Announcements – 20 Nov 2014

1. Prayer
2. Exam 3 starts on **Mon Nov 24**
   a. Covers Ch 9-12, HW 18-24
   b. Late fee on Wed after Thanksgiving, 3 pm
   c. Closes on Thursday after Thanksgiving, 3 pm
   d. Jerika review sessions, both in C295 ESC
      i. Sat Nov 22, 10 - 11:30 am (before Thanksgiving)
      ii. Mon Dec 1, 5:30 - 7 pm (after Thanksgiving)
3. Thanksgiving week:
   a. Homework is due on Monday, as usual
   b. Tuesday is a virtual Friday → we don't have class
   c. No classes on Wednesday
   d. Testing Center not open on Wed, Thurs, Fri, or Sat
4. Final exam – Tuesday Dec 16, either 7-10 am or 8-11 pm.
5. Instructor/course ratings Nov 20 – Dec 14. Extra credit: 2 points
   http://studentratings.byu.edu
   → Please take the ratings and comments seriously!

“Which of the problems from last night's HW assignment would you most like me to discuss in class today?”

Real engines

modeled by PV-diagram cycles

Gasoline engines

- Piston is compressed quickly
- Heat is then added by igniting fuel
- Piston then expands quickly
- Heat is then expelled (by getting rid of old air)
  → Same air is not re-used; the cycle is just an approximation

The "Otto cycle"

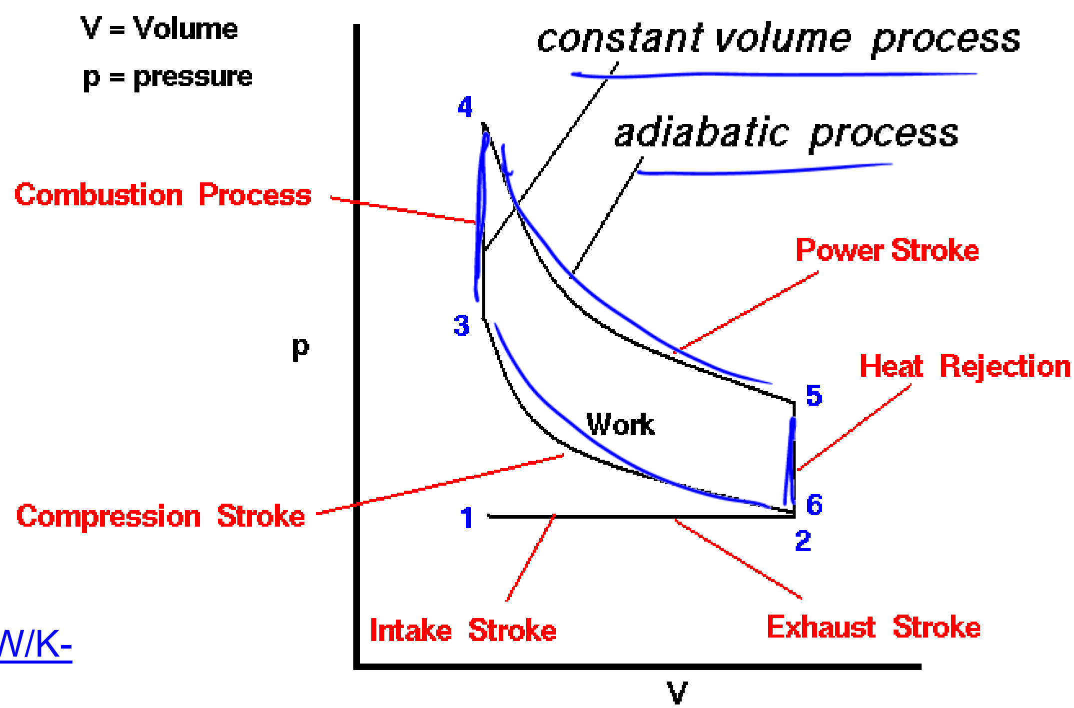
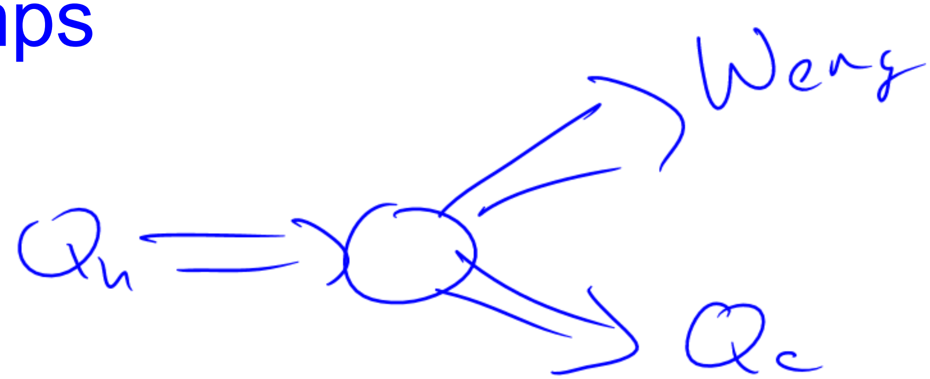


