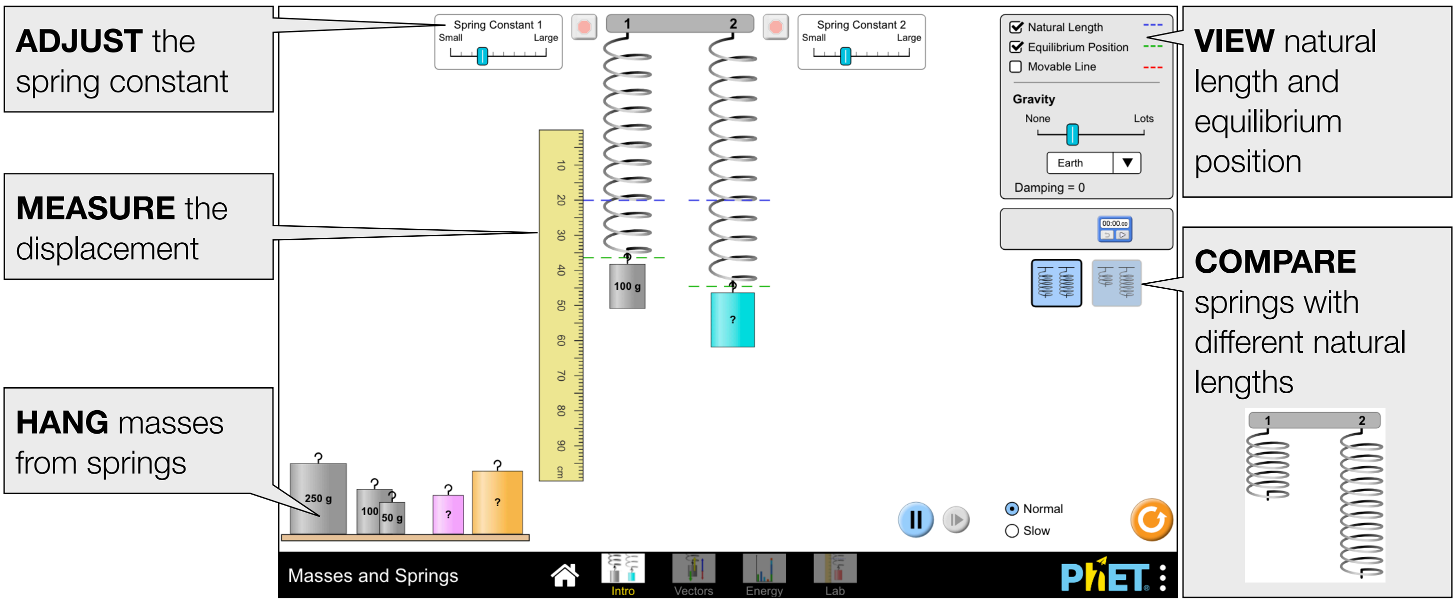
PhET Tips for Teachers — Masses and Springs

