Announcements – 3 Dec 2013

1. Exam 4 results   median was 71% → 5 pt curve!

2. Final exam info
   a. Take in Testing Center any time during Finals week (Mon-Fri)
   b. I plan 40-43 questions
      i. 10-11 on new stuff (Chap 13 & 14)
      ii. 30-32 on Chapters 1-12 (midterms 1-4)

   Written E.C. due next Friday

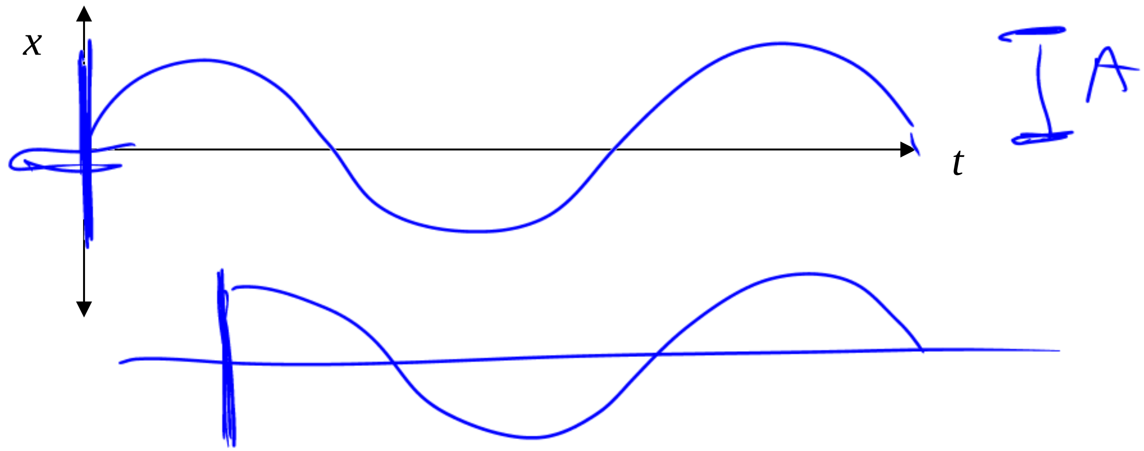
3. Instructor/course ratings due before Sun Dec 15
   http://studentratings.byu.edu
   → Please take the ratings and comments seriously!

4. I also plan to write my own survey, focusing on specific ways to improve the class for next time around.

"Simple harmonic motion"

