Welcome!

June 18, 2007
What are we doing here?

- Learning physics
  - Squeezing all of physics into one week!

- Learning how to teach physics so it is fun for you and the students
  - Most activities can be directly transferred to the classroom

Some math involved!
Topics in Classical Physics

- Motion
- Heat
- Electricity
- Magnetism
- Sound
- Light
Motion

- Motion can be explained by two things:
  - Conservation of Energy
  - Newton’s Laws
Energy Bingo!

- Get a signature in each box from someone who knows the answer.
Conservation Laws

- Energy
- Momentum
- Mass
- Charge
Conservation of Energy

Energy here = Energy there

Roller Coasters are a perfect example!

Energy = Kinetic + Potential + Heat from friction

\[ E_{\text{total}} = KE + PE_g + W_{fr} \]
Energy Transformations

- Identify the energy transformation in each toy, demonstrations, experiment, etc.

**Types of Energy**

- Kinetic
- Potential
- Wind
- Geothermal
- Solar
- Heat
- Nuclear
- Sound
- Electricity
- Magnetism
- Light
- Chemical
How much energy does it have?

Kinetic: \[ KE = \frac{1}{2} mv^2 \]

Gravitational Potential: \[ PE_g = mgh \]

Spring Potential: \[ PE_s = \frac{1}{2} kx^2 \]

Heat: \[ Q = mc\Delta T \]

Work: \[ W = F \cdot x \]

Also (more complicated) equations to describe other types of energy. We’ll see some later this week.
Forces & Newton’s Laws

- Make a list of all the forces you can think of
Types of Forces

Contact Forces
- Push
- Pull
- Tension
- Friction
- Normal

Field Forces
- Strong Nuclear
- E&M
- Weak Nuclear
- Gravity
Forces & Newton’s Laws

- Use the carts to experimentally find Newton’s three laws of motion
- Write them in your own words
Newton’s 1st Law (as traditionally stated)

Law of Inertia: An object in motion stays in motion and an object at rest stays at rest unless acted upon by an unbalanced force.

What does this mean?
Newton’s 1st Law (translation)

- Key word: unbalanced

- What is equilibrium?
  - Can an object in equilibrium be moving?
  - When are there forces acting on it?

Inertia - the property of an object that resists changes in its motion
Newton’s 1st Law

Student Misconceptions

- Balanced forces = no forces
- Imagine a ball thrown in the air
  - What kind of forces are involved?
  - Contact vs. Field forces
Newton’s 2nd Law
(as traditionally stated)

- A net force on an object results in an acceleration inversely proportional to its mass.
- In math terms:
  \[ \Sigma F = ma \]

Huh? What’s that funny letter?
Newton’s 2nd Law (translation)

- A force makes something start or stop moving.
  - Wait...that sounds familiar...

The 2nd Law is just the 1st Law in quantitative terms.
Newton’s 3rd Law
(as traditionally stated)

- Every action force has an equal and opposite reaction force.

AKA The Law of Rockets
Newton’s 3rd Law

Student Misconceptions

- Try this one:
  - Identify the action-reaction pairs:

- $F_{\text{table on book}}$ (Normal Force)
- $F_{\text{earth on book}}$ (Gravity)
- $F_{\text{book on earth}}$
- $F_{\text{book on table}}$
Projectile Motion

- Where are the forces acting?
- When is the ball accelerating? In what direction?

\[ \Delta x = v_0 t + \frac{1}{2} at^2 \]

\[ v = v_0 + at \]

\[ v^2 = v_0^2 + 2a\Delta x \]
Momentum

- What’s conservation of momentum?

- Use the carts to figure out what’s conserved during a collision.
  - Hint: try varying the masses and speeds
Momentum

- Momentum is the product of an object's mass and velocity:
  \[ p = mv \]

- Conservation of momentum:
  \[ p_{\text{before}} = p_{\text{after}} \]
What if something is spinning?

- All parts of linear motion have an angular equivalent:
  
  Force = Torque
  
  Mass = Rotational Inertia
  
  Momentum = Angular Momentum
Gravitation

♦ Newton’s Great Insight
  ♦ Newton unites the heavens and the earth through his Law of Universal Gravitation
  ♦ All bodies attract all other bodies.

♦ Einstein’s Revision
  ♦ Gravity isn’t a force, but a curvature of the spacetime continuum!