Course and Section_______ Names ____________________________

Date____________________ ____________________________

SPRING SIMULATION

Introduction

The restoring force due to a spring is given by the Hooke's Law

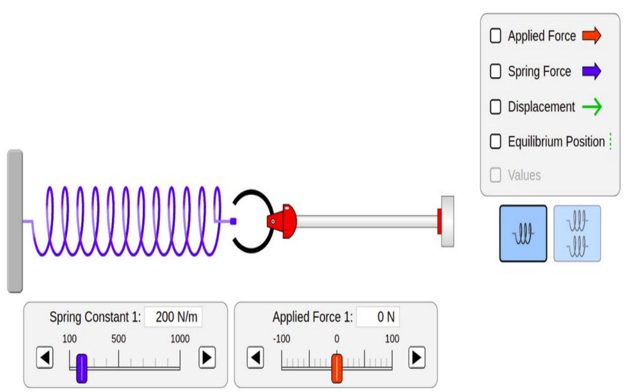
$$\vec{F}_s = -k\,\vec{x}$$

where *k* is the spring constant and *x* is the displacement from equilibrium. The potential energy of object of mass *m* at distance *x* from the equilibrium position is

$$U(x) = \frac{1}{2}kx^2$$

1 – The Hooke Law

Click the following link and run the simulation. Select *Intro*
https://phet.colorado.edu/sims/html/hookes-law/latest/hookes-law_en.html.



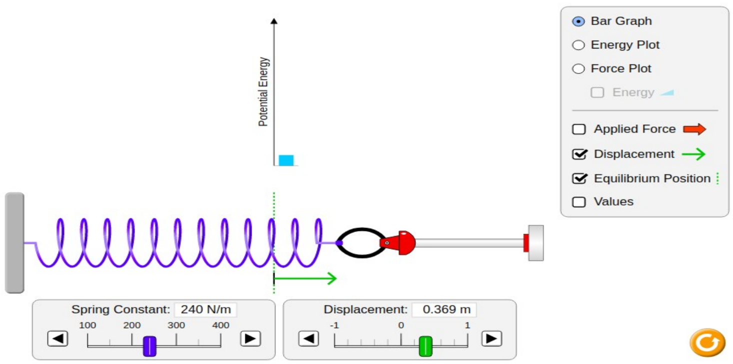
Set the spring constant 1 to be 100N/m and click the buttons to display the applied force, the spring force, the displacement and values.
1. What value of the force must be applied to stretch the spring 1 m?
2. What direction does the applied force point?
3. What direction does the spring force point?
4. What value of the force must be applied to compress the spring 1 m?

5. What direction does the applied force point?
6. What direction does the spring force point?
7. Will the spring force ever point in the same direction as the applied force?
8. Do the applied force and the spring force form a valid action/reaction pair of Newton's third law?

Set the spring constant to 500N/m.
9. For a displacement of x = 0.15 what is the spring force? (N) make sure to get the signs right
10. Use the simulation to verify your result. Do you find the arrow points in the correct direction?

2 – The Potential Energy

Click the following link and run the simulation. Select *Energy*
https://phet.colorado.edu/sims/html/hookes-law/latest/hookes-law_en.html



Select energy plot, values, displacement, applied force and equilibrium position and the spring constant to 300N/m.
11. Using the above equations calculate the potential energy for a displacement of -0.5 (compress the spring). (J)
12. Using the above equations calculate the potential energy for a displacement of 0.5 (stretch the spring)? (J)
13. Verify your calculations with the simulation, do your calculations agree?

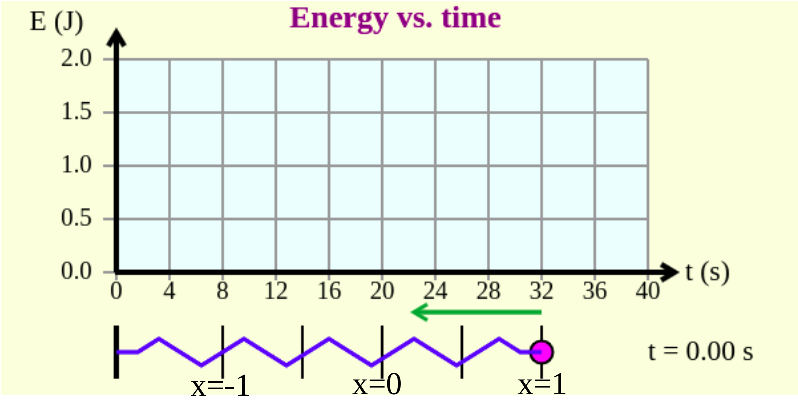
Using the simulation set the spring constant to 150N/m. Fill out the table with the values of x needed to find the corresponding values of the potential energy

