

## 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

Sum of Forces: 50N

Left Force: 100N

Right Force: 150N

Go!

Return

Forces and Motion: Basics

Net Force

Motion

Friction

Acceleration

PhET

## 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)

Applied Force

Applied Force: 200 Newtons

Forces and Motion: Basics

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## 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

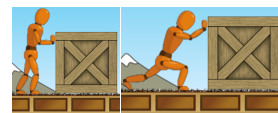
**OBSERVE** the water line tilt when accelerated

## 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.

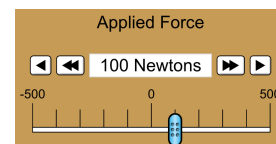
## Model Simplifications

- 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 that 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 an '&'. 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](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](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
<code>screens</code> - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the <a href="#">Help Center</a> .	<code>screens=1</code> <code>screens=2,1</code>
<code>initialScreen</code> - opens the sim directly to the specified screen, bypassing the home screen.	<code>initialScreen=1</code> <code>initialScreen=3</code>
<code>locale</code> - specify the language of the simulation using <a href="#">ISO 639-1</a> codes. Available locales can be found on the simulation page on the <a href="#">Translations tab</a> . Note: this only works if the simulation URL ends in “_all.html”.	<code>locale=es</code> (Spanish) <code>locale=fr</code> (French)
<code>allowLinks</code> - when <code>false</code> , disables links that take students to an external URL. Default is <code>true</code> .	<code>allowLinks=false</code>

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](#).

## Force PhET Simulation

Open PhET.colorado.edu. From the "Simulations" dropdown, select "Forces and Motion: Basics." Select "Net Force." Select "Sum of Forces," "Values," and "Speed" in the box at top, right. Answer the questions and fill in the table.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{Time} = \text{distance} \div \text{speed}$$

$$\text{Distance} = \text{speed} \times \text{time}$$

$$\text{Momentum} = \text{mass} \times \text{speed}$$

$$\text{Acceleration} = \frac{\text{final speed} - \text{begin speed}}{\text{time}}$$

$$\text{Force} = \text{mass} \times \text{acceleration}$$

- \_\_\_\_\_ 1. With what force does the large figure pull?
- \_\_\_\_\_ 2. With what force does the medium-sized figure pull?
- \_\_\_\_\_ 3. With what force does the small figure pull?
- \_\_\_\_\_ 4. What is the sum of the forces when one large figure is pulling against one large red figure?
- \_\_\_\_\_ 5. What is the sum of the forces when one large blue figure is pulling against one large red figure?
- \_\_\_\_\_ 6. What is the sum of the forces when one large blue figure is pulling against the large and the medium red figures? (Give magnitude and direction.)
- \_\_\_\_\_ 7. What is the sum of the forces when one medium blue figure is pulling against the two small red figures? (Give magnitude and direction.)

Motion: Along the bottom of the page, select "Motion." Select "Forces," "Values," "Masses," and "Speed" in the box at top, right.

- \_\_\_\_\_ 8. What is the mass of the wooden crate on the wheeled car on the tracks? (Enter in the table below.)
- \_\_\_\_\_ 9. What is the speed of the wheeled car and one crate if pushed with 50 N of force for five seconds? (Enter in the table below.)
- \_\_\_\_\_ 10. What is the speed of the wheeled car and one crate if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 11. What is the speed of the wheeled car and one crate if pushed with 50 N of force for fifteen seconds? (Enter in the table below.)
- \_\_\_\_\_ 12. What is the speed of the wheeled car and two crates if pushed with 50 N of force for five seconds? (Enter in the table below.)
- \_\_\_\_\_ 13. What is the speed of the wheeled car and two crates if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 14. What is the speed of the wheeled car and two crates if pushed with 50 N of force for fifteen seconds? (Enter in the table below.)
- \_\_\_\_\_ 15. What is the speed of the wheeled car and two crates if pushed with 100 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 16. What is the speed of the wheeled car and two crates if pushed with 150 N of force for ten seconds? (Enter in the table below.)

- \_\_\_\_\_ 17. What is the speed of the wheeled car and two crates if pushed with 200 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 18. What is the speed of the wheeled car and two crates if pushed with 250 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 19. What is the speed of the wheeled car and the refrigerator if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 20. What is the speed of the wheeled car and the little girl if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 21. What is the speed of the wheeled car and the man if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 22. What is the speed of the wheeled car and the trash can if pushed with 50 N of force for ten seconds? (Enter in the table below.)
- \_\_\_\_\_ 23. What is the speed of the wheeled car and the unknown wrapped present if pushed with 50 N of force for ten seconds? (Enter in the table below.)

Object	Mass	Force Exerted	Time of Force	Speed <sub>begin</sub>	Speed <sub>final</sub>	Acceleration
Crate		50 N	5 sec			
Crate		50 N	10 sec			
Crate		50 N	15 sec			
2 crates		50 N	5 sec			
2 crates		50 N	10 sec			
2 crates		50 N	15 sec			
2 crates		100 N	10 sec			
2 crates		150 N	10 sec			
2 crates		200 N	10 sec			
2 crates		250 N	10 sec			
Girl		100 N	10 sec			
Man		100 N	10 sec			
Trash can		100 N	10 sec			
Wrapped		100 N	10 sec			

- \_\_\_\_\_ 24. Estimate the mass of the unknown wrapped present based upon its acceleration - comparing it to the knows.

Friction: Along the bottom of the page, select "Friction." Select "Forces," "Sum of Forces," "Values," "Masses," and "Speed" in the box at top, right. Notice the crate no longer has wheels. Leave the friction slider where it starts, in the middle.

Object	Mass	Force Exerted	Force of Friction	Net Force	Speed <sub>b</sub>	Speed <sub>f</sub>	Time	$\vec{a}$
Crate		150 N					10 sec	
2 Crates		300 N					10 sec	
Refriger		500 N					10 sec	
Girl		150 N					10 sec	
Man		250 N					10 sec	
Trash		300 N					10 sec	
Unknown		150 N					10 sec	

Acceleration: Along the bottom of the page, select "Acceleration." Select "Forces," "Sum of Forces," "Values," "Masses," "Speed," and "Acceleration." Adjust the friction slider to "None."

Object	Mass	Force Exerted	Speed <sub>b</sub>	Speed <sub>f</sub>	Time	$\vec{a}$
Crate		100 N			10 sec	
2 Crates		100 N			10 sec	
Refriger		100 N			10 sec	
Girl		100 N			10 sec	
Man		100 N			10 sec	
Water		100 N			10 sec	