The Ordered Universe

Chapter 2

Great Idea:

Newton's laws of motion and gravity predict the behavior of objects on Earth and in space

Chapter Outline

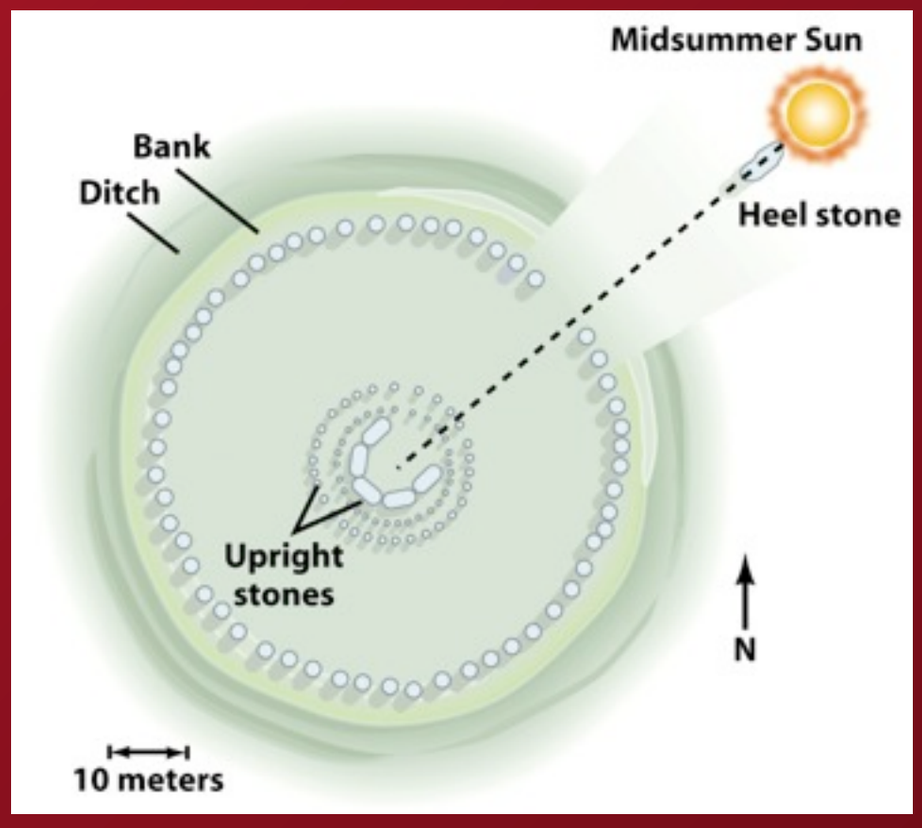
- The Night Sky
- The Birth of Modern Astronomy
- The Birth of Mechanics
- Isaac Newton and the Universal Laws of Motion
- Momentum
- The Universal Force of Gravity

The Night Sky

The Night Sky

- Movement of stars, planets, sun
  - Key for survival of ancestors
- Astronomy
  - First science
- Ancient observers:
  - Physical events are quantifiable and therefore predictable