U (J)	2.0	16.0	25.0	50.0
x (m)				

Plot a graph of U vs. x^2
14. What does the slope of this line correspond to?
15. What is the numerical value slope? (N/m)

3 – Spring Dynamics

Click the following link. Select *Energy vs Position*
http://physics.bu.edu/~duffy/HTML5/mass_on_spring_energy.html



Set the spring constant to 2.0 N/m and mass of the ball 2.0 kg. Note the ball oscillates between -1m and 1m. Play the simulation:
16. Which form of energy does the blue curve represent?
17. Which form of energy does the red curve represent?
18. Which form of energy does the green curve represent?
19. At which position(s) is the kinetic energy equal to zero?
20. At which position(s) is the potential energy equal zero?
21. At which position(s) the kinetic energy equal to the potential energy?
22. What is the numerical value of the total energy? (J)

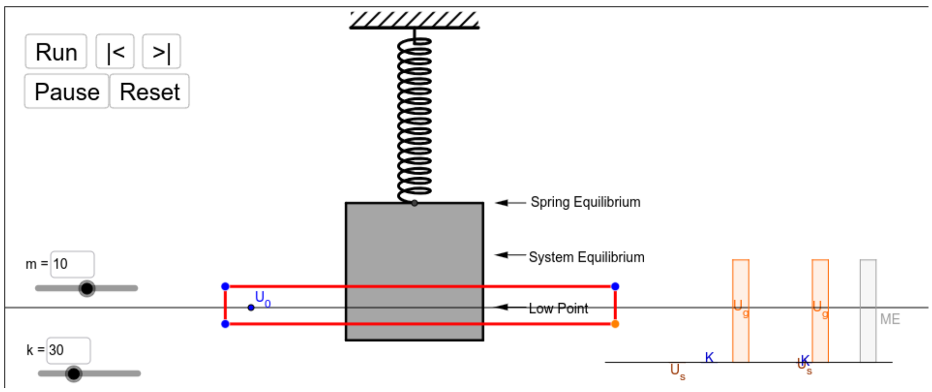
The time it takes for the ball to start and go back to its initial position is called the period of oscillation of the spring.
23. Estimate the period (s)

Click reset and change the spring constant to 3.5 N/m
24. What is the value of the total energy?
25. How does the maximum value of the kinetic energy compare to the previous case?
26. Estimate the period (s)

27. For a fixed spring constant, explore how the period depends on different the masses.

4 – Conservation of Energy

Click the following link and run the simulation.
https://www.geogebra.org/m/TxXK2dnq



Select mass *m* = 10 and spring constant *k* = 30. Three positions of the block are shown: they refer to the top side of the block. The columns on the right indicate the different forms of mechanical energy. Run the simulation and play close attention k. The line labeled U_0 is the reference height used to calculate the gravitational potential energy.

$$U = mg(h-h_0) = mgh-mgh_0 = mgh-U_0, \qquad U_0 = mgh_0$$

Move this line vertically to match with the *Low Point*. (see image above).

28. For which location does the kinetic energy reach its maximum value?
29. For which location does the gravitational potential energy reach its maximum value?
30. For which location does the spring potential energy reach its maximum value?
31. What can you say about the total mechanical energy of the system?

Keep the mass at *m* = 10. As you decrease the value of the spring constant *k:*
32. How does the distance between the three positions change?
33. How does the maximum value of the spring potential energy change?
34. How does the maximum value of the kinetic energy change?

Keep the value of the spring constant set to *k* = 30 N/m. As you increase the mass:
35. How does the maximum value of the spring potential energy change?
36. How does the maximum value of the kinetic energy change?
37. How does the maximum value of the gravitational potential energy change?