Today

- Announcements:
  - HW#2 is due Wednesday by 8:00 am
  - Extra Credit project #1 in on the LONCAPA website. Length should be about 1 paragraph. An excellent description will get 6 points.

- Review

- What is Force? Introduction
Units

• Physical quantities always have a unit attached; for example 2 meters
• Some quantities are a combination of units; for example 1 liter = 1000 cm$^3$ (LONCAPA
  1000 cm$^3$ or 1.0E3 cm$^3$ or 1.0E-3 m$^3$)
• How many liters are in a gallon?
Unit Conversions

3.7854 \text{l} = 1.000 \text{ gallons}

1.000 = \frac{3.7854 \text{l}}{\text{gallon}}

Let's take an example:
Suppose we have 16.4 gallons.

How many liters is that?

16.4 \text{ gal} = 16.4 \text{ gal} \times \frac{3.7854 \text{l}}{\text{gal}} = 62.1 \text{l}
Another example of unit conversion

100\text{cm} = 1.00\text{m}

This means there are: \( \frac{1.00\text{m}}{100\text{cm}} \)

\( 11.2\text{cm}^2 = 11.2\text{cm}^2 \times \left( \frac{1.00\text{m}}{100\text{cm}} \right)^2 = 1.12 \times 10^{-3}\text{m}^2 \)
LONCAPA Units

• We will use the System International (SI) system of units. Link

• Common units
  – Kilogram (mass) kg
  – Meter (length) m
  – Second (time) s
  – Newton (force) N – same as kg*m/s^2
  – Joule (energy) J – same as N*m
  – Moles (Amount of substance) - mol

• The LONCAPA system has help

• Frequency is 1/s (Hz)
# Prefixes

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**Example:**

\[ 2.0 \text{My} = 2.0 \times 10^6 \text{ y} \]
\[ 2.0 \text{My} = \frac{1 \text{Gy}}{1000 \text{My}} \times 2.0 \text{My} = 2.0 \times 10^{-3} \text{Gy} \]
Steps in calculating rates of change:
- Draw a line tangent to the curve at the time you want. The line can be any length.
- Mark two points on the line and record the values.
- Calculate the slope

\[ m = speed = \frac{d_2 - d_1}{t_2 - t_1} = \frac{6 - 2}{9.3 - 2.5} = 0.59 \text{ m/s} \]
Picture of the flight of a ball
Homework Problem Traveling Car

**Speed increasing** – acceleration and velocity in the same direction

**Speed decreasing** – opposite direction (deceleration)
History of our effort to understand motion

• Aristotle
  – Natural motions: items seek their natural locations
  – Violet motions like moving across the room require an agent

• Galileo
  – Tried to deduce the laws of motion from experiments
  – Introduced the concept of inertia. (Inertia is not a well defined concept.)

• Isaac Newton
What is a Force?

- A force is a push or pull.
- Force is a vector, it has a magnitude and a direction.
- A better definition is given by Newton’s Three Laws of Force (my versions)
  - If the net force on an object is zero the object will not accelerate.
  - The amount of acceleration depends on the mass of the object and the amount of the applied force: $F = ma$.
  - For every force, there is an equal and opposite force.
- Improved definition: Force is the rate of change of momentum.
Neglecting friction from the air, a 80.0 kg professor falls off a bench and accelerates toward the ground at 9.81 m/s².

What is the magnitude of the force of gravity on the professor?

\[ F = \text{mass} \times \text{acceleration} = 80.0 \text{ kg} \times 9.81 \text{ m/s}^2 = 785. \text{ N} \]
What is momentum?

- Momentum is mass times velocity.
- Momentum is a vector. Often we write it as a “p”.
- \( p = \text{mass} \cdot \text{velocity} \)
- Momentum is the modern analog to Galileo's idea of inertia.
Momentum Problem Picture

![Graph showing momentum and time relationship](image)
Momentum Problems

Hint: Force is the rate of change of momentum.

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\vec{p}_2 - \vec{p}_1}{t_2 - t_1}$$

magnitude of $F$ for motion in one dimension = $\frac{p_2 - p_1}{t_2 - t_1}$

Note: A negative slope means the direction of the force is toward $-x$. Force is a vector, and direction matters.
What is a force (continued)?

• These laws let us recognize a force, but what causes a force?
  – The modern view is related to field theory.
  – Forces are the result of an exchange of particles.

• To understand field theory, we have to start with energy and quantum mechanics (later in the term).