Physics 5B

Lecture 6, January 23, 2012

Chapter 14, Simple Harmonic Oscillator; Pendulum

Problem 14-20

A 1.25 kg mass stretches a vertical spring 0.215 m. If the spring is stretched an additional 0.130 m and released, how long does it take to reach the new equilibrium position again?

A mass on a spring is undergoing simple harmonic oscillation. If the spring is replaced by one that is four times stiffer, then the period of oscillation will

A. be reduced by 1/4

B. be reduced by 1/2

C. be reduced by 1/√2

D. be increased by 2

E. be increased by 4

$$\omega = \sqrt{\frac{k}{m}} = 2\pi f$$

$$T = \frac{1}{f}$$

Problem 14-14

Determine the phase constant in Eq. 14–4 if at $t=0$ the oscillating mass is at

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

a) $x=-A$

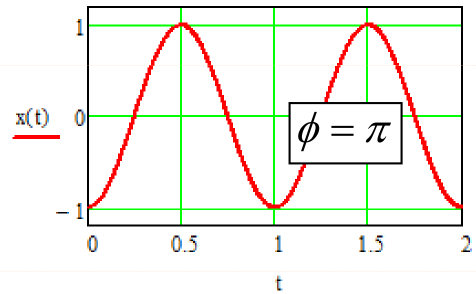
b) $x=0$

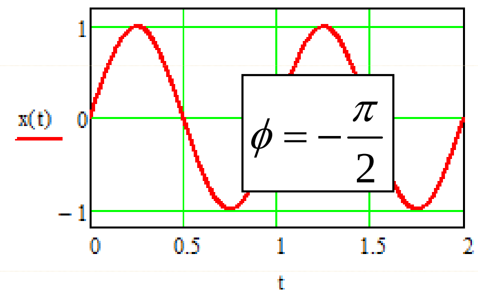
c) $x=A$

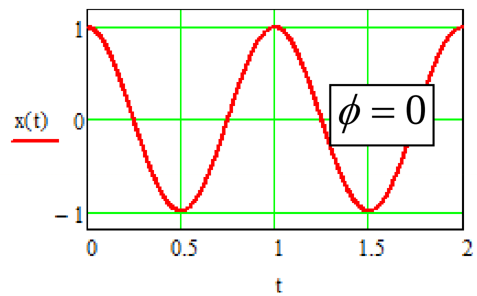
d) $x=\frac{1}{2}A$

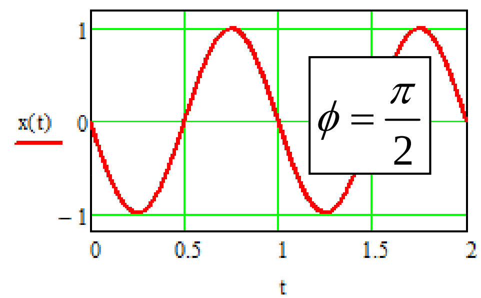
e) $x=-\frac{1}{2}A$

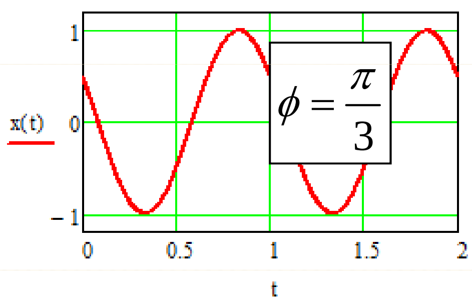
f) $x=A/\sqrt{2}$

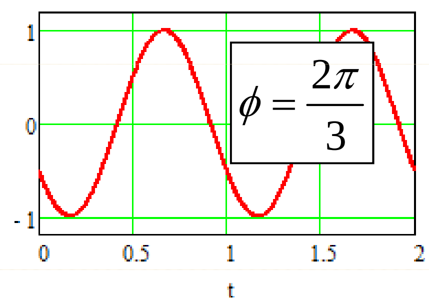


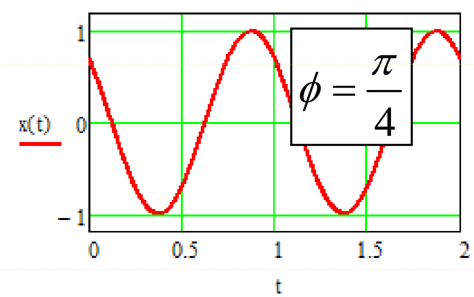




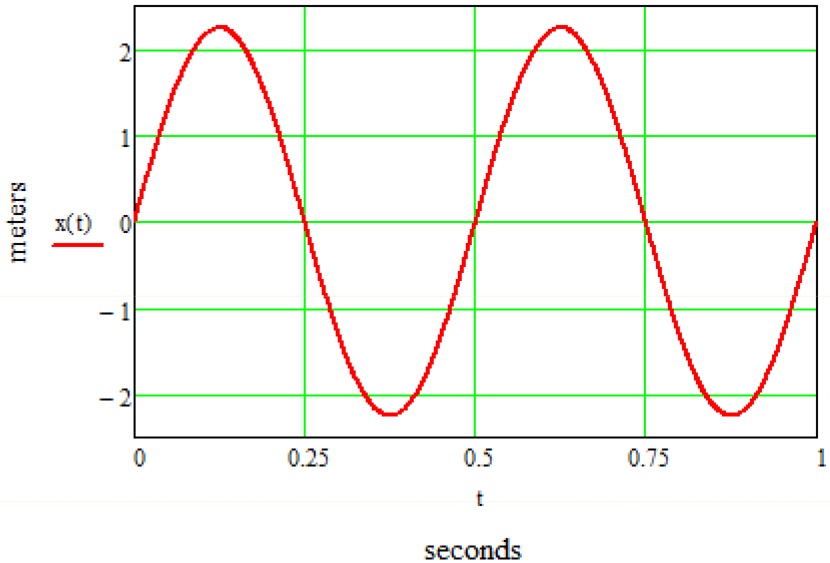








Note that the answer is not always unique, because we are not told the sign of the velocity at $t=0$.



$$\omega \equiv 2\pi f = \frac{2\pi}{T}$$

Which function describes the above harmonic oscillation?

