Announcements 4 May 09

- **Homework**
  - **Online homework #12 due tomorrow by 8 am**
  - **Homework #13 (last one!) will be due next week**
- **Exam 3**
  - **Wednesday May 6 from 7 to 9 pm**
  - **See info on course blog**
  - **Help session tonight 5:30 – 7:00 pm (in HAS 20)**
  - **SI session tonight 7:15 – 8:30 pm (in DuBois 1085)**

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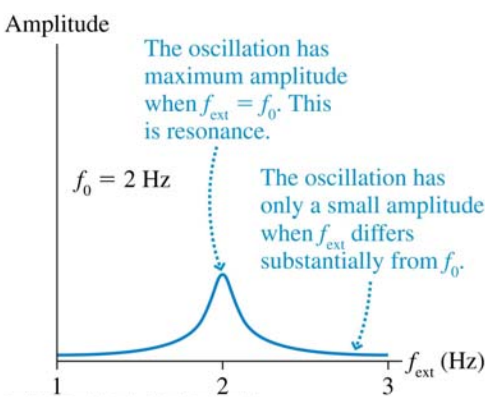
Resonance



DEMO:
glass beaker breaking

- A system displaced from its equilibrium position will oscillate with a *natural frequency f_0* if left to oscillate freely.
- If an oscillating external force is exerted with a *driving frequency f_{ext}* then the system will also oscillate at frequency f_{ext}. The amplitude of this oscillation is amplified when f_{ext} is close to f_0. *We then talk about a resonance.*

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Exam #3 Information (I)

- What will be covered?
  - Momentum (Chapter 9 of the textbook Secs. 1-5)
  - Energy and work (Chapter 10 Secs. 1-10 and Ch 11 Secs. 1-6)
  - Oscillations (Chapter 14 Secs. 1-7)
  - Material from homework assignments #9, #10, #11, #12
- Exam format
  - Multiple choice + 1 written problem
  - Mixture of conceptual questions (PRS like) and numerical problems (homework like)
  - Sample exam provided for practice (sample exam will be discussed during the special help session)

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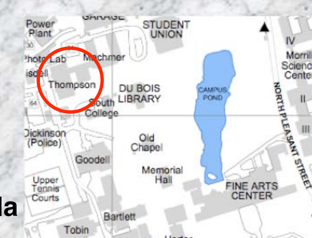
Exam #3 Information (II)

- Exam location on Wednesday May 6 from 7 to 9 pm
  - Location depends on the first letter of your last name:
    - A through F THOM 102
    - G through O THOM 104
    - P through Z THOM 106



- What to take to the exam?
  - Calculator, #2 pencil, *hand-written* formula sheet + student ID
  - No book, no scratch paper (should not be needed)
- Resources
  - Help session on Monday May 4 from 5:30 to ~7:00 pm in HAS 20
  - Sample exam 3 + homework + lecture notes + MasteringPhysics Exam 3 practice + textbook problems (answers to odd-numbered problems are in the back of the book)

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Exam 3: units

Use SI units

Generally need to convert all quantities to SI units

distance unit:	m
mass unit:	kg
time unit:	s
force unit:	N (or kg m/s^2)
momentum unit:	kg m/s
energy unit:	J (or kg m^2/s^2)

Conversions

1 km = 10^3 m   1 cm = 10^{-2} m   1 mi = 1600 m

1 gram= 10^{-3} kg

1 h = 3600 s   1 min = 60 s

1 lb = 4.45 N

1 cal = 4.19 J

1 "food calorie" is 1 Cal = 1 kcal = 4190 J

$360^o = 2\pi$ radians

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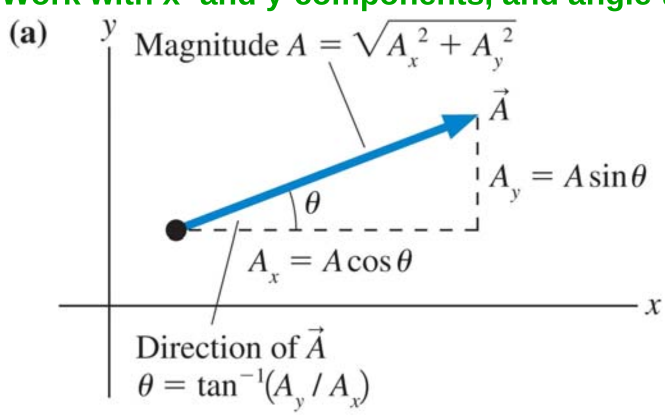
Exam 3: vectors & concepts

