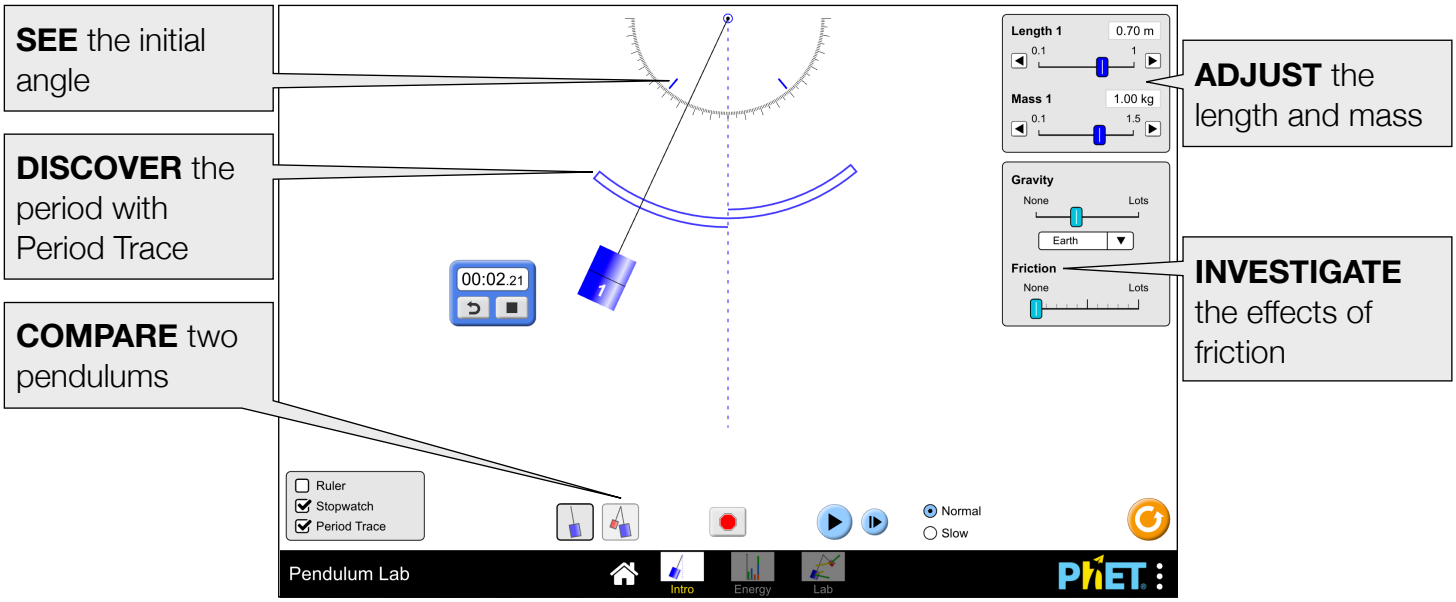
PhET Tips for Teachers

Pendulum Lab

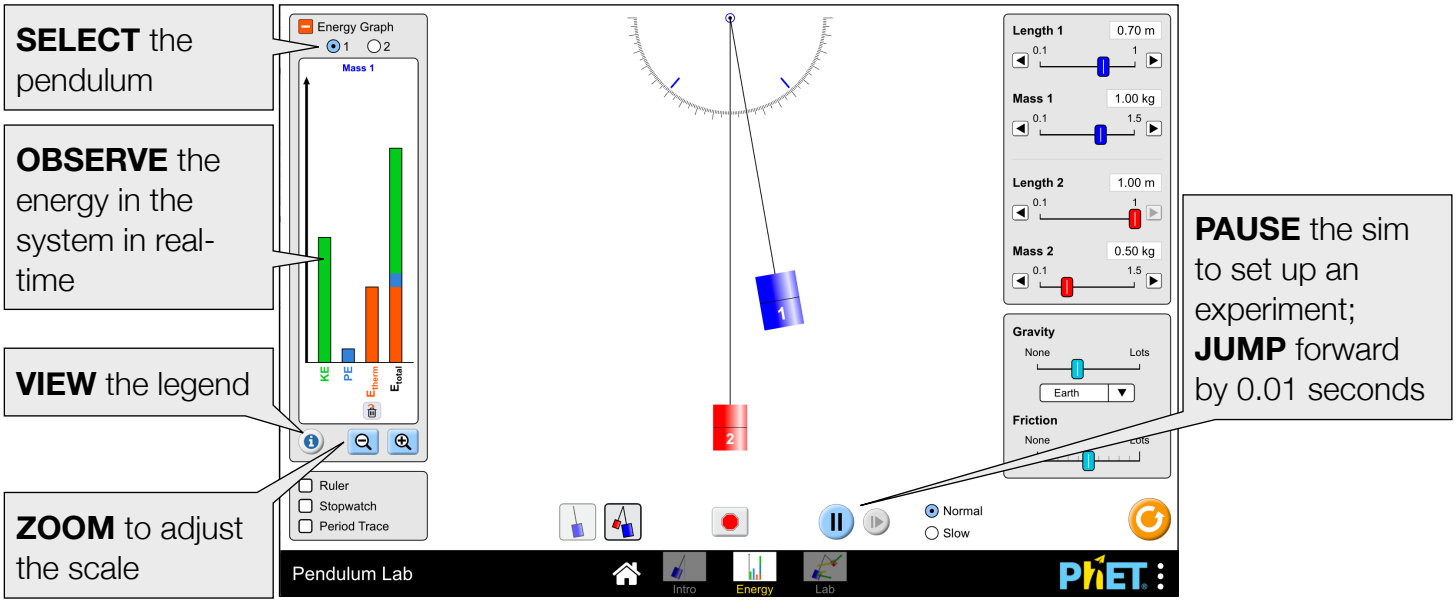
Intro Screen

Play with one or two pendulums and discover which variables (such as length, mass, gravity, or angle) affect the period.