A. $x(t) = 2.00\cos(2\pi t - \pi/2)$

B. $x(t) = 2.25\sin(4\pi t - \pi/2)$

C. $x(t) = 2.25\cos(4\pi t - \pi/2)$

D. $x(t) = 2.25\cos(\pi t + \pi/2)$

Problem 14-17

The position of a simple harmonic oscillator as a function of time is given by

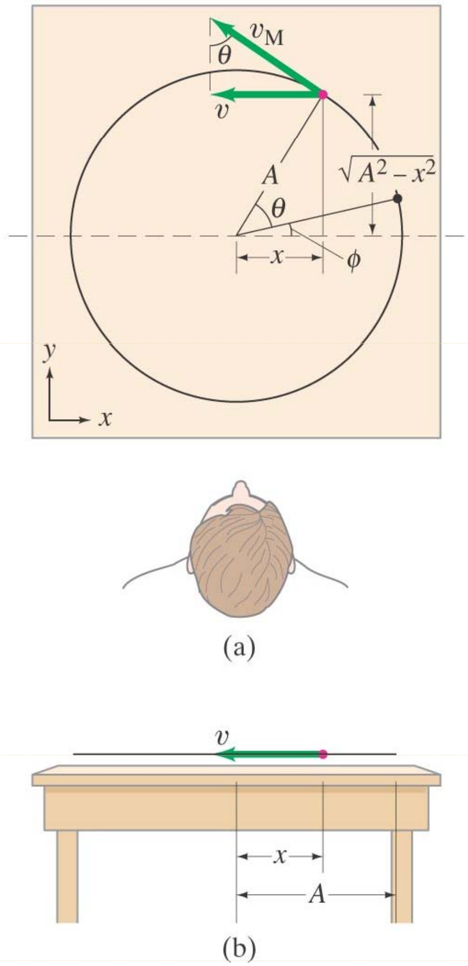
$$x = 3.8\cos(5\pi t / 4 + \pi / 6)$$

where t is in seconds and x in meters. Find

(*a*) the period and frequency,

(*b*) the position and velocity at $t=0$

Simple Harmonic vs Uniform Circular Motion



The x component of the location of the red point is

$$x = A\cos(\theta + \phi)$$

In uniform circular motion the angle theta is changing with time as

$$\theta = \omega t$$

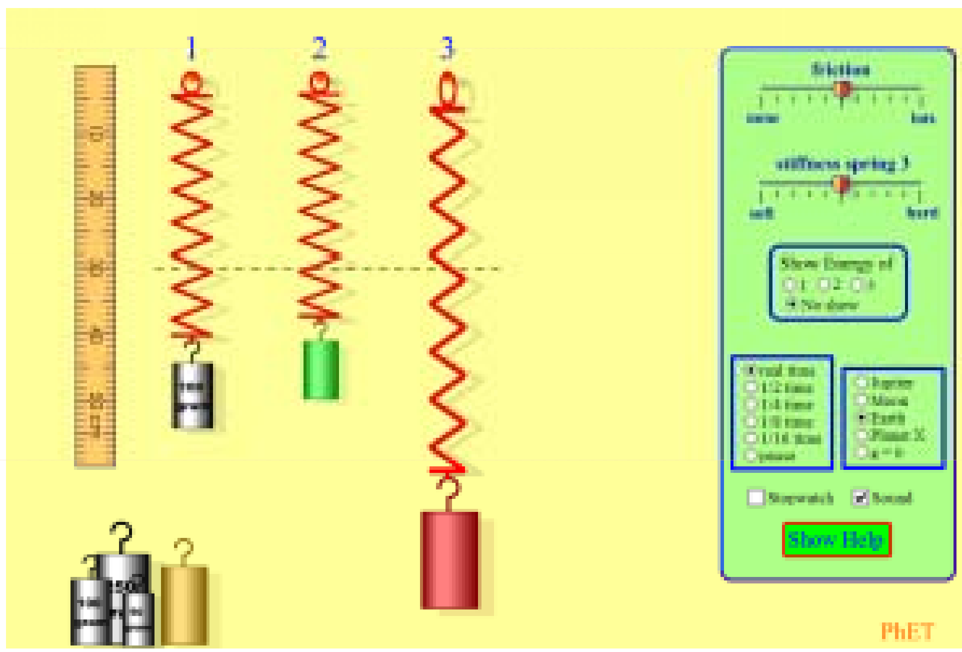
$$\text{so } x(t) = A\cos(\omega t + \phi)$$

http://physics.bu.edu/~duffy/semester1/semester1.html

