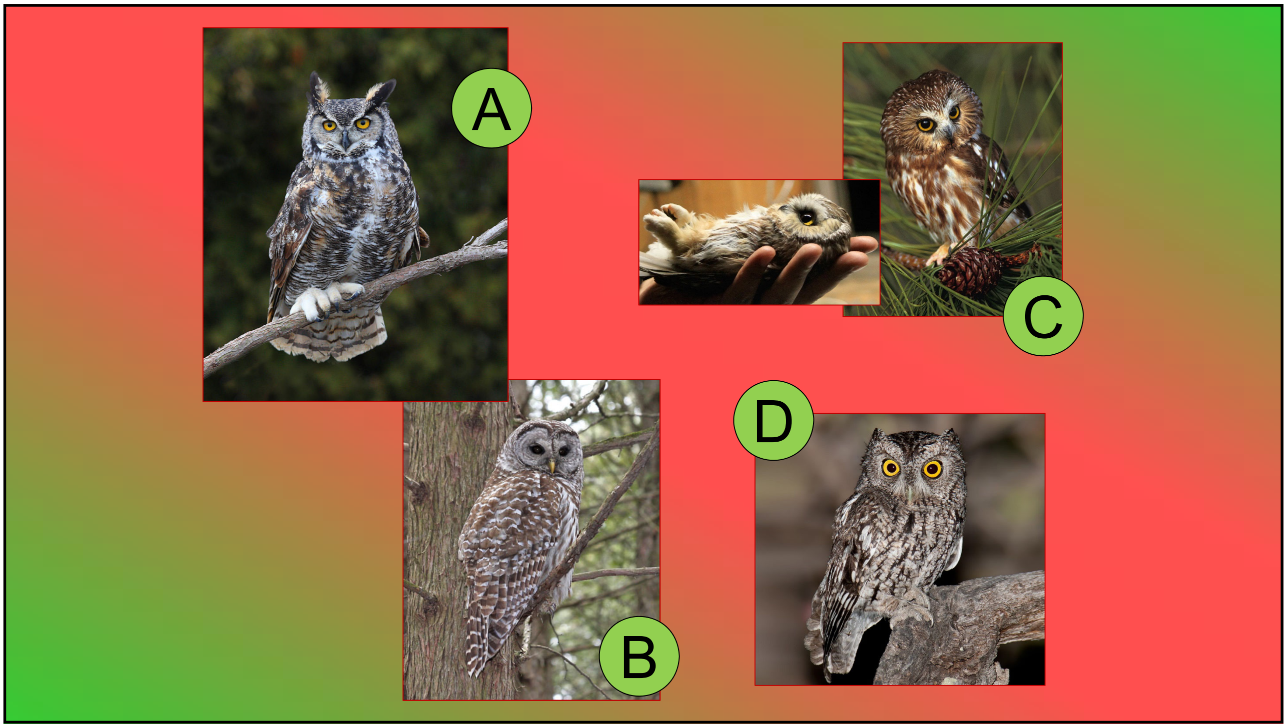
PHYS 210 General Physics I

Today:

- Q & A Session: Tuesday, 10 Dec 2019 @ 7:00 pm
- Post-assessment on Canvas
- Course evaluations!
- The SHO & SHM



The Equation of Motion

- Using Hooke's Law for the net force on a horizontal oscillator (mass on a spring along *x*-axis):

$$\vec{F}_{net} = m\vec{a}$$

$$-k\,x(t) = m\frac{d^2x(t)}{dt^2}$$

$$\frac{d^2x(t)}{dt^2} = -\frac{k}{m}\,x(t) = -\omega^2\,x(t)$$

This is the "differential equation" of SHM. It's "solutions" are sines (or cosines).

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

They're really the same; just differ by phase!

SHO - Oscillation

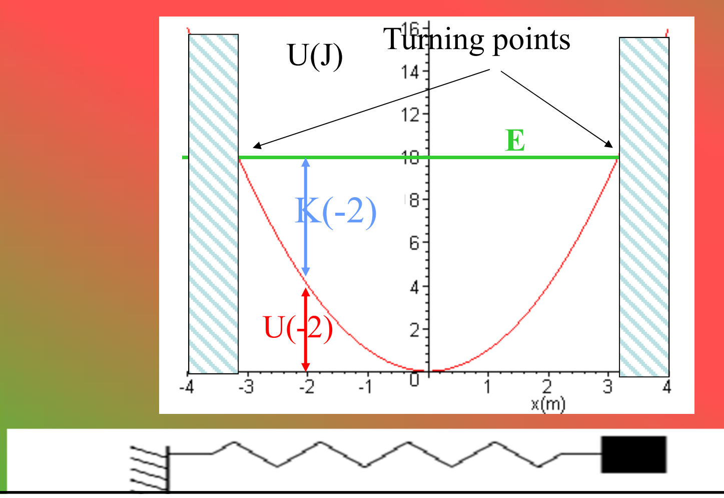
- Relate to potential energy "wells" and turning points.

