Read 11.7 - 11.12

Evaluations ~20%

No group this week

Action Center Thursday

Bonus H.W Due Friday

Office hours
10:30 - 11:30 today

Final Exam: Wednesday
10:30 - 12:30 Here

Simple Harmonic Motion

Vibrations and waves occur in many areas

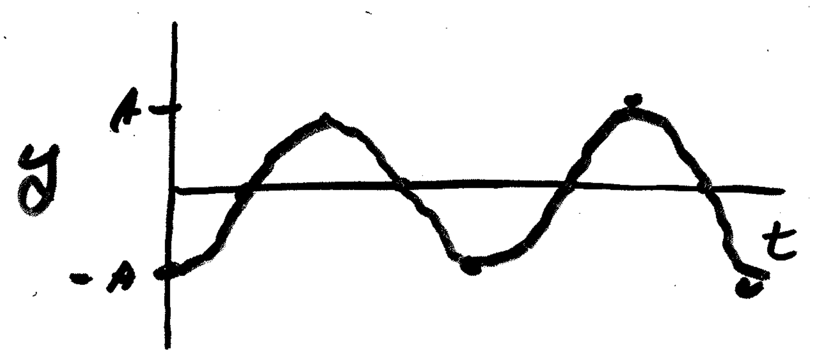
sound, microwaves, light, ...

simplest to understand is called
Simple Harmonic Motion

This is the motion of a spring with a mass displaced from equilibrium

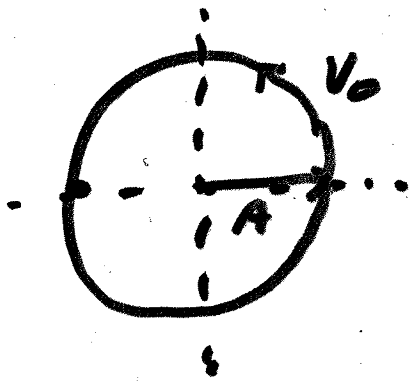
spring $F = kx$

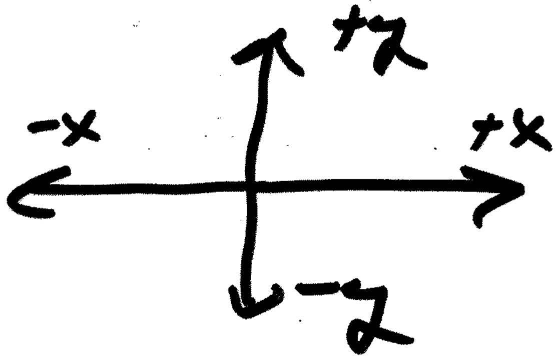
Let's plot position as a function of time



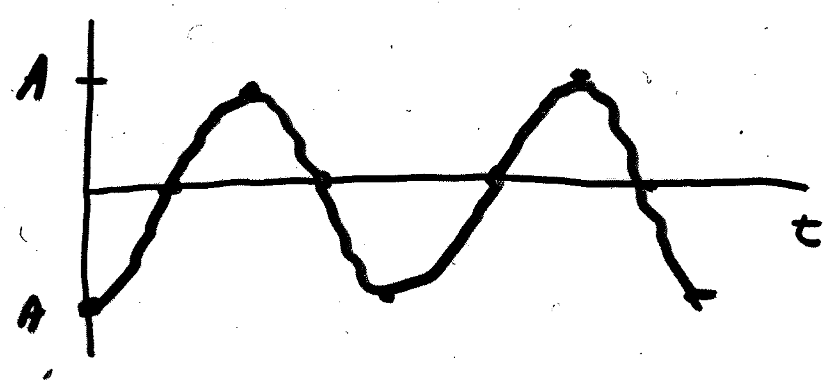
we want to understand this motion

To do this, let's look at uniform circular motion





Lets plot x position as function of time



They look the same so let's apply what we have learned previously to understand simple harmonic motion circular motion

$$T = \frac{\text{Distance}}{\text{Velocity}} = \frac{2\pi A}{V_o}$$

period)

$$f = \frac{1}{T} \qquad f = \frac{V_o}{2\pi A}$$

simple Harmonic motion

Let's use energy to find relationship between Velocity and amplitude of oscillation

$$E = \underset{(K)}{\frac{1}{2} m v^2} + \underset{(U)}{\frac{1}{2} k x^2}$$

at maximum displacement (Amplitude)