Image credit:
http://www.grc.nasa.gov/WWW/K-12/airplane/otto.html

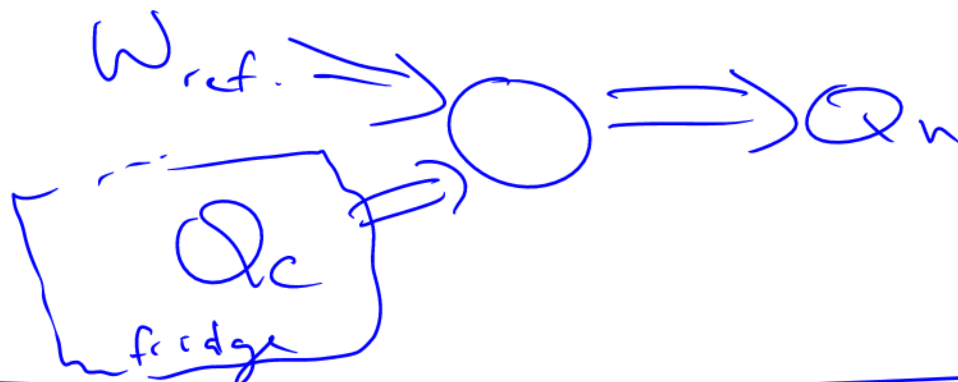
Refrigerators/Heat Pumps

Engine picture (review):



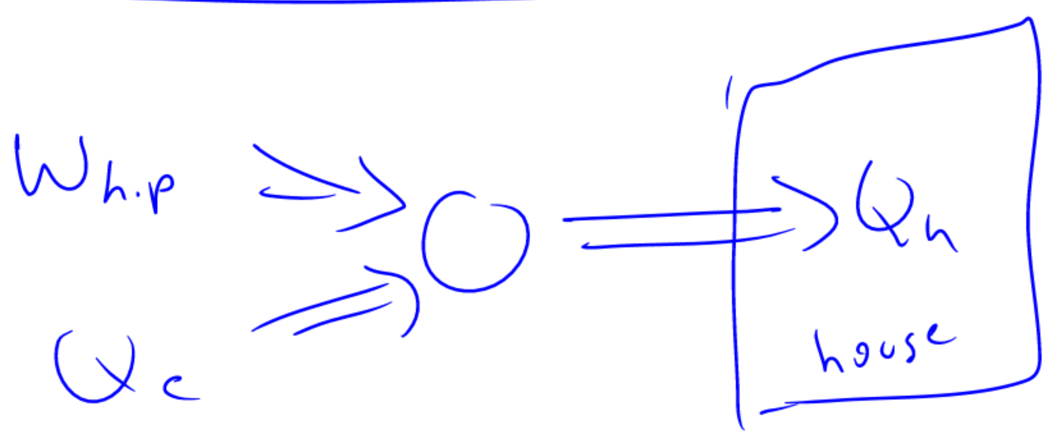
Refrigerator picture:

$$COP_r = \frac{Q_c}{W_{ref}}$$



Heat pump picture:

$$COP_{hp} = \frac{Q_h}{W_{hp}}$$



From warmup (last time)

The second law of thermodynamics says that for a heat engine:

a. The efficiency is always 100% because energy is conserved.
b. The efficiency must always be less than 100%, because not all of the heat energy can be turned into work.
c. The efficiency must in general be substantially less than 100%, because T_c is not zero and/or T_h is not infinity.

