium –
        iii. Large –

2. Place 2 small blue figures on the left against 1 medium red figure on the right
    a. What is the resulting motion or speed?

    b. What is the sum of the forces (net force)?

    c. Use a math equation to show how the net force was calculated?

    d. Are the forces balanced or unbalanced? How do you know?

3. Place 2 small blue figures on the left against 1 large red figure on the right
    a. What is the resulting motion or speed?

    b. What is the sum of the forces (net force)?

    c. Use a math equation to show how the net force was calculated?

    d. Are the forces balanced or unbalanced? How do you know?

4. What happens to the speed of the cart when one side is winning the tug of war?

    a. Is this type of motion considered "acceleration"? Why or why not?

5. What happens to the speed of the cart when the tug of war is a tie?

    a. Is this type of motion considered "acceleration"? Why or why not?

6. When 2 small figures are both pulling in the same direction, their individual forces are _____ together.
7. When 2 small figures are pulling in the opposite direction, their individual forces _____.
8. An unbalanced force results when the sum of all forces is _____ and causes the object to _____.
9. A balanced force results when the sum of all forces is _____ and does not cause the object to _____.

Friction Section – Be sure to enable the functions at the top corner of the screen.

10. Set your friction bar to medium, select one 50-kg crate, and slowly apply rightward force using the single arrow button.

    a. Stop when applied force reaches 10N
        i. What is the friction force?

        ii. What is the sum of the forces? In which direction?

        iii. Is the crate accelerating (speeding up, slowing down, or changing direction)?

    b. Stop when applied force reaches 100N
        i. What is the friction force?

        ii. What is the sum of the forces? In which direction?

        iii. Is the crate accelerating (speeding up, slowing down, or changing direction)?

c. Stop when applied force reaches 200N
    i. What is the friction force?

    ii. What is the sum of the forces? In which direction?

    iii. Is the crate accelerating (speeding up, slowing down, or changing direction)?

d. Move applied force back down below 50N, but above 0N and observe
    i. What is the friction force?

    ii. What is the sum of the forces? In which direction?

    iii. Is the crate accelerating (speeding up, slowing down, or changing direction)?

11. What happens to the box when the frictional force is greater than the applied force?

12. Compare the applied force required to move a 50-kg crate and the applied force required to move something much more massive, like the 200-kg refrigerator
    a. 50-kg crate

    b. 200-kg fridge

    c. Why?

13. Compare the applied force required to move a 50-kg crate when there is LOTS of friction, MEDIUM friction, and NONE friction
    a. LOTS of friction

    b. MEDIUM friction

    c. NONE friction

If you are done, feel free to continue to experiment in the Net Force and Friction simulations, but you may also check out the acceleration and motion simulation if you wish.