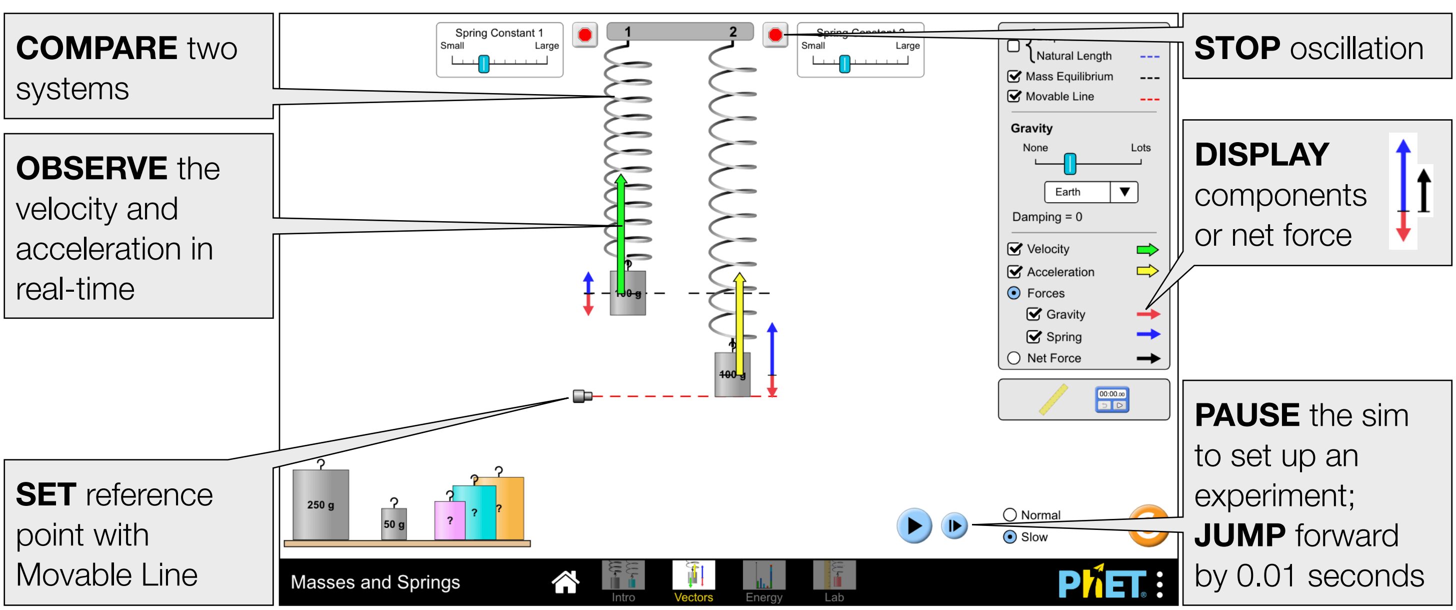
Intro Screen

Play with one or two mass-spring systems and discover which variables (such as mass, gravity, spring constant, spring length) affect the period.



Vectors Screen

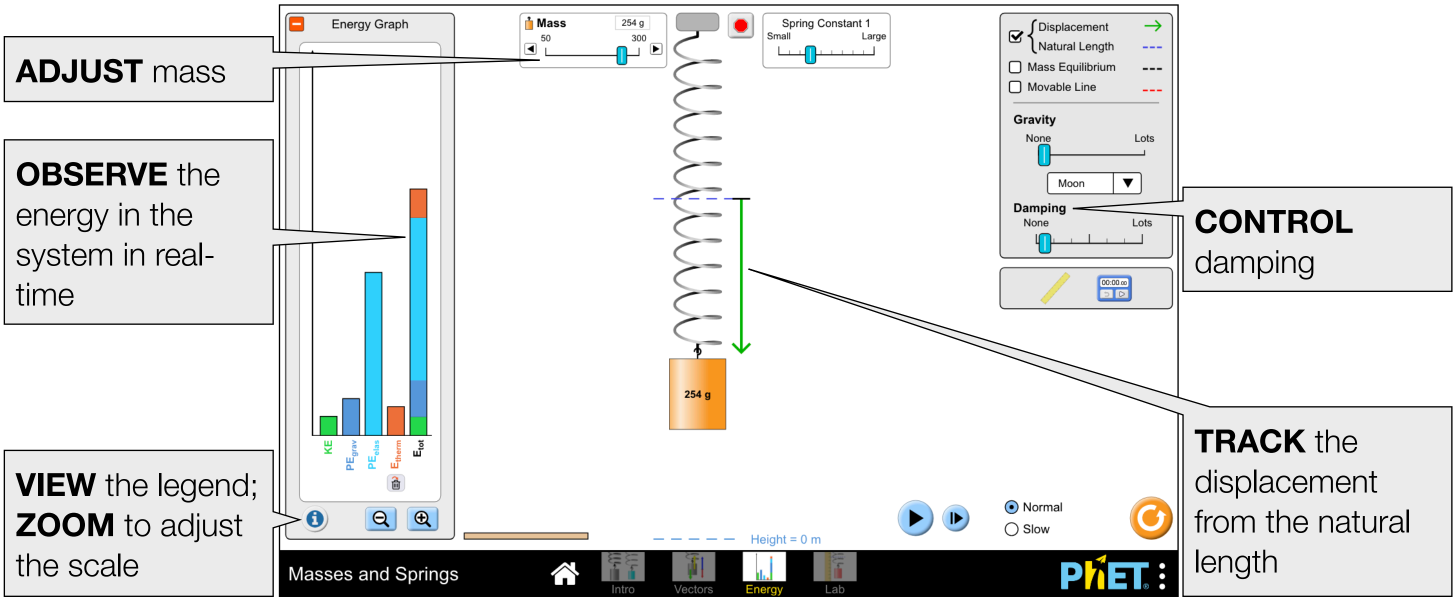
View the net force or component forces in the system, and explore how the velocity and acceleration change throughout the oscillation.



