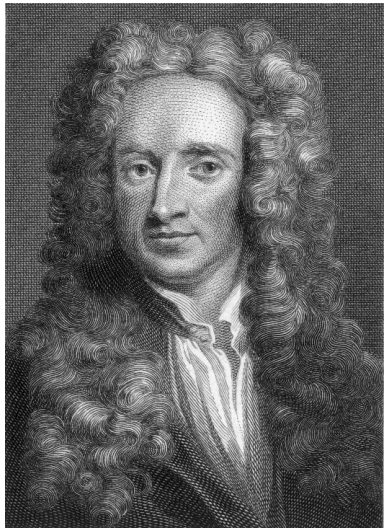
BRIEF

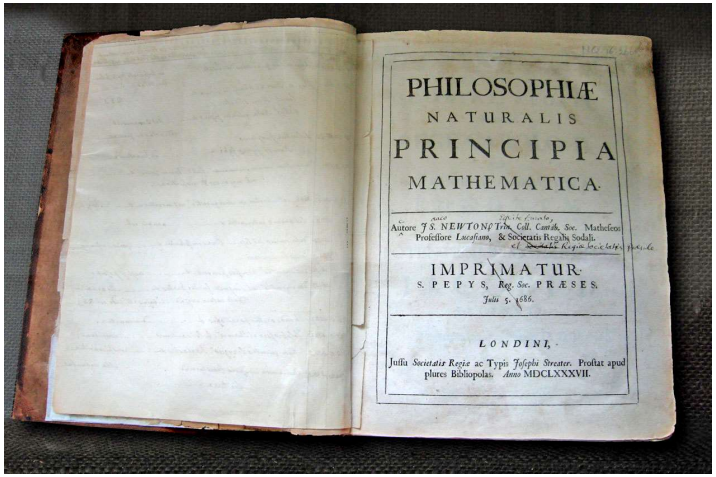
BASIC PHYSICS
Newton's Laws



Overview

Newtonian Mechanics

- Book *Philosophiæ Naturalis Principia Mathematica* ("Mathematical Principles of Natural Philosophy")
  - Laid the foundations for classical mechanics
- Mathematically described the observations of Copernicus, Kepler and Galileo
- Discovered the three laws of motion
- Discovered the universal law of mutual gravitation


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore JS. NEWTONO Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodale.

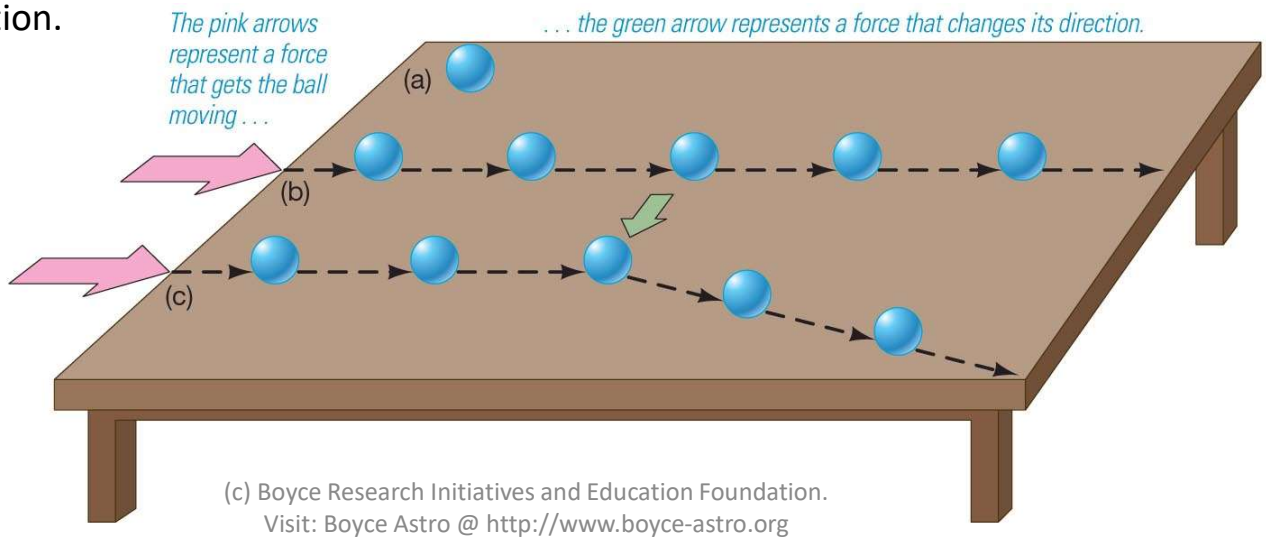
IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