Work with x- and y-components, and angle θ



Know and understand main concepts in the lecture notes

impulse, momentum, energy, work, heat, collisions, oscillations

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Exam 3: Equation toolkit

Impulse (J) and Momentum (p)

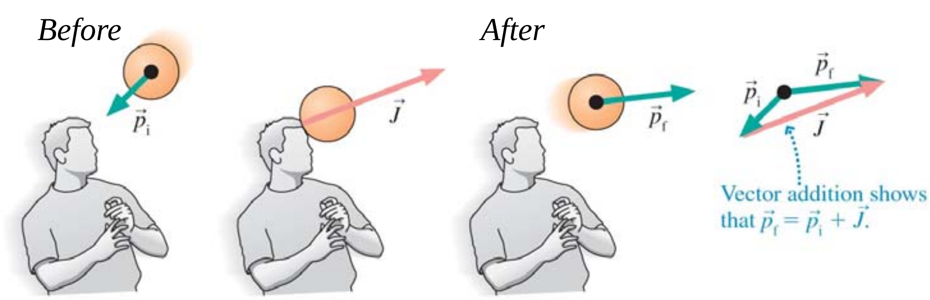
remember these are vector quantities
important to keep track of direction
(negative for motion to the left)

$$\vec{J} = \vec{F}\Delta t$$

$$\vec{J} = \vec{p}_f - \vec{p}_i = \Delta\vec{p}$$

$$\vec{p} = m\vec{v}$$

m: mass of object
v: velocity of object



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Exam 3: Equation toolkit

Collisions and Explosions

analyze with *momentum conservation* (p is vector quantity!)
can apply momentum conservation if system is isolated or if external forces can be neglected during brief moment of collision

SOLVE The mathematical representation is based on the law of conservation of momentum: $\vec{P}_f = \vec{P}_i$. In component form, this is

$$(p_{1x})_f + (p_{2x})_f + (p_{3x})_f + \cdots = (p_{1x})_i + (p_{2x})_i + (p_{3x})_i + \cdots$$
$$(p_{1y})_f + (p_{2y})_f + (p_{3y})_f + \cdots = (p_{1y})_i + (p_{2y})_i + (p_{3y})_i + \cdots$$

typical cases:

1. collision between two objects
2. explosion into two parts
   (P_i = 0 if "exploding" object is at rest)

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Exam 3: Equation toolkit

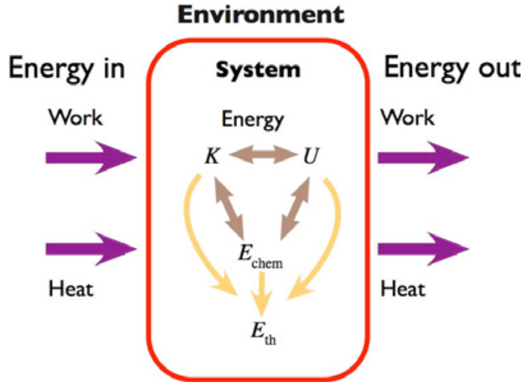
Energy

- A system is characterized by a total energy *E*

$$E = K + U_g + U_s + E_{th} + E_{chem} + \ldots$$

- Energy is conserved if system is isolated, or $\Delta E = W+Q$

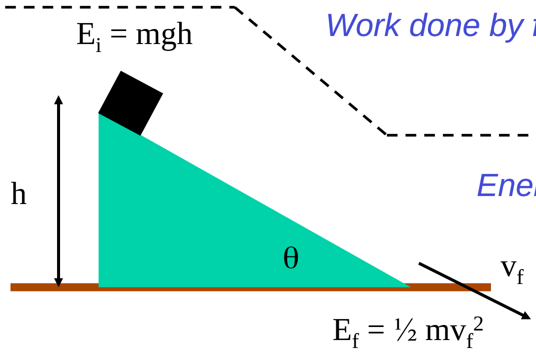
$$\Delta K + \Delta U_g + \Delta U_s + \Delta E_{th} + \Delta E_{chem} + \ldots = W + Q$$