Rouinfar, August 2023

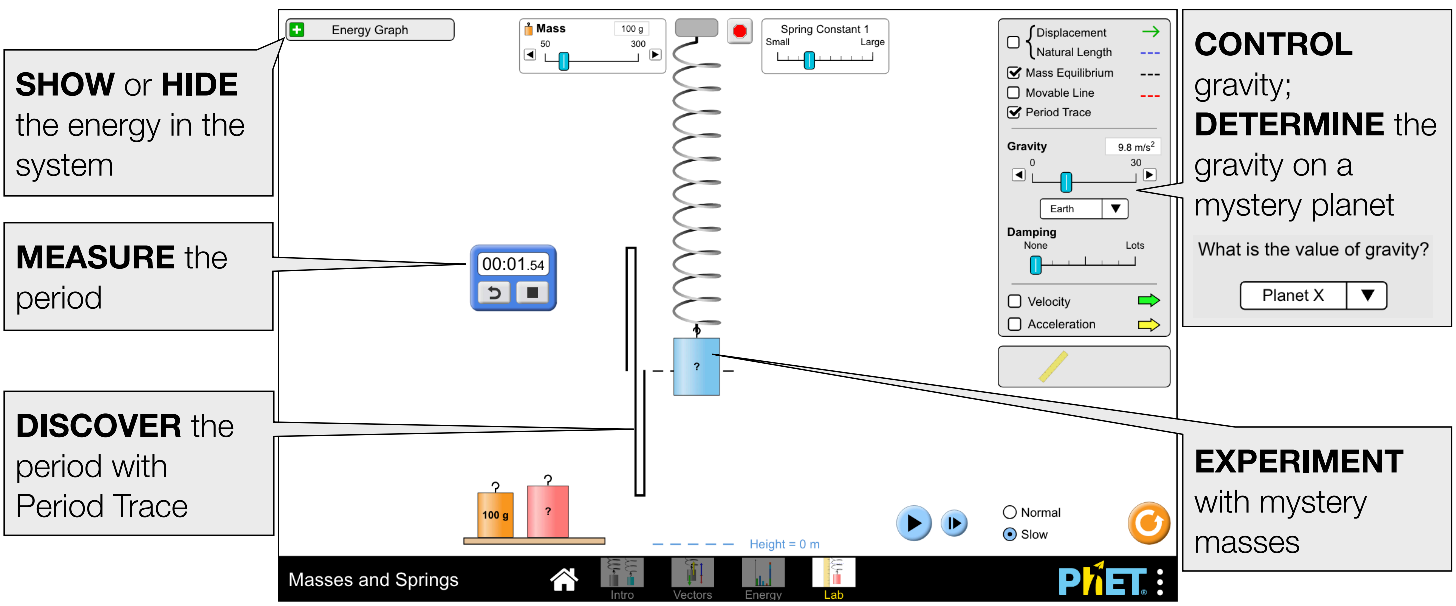
Energy Screen

Explore the energy in the system in real-time and discover the conservation of mechanical energy.



Lab Screen

Collect data and determine the value of the mystery mass or g on Planet X.