→ Sinusoidal oscillations

Demo: weight on spring

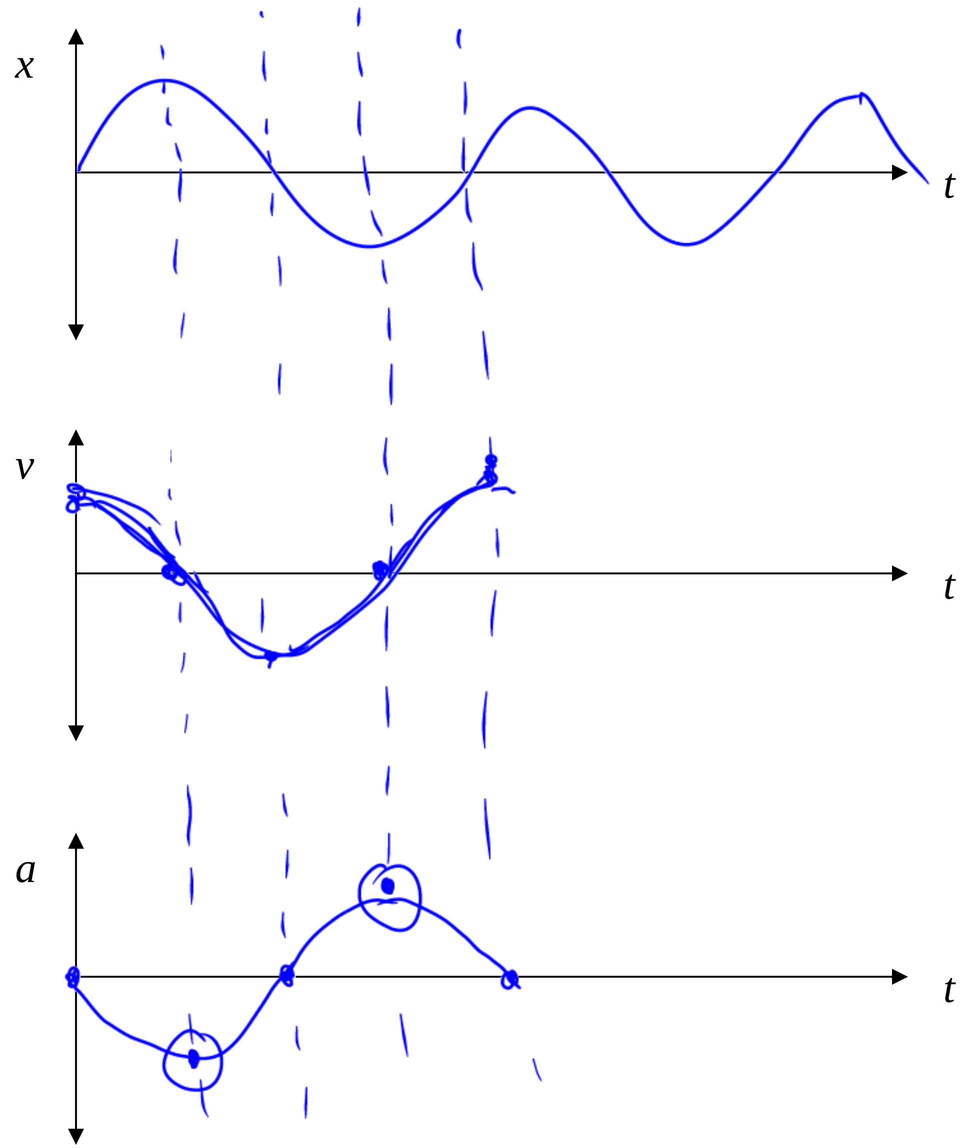


Result: $\boxed{x = A\cos(\omega t)}$ *A* = amplitude

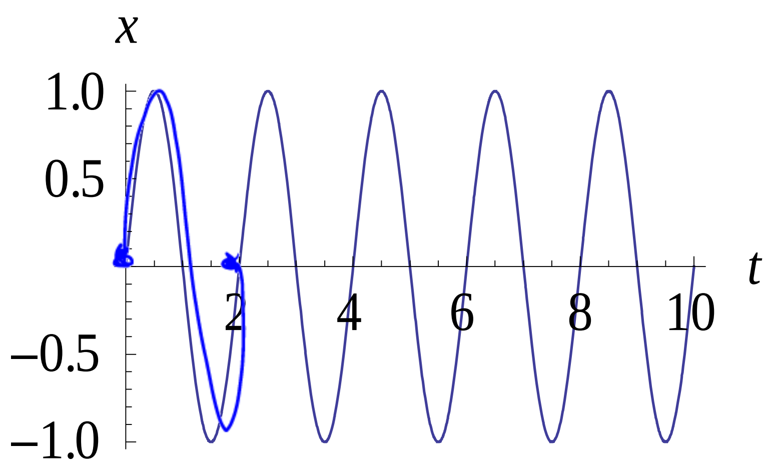
ω = rad/sec

→ or x=Asin(ωt) or x=Acos(ωt + ϕ) ...what's the difference?

Plots of x, v, and a



Reading info from graph



Amplitude A= ___1 m___
Period T = ___2___ sec
Frequency f = ___1/2___ cycles/sec (Hz)
Angular frequency ω =___π___ rad/sec