2nd Law of thermodynamics (alternate)

Heat spontaneously flows from hot to cold, not the other way around.

Why? **<u>Order and probability.</u>**
From textbook: which hand is more likely?

… but which is more likely, a straight flush or a garbage hand?

Entropy concept

Question: You separate a deck into two halves: one is 70% red, 30% black; the other is 30% red, 70% black. What will happen if you randomly exchange cards between the two?

Entropy equation in section 12.5 (8th edition):
you don't need to know

Second Law, Two versions

In an engine, you can't convert all the heat into usable work

Heat doesn't flow from cold to hot

Why are they equivalent?

1. If you had a process whereby heat flows from cold to hot… then $e = 100\%$

2. If you had an engine that completely converts heat to usable work…

Could get heat going from cold to hot

From warmup (last time)

Carnot's theorem says that for a heat engine:

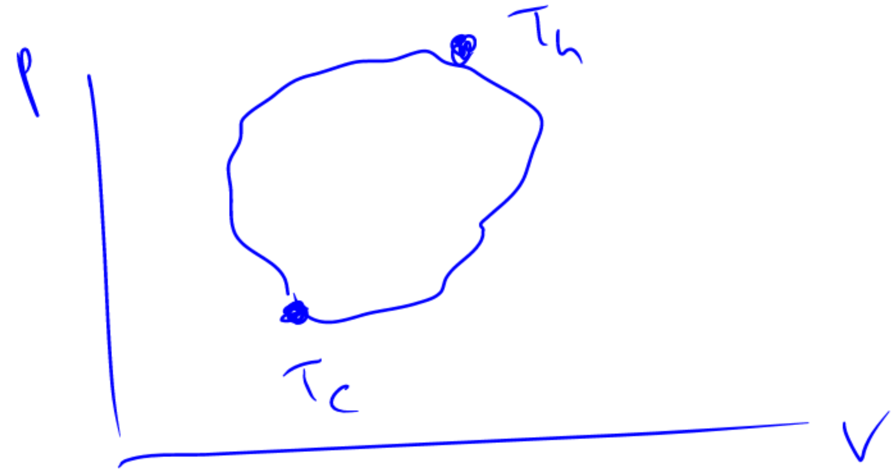
a. The efficiency is always 100% because energy is conserved.
b. The efficiency must always be less than 100%, because not all of the heat energy can be turned into work.
c. The efficiency must in general be substantially less than 100%, because T_c is not zero and/or T_h is not infinity.

Carnot's Theorem:

You often can't even convert *most* of the heat into work

$$e_{\max} = "e_C" = 1 - \frac{T_c}{T_h}$$

C for Carnot



Why? Usable energy lost through "irreversibilities"

Exam/HW guidance: If the problem says "theoretical maximum efficiency", that's a code phrase telling you to find the Carnot efficiency for the min and max temperatures of the cycle.

Song

http://www.physics.byu.edu/faculty/colton/courses/PHY105resources/song/first_second_law.mp3

(4 minutes)

End of chapter 12!

End of exam 3 material!