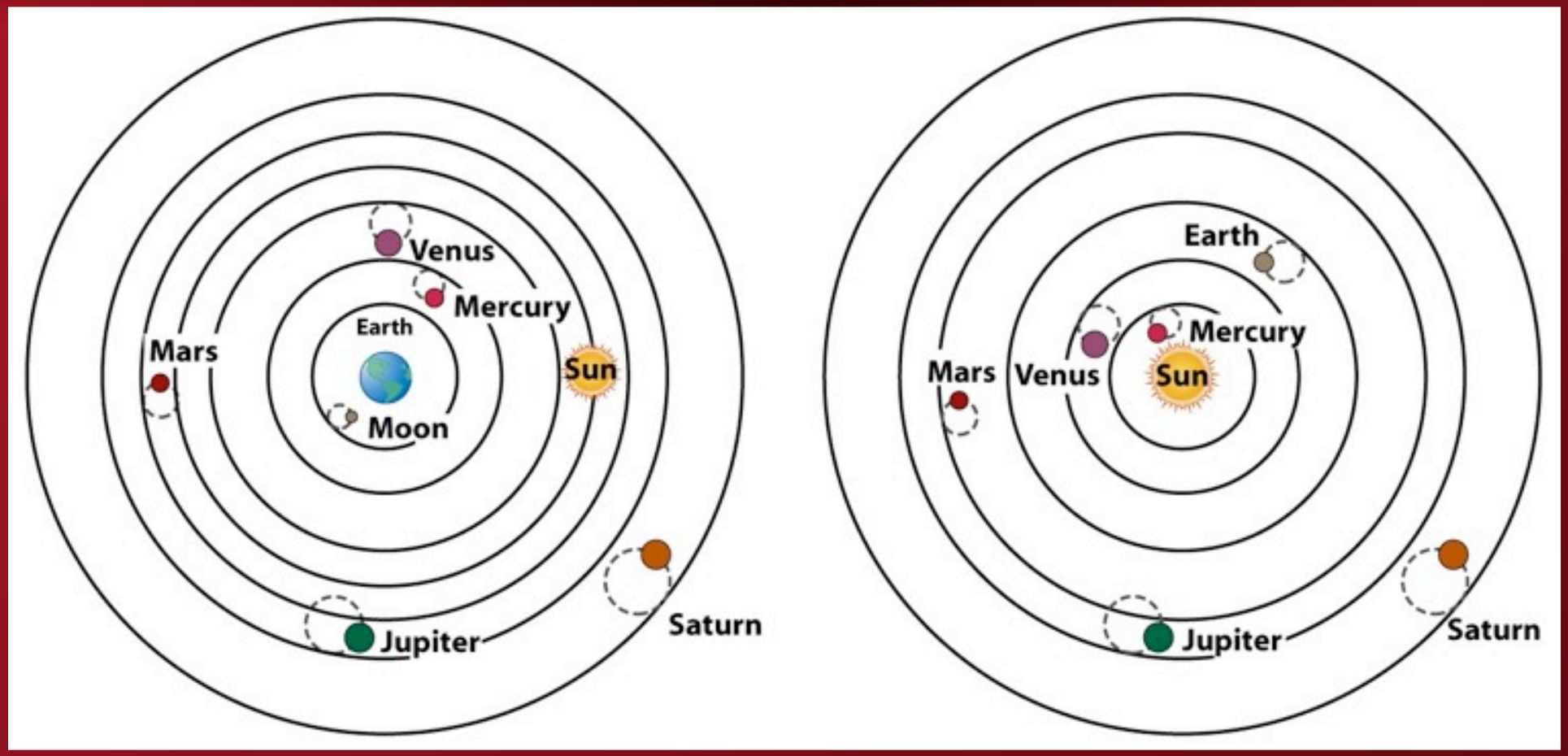
Stonehenge



- Started in 2800 B.C.
  - Built over long time
  - Built by different peoples
- Marks passage of time
  - Specifically the seasons
- Still functions today

The Birth of Modern Astronomy

The Historical Background: Ptolemy & Copernicus



Ptolemy

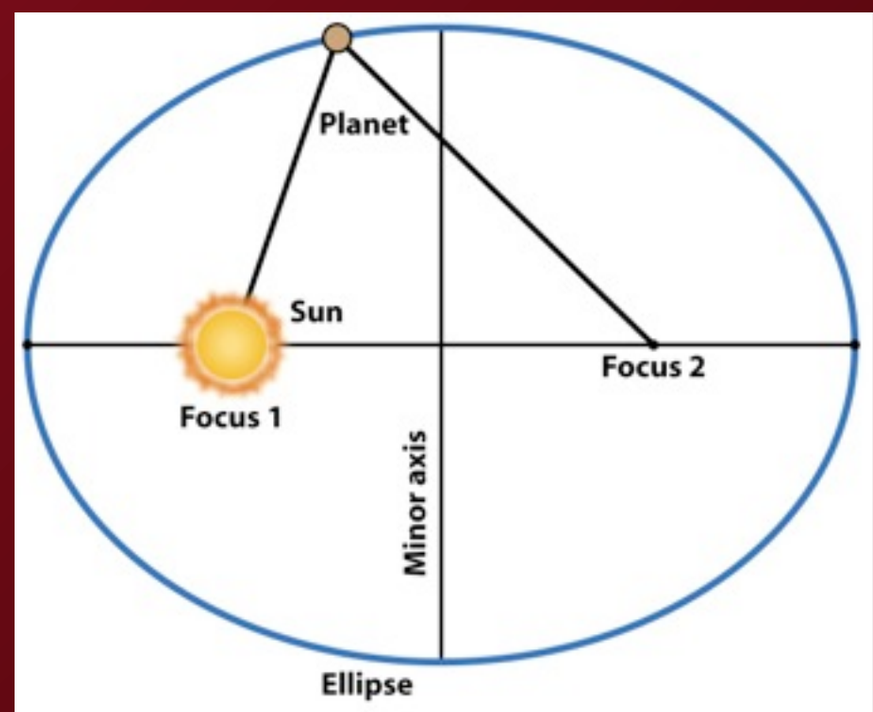
- 2nd century A.D.
- First planetary model
- Earth at center, stationary
- Stars and planets revolved around earth

