PHY131 Practicals Day 7
Student Guide

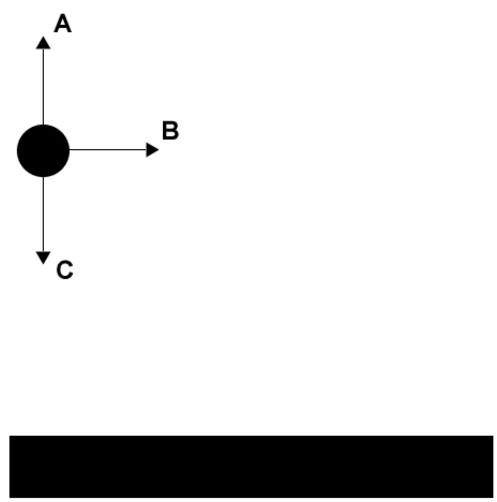
Summer 2009

Concepts of this week's Module

- Gravitational Potential Energy
- Kinetic Energy
- Elastic Potential Energy
- Total Mechanical Energy
- Work

Mechanics Module 5, Activity 3

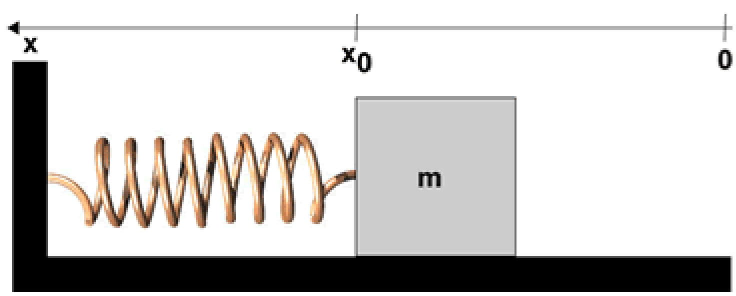
Three balls are the same height h above the ground and are fired with the *same* initial speeds v_0. Ball A is fired straight up, ball B is fired horizontally, and ball C is fired straight down. Air resistance is negligible.



A. Rank the speeds, from the largest to the smallest, of the three balls when they hit the ground. Explain.
B. Rank the time, from the largest to the smallest, it takes the three balls to hit the ground. Explain.

The following is used in Mechanics Module 5, Activities 5 - 8

A horizontal spring has an equilibrium position x_0. When the mass m is at position x_0 as shown the spring exerts no force on it. When the spring is either stretched or compressed, the position of the mass is x and the force the spring exerts on the mass is:



$$F = -k(x - x_0) \qquad 4.1$$

We assume an ideal spring and negligible air resistance. If the mass is oscillating, the mechanical energy is conserved and equal to:

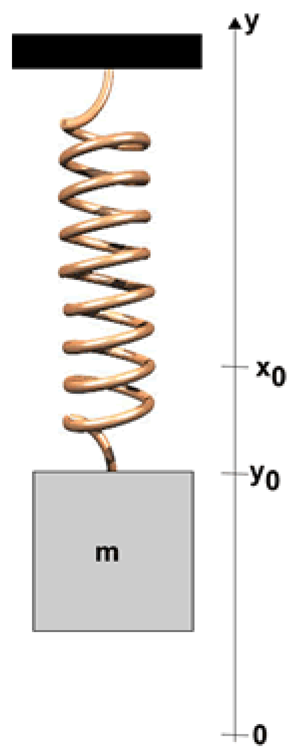
$$\frac{1}{2}mv^2 + \frac{1}{2}k(x - x_0)^2 \qquad 4.2$$

Mechanics Module 5, Activity 5

In the above figure we have chosen a coordinate system that points from the right to the left.

A. For values of $x > x_0$ does the force point in the $+x$ or the $-x$ direction?
B. For values of $0 < x < x_0$ does the force point in the $+x$ or the $-x$ direction?
C. For values of $x < 0$ does the force point in the $+x$ or the $-x$ direction?

