Announcements

1. Start thinking about Exam 4
   a. Covers chapters 9-12
   b. Starts Dec 7, a week from tomorrow!

2. Instructor/course evaluations before Dec 13
   http://studentratings.byu.edu

Review of Last Lecture

- **Work on gas** = area under curve in P-V diagram
  
  \[ W_{\text{on gas}} = \text{area under curve in P-V diagram} \]

  (\( = -P\Delta V \) for constant pressure process)

- **Internal energy** \( U \) depends only on \( T \); often it’s strictly proportional
  
  \( U = \frac{3}{2} nRT \) for monatomic ideal gas

- Visualizing isothermal contours in P-V diagrams helps understand changes in temperature—and hence \( U \)

  1st Law: \( \Delta U = Q_{\text{added}} + W_{\text{on system}} \)

  Engines: transform heat to work

  2nd Law: \( Q_h = |W_{\text{net}}| + Q_c \)

  Efficiency: \( \eta = \frac{|W_{\text{net}}|}{Q_h} \)

  **Carnot Theorem:**

  \[ \eta = \frac{T_c}{T_h} \]

  **Song:**

  http://www.uky.edu/~holler/CHE107/media/first_second_law.mp3

  The end of Exam 4 material!

Simple harmonic motion → **Sinusoidal vibrations**

- **Demo:** weight on spring

  Occurs if the force on a mass is spring-like:

  \( F = -kx \) displacement

  Displacement \( x = A \cos(\omega t) \) or \( x = A \sin(\omega t) \) or \( x = A \cos(\omega t + \phi) \)

  **Example:**

  - Amplitude \( A = \) __________, (from 0 to max)
  - Period \( T = \) __________ sec
  - Frequency \( f = \) __________ cycles/sec (Hz)
  - Angular frequency \( \omega = \) __________ rad/sec

  \[ f = \frac{\omega}{2\pi} \]

  **Demo:** Circular motion/SHM analogy

Kinetic and potential energy vs time?

Mass and spring

- **Pendulum**

  Frequency, period:

  **Demo:** pendulum

  Does period depend on amplitude?
Simple Problem: The position of a mass vibrating on a spring is
\[ x(t) = 4\text{cm} \cos(8t). \]
What’s the amplitude and frequency \((f)\) of oscillation?

Q4. What’s the period of oscillation in the graph below?

![Graph of oscillation]

a. 1 s  
 b. 2 s  
 c. 3 s  
 d. 4 s

Q5. What’s the correct equation for the above oscillation?

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. \(x(t) = 3 \cos(\pi t)\)

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Worked Problem: A 70 kg trapeze artist swings on a long trapeze 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? _______ sec

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

How long is the rope? __________ m

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Types of Waves

Transverse—The disturbance is \(\perp\) to the direction of the wave

Longitudinal—The disturbance is along the direction of the wave

Web Link: http://www.gmi.edu/~drussell/Demos/waves/wavemotion.html

The medium of the wave:

- slinky  
  Demo: slinky
- rope
- sound  
  gas  
  solid  
  earthquake P & S waves  
  Mnemonic: “S” for “shear”
- light
- water

What’s “moving” locally as a wave goes by?

Demo: Shive wave machine
Demo: Sinewave animation: http://www.colorado.edu/physics/phet/simulations/stringwave/stringWave.swf

What gets transported by the wave?

Speed, wavelength and frequency  

\[ v = f \lambda \]

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Worked Problem: One of my favorite radio stations is AM 1320, 1320 kHz (Go Jazz!). Radio waves travel at the speed of light, \(3 \times 10^8\) m/s. What is the wavelength of these radio waves? What is the period?
Why do some waves go faster than others?

Wave speed on string, rope or cable: \( v = \sqrt{\frac{T}{\mu}} \)

**Demo:** surgical tubing

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Q6. 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. \( \frac{1}{4} \)
- b. \( \frac{1}{2} \)
- c. the same as
- d. \( 2 \times \)
- e. \( 4 \times \)

Q7. 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

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**Reflection**

- What happens when a pulse hits the end and turns around? Does it return on the same side of the rope or does it invert?

heavy and light ropes.

light, sound

**Superposition**

- What happens if two pulses, one from each end, meet in the middle? Do they pass through or reflect back when they meet?

Web Link:
http://www.kettering.edu/~drussell/Demos/superposition/superposition.html