$$U_s = \frac{1}{2}kx^2$$

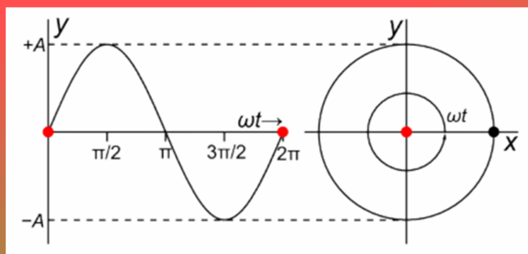
- With no friction ("damping"), mechanical energy is conserved: $K + U_s = constant$
- Linear oscillations (motion in regions where Hooke's Law is valid) depend on k and m:

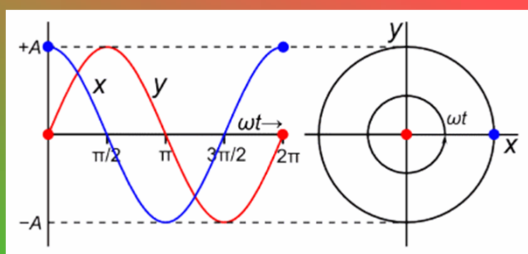
$$\omega = \sqrt{\frac{k}{m}} \qquad T = 2\pi\sqrt{\frac{m}{k}}$$

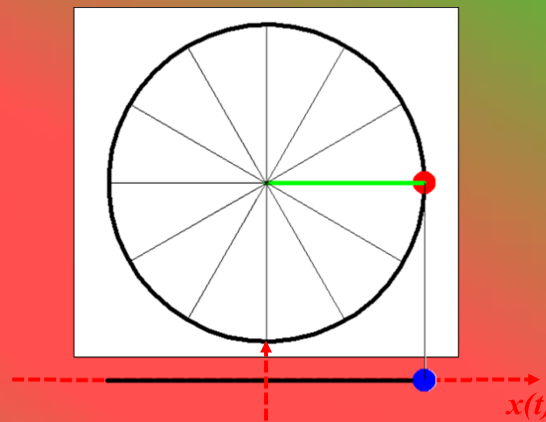
Visualizing E conservation via potential energy curves



SHM & its relation to uniform circular motion





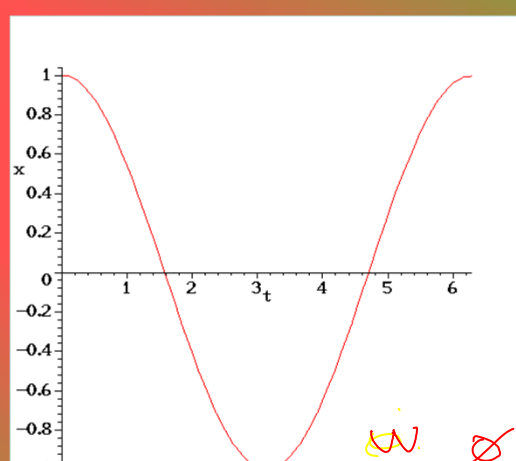


$x(t) = A\cos(\omega t + \varphi)$

$(\omega t + \phi)$

Phase Shifts

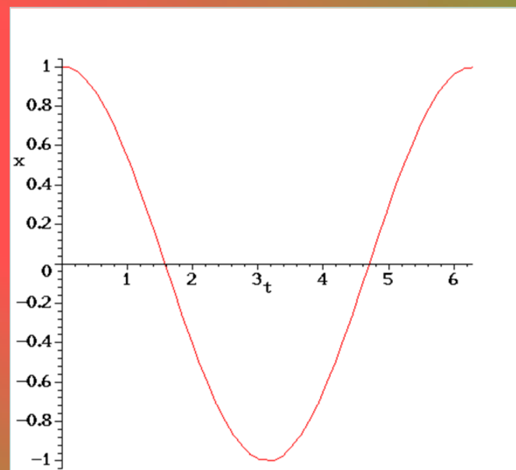
- If φ is positive, the shift is to the left.
- In the plot, the increments are in 0.1 radians