Final topic: Waves

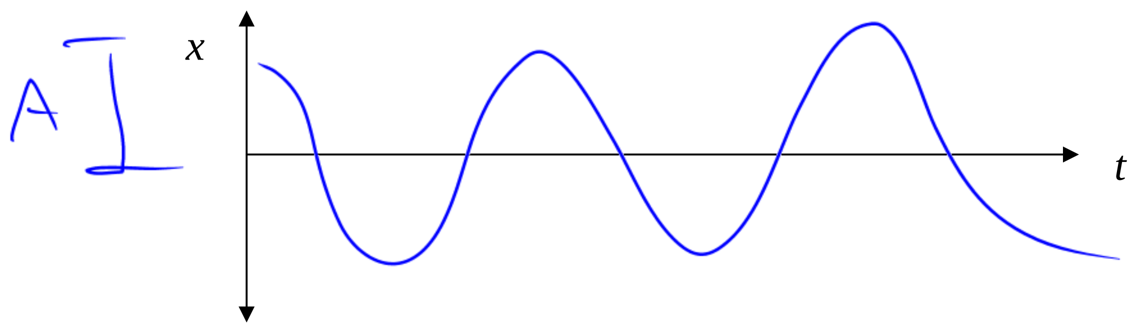
General oscillations
Waves
Sound waves
Standing waves
Music (just a little, for fun)

“Simple harmonic motion”

→ Sinusoidal oscillations

Demo: weight on spring

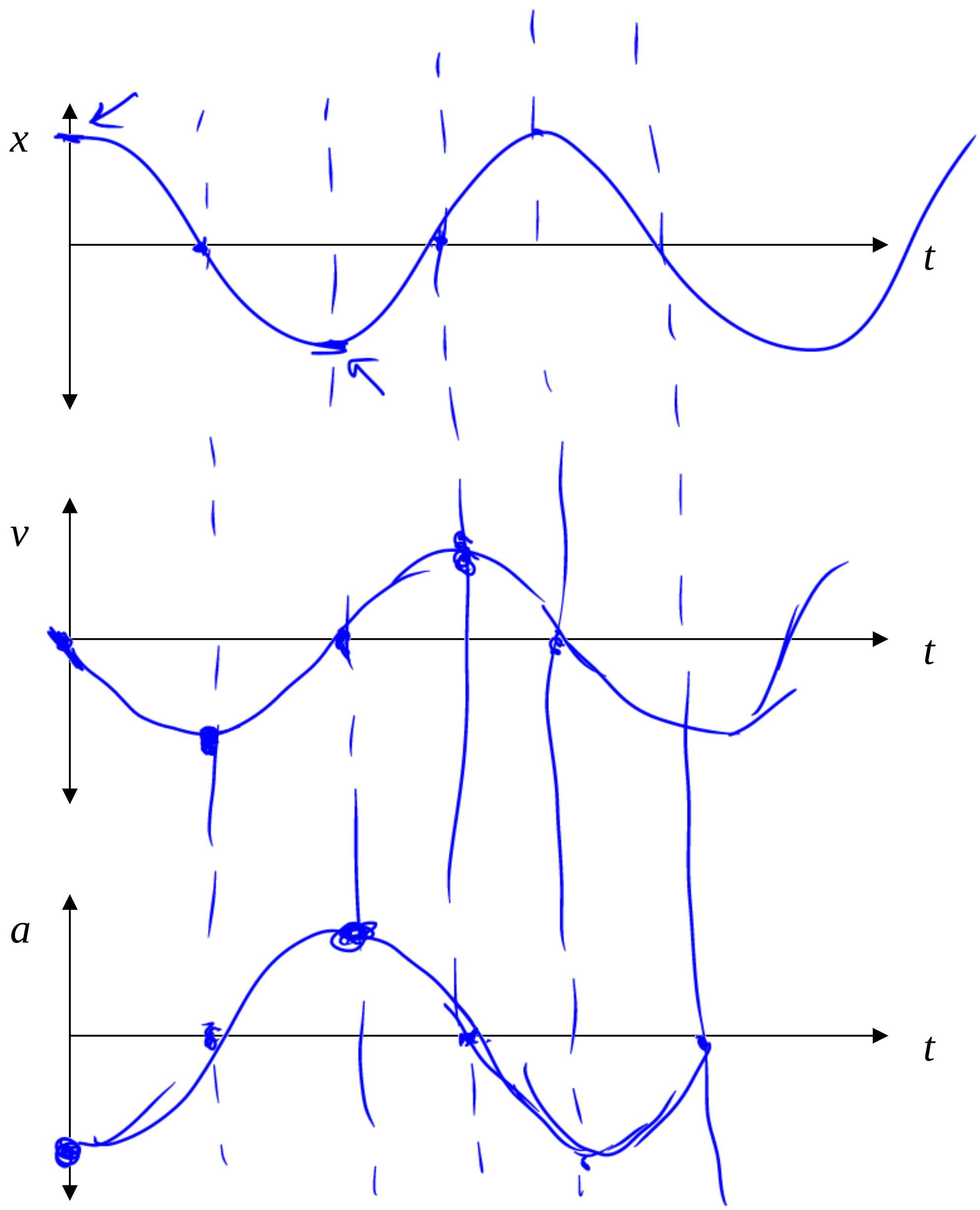
$f = \omega/2\pi$



Result: $\boxed{x = A\cos(\omega t)}$ A = amplitude, ω = angular freq, $\frac{\text{rad}}{\text{s}}$

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

Plots of x, v, and a



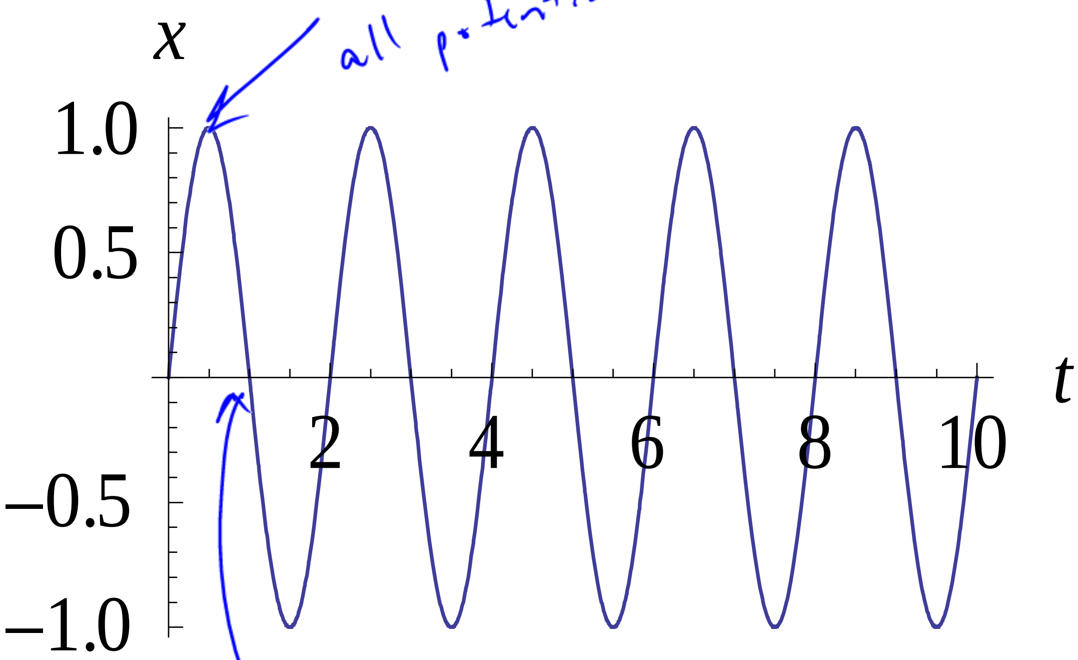
From warmup: Where does it have the largest acceleration?

