Chapter 2: Laws Governing Motion

Did you read chapter 2 before coming to class?
A. Yes
B. No

A few items of business

- Clickers and quizzes.
  - You can't register your clicker until we get you into the roll in our system. This may take a few days. Keep taking quizzes, and after you register we'll import the scores.
  - 2 pts per lecture (average of all clicker quizzes day), and we count your best 30 lectures out of 42 days of class.
- Homework
  - 33 Questions/worksheets worth 4 pts each. We count your best 25.
- Lecture slides at http://qoptics.byu.edu/ps100.aspx

What should you be doing now?

- Read each chapter before coming to class
- Review the learning objectives at the beginning of each chapter to make sure you "get it" (The learning objectives are our guidelines when we go to make a test)
- Quiz yourself with the questions at the end of the chapter
- Go to your TA section
- Do your homework (often can be competed in TA section)
- I highly recommend that you take some time to prepare for and take the exemption exam.

Large and small numbers

- Large and small numbers are hard to visualize

3 Marbles

16 marbles

1,079 marbles

Small numbers: imagine fractions (pie slices).

Large and small numbers

- We will use "scientific notation" to write large and small numbers

Examples

$1x10^{5}$ =100,000

$1x10^{42}$ =1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

$1x10^{-5}$ =0.00001

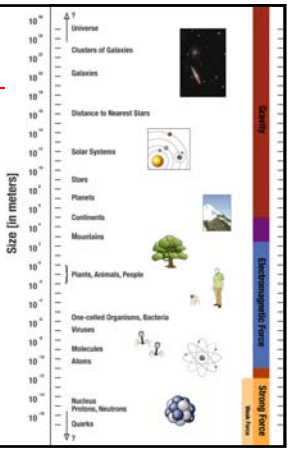
$1x10^{-42}$ =0.00000000000000000000000000000000000000000001

Changes in motion are the essential elements of *all* change that we observe.

- Changes in an object's motion arise only when it interacts with another object.
- We know of only four ways that objects can interact:
  1. Nuclear Strong
  2. Nuclear Weak
  3. Electromagnetic
  4. Gravity

Interactions

- Interactions between objects result in a "push" or a "pull" referred to as a force
  - Objects with mass experience the gravitational force
  - Objects with charge experience the electromagnetic force
  - We won't talk about nuclear forces until chapter 25.



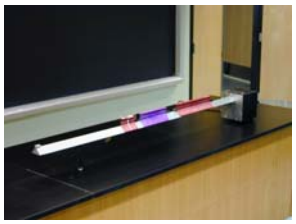
Newton's laws of motion

1st Law: Inertia

An object in a state of rest or in a state of uniform motion will stay in that state of rest or uniform motion until compelled to do otherwise by forces acting upon it.

Uniform motion

- Uniform motion is motion at a constant speed in a straight line.
- Forces arise when objects interact to create a "push" or "pull" and can change uniform motion.



Some examples of the first law

- The "dinner table" magic trick
- Car seats and safety belts

Newton's laws of motion

2nd Law: Acceleration

An object's acceleration (i.e. its change in motion) can be quantified if we know the mass of an object and the forces that act on the object

This is vague—let's refine what we mean!

Speed vs. velocity

Speed

- The rate of change in position, independent of direction. Represented by a single number.

Velocity

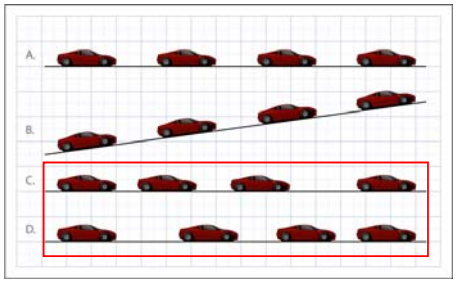
- Speed combined with the direction of motion. Represented by an arrow with length and direction.

Acceleration

- Acceleration: The change in an objects velocity—speed and/or direction
- A car has three "accelerators":
  - Speeding up
  - Slowing down (deceleration)
  - Changing directions (centripetal)

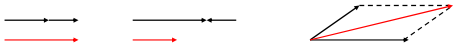
- Like velocity, acceleration is represented with an arrow

In which of the following cases is the car in accelerated motion?



Forces cause acceleration

- We use arrows to represent the forces (size and direction)
- If more than one force acts on an object, the arrows add to make the net force (i.e. the combined force)



Example

- Are there forces acting on the rock?
- Is there a net force on the rock?
- Is the rock accelerating?

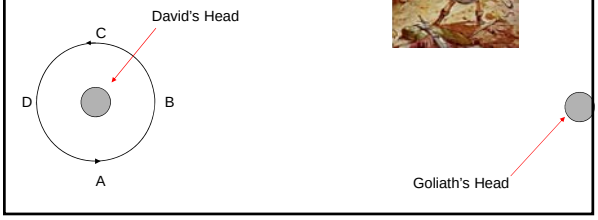
Some Key Ideas

- If you observe an object at rest or in uniform motion then:
  - The acceleration is zero by definition.
  - There are no unbalanced forces.
- If you observe an object being accelerated then:
  - There is an unbalanced force on that object.

NO EXCEPTIONS!!!!

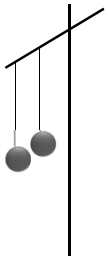
David and Goliath

- At what point should David let go of the rock?



Besides the net force, what else determines acceleration?

- Mass: the property of objects that determines how much they accelerate in response to a given applied force. (mass resists acceleration)



Newton's laws of motion

2nd Law: Acceleration

The acceleration of an object is proportional to net force acting on it, and inversely proportional to its mass. The direction of the acceleration is the same as the direction of the net force.

$$\text{Acceleration} = \frac{\text{Force}}{\text{mass}}$$

or

$$F = ma$$

Which statement best describes the situation pictured below

A. The racket is exerting a force on the ball
B. The ball is exerting a force on the racket
C. Both A and B are correct, but the force on the ball is greater
D. Both A and B are correct and the forces are equal in magnitude

Photo by Amoz Eckerson, 1995

Newton's laws of motion

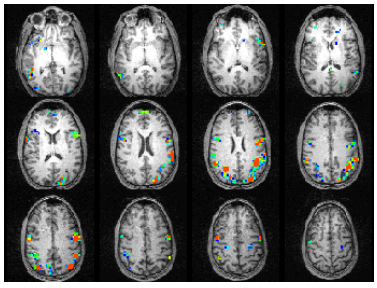
3rd Law: Interactions

All forces result from interaction between pairs of objects. No Exceptions.

When interacting, each object exerts a force on the other.

The two forces have the same strength and act in exactly opposite directions (but act on different objects).

A memory device…



Artillery experiment

- Did we create a force on the projectile?
- What exerted the force on the projectile?
- Did the projectile exert a force on anything?
- Why did the two objects accelerate differently?

How does a rocket work?

New York Times on Robert Goddard January 13, 1920

… after the rocket quits our air and really starts on its longer journey it will neither be accelerated nor maintained by the explosion of the charges it then might have left…

[Professor Goddard] does not know of the relation of action to reaction, and the need to have something better than a vacuum against which to react.

[He] only seems to lack the knowledge ladled out daily in high schools.

New York Times on Robert Goddard July 17, 1969

Further investigation and experimentation have confirmed the findings of Isaac Newton in the 17th century and it is now definitely established that a rocket can function in a vacuum as well as in an atmosphere. The Times regrets the error.

Using the laws of motion, we can predict the future

Something to think about: The reluctant horse

- "Every time I pull on the cart, it pulls back with equal force. Therefore I cannot pull the cart."