$$f = 1/T$$

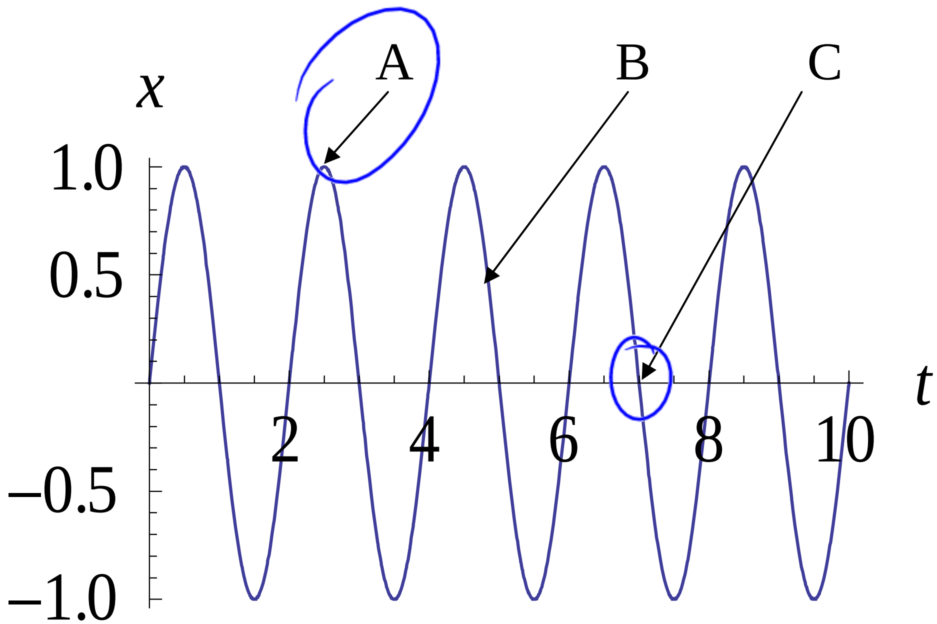
$$\omega = 2\pi f$$

rad/s

Angular frequency?? Where's the angle??

Demo

SHM/Circular motion analogy



Clicker quiz 1: Where does it have the most kinetic energy?

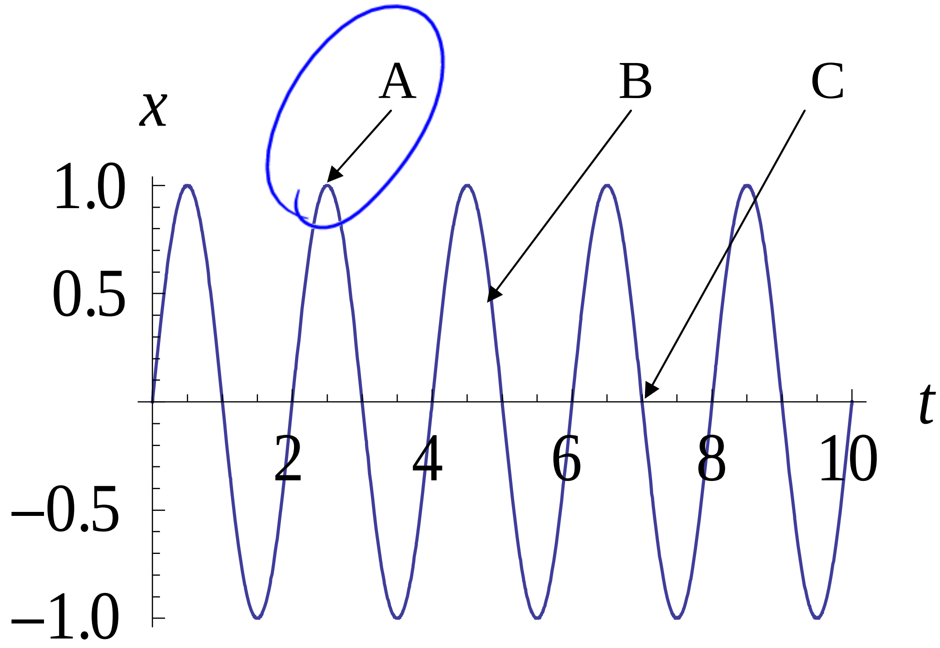
a. position A
b. position B
c. position C

$\frac{1}{2}mv^2$

Clicker quiz 2: Where does it have the most potential energy?

a. position A
b. position B
c. position C

spring?
gravity?