$V = 0 \qquad E = \frac{1}{2} k A^2$

at maximum velocity, [redacted] $x = 0$

$E = \frac{1}{2} m V_o^2 \qquad V_o = \text{max velocity}$

$\Rightarrow$ Energy conserved $\Rightarrow \frac{1}{2} k A^2 = \frac{1}{2} m V_o^2$

$$v_0^2 = \frac{k}{m} A^2$$

$$v_0 = \sqrt{\frac{k}{m}}\, A$$

put this into equation for the period

$$T = \frac{2\pi A}{v_0} = \frac{2\pi A}{\sqrt{\frac{k}{m}}\, A} = \boxed{2\pi\sqrt{\frac{m}{k}} = T}$$

$$f = \frac{1}{T} = \boxed{\frac{1}{2\pi}\sqrt{\frac{k}{m}} = f}$$

$x = A\cos\theta$ for uniform circular motion

rotating with angular velocity ω

$$\theta = \omega t$$

$$\omega = 2\pi f$$

$$\boxed{x = A\cos\omega t = A\cos 2\pi f t}$$

ex] Suppose I have a spring which oscillates according to the following equation

$$X = (0.25\,m)\cos\left(\frac{\pi t}{8.0}\right)$$

what is the amplitude, frequency and period of oscillation?

$$X = A\cos 2\pi f t$$

$$A = .25\,m$$

$$2\cancel{\pi} f \cancel{t} = \frac{\cancel{\pi t}}{8.0} \Rightarrow f = \frac{1}{2 \cdot 8.0} = \frac{1}{16}\ Hz$$

$$Hz = \frac{1}{s}$$

$$T = \frac{1}{f} = 16\,s$$

Interactive Question

A mass vibrates back and forth from the free end of an ideal spring (k =20 N/m) with an amplitude of 0.30 m. What is the kinetic energy of this vibrating mass when it is 0.30 m from its equilibrium position?

A) Zero
B) 1.80 J
C) 0.90 J
D) 0.45 J
E) It is impossible to know without knowing the object's mass.

Interactive Question

Doubling only the amplitude of a vibrating mass and spring system produces what effect on the system's mechanical energy?

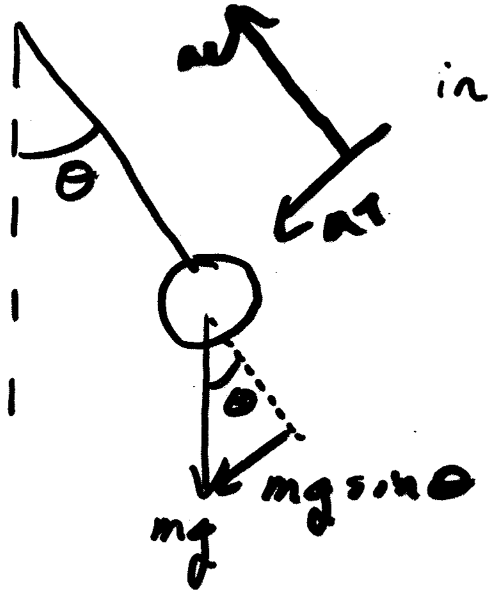
A) It decreases the energy by a factor of four.
B) It decreases the energy by a factor of two.
C) It increases the energy by a factor of two.
D) It increases the energy by a factor of four.
E) It produces no change.

Interactive Question

A mass is attached to an ideal spring. When it is stretched a distance x, the system vibrates with a frequency f. In order to increase the frequency, one would have to

A) reduce the spring constant.
B) increase the length of the spring.
C) decrease the mass on the end of the spring.
D) reduce the distance that the spring is initially stretched.
E) increase the distance that the spring is initially stretched.

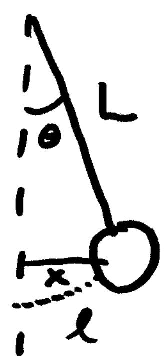
Pendulum



in Tangential direction

$F_T = mg\sin\theta$

if θ small, $\sin\theta \approx \theta$, $x \approx l$



$\sin\theta = \frac{x}{L}$

$F = \frac{mgx}{L}$ $\qquad$ $F = kx$

This looks like $F = kx$ if "k" $= \frac{mg}{L}$

for small angles, a pendulum behaves as a simple harmonic oscillator with a "spring constant"

$$\frac{mg}{L}$$

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

period of a pendulum

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

only depends on length of pendulum not the mass

Final Exam

Wednesday May 8 10:30-12:30

"Double" midterm

33 Questions

2 free

$\sim\frac{1}{2}$ concept $\sim\frac{1}{2}$ calculational

comprehensive

$\left.\begin{array}{l}\text{angular motion}\\ \text{torque}\\ \text{equilibrium}\\ \text{angular momentum}\end{array}\right\}$ more emphasis

fluids, simple harmonic motion

2-3 questions