Copernicus

- 1543: *On the Revolutions of the Spheres*
- Sun at center

Observations: Tycho Brahe & Johannes Kepler

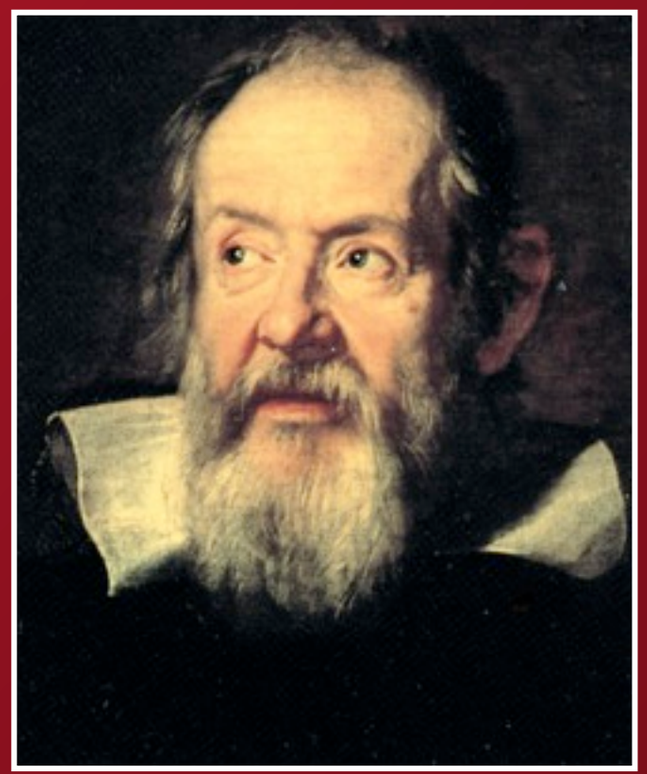
- Tycho
  - –Observed new star
    - Showed heavens can change
  - –Designed and used new instruments
    - Collected data on planetary movement
- Kepler (Tycho's colleague)
  - –First Law:
    - Planets have elliptical orbits



The Birth of Mechanics

Galileo Galilei

- Mechanics: motions of material objects
- Galileo (1564-1642)
  - –Mathematics professor
  - –Inventor
  - –First to record observations with telescope
    - Supported Copernicus' vie



Speed, Velocity, and Acceleration

- Speed-distance traveled over time
- Velocity-speed with direction
- Equation for speed:

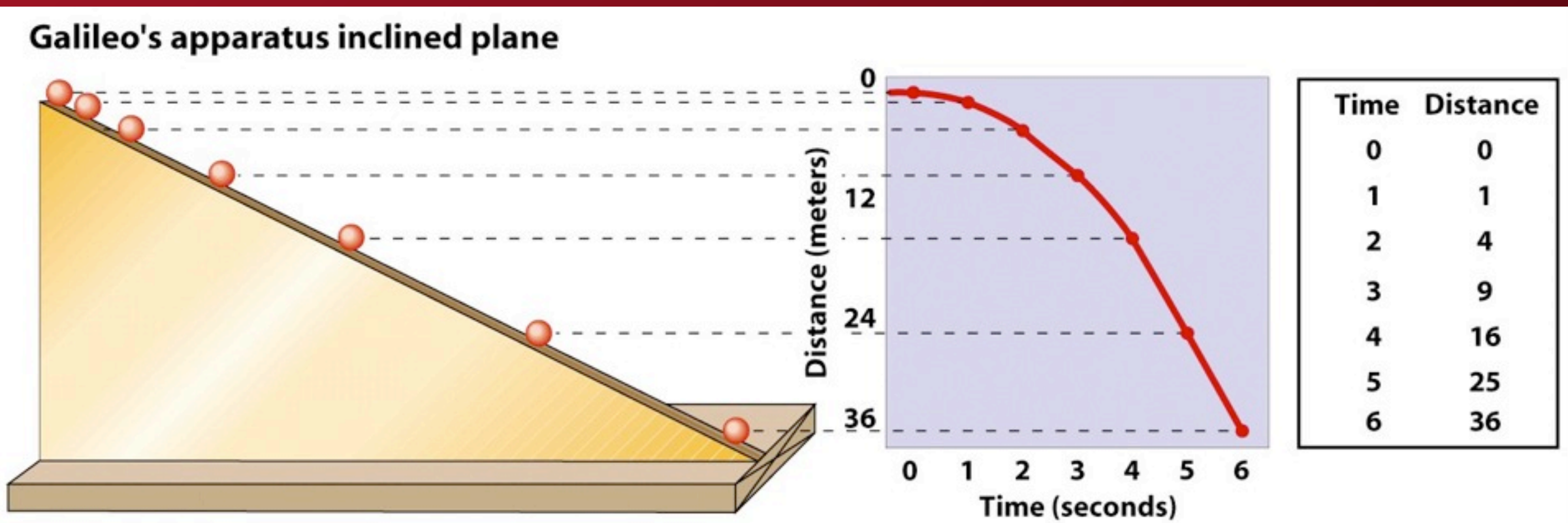
$$v = \frac{d}{t}$$

- Acceleration-rate of change of velocity
- Equation for velocity:

$$a = \frac{(v_f - v_i)}{t}$$

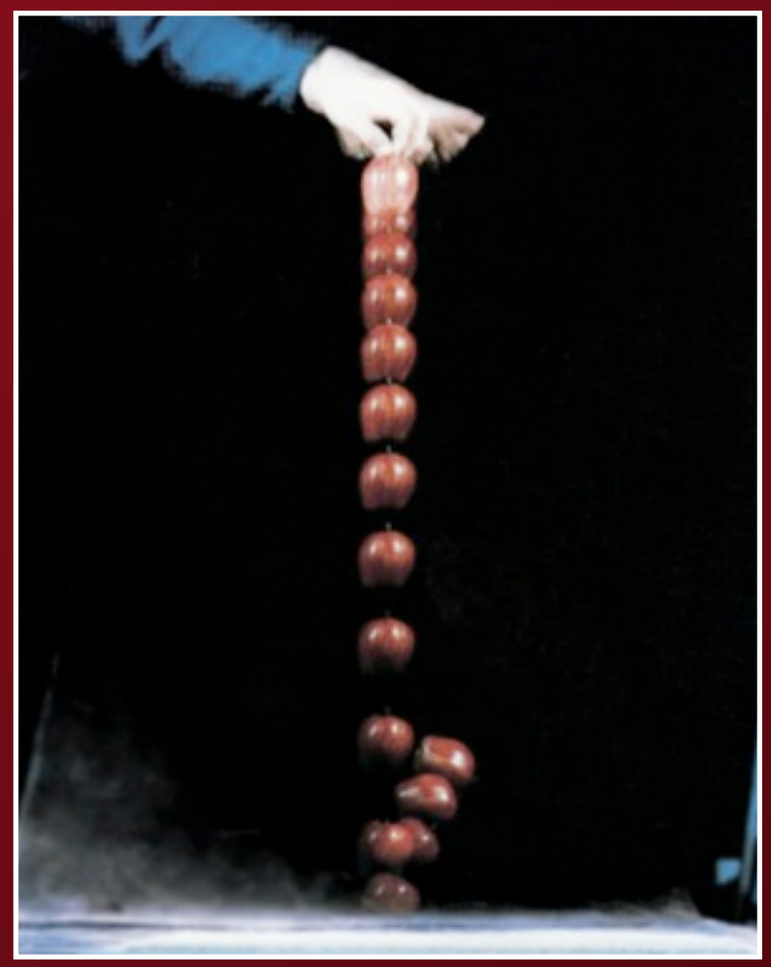
The Founder of Experimental Science

- Galileo
  - –Relationship among distance, time, velocity and acceleration
  - –Found objects accelerate while falling



Galileo cont.