Energy in Simple Harmonic Motion

- Zero friction (no damping) means that mechanical energy is conserved

$$E = T + V = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$



http://phet.colorado.edu/en/simulation/mass-spring-lab

http://scipp.ucsc.edu/~johnson/applets/SHO_1D.htm

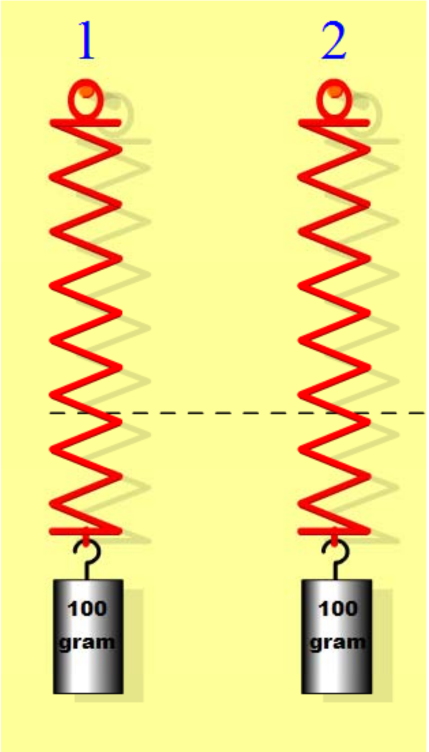
Two identical masses are attached to separate identical springs. If mass #1 is pulled to an amplitude of 10 cm and released from rest while mass #2 is pulled to an amplitude of 20 cm and released from rest, the kinetic energy of mass #2 when it passes through the equilibrium position will be

A. Equal to that of mass #1.

B. Twice that of mass #1.

C. Four times that of mass #1.

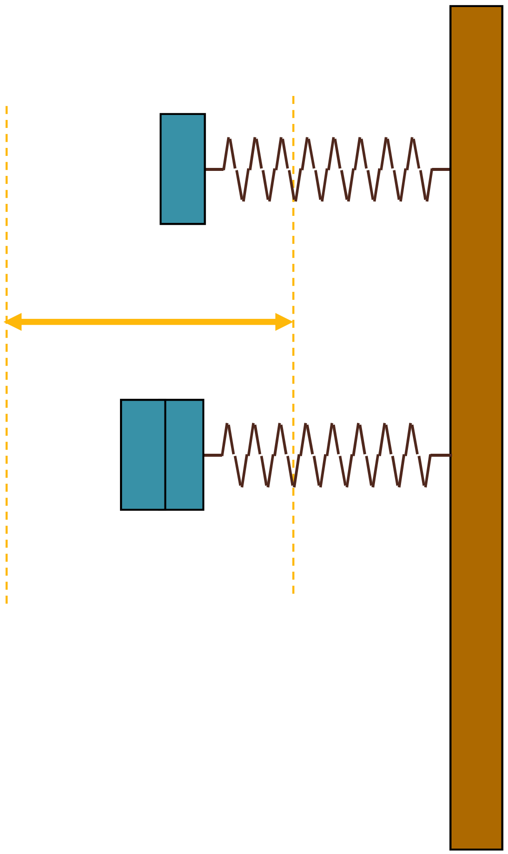
D. Sixteen times that of mass #1.