Energy Screen

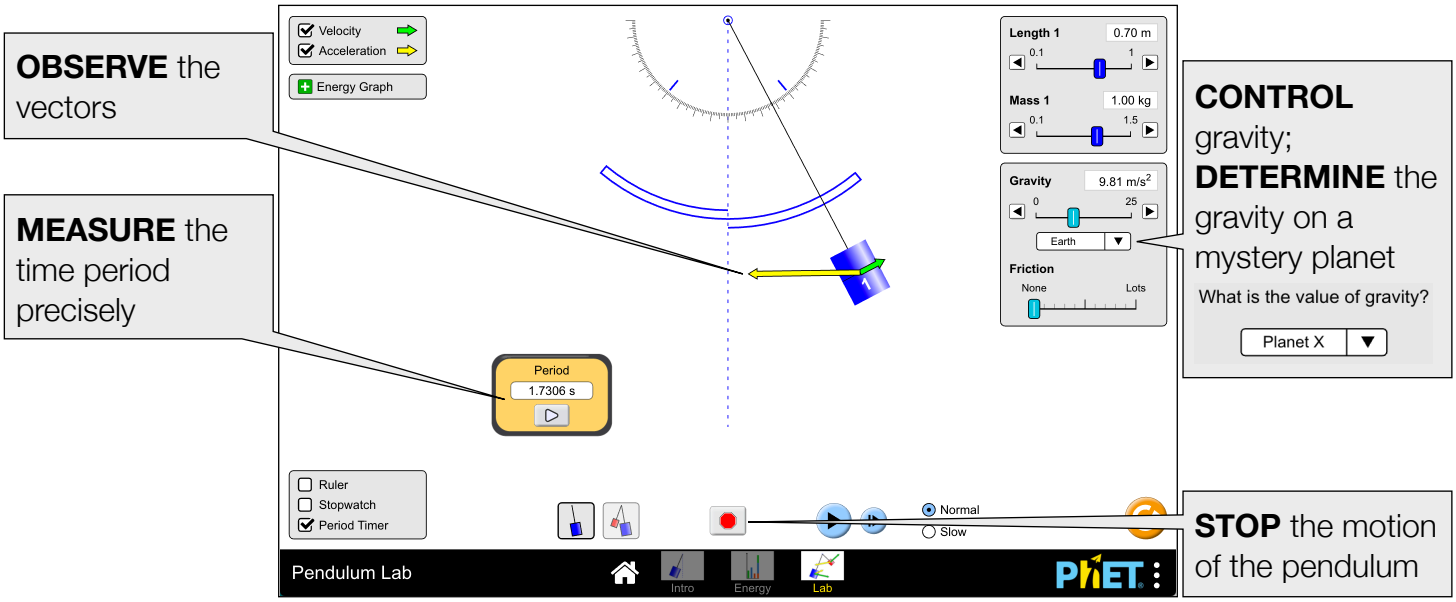
Explore the energy in the system in real-time and discover the conservation of mechanical energy.



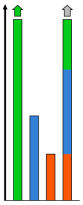
Rouinfar, September 2017

Lab Screen

Measure the period precisely and view the velocity and acceleration throughout the pendulum's swing.



Complex Controls



- The remove heat button in the Energy Graph will instantaneously remove the thermal energy from the system. If friction is on, the thermal energy will still continue to accumulate.
- 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

Insights into Student Use

- Students may try to use the formula for the period of a pendulum, $T = 2\pi\sqrt{l/g}$, which is only valid in the small-angle regime. Students can experiment using Jupiter or the Moon to discover what "small" means or they might be able to conduct a literature search. Note that there is no absolutely clear answer to this question — it depends on the level of precision maintained.
- When experimenting, it may be helpful to first pause the sim and then set up the experiment.
- The purpose of the ruler is to set the scale. Students generally use the ruler to verify that the length is measured to the pendulum's center of mass.

Model Simplifications

- As you move the pendulum, the angles are constrained to be an exact integer number of degrees.
- The potential energy is relative to the resting point of the mass, so pendulums with different lengths will have different zero-points.
- The Period Timer operates as a triggered mechanism (photogate), which starts when the pendulum crosses the vertical dotted line. The period will be displayed after one cycle.
- If a parameter (e.g. gravity, mass) is changed mid-swing, the instantaneous length, mass, angle, and tangential velocity will be used as the new initial conditions for the equation of motion. As a result, the

amplitude of the swing may be affected, and will no longer correspond to the tick mark on the protractor.
- Friction is modeled as quadratic drag ($F_{drag} \propto v^2$) which is valid in the high Reynold's number limit appropriate for macroscopic objects. Increasing the friction will increase the value of the drag coefficient in the model.
- For more information about the drag force or the equation of motion, see Pendulum Lab Model.

Suggestions for Use

Sample Challenge Prompts

- Explain what the period of a pendulum represents.
- Determine a method to measure the period without using the Period Timer tool.
- Design a controlled experiment to (qualitatively or qualitatively) determine how a variable — such as length, mass, gravity, or angle — affects the period.
- Estimate the speed of the pendulum from the Energy Graph (e.g. maximum, medium, or zero).
- Predict the position of the pendulum from the Energy Graph.
- Compare the period on Planet X to Earth. Which planet has a larger gravitational acceleration
- Calculate the value of g on Planet X.
- Predict the direction and magnitude of the velocity vector at various points along the swing.
- Determine what constitutes a "small" angle. (Note that the answer depends on the desired level of precision.)

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