- Constant acceleration
  - Balls on a plane: $v=at$
- Freefall
  - Constant acceleration at g
  - $g=9.8 m/s^2=32 feet/s^2$
  - Distance traveled (d)$=\frac{1}{2}at^2$



Isaac Newton and the Universal Laws of Motion

The First Law

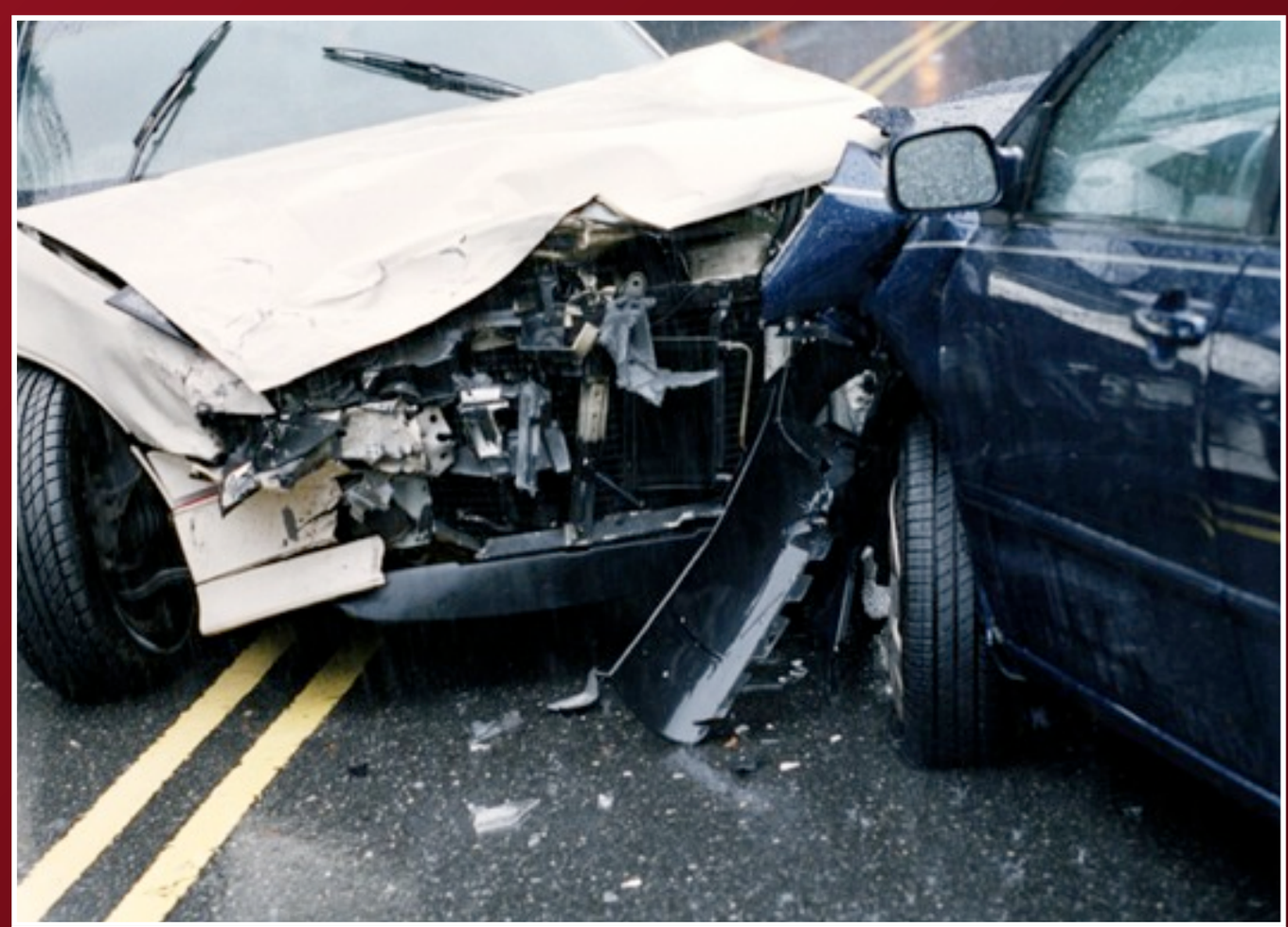
- An object will continue moving in a straight line at a constant speed, and a stationary object will remain at rest, unless acted upon by an unbalanced force
- Uniform motion vs. acceleration
- Force
- Inertia