Mechanics Module 5, Activity 7

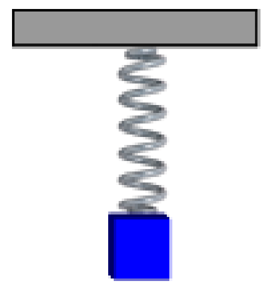


Now the same spring is suspended vertically. You may wish to note that the coordinate axis is now labeled y, while in the introduction above it was labeled x. The position labeled x_0 to the right is the same equilibrium position of the spring as before.

A. If the mass is at position x_0, the equilibrium position of the spring, draw the free body diagram of the forces acting on the mass.
B. At this position what is the net force acting on the mass?
C. If the mass is at some position y_0, the net force on the mass is zero. Draw the free body diagram of the forces acting on the mass.
D. What is the expression for y_0 in terms of m, g, k, and x_0?
E. What is the total vertical force acting on the mass as a function of k, y, and y_0?
F. What is the total mechanical energy when the mass is oscillating?

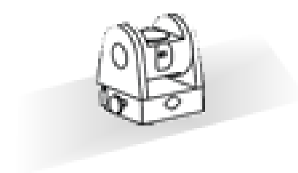
Mechanics Module 5, Activity 8

Suspend the supplied mass from the supplied spring. Place the Motion Sensor under the mass with the transducer pointing up so it tracks the position of the mass. Later we will learn how to describe the distance as a function of time. Here we will begin to explore oscillatory motion and look at the total mechanical energy of the system.



Collect distance-time data for the mass when it is vertically oscillating. Recall that the Motion Sensor can only measure distances greater than 0.15 m. This means that for the coordinate system of Activity 7, if the Motion Sensor is at $y = 0$ the bottom of the mass must always have a value of $y > 0.15$m.

- Set the vertical position of the mass-spring position so that when the mass is oscillating the minimum distance from the Motion Sensor is **close** to but greater than 0.15 m. Try to have the mass moving only up and down.
- Set the Motion Sensor for the wide beam. On some units this is indicated by an icon of a person.
- After starting the *MotionSensor.vi* software, set the sample rate to about 110 samples per second.
- Collect data for just a few oscillations.



Here are some tips for analyzing your data:

- It is likely that there will be noise in your values of the distance. These propagate to even greater noise in the displacement, velocity and acceleration. Use the cursors in the main Distance-Sample plot to select a reasonably clean set of data encompassing at least a bit more than half of one complete oscillation. The velocity-time graph is often particularly useful in determining the "region of interest" that you wish to keep. Sometimes the data will be so noisy that it is a good idea to take another set.
- The acceleration plot will be particularly noisy. By default this plot displays all of the values. You can adjust the minimum and maximum values of the plot to show the main features of the data without showing any noisy values by double-clicking on the minimum or maximum value of the vertical axis, putting in a new value, and pressing Return on the keyboard.

Now the Activities:

A. From your data, what is the value of y_0?
B. When the mass is at y_0, is its speed a maximum or a minimum?
C. What is the value of the speed when the mass is at y_0? Try to account for the noise in the plot by assigning an error to the value.
D. When the mass is at y_0, is its acceleration a maximum or a minimum?
E. When the mass is at y_0 what is the value of its acceleration? Try to account for the noise by assigning an error to the value.
F. From your data what is the maximum amplitude of the oscillation? When the mass is at this position, is its speed a maximum or a minimum?
G. What is the value of the speed when the mass is at its maximum amplitude? What is the error in this value?
H. **[If you have time]** When the mass is at its maximum amplitude is its acceleration a maximum or a minimum?
I. **[If you have time]** What is the value and error of the acceleration? What is the value for the spring constant k and the error in this value?
J. **[If you have time]** When the mass is at y_0 what is the total mechanical energy? When the mass is it the maximum amplitude of the oscillation what is the total mechanical energy? Is mechanical energy conserved within errors? Explain.

Last revision to this write-up: May 28, 2009 by Jason Harlow.

The Mechanics Module 5 Student Guide was written by David M. Harrison, Dept. of Physics, Univ. of Toronto, in the Fall of 2008. Last revision: October 30, 2008.

Mechanics Module 5 Activity 3 is from Randall Knight, Student Workbook that accompanies the 1st edition of **Physics for Scientists and Engineers** (Pearson Addison-Wesley, 2004), Section 10.3, Activity 10.