A=10 cm A=20 cm

Masses are connected to two identical springs. As indicated in the diagram, twice as much mass is attached to the lower spring compared with the upper spring. Both masses are set in oscillation with *identical amplitudes*. Which of the following is true?

1. The maximum kinetic energy of the upper mass is less than that of the lower mass.
2. The maximum kinetic energy of the upper mass is greater than that of the lower mass.
3. The maximum kinetic energy of the upper mass is identical to that of the lower mass.



Problem 14-30

A 0.35-kg mass at the end of a spring oscillates 2.5 times per second with an amplitude of 0.15 m. Determine

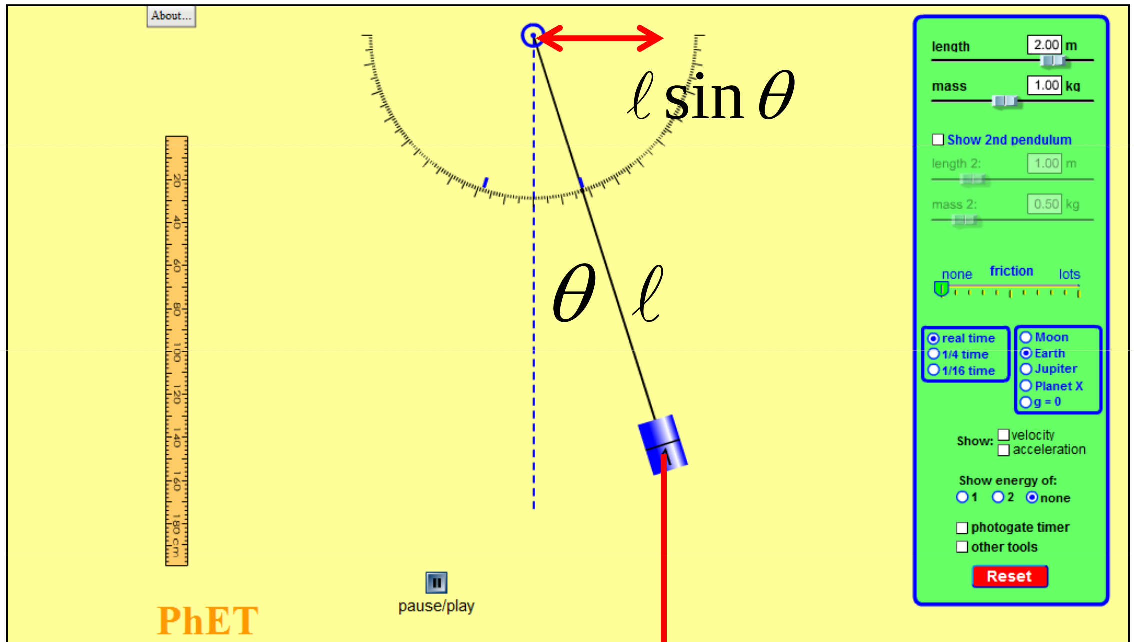
(a) the velocity when it passes the equilibrium point,

(b) the velocity when it is 0.10 m from equilibrium,

(c) the total energy of the system, and

(d) the equation describing the motion of the mass, assuming that at $t=0$, x was a maximum.

Simple Plane Pendulum



torque : $\tau = -mg\ell \sin\theta$

2nd law : $I\alpha = \tau$

$$m\ell^2\ddot{\theta} = -mg\ell \sin\theta$$

$$\ddot{\theta} + \frac{g}{\ell}\sin\theta = 0$$

http://scipp.ucsc.edu/~johnson/applets/PlanePendulum.htm

http://phet.colorado.edu/en/simulation/pendulum-lab

Pendulum Demo

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{\ell}}$$

For small amplitudes

http://www.online-stopwatch.com/full-screen-stopwatch/