The Second Law

- The acceleration produced on a body by a force is proportional to the magnitude of the force and inversely proportional to the mass of the object
- Equation: $F=ma$

The Third Law

- Interacting object exert equal but opposite forces upon each other
- The reactions may not be equal and opposite



Momentum

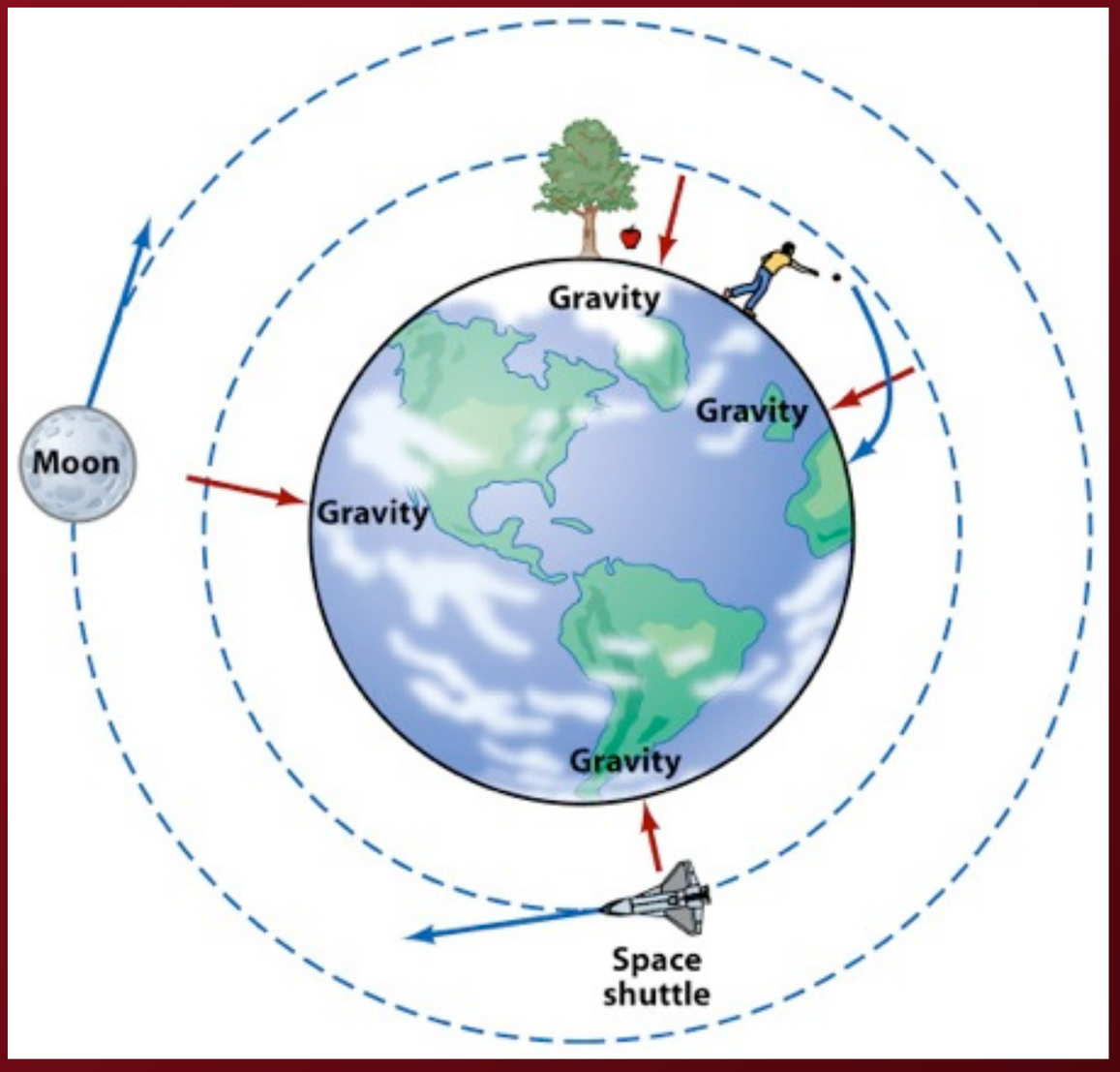
Momentum

- Motion depends on mass and speed
- Linear momentum:
  - $p=mv$
- Law of conservation of linear momentum
- Angular momentum

