# Lecture 05 – 27 January 2009

**HWK 1: Due Tonight**
**HWK 2: Out now, due Tuesday, 03 February 2009, 23:59**

- **SCIENCE TOPICS**: Kepler, Newton and Gravity
- **READING**
  Chapter 1
- **PRACTICE**
  p.40 Review: 1–9, 12–15
  p.40 Self-Test: 1–15
  p.41 Problems: 4–6, 9

Homework 01 is due in tonight, 11:59pm

Homework 02 is out now!

| Planet | eccentricity |
| --- | --- |
| Mercury | 0.205 |
| Venus | 0.006 |
| Earth | 0.017 |
| Mars | 0.093 |
| Jupiter | 0.049 |
| Saturn | 0.055 |
| Uranus | 0.044 |
| Neptune | 0.011 |
| (Pluto) | (0.248) |

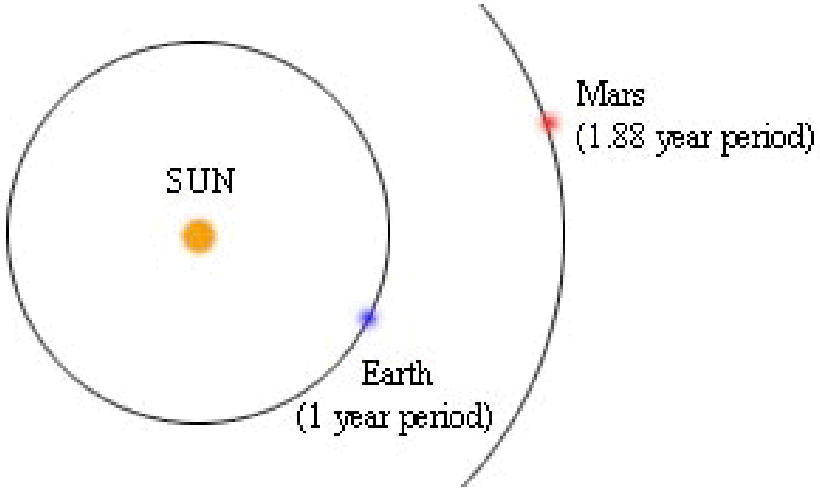
# Kepler's Laws

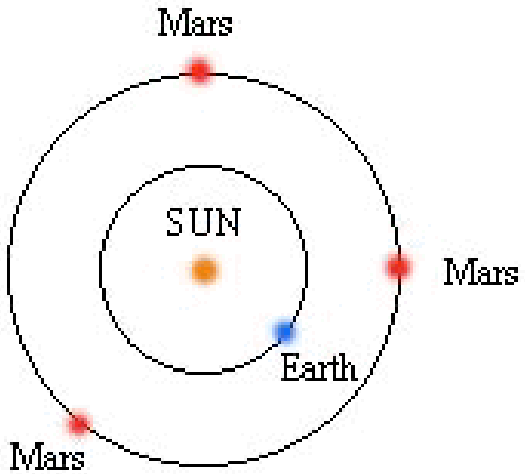
1. The orbits of planets are ellipses with the Sun a one focus.

2. During their orbits around the sun, the planets sweep out equal areas in equal times (they move faster when they are closer to the Sun)

3. $P^2 = a^3$

# Orbit of Mars



| Planet | Orbital Period (yrs) | Distance (AU) | $P^2$ | $a^3$ |
|---|---|---|---|---|
| Mercury | 0.24 | 0.387 | 0.058 | 0.058 |
| Venus | 0.61 | 0.723 | 0.372 | 0.378 |
| Earth | 1.00 | 1.00 | 1.00 | 1.00 |
| Mars | 1.88 | 1.523 | 3.53 | 3.53 |
| Jupiter | 11.9 | 5.204 | 141.6 | 140.9 |
| Saturn | 29.6 | 9.582 | 876.1 | 879.7 |
| Uranus | 84.3 | 19.23 | 7106 | 7111 |
| Neptune | 164.8 | 30.4 | 27,159 | 28,094 |