a. midpoint
b. endpoints
c. same value

Energy: potential vs. kinetic

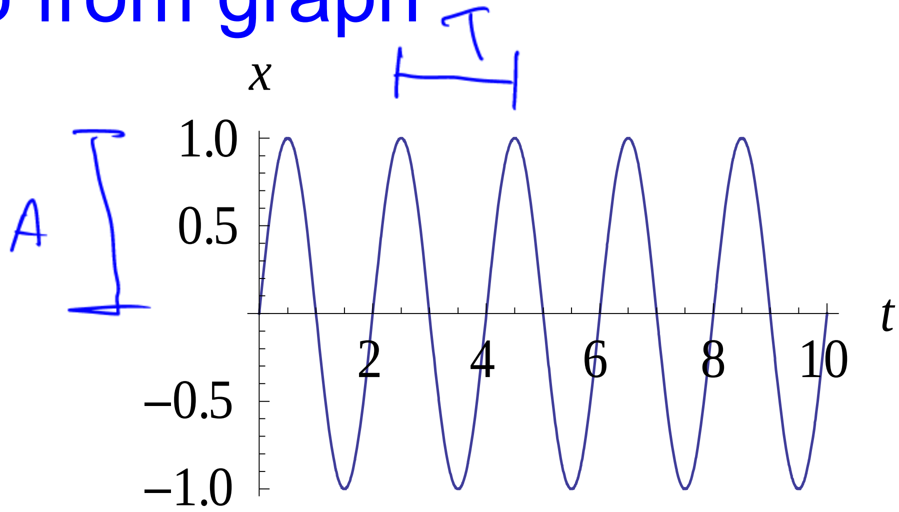
$PE_{spring} = \frac{1}{2} k x^2$

no kinetic
all potential spring



no potential
all kinetic

Reading info from graph



Amplitude A= ___1 m___

Period T = ___2___ sec   Hertz

Frequency f = ___.5___ cycles/sec (Hz)

Angular frequency ω =___π___ rad/sec

$$f = 1/T$$

$$\omega = 2\pi f$$

$f = \omega / 2\pi$

$x = (1\text{m}) \sin\left(\pi \frac{\text{rad}}{\text{s}} \cdot t\right)$

Angular frequency?? Where's the angle??

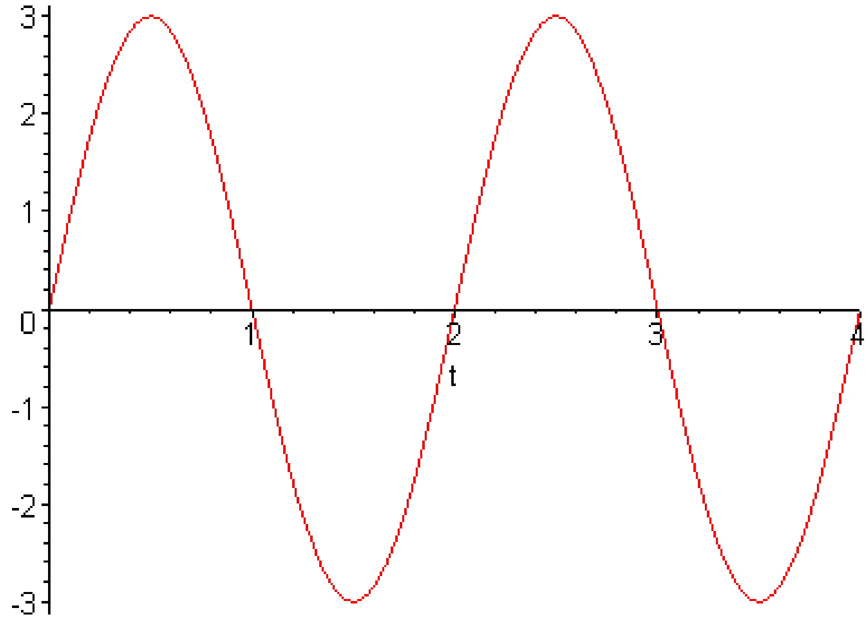
$x = A \cos \omega t$

Demo

SHM/Circular motion analogy

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

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

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

Period

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

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 ← book formula
c. it depends

Experiment: change amplitude

Experiment: change mass

Summary:

$$\omega = \sqrt{\frac{g}{l}}$$

Frequency

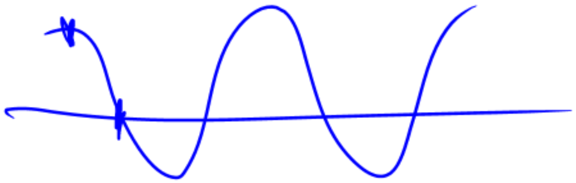
$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

