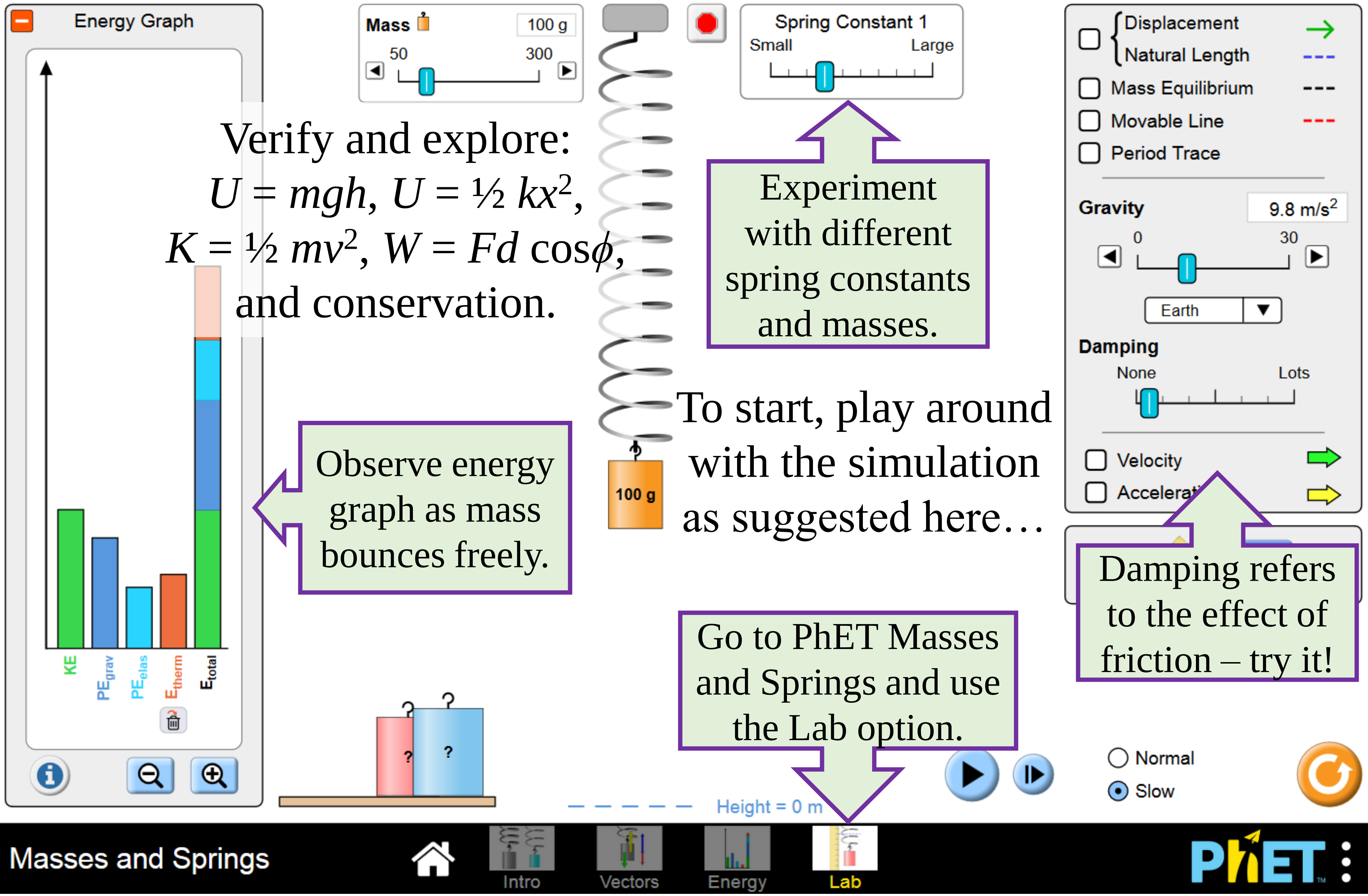
Virtual Lab – Mass on a Spring, Work and Energy



Verify and explore:
$U = mgh$, $U = ½\, kx^2$,
$K = ½\, mv^2$, $W = Fd\cos\phi$,
and conservation.

Experiment with different spring constants and masses.