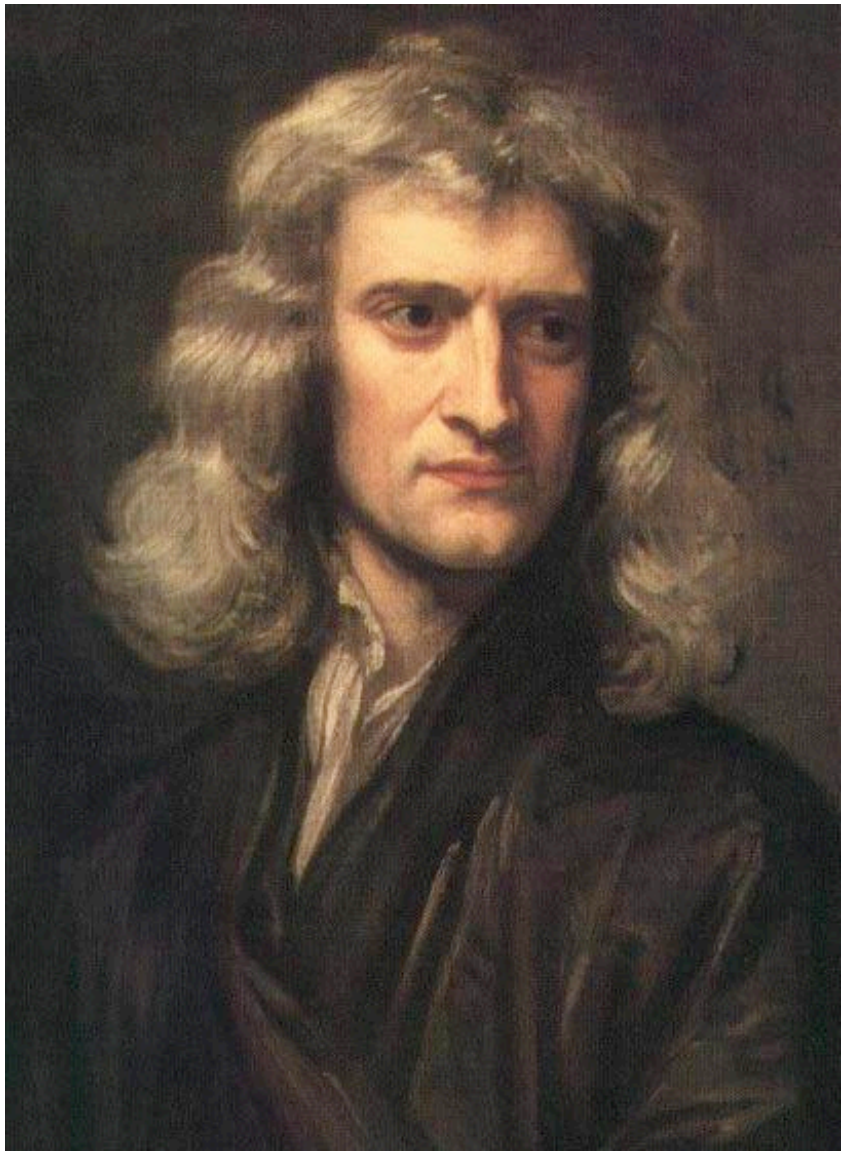
**So, Kepler's Laws tell us HOW the planets move,**

**BUT**

**we also want to know WHY the planets move the way they do...**

# Sir Isaac Newton

- 1643 - 1727
- English (Cambridge)
- 1687: *Principia Mathematica*
- Invents: modern day mathematics, physics optics and engineering.
- (Arguably) the No. 1 scientist of all time.



**Newton has 3 Laws of motion....**

**and also one of Gravitation.**

# Newton's Laws of Motion

1. An object will not change its state of motion unless compelled by an external force.
2. $F = m\ a$
3. For every action there is an equal and opposite reaction.

# Newton I

- An object will not change its state of motion unless compelled by an external force.

- e.g. If you are at rest, you will remain at rest unless acted on by a force. If you are moving, you will continue to move - at a constant speed - unless acted on by a force.
- Imagine one of those air hockey tables, very large...
- Opposing forces on Earth: friction, air resistance, gravity

# Newton's Laws of Motion

1. An object will not change its state of motion unless compelled by an external force.
2. $F = m\,a$
3. For every action there is an equal and opposite reaction.

# Newton II

**Force = Mass x Acceleration**

Force: measured in "Newtons"

Mass: measured in kilograms

Acceleration: measured in m/s/s

# Newton's Laws of Motion

1. An object will not change its state of motion unless compelled by an external force.
2. $F = m\ a$
3. For every action there is an equal and opposite reaction.

# Newton III

For every action there is an equal and opposite reaction.

e.g.

# Gravity

# