IMPORTANT TERMS:
- **Inverse square law**
- **Law of universal gravitation**
- **Perturbation**
- **Universal gravitational constant, G**

EQUATIONS:

$$F \propto \frac{m_1 m_2}{d^2}$$

$$G = 6.67 \times 10^{-11} \, N \cdot m / kg^2$$

TANGENTIAL VELOCITY

PULL OF GRAVITY

I. The Falling Apple (13.1)

    A. **Isaac Newton** (1642-1727) -

        1. Formulated ideas based on earlier work by _____ (concept of inertia)

   2. Concept– if object undergoes **change in speed or direction**, then a _____ is responsible

    B. Related "falling apple", to the motion of the moon (falling around the earth)

II. The Falling Moon (13.2)

    A. Newton hypothesized that moon was simply a _____ circling Earth under the attraction of _____

        1. Newton had to test hypothesis

        2. Compared fall of apple to fall of moon

        3. Newton reasoned that gravitational attraction was "_____" **by distance**

            a. Moon is _____ times farther from the center of the Earth than the apple

            b. Calculated difference to be $1/(60)^2$
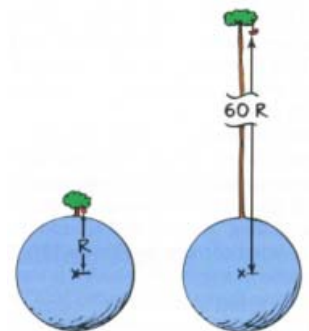
   B. Newton waited 20 years to prove hypothesis

        1. Invented a new math (_____) to explain theory

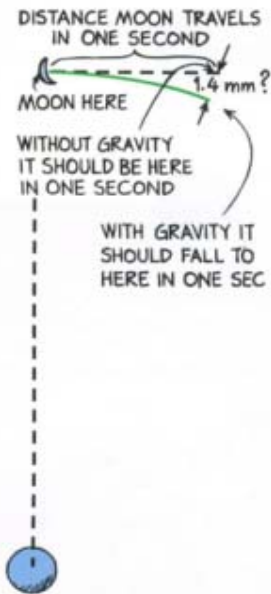   2. Published his findings– The Law of Universal Gravitation. (applied to _____objects in the universe)

III. The Falling Earth (13.3)

    A. Newton's theory confirmed **Coperincan** theory of the solar system.

        1. Earth no longer considered _____ of universe

        2. Earth not even center of _____

    B. Planets _____ **velocities** enough to keep in orbit
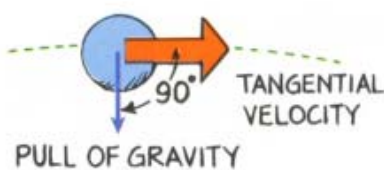
IV. Newton's Law of Universal Gravitation (13.4)

    A. Law states: ***every object attracts every other object with a force that for any two objects is directly proportional to the mass of each object***

        1. The **greater the** _____ the **greater the attraction**

        2. The _____ **away the objects** are from each other, the **less the** _____ **of attraction** between them

    B. Law expressed as:

        m₁ is mass of one object

        m₂ is mass of other

        d is distance between their centers

    C. **The Universal Gravitational Constant (G)**

        1. The above equation is a _____ form of law.

        2. Can be expressed exactly when ***universal gravitational constant (G)*** is introduced

            a. Value of G first measured 150 years later by Henry Cavendish
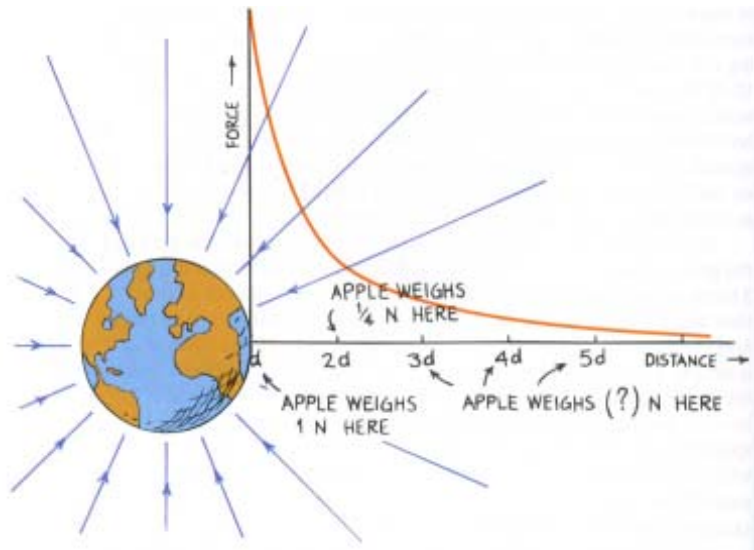
            b.

        3. Value of G tells us that force of **gravity** is a **very** _____ **force** (weakest of known four fundamental forces (electromagnetic and two known nuclear forces

    D. Cavendish used value of G to calculate the mass of the Earth (**mass of Earth = 6 X 10²⁴ kilograms**)

V. Gravity and Distance: The Inverse Square Law (13.5)

    A. **Inverse Square Law**– when **quantity varies** as the **inverse square** of its **distance** from its source

    B. Also applies to _____, _____, and _____

FORCE

APPLE WEIGHS ¼ N HERE

d 2d 3d 4d 5d DISTANCE →

APPLE WEIGHS 1 N HERE

APPLE WEIGHS (?) N HERE

VI. Universal Gravitation (13.6)

A. Law was used to explain perturbation of planets in our solar system

1. **perturbation**-deviations from normal _____

2. Used law to explain Uranus's perturbation (caused by presence of another unknown planet-Neptune)

B. Theory dramatically affected **science** and **society**

1. Ushered in the **Age of Reason** or **Century of Enlightenment.**

2. Nurtured the thinking of scientists, artists, writers, and philosophers of the 1700's

a. **John Locke**– argued that observation and reason, as demonstrated by Newton, should be our best judge and guide in all things

b. Locke and followers modeled system of government that culminated in the **Declaration of Independence** and **Constitution of the United States of America**