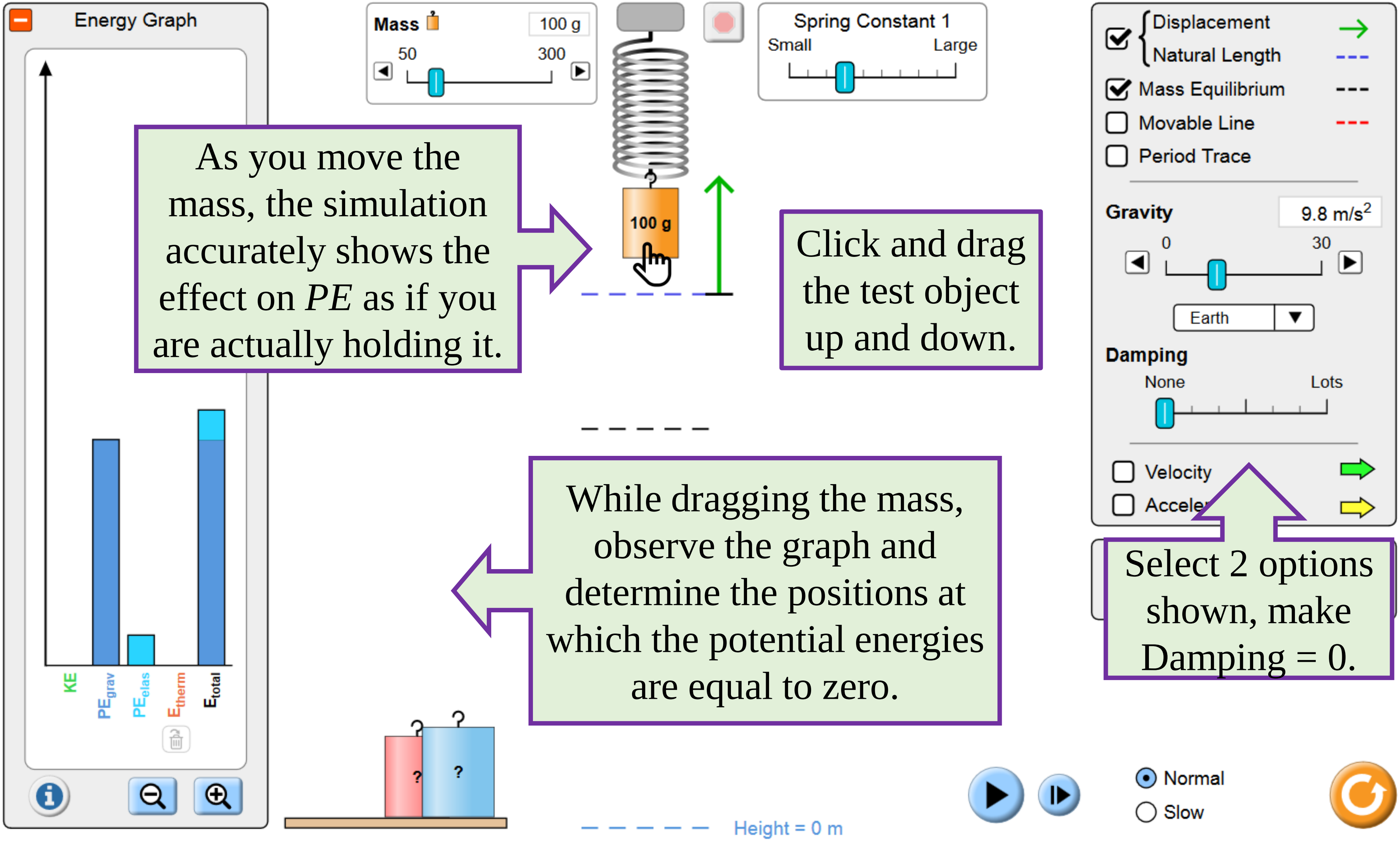
Observe energy graph as mass bounces freely.

To start, play around with the simulation as suggested here…

Damping refers to the effect of friction – try it!

Go to PhET Masses and Springs and use the Lab option.

Determine References for Two Potential Energy Types



As you move the mass, the simulation accurately shows the effect on *PE* as if you are actually holding it.