Exam 3: Equation toolkit

Energy

- Kinetic energy $K = \frac{1}{2}mv^2$
- Gravitational potential energy $U_g = mgy$
- Spring potential energy $U_s = \frac{1}{2}kx^2$



Work done by force F: $W = Fd\cos\theta$

Energy conservation leads to: $v_f = \sqrt{2gh}$

Exam 3: Equation toolkit

Thermal Energy & Temperature (Ideal Gas)

- Temperature is related to average kinetic energy of the atoms $$T = \frac{2}{3}\frac{K_{\text{avg}}}{k_{\text{B}}}$$
- Typical speed of atoms in the gas $$v_{\text{rms}} = \sqrt{\frac{3k_{\text{B}}T}{m}}$$
- Thermal energy of a system of N atoms $$E_{\text{th}} = \frac{3}{2}Nk_{\text{B}}T$$

Boltzmann's constant: $k_B = 1.38 \times 10^{-23}$ J/K

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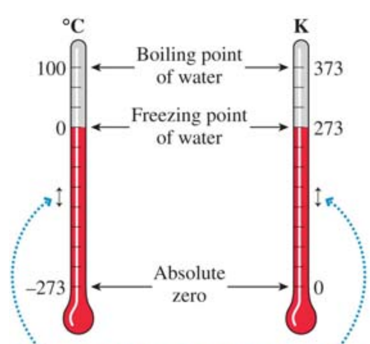
Exam 3: Equation toolkit

Thermal Energy & Temperature (Ideal Gas)

- Celsius scale (T_C)
  - 0 °C freezing point of pure water
  - 100 °C boiling point of pure water
- Fahrenheit scale (T_F)
  $$T_C = \frac{5}{9}\left(T_F - 32°\right)$$
- Kelvin scale (T)
  - 0 K kinetic energy of atoms is zero
  - $T = T_C + 273$

use Kelvin for E_{th} and temperature calculations



Temperature *differences* are the same on the Celsius and Kelvin scales. The temperature difference between the freezing point and boiling point of water is 100°C or 100 K.

$$e_{\text{max}} = 1 - \frac{T_C}{T_H}$$

Theoretical maximum efficiency of a heat engine

Heat Engine max efficiency

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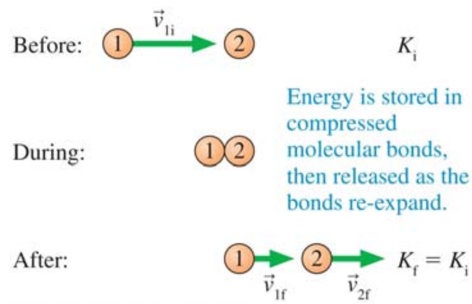
Exam 3: Equation toolkit

Collisions

- Perfectly elastic:

  momentum and mechanical energy is conserved



- Perfectly inelastic:

  (objects "stick" together after the collision)

  only momentum is conserved

Power

Energy / time

$$P = \frac{W}{\Delta t}$$

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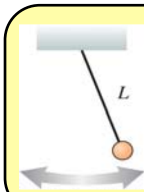
Exam 3: Equation toolkit

Oscillations

Period of oscillation T (time for one cycle) does not depend on the displacement from equilibrium



Pendulum:

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

Spring:

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

Simple harmonic motion described by

$$x(t) = A\cos(2\pi f t)$$
$$v_x(t) = -(2\pi f)A\sin(2\pi f t)$$
$$a_x(t) = -(2\pi f)^2 A\cos(2\pi f t)$$

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

Amplitude A = max displacement from equilibrium point

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