Forces and Newton's Laws of Motion

- You will not be TESTED over the first few slides here, but you should be aware of the information as it represents the history of the material.

Aristotle

- Two types of motion
  - Natural Motion
    - Either straight up or down
    - Objects would seek their natural resting place
      - Light objects – up
      - Heavy objects - down
  - Violent motion
    - Result of forces – pushed or pulled
    - External cause
    - Objects could not move on their own

Copernicus

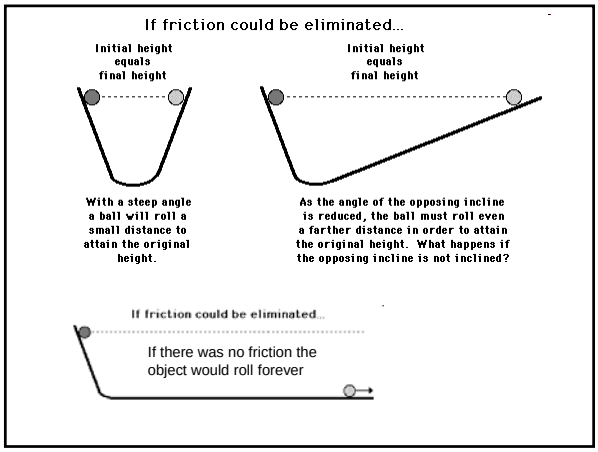
- Formulated theory that the Earth moved.
- Reasoned from his astronomical observations:
  - Sun was the center of the Universe
  - Earth and other planets moved around the Sun
- Published his theory in a book *De Revolutionibus,*
  - *First copy delivered to him on the day he died, May 24, 1543.*

Galileo

- Supported Copernicus' belief about the Earth revolving around the Sun
  - He was tried, excomunicated, and sentenced to house arrest for supporting the Copernican Theory
- Demolished the idea that a force was needed to keep an object moving
  - Determined that only when friction was present that an object needed a force to keep moving
- He observed balls rolling on inclined planes
- Galileo said that every material object has resistance to change in its state of motion.
  - He called this resistance ***inertia***

Galileo

- In his work with inclined planes found the following
  - A ball rolling down an inclined plane picks up speed
  - A ball rolling up an inclined plane slows down
  - A ball rolling on a horizontal plane has almost constant velocity



What is a force *(F)*?

- **A PUSH or a PULL on an object.**
- **An agent that results in the acceleration or deformation of an object.**
- **A vector quantity—it has magnitude and direction.**

Types of Forces

Contact Force
- Results from **direct physical contact** between two objects

Field Force
- Results without physical contact
- Theory: the presence of an object affects the space around it. The 'field' refers to the region of influence.
- Examples: gravity, electrical charges

Newton's First Law of Motion

(Sir Isaac Newton 1642-1727)

The Law of Inertia

An object at rest remains at rest,

OR

An object in motion remains in motion unless acted upon by a ***NET*** force

This is a restatement of Galileo's idea.

Since more than one force can act upon an object, the sum of all forces or *net* force (ΣF) must be considered.

Inertia

- Property of matter that opposes any change in its state of motion.
- Mass
  - It is harder to move something that has more mass than an object with little mass
  - amount of material in an object and depends only on the number of and kind of atoms that compose it
- Inertia is proportional to mass – if something has twice as much mass, it also has twice as much inertia

Newton's Second Law of Motion

Law of Acceleration

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

Better stated mathematically:

$$a = \frac{\sum F}{m} \qquad \textbf{or} \quad \sum F = ma$$

Force is in *Newtons* (N)
mass is in *Kilograms* (kg)
acceleration is in *Meters per Second per Second* (m/s/s or m/s^2)

Newton's Third Law of Motion

The Law of Interaction

For every force there is another force *equal in magnitude*, but *opposite in direction*.

These forces act on different masses.

These two forces are called action-reaction forces or third-law force pairs.

$$F_{ab} = -F_{ba}$$

Mass (kg) vs Weight (N)

Mass (m)

A measure of quantity of matter. The mass of an object is the *same everywhere*.

Weight (F_g) (WEIGHT IS A FORCE!!)

The force of that mass and depends upon the gravitational acceleration (*g*) due to the object attracting that mass.

The relationship between mass (m) and weight (F_g):

$$F_g = mg$$

Practice on Earth…near equator

Weight: 50.0 N
Mass: ?

Note "g" the acceleration due to gravity is a **positive** 9.8 m/s^2

$F_g = mg$

50.0 N = m(9.8 m/s^2)

m = 5.1 kg

Mass: 50.0 kg
Weight: ?

$F_g = mg$

F_g = 50.0 kg(9.8 m/s^2)

F_g = 490 N