PHY131 Practicals Day 9
Student Guide

Summer 2009

Concepts of this week's Module

- Periodic and simple harmonic motion.
- Simple harmonic motion as one component of uniform circular motion.
- Simple harmonic motion of a mass hanging from a vertical spring.

Course Concepts *Oscillations Module, Activity 2*

Here is the URL of a Flash animation comparing uniform circular motion to simple harmonic motion:

http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/Circular2SHM/Circular2SHM.html

The above link is to a fixed size animation which works nicely if only one person it viewing it. For use in the Practical itself a version which can be resized to be larger so that the entire Team can see it is better. Here is a link to such a version:

http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/Circular2SHM/Circular2SHM.swf

Open and run the animation.

A. For an object in uniform circular motion, the angle θ as a function of time changes according to:

$$\theta = \omega t$$

where ω is called the angular **velocity**. What are the units of ω?

B. For an object in uniform circular motion, the y coordinate of a point on the object changes as a function of time according to:

$$y = r \sin(\omega t)$$

What is the meaning of r? What are its units?

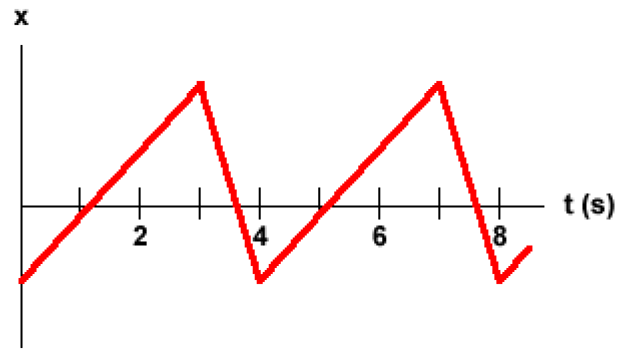
C. An object executing *Simple Harmonic Motion* is described by:

$$y = r \sin(\omega t)$$

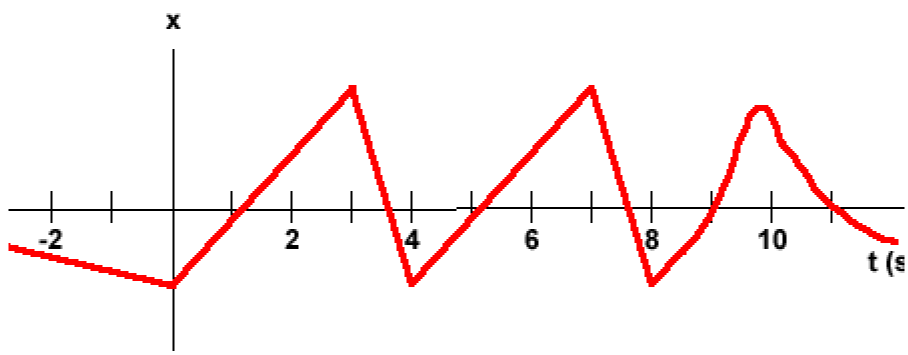
Note that this is the same equation as in Part B. However in this case ω is called the angular **frequency**. In this case what are the units of ω? In your own words explain why two somewhat different names are used for the same symbol ω. For Simple Harmonic Motion what name is usually used for r? What are the units of r?

Oscillations Module, Activity 3

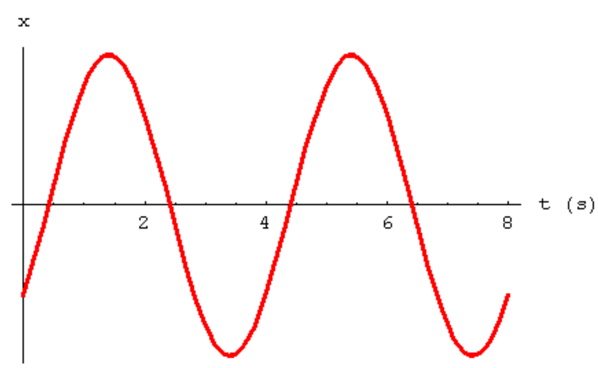
A. Here is a plot of the position versus time for a particle. Does the motion appear to be *periodic*? Does the motion appear to be *Simple Harmonic*? What is the period of the motion? What is the frequency of the motion?



B. Here is another position versus time plot. For values of the time between 0 and 8 s it is identical to Part A. Does this motion appear to be periodic? For the particle of Part A, if you only have data for times between 0 and 8 s can you tell the difference between that motion and the motion shown here?

