


Chapter 4

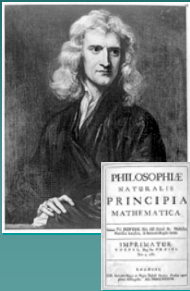
Making Sense of the Universe

"If I have seen farther than others, it is because I have stood on the shoulders of giants." — Sir Isaac Newton (1642 – 1727)

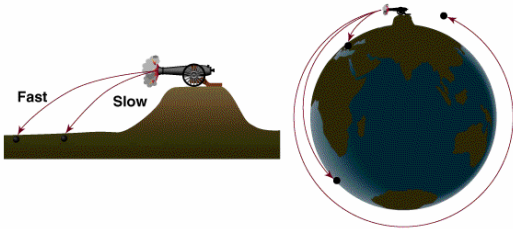


Newton's First Law

- ◆ Law of Inertia
- ◆ "A body remains at rest or moves in a straight line at a constant speed unless acted upon by a force."
- ◆ Newton's Cannon

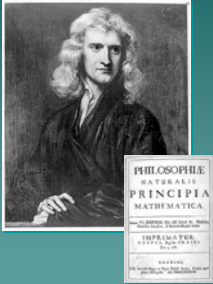


Newton's Cannon and Orbit



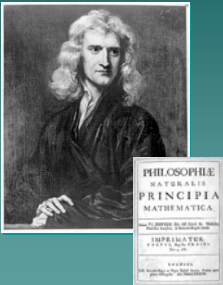
Newton's Second Law

- ◆ $F = m a$
- ◆ "The amount of acceleration that a force produces depends on the mass of the object being accelerated."



Newton's Third Law

- ◆ Action-Reaction
- ◆ "Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body."



Newton's The Law of Gravity

- ◆ Every mass exerts a force of attraction on every other mass.
- ◆ The math...

$$F = \frac{GMm}{r^2}$$

- ◆ $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Gravity Questions

- ◆ Did the Moon exert a gravitational force on the Apollo astronauts?
- ◆ What kind of objects can exert a gravitational force on other objects?
- ◆ The constant G is a rather small number. What kind of objects can exert strong gravitational forces?

<http://football.fedex.com>

Gravity Questions

- ◆ If the distance between two objects in space is doubled, then what happens to the gravitational force between them?
- ◆ What if the distance is tripled?
- ◆ ...quadrupled?

Definitions

- ◆ Speed
 - Distance per unit time (miles/hour)
- ◆ Velocity
 - Speed with direction (mile/hour North)
- ◆ Acceleration
 - Change in Velocity
- ◆ What are three examples of acceleration?
 - Speeding up
 - Slowing Down
 - Turning
- ◆ Force
 - An influence on motion
 - e.g. pushing, pulling, friction, gravity, etc.

What is universe made of?

- ◆ Answers:
 - Space
 - Energy
 - Matter
 - ◆ e.g. rock, water, air
- ◆ What is Energy?
 - It is the mover of matter.
 - It is measured in Joules or BTU's.

