Basic Kinetic Concepts

- Inertia**:**
  - Natural property of a body to resist **a change** in state of motion (i.e., state of motion defined by velocity, Δ state of motion = acceleration)

Newton's 1st Law: Inertia

- A body will stay at rest...
- A body will continue to move with the same ***velocity*** unless...
- **A *net* force acts on the body**
  - e.g., to speed up or slow down an object's motion, and/or to change an object's direction of motion, and object's inertia must be overcome.

Mass

- **Quantity of matter** of which a body is composed (a measure of "stuff")
- Direct measure of a body's resistance to change in ***linear*** motion
  - e.g., it is more difficult to change the motion of a large object (large mass) than a small object
  - large mass (e.g., shot) vs. small mass (e.g., tennis ball). Which requires more effort (i.e., force)?

Definitions

- **Force**:
  - Effect of one body on another
  - A push or a pull applied to an object
  - That which is needed to change the state of motion (i.e., velocity) of an object
- Acceleration:
  - Rate of change of **velocity** of an object with respect to time.
    - Describes the change in state of motion of an object (i.e., Δ velocity)

Newton's 2nd Law: ΣF = ma

ΣF = "***Net force***" = **Sum of all forces**

m = mass (a measure of **inertia**)

a = **linear acceleration**

Example

- What average net force must a baseball catcher apply to an 80 mph (35.8 m/s) pitch to stop it over a time of .025 s? (mass = 4.5 oz = 0.13 kg)
  - Know:

    $m = .13\ kg;\ t = 0.025\ s;\ v_i = 35.8\ m/s;\ v_f = 0\ m/s$
  - Need:

    F
  - Use:

    $F = ma$ ...but…we must find a first and $a = (v_f - v_i)/t$
  - Answer:

    $F = ma = 0.13\ kg \times (0\ m/s - 35.8\ m/s)/0.025\ s =$ $\mathbf{-186.2\ N}$

- Things to consider:
  - The meaning of a negative force
  - Average v. instantaneous force
  - The effect of Δt on F
- Important interpretations of the $\Sigma F = ma$ relationship:
  - Cause (ΣF) and effect (a) relationship: *the most important concept in this class!*
    - ***a*** directly **proportional** to and in the same **direction** as ΣF
    - To produce a given ***a***, it takes a larger ΣF for a more **massive** object

Newton's 3rd Law: Action/Reaction

- Action-reaction: describes how objects interact with one another.
  - If one body exerts a force on a second body, the second exerts back on the first a force of **equal** magnitude but **opposite** direction
  - example: Vertical jumping
    - "Action" force is applied by **person (via muscles)** and acts on **ground**.
    - "Reaction" force is applied by **ground** and acts on **person**.

Newton's Law of Gravitation

- A fundamental physical principle that describes the concept of gravity...
- Any two particles of matter (any objects or bodies) attract one another with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them (i.e., distance between their centers).

$$F = G \cdot \frac{(m_1 \cdot m_2)}{l^2}$$

G = gravitational constant = 6.7 x 10^{-11} N·m^2/kg^2

- Like it or not, there is a force of attraction between you and the person sitting next to you.
  - However, this force is so small that you don't notice it.
  - When one of the objects is the earth (with its huge mass), the force of attraction (i.e. gravity) is very significant.

Example

$$F = G \cdot \frac{(m_1 \cdot m_2)}{l^2}$$

- Two students sitting 1.5 m apart

$$F = \left(6.7x10^{-11}\ N \cdot m^2 / kg^2\right) \cdot \frac{(70\ kg)(50\ kg)}{(1.5m)^2}$$

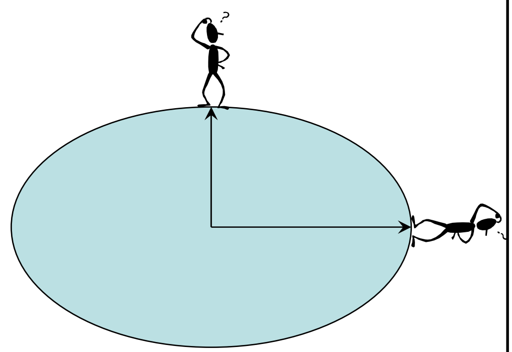
$$F = 10422x10^{-11} = 1.04x10^{-7}\ N$$

- Attraction between earth and student

$$F = \left(6.7x10^{-11}\ N \cdot m^2 / kg^2\right) \cdot \frac{(5.98x10^{24}\ kg)(50\ kg)}{(6.38x10^{6}\ m)^2}$$

$$F = 4.92x10^{1} = 491\ N$$

Weight



- Question: Is earth's gravitational attraction the same for all objects on or near the earth's surface?
- Answer: **NO**...this force is dependent on the involved masses and the distance between the CM of the object and the CM of the earth.

Weight vs. Mass

- Are weight and mass the same thing? **NO** (Why or why not)
  - An objects **weight** represents the force of attraction between the earth and the object. Mass represents the **quantity of matter or stuff of which a body is composed**.
- Simplified relationship for the link between weight and mass on earth:

$$W = mg$$

where $g = G \cdot \frac{m_{earth}}{l^2}$