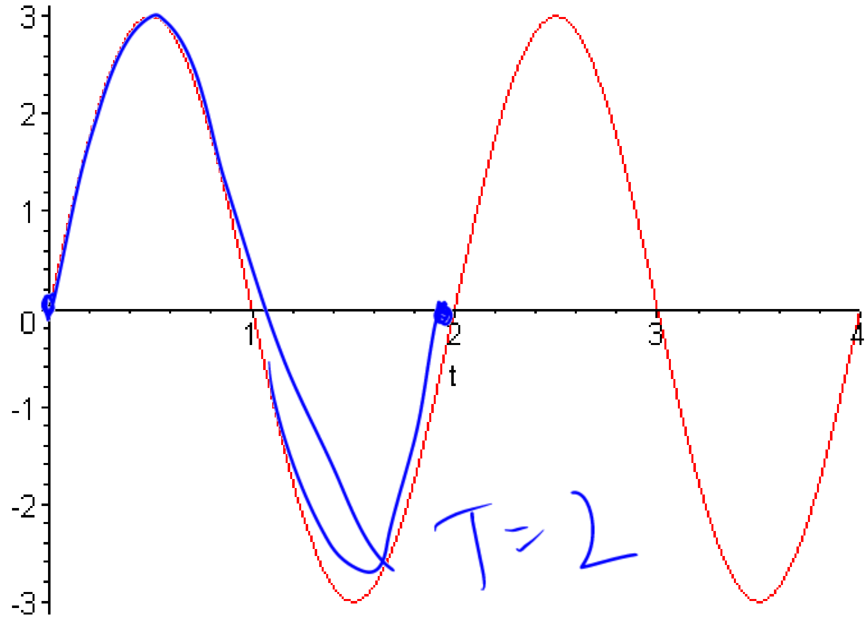


Clicker quiz 3 (from warmup): Where does it have the largest acceleration?

a. position A
b. position B
c. position C

Clicker quiz

Given this oscillation,



what's the correct equation to describe the position vs. time?

a. $x(t) = 6 \cos(t)$
b. $x(t) = 3 \sin(2t)$
c. $x(t) = 6 \sin(2t)$
d. $x(t) = 3 \sin(\pi t)$
e. $x(t) = 3 \cos(\pi t)$

Springs

Experiment: change mass on spring

Experiment: change spring, keep mass the same

<u>Summary</u>:

Frequency

Period

$$\omega = \sqrt{k/m}$$

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

$$\omega = 2\pi f$$

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

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

From warmup

Consider a mass *m* hanging on a spring. We pull the weight downward and then release it so that it oscillates up and down. If we repeat this on the *moon* with the same weight and the same spring, the frequency of the oscillation will be:

a. larger
b. smaller
c. the same

Pendulums

Clicker quiz: Does the pendulum period depend on amplitude?

a. yes
b. no
c. it depends

Experiment: change amplitude

Experiment: change mass

Summary:

Frequency

Period

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

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

(typo in syllabus "chapter summaries" document)

Worked Problem

A 70 kg trapeze artist swings on a long rope and takes 5 seconds to return to his starting spot.

How long will it take a woman of mass 50kg to make the same swing?
____5____ sec

How long will it take for the 70 kg man to swing from his starting place to when he first reaches the bottom? ___5/4____ sec

How long is the rope? ________________ m

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

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

$$\frac{T^2}{4\pi^2} = \frac{L}{g}$$

$$L = \frac{T^2 g}{4\pi^2} = 6.2\,m$$

Answers: 5 s, 1.25 s, 6.21 m

From warmup

Ralph is confused about pendulums. He read in the textbook that the period *T* of a pendulum depends on its length *L* and on the acceleration of gravity *g*, but does not depend on its mass. Ralph thinks that heavier pendulums should swing with a longer period. After all, if he puts a heavier weight on the end of the spring, it oscillates more slowly. Can you help Ralph understand this?

