SHM and Circular Motion

Pre-Lecture Questions

Problem Set #35 (due next time)

Lecture Outline

1. Uniform Circular Motion and SHM
2. Energy in SHM
3. The Simple Pendulum

Pre-Class Summary:

An object with an acceleration that is equal to minus the product of some constant and the position is in SHM an obeys the SHM equations of motion,

$$a(x) = -\omega^2 x$$

$$v(x) = \pm\omega\sqrt{A^2 - x^2}$$

$$x(t) = A\cos(\omega t + \delta)$$

$$v(t) = -\omega A\sin(\omega t + \delta)$$

$$a(t) = -\omega^2 A\cos(\omega t + \delta)$$

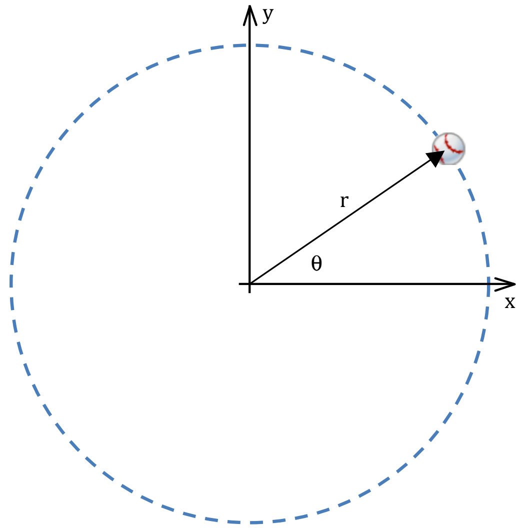
The equations of motion for the x-component of uniform circular motion are identical to the equations of motion for SHM.

For a mass on the end of a spring, $\omega = \sqrt{\frac{k}{m}}$.

For a simple pendulum, $\omega = \sqrt{\frac{g}{\ell}}$.

Gonna Go Round in Circles…

The baseball is going in circular motion counterclockwise at a constant angular speed ω. At t = 0, the ball is along the x-axis.



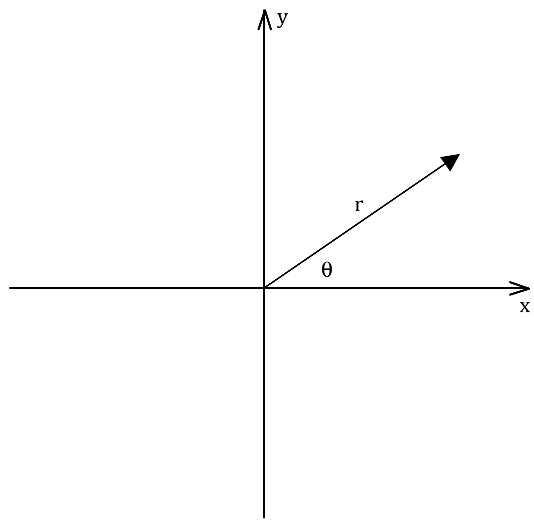
1. If the time to go all the way around is T and the angle once around the circle is 2π, express θ in terms of time t by completing the ratio,

$$\frac{\theta}{2\pi} = \frac{t}{\square}.$$

2. Use the ratio above to express θ in terms of ω and t.

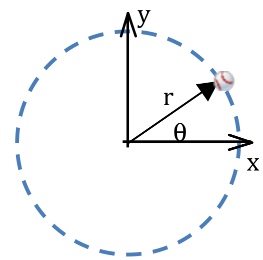
3. Draw the velocity and acceleration vectors for the ball in the drawing above.

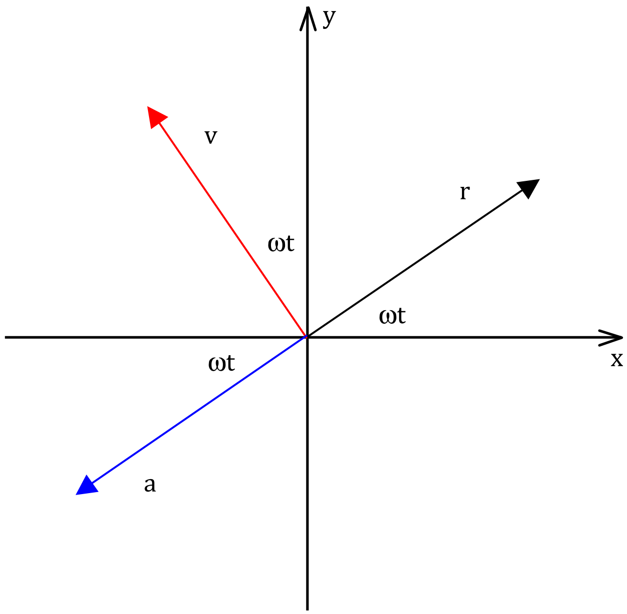
4. Redraw the displacement, velocity, and acceleration vectors on the coordinates below.



Gonna Go Round in Circles II…

The baseball is going in circular motion counterclockwise at a constant angular speed ω. At $t = 0$, the ball is along the x-axis.





5. Write the x-components of all three vectors in terms of trig functions, ω, and t.

$x = r \cos \omega t$

$v_x =$

$a_x =$

6. Write the speed and acceleration for circular motion in terms of r and ω.

$$v = \frac{2\pi r}{T} =$$

$$a = \frac{v^2}{r} =$$

7. Substitute the results from part 6 into part 5.

$x = r \cos \omega t$

$v_x =$

$a_x =$

8. Write a_x in terms of x. Explain the connection between this answer and SHM.

Equations of Motion for SHM:

$$a(x) = -\omega^2 x$$

$$v(x) = \pm\omega\sqrt{A^2 - x^2}$$

$$x(t) = A\cos(\omega t + \delta)$$

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are the same as the equations of motion for the x-component of uniform circular motion.