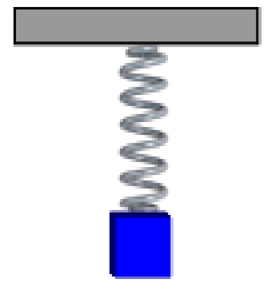


C. Here is another plot of the position versus time for a particle. Does the motion appear to be *periodic*? Does the motion appear to be *Simple Harmonic*? What is the period of the motion? What is the frequency of the motion? What is the angular frequency of the motion?



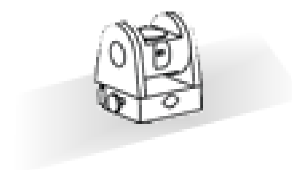
D. Does it make sense to talk about the angular frequency of the motion of Part A? Explain.

Oscillations Module, Activity 4



Mount the supplied spring on the support and hang the supplied mass from it. Position the Motion Sensor under the mass and pointing up at it, as shown. You will connect the Motion Sensor to the U of T DAQ Device. You may have used this same setup in Mechanics Module 5 Activity 8.

Recall that the Motion Sensor can only measure distances greater than 0.15 m. This means that for the given coordinate system, if the Motion Sensor is at $x = 0$ the bottom of the mass must always have a value of $x > 0.15$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 a few oscillations.

Now the Activities:

A. Does the motion appear to be Simple Harmonic? What is the period, frequency, angular frequency, and amplitude of the motion?
B. What physical characteristics must the spring-mass system have for the motion to be truly Simple Harmonic and not just approximately so? Do you think this spring-mass system has those characteristics?

If you have time: Oscillations Module, Activity 5

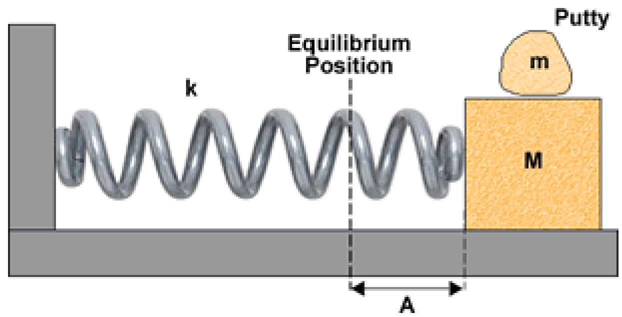
In Oscillations Activity 4 a Motion Sensor is used to measure the position versus time for a mass oscillating on a spring. We took about 110 samples every second and, depending on the particular spring and mass used the period of the oscillation was about 0.5 s.

Imagine we have an ideal spring-mass system oscillating with maximum amplitude = 1 m and angular frequency $\omega = 6\ s^{-1}$. The motion is:

$$y = A\sin(\omega t) = \sin(6t)$$

A. What is the period of the oscillation?
B. Imagine we use a Motion Sensor to measure the position once per second and take the first measurement at $t = 0$ s. Remember that in the above formula the argument to the sine function is in radians. What will be the measured values of y for the first few measurements? Is your results reasonable? Explain. You may find it helpful to draw a rough sketch of y versus t for a few periods of the oscillation and locate on the graph the points where you would have measured the values of y.

If you have time: Oscillations Module, Activity 7



A block of mass M is attached to a spring of spring constant k, and oscillates back and forth with amplitude A on a frictionless surface. At the moment shown the block is at its maximum amplitude and a lump of putty of mass m is dropped from a very small height and sticks to the block. The mass of the spring is negligible.

What are the new amplitude and frequency of the block plus putty system?

Last revision to this write-up: June 8, 2009 by Jason Harlow.

The Oscillations Module Student Guide was written by David M. Harrison, Dept. of Physics, Univ. of Toronto in May 2008. Last revision: November 8, 2008.

Oscillations Module Activity 3.A is based on Activity 14.1 Part 3 of Randall D. Knight, **Student Workbook with Modern Physics** (Pearson Addison-Wesley, 2008). Oscillations Module Activity 6 is based on Activities 1.43 Parts 10, 11, and 12 of Knight's **Student Workbook**. Oscillations Module Activities 7 are 8 are from David Harrison and William Ellis, **Student Activity Workbook**, 3rd ed. (Norton, 2008), Activities 15.8, 15.9.