- Last Lecture
  - Intro to Simple Harmonic Motion
- Today
  - More on Simple Harmonic Motion
  - Intro to more accurate gravity formula
- Important Concepts
  - The physics of the motion is in the mass and spring constant which determine the period of each oscillation.
  - The amplitude does not affect the period.
  - Energy oscillates between Kinetic and Potential.
  - Gravity depends on M and inverse of distance squared.

Important Reminders

- IAP class schedule posted under "General Info"
  - Lecture M 11-12, T 10-12, W 10-12, F 11-12
  - Some recitations moved, all still on Thursday.
- MasteringPhysics due next Tuesday
- Pset #9 due next Friday.
- Have a relaxing holiday!
  - Give someone else an opportunity to be thankful. Give blood at the student center today until 8pm.

Simple Harmonic Motion - Summary

- Basics: $F_x = -kx = m\,{d^2x}/{dt^2}$
- General solution: $x = A\cos(\omega t + \phi)$ $\quad \omega = \sqrt{k/m}$
- Practical solutions:
  - t=0 when position is maximum and therefore v=0 $\quad \phi = 0$ $\quad x = A\cos(\omega t)$, $v_x = -A\omega\sin(\omega t)$, $a_x = -A\omega^2\cos(\omega t)$
  - t=0 when speed is maximum and therefore a=0 and therefore x=0 $\quad \phi = \frac{\pi}{2}$ $\quad x = A\sin(\omega t)$, $v_x = A\omega\cos(\omega t)$, $a_x = -A\omega^2\sin(\omega t)$

Energy in SHM

- Summary:

$$E_{Total} = KE + PE = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$= \frac{kA^2}{2}\left(\cos(\omega t + \phi)\right)^2 + \frac{m(A\omega)^2}{2}\left(\sin(\omega t + \phi)\right)^2$$

$$E_{Total} = \frac{kA^2}{2} = \frac{1}{2}mv_{Max}^2$$

$$\frac{kA^2}{2} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}mv_{Max}^2$$

Simple Harmonic Motion - General

- Assume you know x & v at t=0. Call them: x_0 v_0
- Then: $x_0 = A\cos(\phi)$ $\quad v_0 = -A\omega\sin(\phi)$
- Solve: $\tan(\phi) = \frac{-v_0}{\omega x_0}$ $\quad A = \sqrt{x_0^2 + \frac{v_0^2}{\omega^2}}$
- For small amplitudes, a pendulum will also oscillate with simple harmonic motions with frequency:

$$\omega = \sqrt{g/L}$$

Gravity far from the Surface

- Force depends on:
  - the product of the two masses
  - the inverse square of the distance
  - a universal constant: $G = 6.673 \times 10^{-11}\,\frac{Nm^2}{kg^2}$
- Force points along the line between the two objects in the direction to cause attraction

$$F_G = -\frac{GM_1M_2}{r^2}\hat{r}$$