

Net Force Screen

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

VIEW the forces in the system

DRAG pullers onto the rope

RETURN the cart to its starting position

VIEW the magnitude of the forces

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 1N (single arrow) or 50N (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.

SEE the sum of the forces

ADJUST the amount of friction

DISPLAY the masses of the objects

FIND the mass of an unknown object

Forces and Motion: Basics

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

Forces and Motion: Basics

Model Simplifications

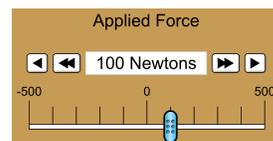
- The pullers and pushers are used to embody the applied force, but are somewhat “magical” as they don’t require friction between the ground and their feet to apply a force. One could also imagine the pullers and pushers being propelled in a way does not require pushing against the ground, such as rocket 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 first knot aligns with the ^ 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.



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.

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.

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](#).