$x = x_m \cos(\omega t + \varphi)$

Phase Shifts

- If φ is negative, the shift is to the right.
- In the plot, the increments are in 0.1 radians



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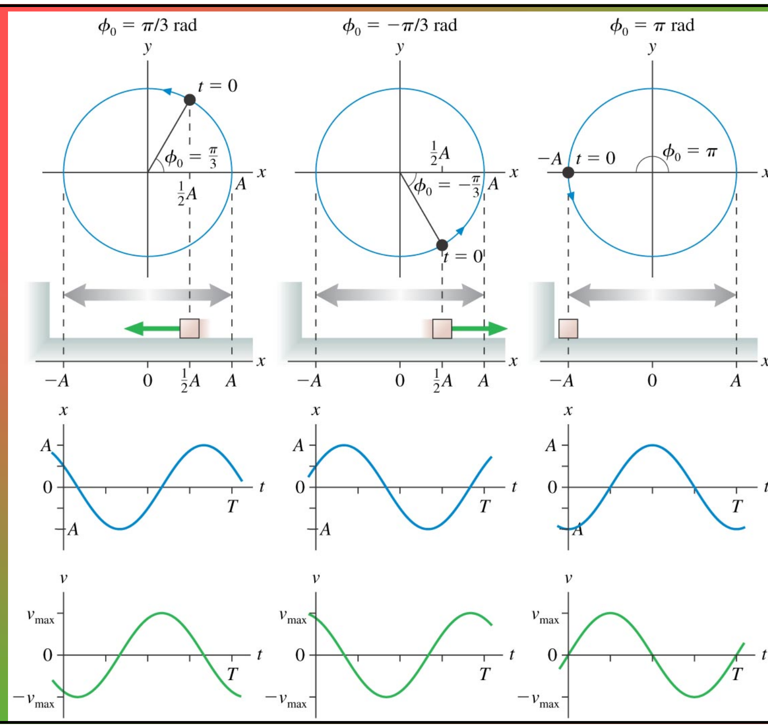
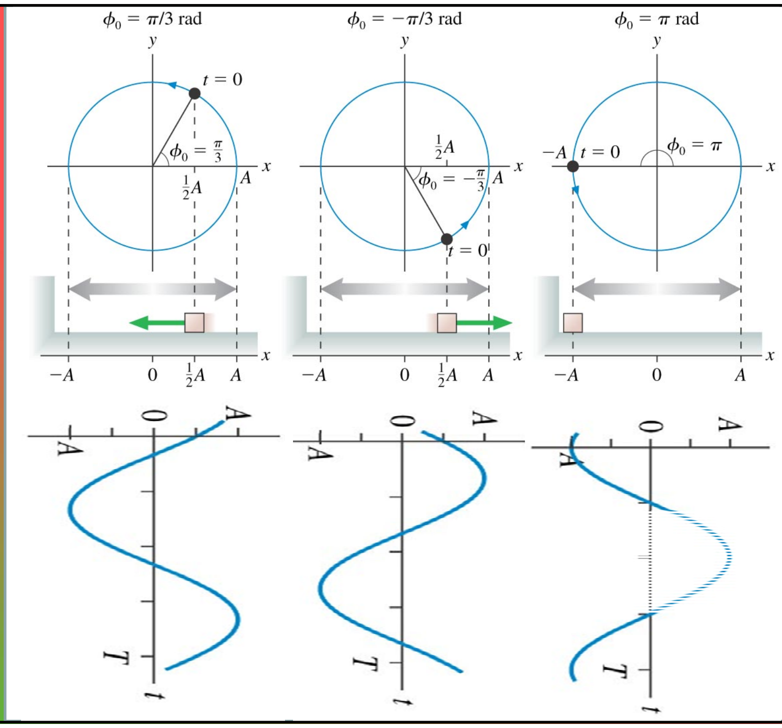


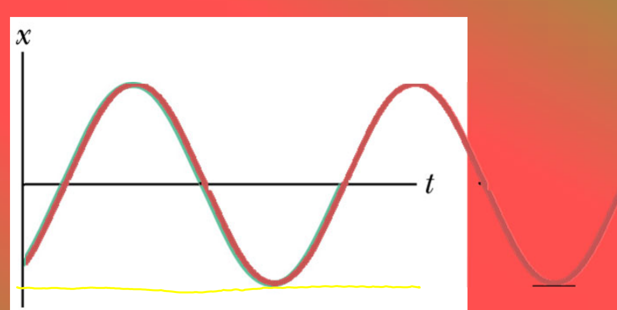


Which of the following describe φ for the SHM of the figure?