The Universal Force of Gravity

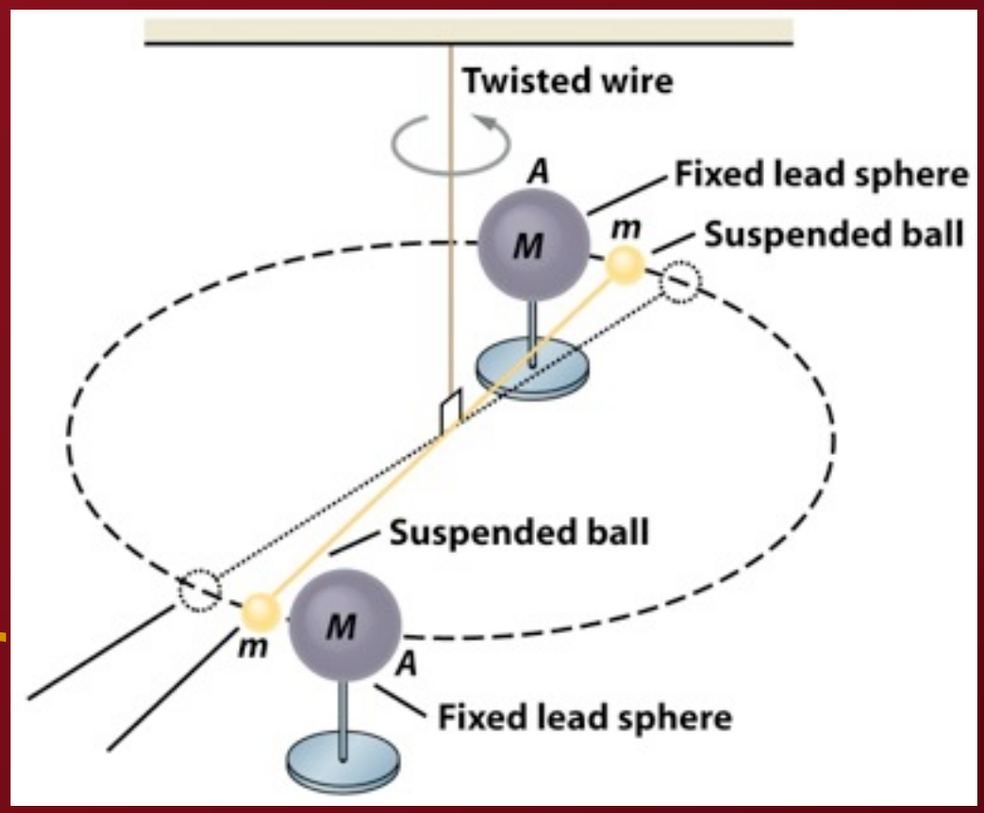
The Universal Force of Gravity

- Gravity
- Newton's law of universal gravitation
  - $F=Gm_1m_2/d^2$



The Gravitational Constant, G

- G-constant of direct proportionality
  - Universal
- Henry Cavendish
  - $G=6.67 \times 10^{-11} m^3/s^2\text{-}kg$ or $6.67 \times 10^{-11} N\text{-}m^2/kg^2$



Weight and Gravity

- Weight
  - –Gravity acting on an object's mass
- Weight depends on gravity
  - –Different on earth vs. moon

- Mass is constant

Big *G* and Little *g*

- Closely related:
  - Force=(G x mass x M_E)/R_E^2
  - Force=mass x g
- Setting equations equal:
  - Mass x g=(G x mass x M_E)/R_E^2
    - Divide by mass
  - g= (G x M_E)/R_E^2
    - Plug in values
  - 9.8 N-kg = 9.8m/s^2