"Pair share"–I am now ready to share my neighbor's answer if called on.

a. Yes

Waves

→ Oscillating motion that transfers ***energy*** but not mass

Direction: where the energy is going

Medium: what is doing the “waving”

Oscillation: how the medium is moving

Transverse—Oscillation is ⊥ to the direction of the wave

Longitudinal—Oscillation is // to the direction of the wave

Demo: Suspended slinky

Wave Examples

Slinky (demo)

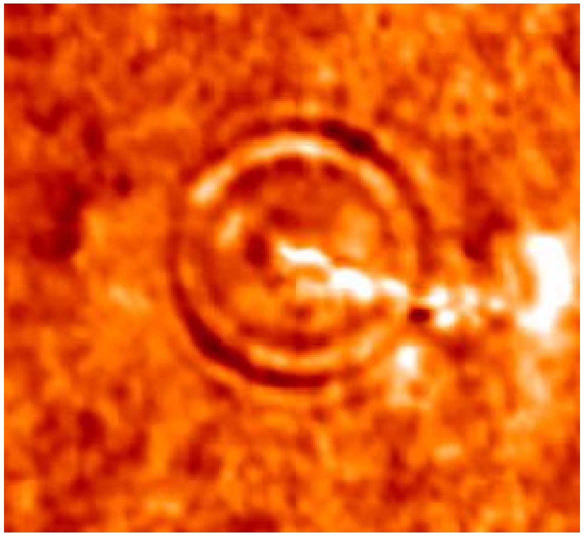
Rope (demo)

Water

Earthquake (P & S)
http://en.wikipedia.org/wiki/S-wave

Sound

Light



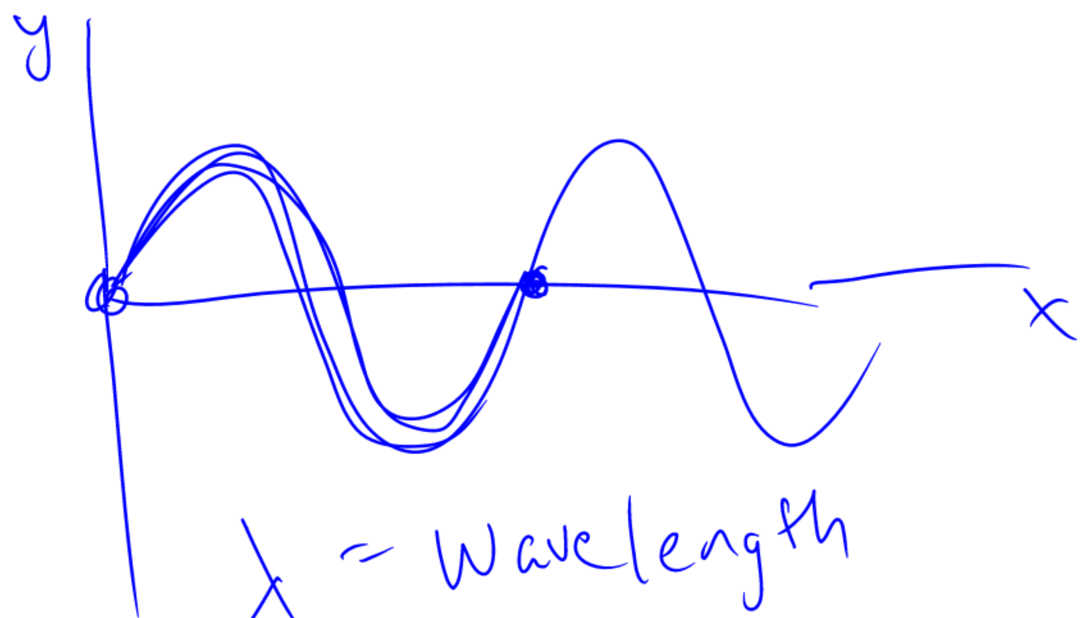
surface of the Sun

Speed, frequency, wavelength

m/s   (wave/s) × (m/wave)

m/s

$$v = f\lambda$$



λ = wavelength

→ lambda

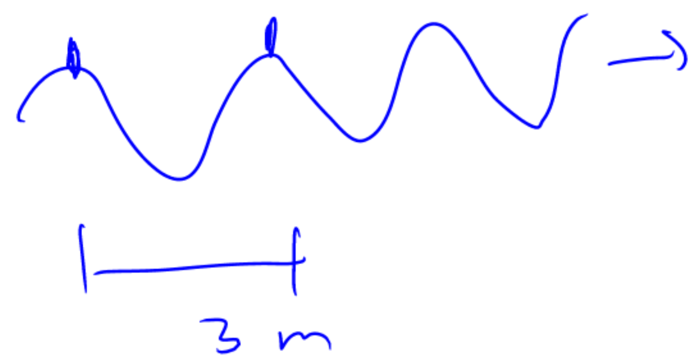
Worked Problem

$f = 97.5 \cdot 10^6\ \text{Hz}$

You can listen to Utah Jazz games on FM 97.5. The number refers to a broadcasting frequency of 97.5 MHz. Find the wavelength and period of the radio waves. Hint: how fast do radio waves travel?

$$T = \frac{1}{f} = \frac{1}{97.5 \cdot 10^6 \left(\frac{1}{s}\right)} = \boxed{10.3 \cdot 10^{-9}\ s}$$

$$v = \lambda f \rightarrow \lambda = \frac{v}{f} = \frac{3 \cdot 10^8\ m/s}{97.5 \cdot 10^6 (1/s)} = \boxed{3.08\ m}$$



Answers: 3.08 m, 10.3 ns

Waves on Ropes

What will changing the **tension** do?

$$v = \sqrt{\frac{T}{\mu}}$$

For waves on a rope/string/etc

mu = linear mass density = $\frac{m}{L}$

Note: the book uses symbol *F* for tension in this section
(I don't know why)

Web demo
http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

From warmup

Two students play with an extra-long Slinky. The student on the left end sends waves to the other student by shaking her end back and forth. After the waves die down, both students take a step backwards and try it again. How will the speed of the waves now compare to the previous waves?

a. They will be faster
b. They will be slower
c. They will go the same speed

Demo: rubber tubing

Question

What happens when you increase the wave speed while keeping the wavelength constant?

$$\overset{\uparrow}{v} = \lambda \overset{\uparrow}{f}$$

Demo: violin

Clicker quiz

Two guitar strings of the same length have the same tension, but one has four times the mass of the other. The speed of a wave on the heavier guitar string is ___________ that of the lighter string.

a. ¼
b. ½
c. the same as
d. 2×
e. 4×

$\mu = m/L$

$v = \sqrt{T/\mu}$ ← ×4

$\sqrt{\frac{1}{4}}$

$= \frac{1}{2}$

Clicker quiz

A boy shakes a rope, moving his hand up and down. He sends a wave crest out every 0.5 seconds. He sees the wave crests move away with a distance between them of 25 cm. How fast is the wave moving?

a. 0-10 cm/s
b. 10-20 cm/s
c. 20-30 cm/s
d. 30-40 cm/s
e. more than 40 cm/s

$v = \lambda f$

λ

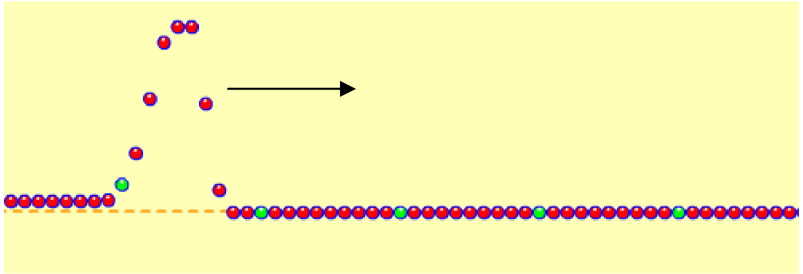
$T = .5 \text{ sec}$

$f = 2 \text{ Hz}$

$v = (25\text{cm})(2 \tfrac{1}{s})$

50 cm/s

Reflections



Clicker quiz: What happens when an upward pulse hits the end and turns around?

a. the wave reflects back, upward
b. the wave reflects back, downward
c. it depends

Web demo, cont.
http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

Boundaries

Rope: Light rope meets heavy rope
Light: Air meets glass

In both cases: ________________________________

Sound: Thin air meets dense air
$\rightarrow$ Also can cause reflections