Follow the Bouncing Ball

The nine images at the right were taken sequentially with a video camera as the ball oscillated back and forth on the end of the spring. Rank them from largest to smallest. If some are equal to others put an equal sign between them.

Rank the frequency of oscillation of the system:

___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the acceleration vector of the ball:

___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the speed of the ball:

___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the velocity of the ball:

___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the ball's kinetic energy:

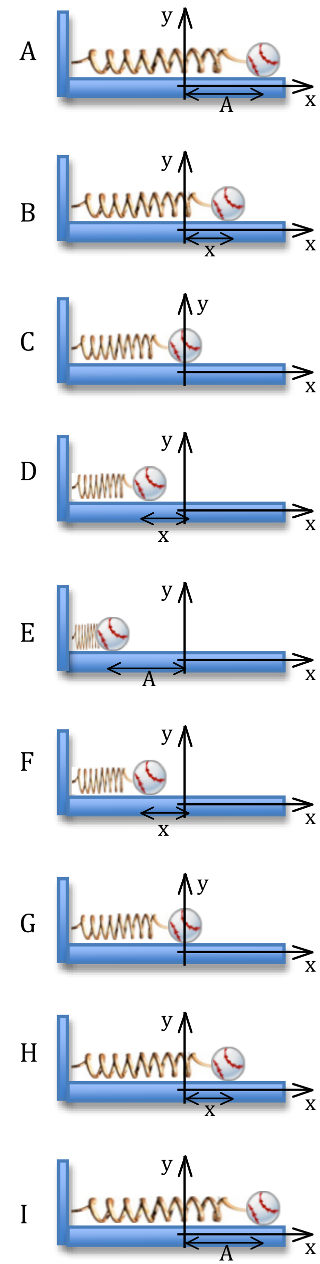
___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the spring's potential energy:

___ ___ ___ ___ ___ ___ ___ ___ ___

Rank the total energy of the system:

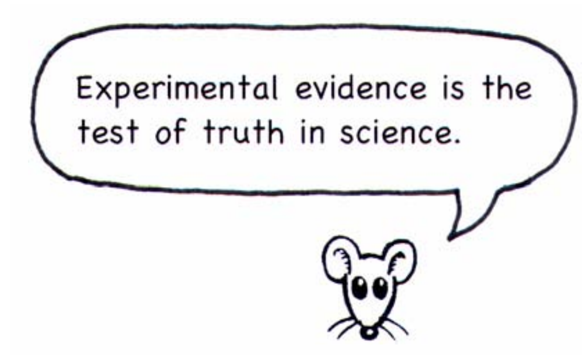
___ ___ ___ ___ ___ ___ ___ ___ ___



Example 1: A 0.15kg baseball is on the end of a spring with spring constant 8.0N/m. The ball is pulled horizontally 20cm from equilibrium and released. When the ball is 10cm from equilibrium, find its speed.

Find the Value of g.

1. Hold your pendulum so that it is one meter long.



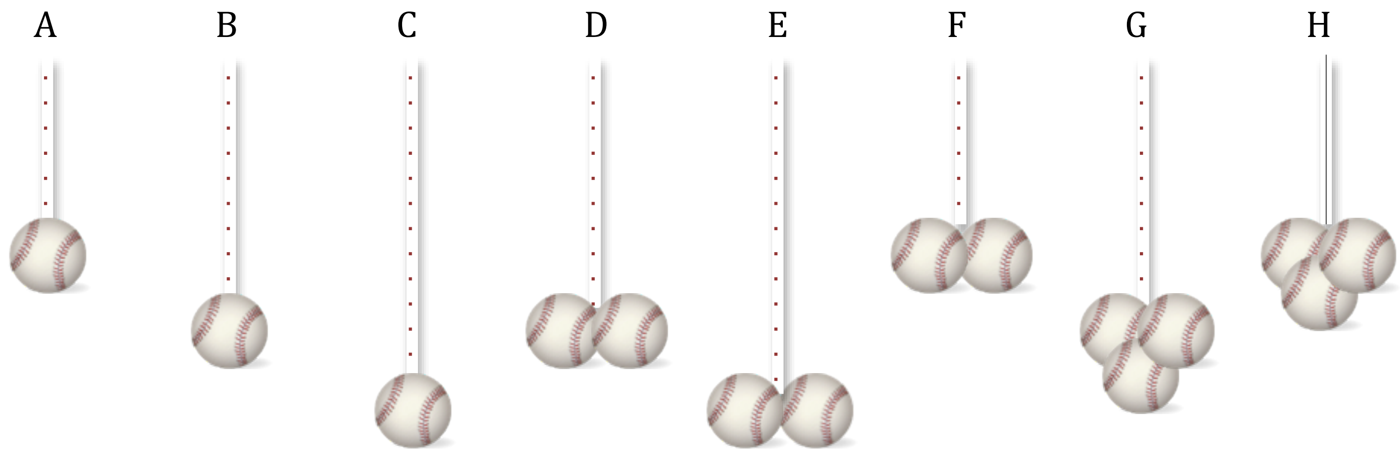
2. Measure the time for ten complete oscillations.

3. Calculate the period for the pendulum.

4. Calculate the frequency, angular frequency, and the value of g.

The Best Damn Pendulums Period!

The eight pendulums below are set oscillating. Rank them from largest to smallest based upon the period of oscillation. If some are equal to others put an equal sign between them.



Lecture 35 - Summary

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