Complex Controls

- The remove heat button in the Energy Graph will instantaneously remove the thermal energy from the system. If damping is on, the thermal energy will still continue to accumulate.
- The zero-point of the gravitational potential energy is indicated by the — — — — — Height = 0 m dashed line at the bottom of the screen. GPE will be zero when the bottom of the mass is at this line.
- When the energy is off-scale, an arrow will appear above the bar in the Energy Graph. To re-scale the graph, zoom out until the arrows are no longer visible.

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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 Masses and Springs, 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/masses-and-springs/latest/masses-and-springs_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_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`

Insights into Student Use

- When setting up an experiment, it may be helpful to first pause the sim.
- Students may notice that the displacement vector is asymmetric about the natural length. You can ask students to find a way to make this displacement equal (g = 0) or ask them to instead compare the displacement about the Mass Equilibrium (always symmetric).

Model Simplifications

- The thickness of the spring is used to indicate the spring constant. A spring with n coils can be treated as n identical springs (each with spring constant k) connected in series, with an effective spring constant of $k_{eq} = k/n$. For springs with an unequal number of coils (unequal natural lengths) to have the same effective spring constant, the shorter spring must have a thinner gauge. Similarly, if these two springs have the same thickness, the shorter spring will have the greater effective spring constant.
- The spring constant range is 3-12 N/m, with tick mark intervals of 1 N/m.

- The mystery masses on the Intro and Vectors screens have the same density as the other masses, so their size can be used to (roughly) determine their mass. On the Lab screen, the mystery masses have different densities, so students will need a more sophisticated strategy to determine their value.
- Two equilibrium reference positions can be displayed in this sim: Equilibrium Position (end of spring) and Mass Equilibrium (center of mass). The Equilibrium Position appears on the Intro screen to allow students to discover the displacement. Vectors are drawn with respect to the center of mass, so the Mass Equilibrium is a more useful visual reference on the later screens.
- The damping force is proportional to the velocity ($F = -c \cdot v$), and the damping slider controls c. For more information about the damping or the equation of motion, see Masses and Springs Model.
- If a parameter (e.g. gravity, mass) is changed mid-oscillation, the instantaneous displacement, mass, spring constant, gravity, and velocity will be used as the new initial conditions for the equation of motion. Frequent mid-oscillation changes can lead to hard-to-interpret (though technically still accurate) behavior, so we recommend stopping the mass between experiments.

Suggestions for Use

Sample Challenge Prompts

- Describe the Natural Length and Equilibrium Position in your own words.
- Identify all the ways to increase the displacement at equilibrium.
- Determine the relationship between the applied force and displacement.
- Explain what the period represents, and determine a method to measure it.
- Design a controlled experiment to (qualitatively or qualitatively) determine how a variable — such as mass, gravity, spring constant, or displacement — affects the period.
- Determine a way to give a heavier mass a shorter period than a lighter mass.
- Sketch the gravitational and spring forces at several points throughout the oscillation.
- Predict the direction and magnitude of the velocity and acceleration vectors throughout the oscillation.
- Identify where in the oscillation the kinetic energy, gravitational potential energy, and elastic potential energy are increasing/decreasing, and identify the locations where the energies are maximum or zero.
- Estimate the speed of the mass (e.g. max, medium, zero) or its position from the Energy Graph.
- Determine the mass of the mystery masses or the value of g on Planet X (qualitatively or quantitatively), and explain your method(s).

See all published activities for Masses and Springs here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