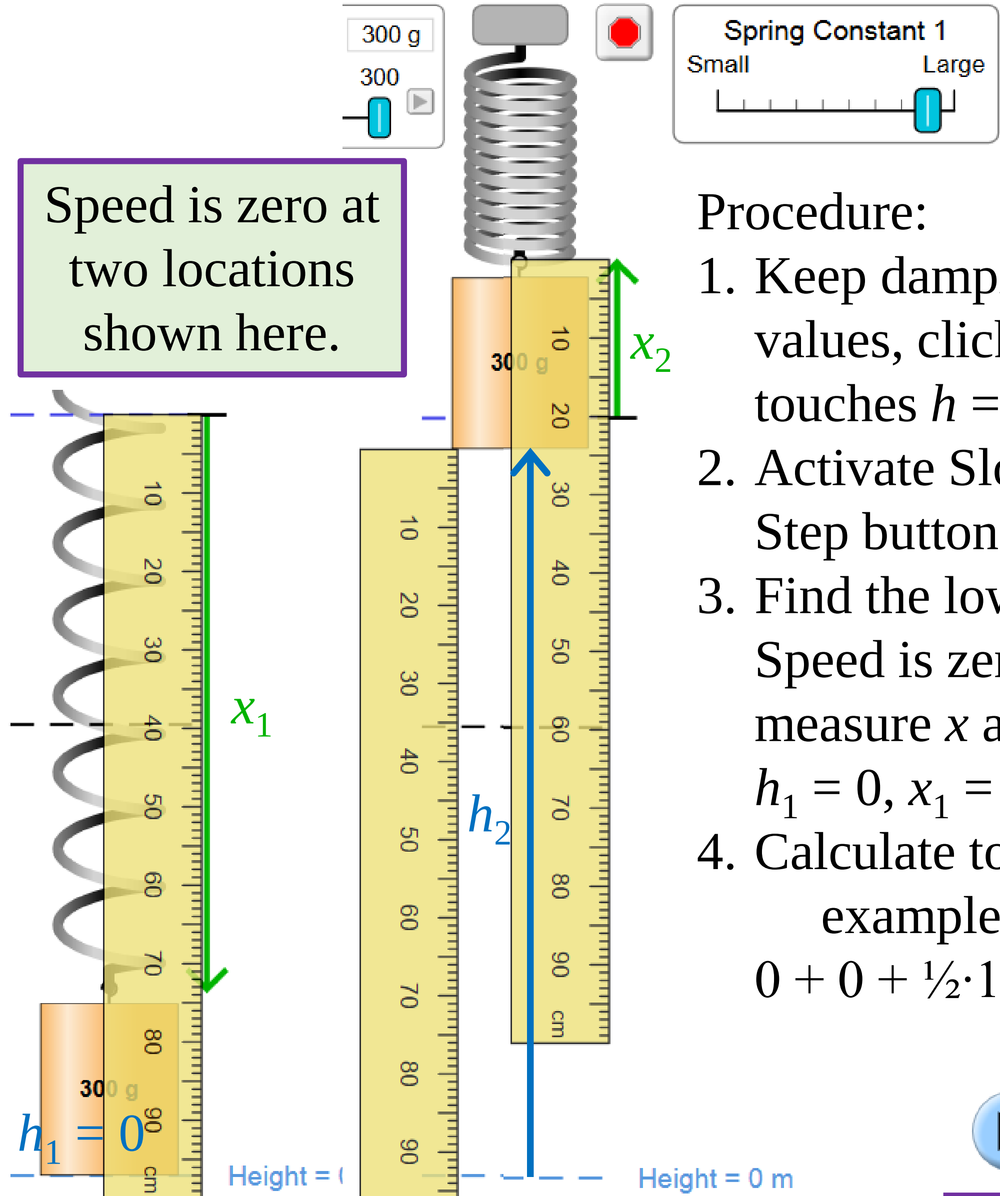
Click and drag the test object up and down.

While dragging the mass, observe the graph and determine the positions at which the potential energies are equal to zero.

Select 2 options shown, make Damping = 0.

Repeat the experiment described above using different values for mass and different spring constants.

Illustrate Conservation of Energy Numerically



Control for spring constant is in integer increments:
k = 3 to 12 N/m
(shown here k = 11 N/m)

Speed is zero at two locations shown here.

Procedure:

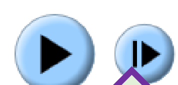
1. Keep damping = 0, set m and k to any convenient values, click and drag mass so that bottom edge touches $h = 0$ and release.
2. Activate Slow Motion, click Pause and then use the Step button to move through the animation.
3. Find the lowest and highest points in the oscillation. Speed is zero at each: $v_1 = v_2 = 0$. Use the ruler to measure x and h at each point, *e.g.* shown here: $h_1 = 0$, $x_1 = 73.9$ cm; $h_2 = 98.0$ cm, $x_2 = 20.1$ cm
4. Calculate total energy at each point and compare!

example: $K_1 + U_{g1} + U_{s1} = K_2 + U_{g2} + U_{s2}$

$0 + 0 + ½·11·0.739^2 = 0 + 0.3·9.8·0.98 + ½·11·0.201^2$

3.00 J = 2.88 J + 0.22 J

3.0 J ≈ 3.1 J



Step button

5. Repeat the process with different values m and k.

Other Things to Try – Open Ended Investigations

- Try setting the gravity to zero and observe the mass oscillating on the spring. With only two types of energy it is easier to think about! Potential energy of the spring becomes kinetic energy of the mass and vice versa. Experiment with mass and spring constant. Can you devise a way to measure the speed and calculate ½ mv^2? Try to verify by calculations that $U_{max} = K_{max}$ for this situation.
- Leave gravity set on zero and experiment with damping and observe thermal energy. Increasing the damping setting causes there to be a greater amount of friction in the simulation. Why should the work done by friction be equal and opposite to the increase in thermal energy shown in the graph? Try repeatedly releasing the mass from the same starting point, but with more and more friction. What is different? What is the same? What happens to the total distance that the object moves before coming to rest? Why?
- Challenge: devise an experiment and make measurements and/or observations with which you can determine whether or not friction acting on the object is a constant magnitude with a particular setting for damping.