ω ϕ

Assume $x = A\cos(\omega t + \varphi)$

A. $0 < \varphi < \pi/2$
B. $\pi/2 < \varphi < \pi$
C. $\pi < \varphi < 3\pi/2$
D. $-\pi/2 < \varphi < 0$
E. $-\pi < \varphi < -\pi/2$
F. $-3\pi/2 < \varphi < -\pi$



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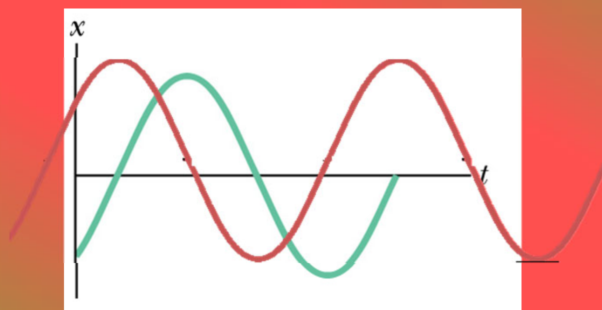


What if the mass on a spring is hanging?

- Same equation of motion (differential equation).
- Same solutions!
- Same physics (basically)!

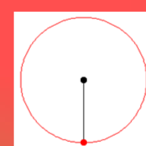
Pendula and SHM

$\sin\theta \approx \theta$
Use radians!

- Pendula exhibit SHM, for small oscillations about their equilibrium positions.
- Simple pendulum: $T = 2\pi\sqrt{\dfrac{L}{g}}$

  (of length *L*)
- Physical pendulum: $T = 2\pi\sqrt{\dfrac{I}{mgh}}$

  (of mass *m*, rotational inertia *I*
  and distance from axis to CM of *h*)



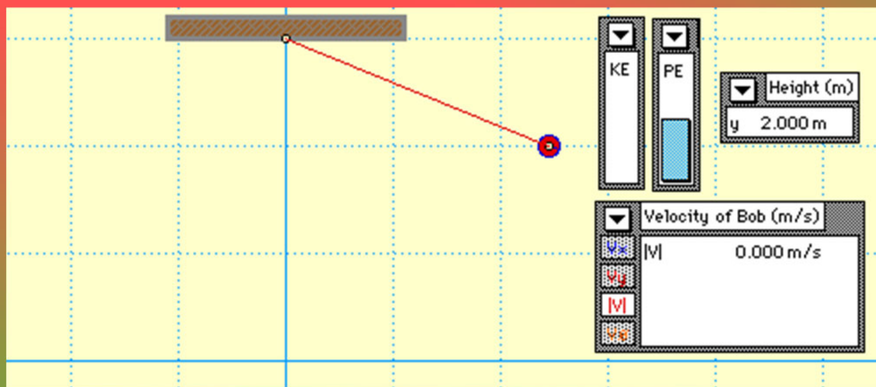
Pair up!!

- Find the value of *g* here in SCIC 202 by measurement of the period.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

- Does the period vary as expected with *L*?

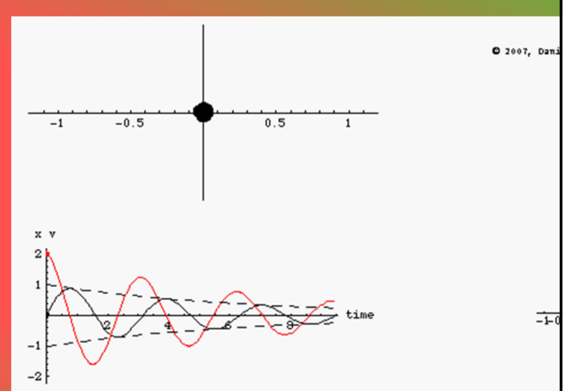
Energy and the Pendulum



Real oscillators

- Any real oscillating system has some damping (resistance to motion) that transfers some of the energy into heat. Such a damped oscillator can be modeled with linear damping.

- Often oscillators are driven by an external force. If the ω of the driving force is near the natural ω of the oscillator, resonance can occur.




Good luck with finals!
Peace on Earth