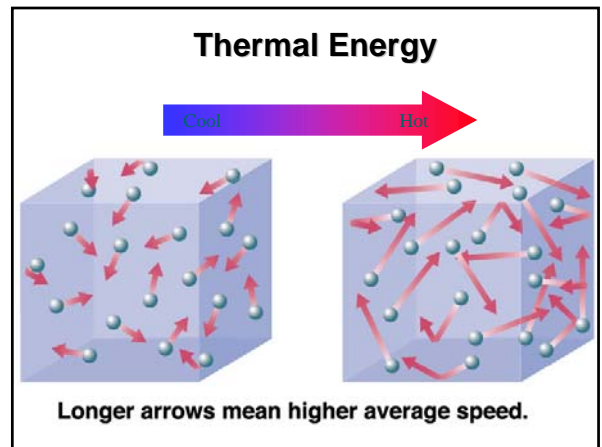
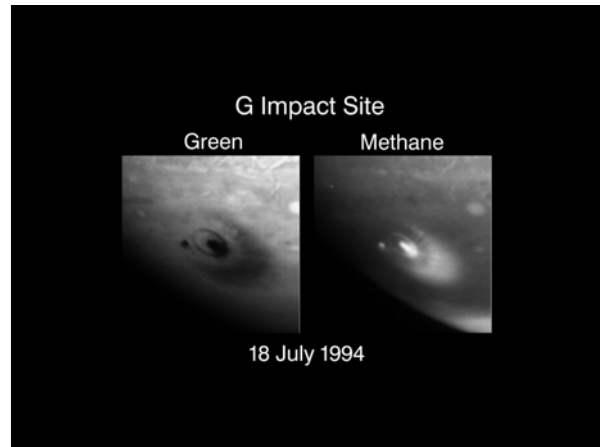
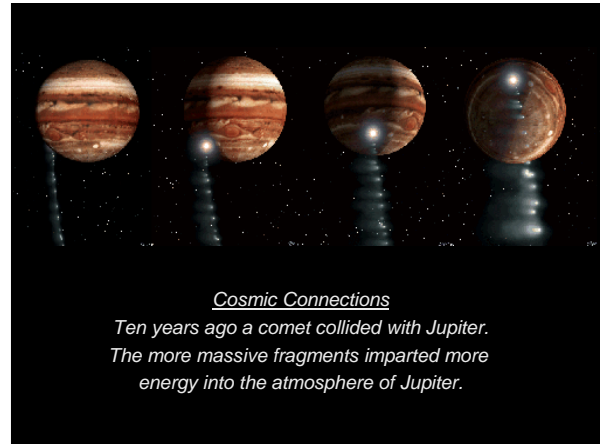
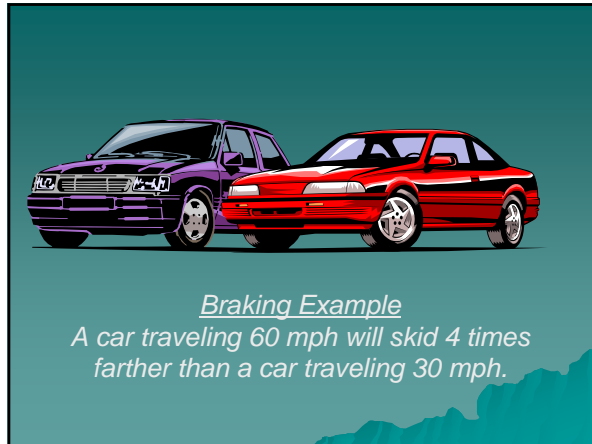
Types of Energy

- ◆ Kinetic
- ◆ Potential
- ◆ Radiative
- ◆ Thermal
- ◆ Mass-energy
- ◆ And others...

Kinetic Energy

- ◆ Kinetic Energy is the energy of motion.
- ◆ Kinetic Energy = $\frac{1}{2}$ mass \times speed²

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

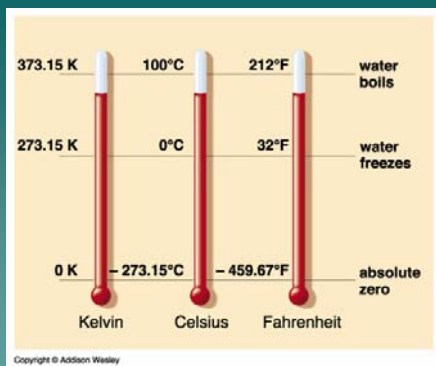


◆ Thermal Energy

– Particles move faster in hot objects.

Temperature Scales

	Fahrenheit	Celsius	Kelvin
Boiling Point of Water	212°F	100°C	373 K
Freezing Point of Water	32°F	0°C	273 K
Absolute Zero	-459°F	-273°C	0 K



Potential Energy

◆ The energy that is stored is called potential energy.

◆ Examples:

- Rubber bands
- Springs
- Bows
- Batteries
- Gravity
- Chemical

Mass-Energy

◆ $E=mc^2$

◆ Is it possible to convert mass into pure energy?

– Answer: Yes, our Sun does this.

Conservation of Energy

- ◆ “Energy cannot be created or destroyed...
- ◆ ...it may be transformed from one form into another.”

◆ Example

- Our Sun converts mass energy into radiative energy (i.e. light).
- Wow!