Newton's Laws of Motion: 1st Law

An object at rest tends to stay at rest and an object in motion tends to stay in motion unless acted upon by an unbalanced force

a) An object remains at rest until some force acts on it.
b) When a force (red arrow) acts on the object, it will remain in that state of uniform motion until another force acts on it.
c) When a second force (green arrow) acts in a direction different from the first force the object changes its direction of motion.

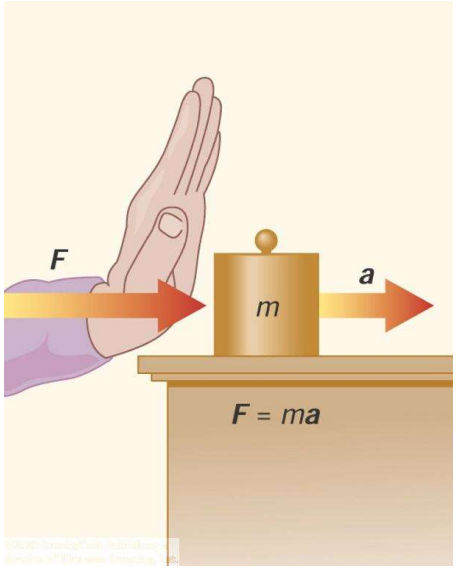


Newton's Laws of Motion: 2nd Law

When a force (F) acts on a body of mass (m), it produces in it an acceleration (a) equal to the force divided by the mass. Thus, a = F/m, or F = ma.

- The greater the force acting on an object or smaller the mass, the greater the acceleration
- Acceleration is the rate of change of velocity.
- The properties of velocity: Speed and direction measured in units per time (m/s^2)

$$\vec{a} = \vec{F}/m \quad \Leftrightarrow \quad \vec{F} = m\,\vec{a}$$

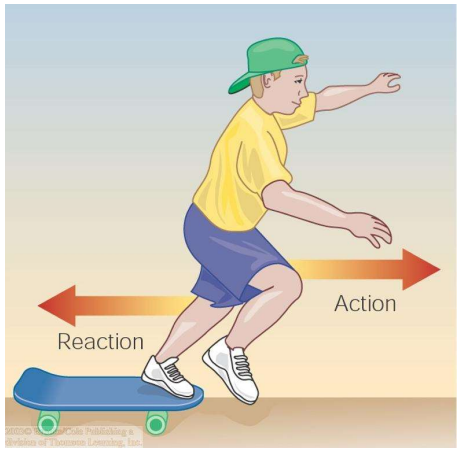


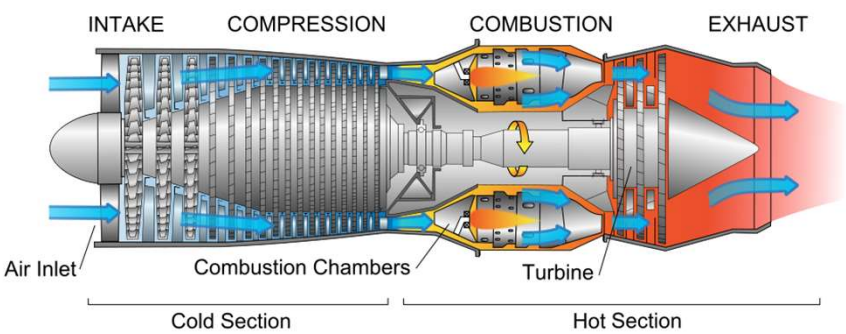
Newton's Laws of Motion: 3rd Law

- For every action, there is an equal and opposite reaction
- Whenever objects A and B interact with each other, they exert forces upon each other that are equal but in opposite directions
- Examples below…