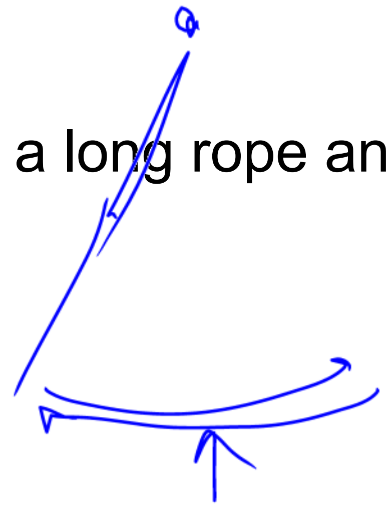
Period

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

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

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

$$g\frac{T^2}{(2\pi)^2} = l$$

$$\frac{(9.8\,\frac{m}{s^2})(5\,s)^2}{(2\pi)^2} = 6.21\,m$$

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?

"Think-pair-share"

- Think about it for a bit
- Talk to your neighbor, find out if he/she thinks the same as you
- Be prepared to share your answer with the class if called on

Clicker: I am now ready to share my answer if randomly selected.

a. Yes

Note: you are allowed to "pass" if you would really not answer.

Waves

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

Direction: where the energy is going

Medium: what is doing the "waving"

Transverse vs. Longitudinal: how the medium is moving

Transverse—Oscillation is $\perp$ to the direction of the wave

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

Demo: Suspended slinky

Wave Examples

Slinky (demo)

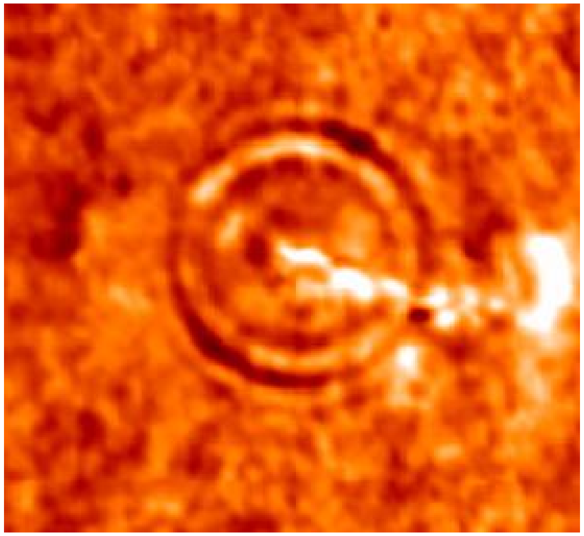
Rope (demo)

Water

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

Sound

Light



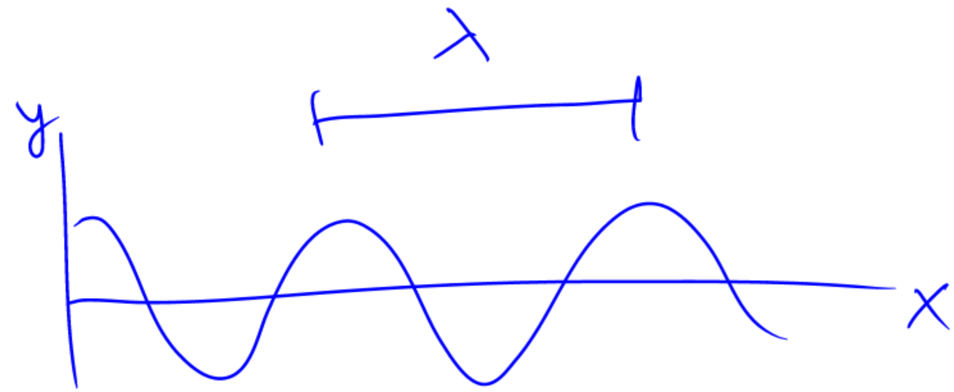
surface of the Sun

λ lambda

Speed, frequency, wavelength

m/s — wave/s — m/wave

$$v = f\lambda$$



$f = 97.5 \cdot 10^6$ Hz

Worked Problem

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?

$$c = f\lambda$$

$$v_{light} = 3 \cdot 10^8 \text{ m/s}$$

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

$$T = \frac{1}{f} = \frac{1}{97.5 \cdot 10^6 \ \frac{1}{s}} = \boxed{10.3 \cdot 10^{-9} \text{ s}}$$

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

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?

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×