Hooke's Law & Springs – PhET Simulation

Introduction

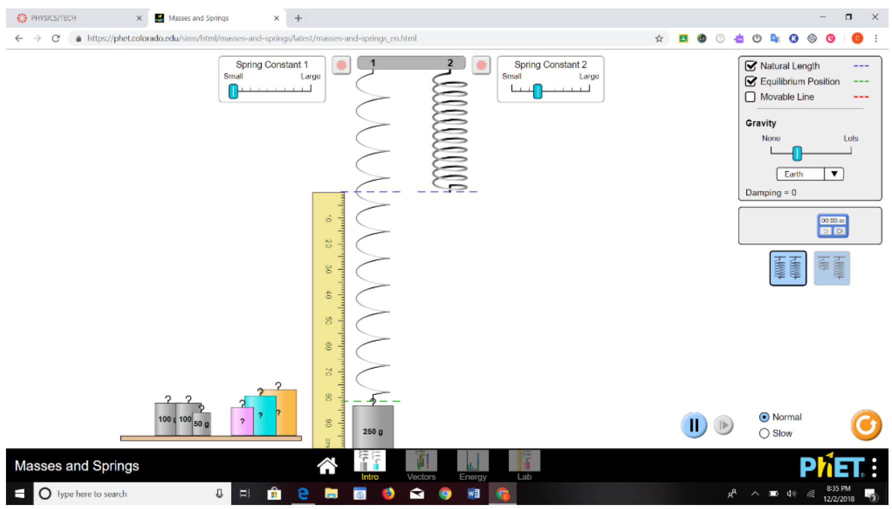
Hooke's Law teaches us how springs can store and use potential energy. It is expressed as a ratio of the force needed to stretch a spring and the distance it is stretched:

$$k = \frac{F}{x}$$

Where "k" is the spring's constant, a value that is the same for the spring no matter how much force is acting on it; "F" is the force used to displace the spring, and "x" is the distance the spring is displaced, in meters. The units for spring constant are N/m.

In this simulation lab, you will calculate the spring constants of three different springs, one with a low spring constant, one with a medium spring constant, and one with a large spring constant. You will then use those spring constants to find the mass of three unknown weights.

Click the picture at the right to open the simulation



Steps

1. This whole lab can be done from the "Intro" page, so click that. Spend some time playing with the springs and seeing how they work. Clicking "Natural Length", "Equilibrium Position" and using the ruler can help you find the displacement of the spring.
2. When you are ready to begin the lab, turn on the "Natural Length", "Equilibrium Position" and use the ruler. Start with 50 grams (0.05 kg) and the Spring Constant slid all the way down to small. Use this and your Weight formula to find the force pulling on the spring, and measure how many meters the spring is displaced. Click the Stop Sign at the top to get it to stop oscillating. **Remember, divide by 100 to convert cm to m!** Add this to your data table below, and use these values to calculate the spring constant. Repeat with 100 g (0.1 kg) and 250g (0.25 kg), and find the average of all the spring constants that you calculated.

Spring Constant set to Small

Mass (kg)	Gravity (g)	Weight/Force (N)	Displacement (m)	Spring Constant (N/m)
0.05 kg				

0.1 kg				
0.25 kg				
			Average:	

3. Repeat the lab with the spring constant set halfway between "Small" and "Large".

Spring Constant Set Halfway between Small and Large

Mass (kg)	Gravity (g)	Weight/Force (N)	Displacement (m)	Spring Constant (N/m)
0.05 kg				
0.1 kg				
0.25 kg				
			Average:	

4. And repeat once more with the Spring Constant set all the way up to "Large"

Spring Constant Set at Large

Mass (kg)	Gravity (g)	Weight/Force (N)	Displacement (m)	Spring Constant (N/m)
0.05 kg				
0.1 kg				
0.25 kg				

			Average:	

5. Now we'll find the mass of the three "Mystery Weights" That are provided. Since we now know the spring constant (or at least an average) we can work backwards to find the mass. Rearranging Hooke's Law, we have:

$$F = kx$$

And using the weight in place of force, we get:

$$W = kx$$
$$mg = kx$$
$$m = \frac{kx}{g}$$

So we'll multiply the spring constant you found above by the displacement, then divide that by gravity to get the mass of our "mystery masses". Fill in the data table below, being careful to use meters and kilograms.

Mass Color	Spring Constant (N/m)	Displacement (m)	Force/Weight (N)	Gravity (g)	Mass (kg)

6. Select the words that best fill in the conclusion:

"The larger the Spring Constant, the (**Stiffer/ Looser)** the spring, and the (**More/Less)** force is required to get it to be displaced."