Table to the Head

Head to the Earth





Newton's Law of Universal Gravitation: What is Gravity

Law of Universal Mutual Gravitation:

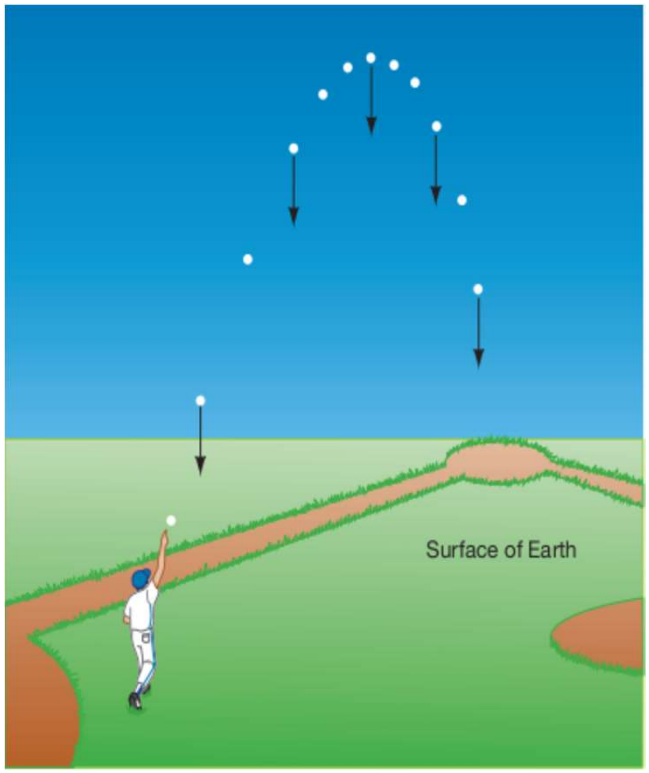
- Gravity is an **Attractive** force: It draws massive objects closer together
- Gravity is a **Universal** force: It operates everywhere in the Universe.
- Gravity is a **Mutual** force: It works between **pairs** of massive objects.

Therefore, any object having mass always exerts an attractive gravitational force on other objects.

The more massive, stronger gravitational force

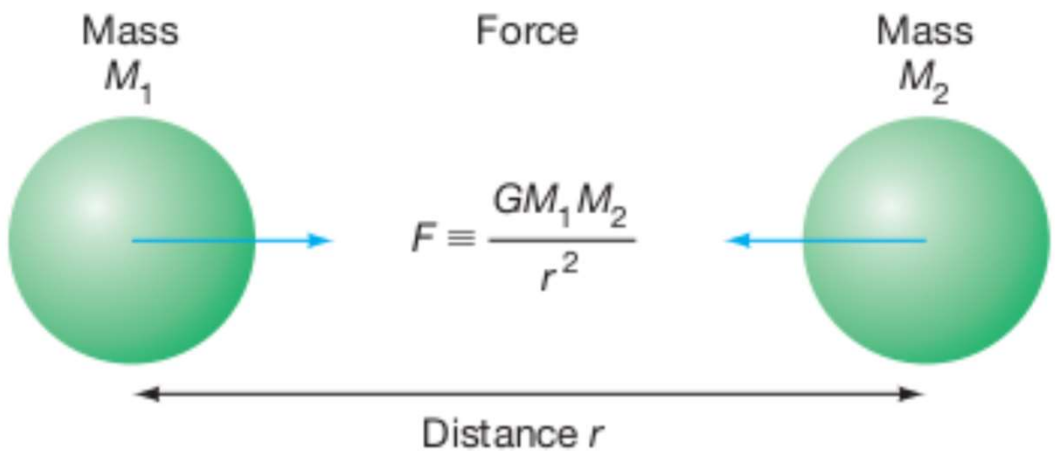
Baseball example:

- Baseball released
- Gravity acts against its initial path
- Gravity exceeds initial motion
- Falls back to Earth



Newton's Law of Universal Gravitation

- The force constant, G, is a number which gives the size of the gravitational coupling between two massive objects.
- G is a very small constant, in metric units: $G=6.7\times10^{-11}$ Newtons meter^2 / kilogram^2

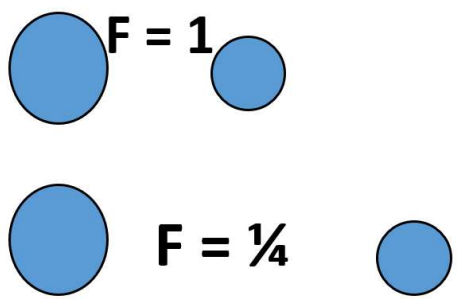


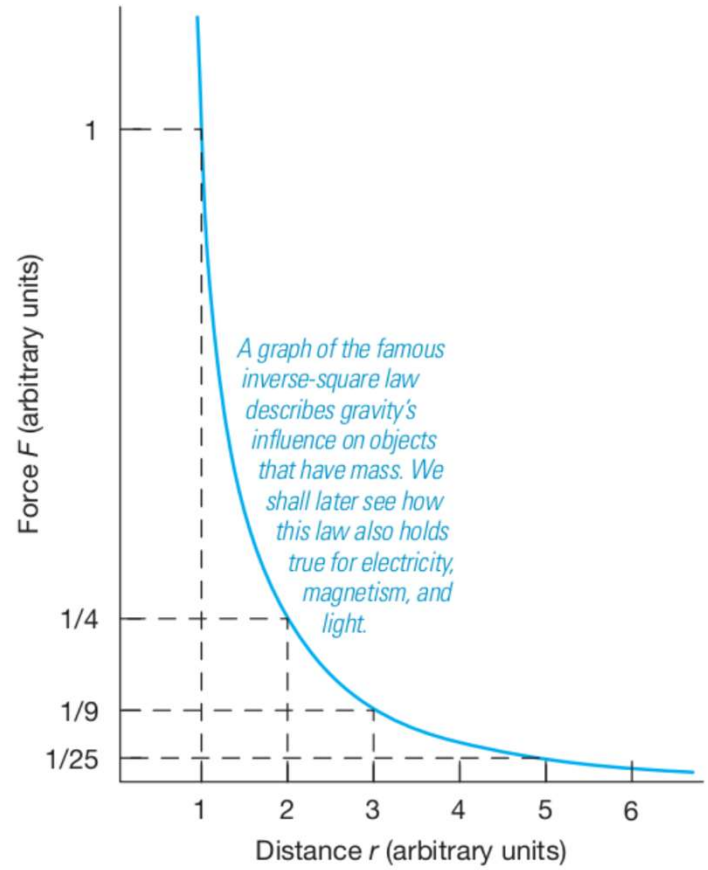
Force ='s (Mass)x(Acceleration) decreasing as a square of their distance apart

- There is no preference for one over the other
- Gravitational tugs are mutual – the Earth is pulling on your mass (giving you weight) just as strongly as your mass is pulling on the Earth. (3rd Law)

Newton's Law of Universal Gravitation

- It is an inverse-square law
  - The strength of the force is directly related to the inverse of ("one over") the square of the distance.
  - Can you name another inverse square law?





Summary

These Newtonian laws should be kept in mind when performing an analysis in Astrometric projects.

For example, the first two laws and the Universal Law of Gravitation will be used most often.

Questions?

Newtonian Mechanics: Orbits

Orbits - Moon is constantly in free fall, as are all orbiting objects

- "Always falling to earth, but never getting closer!"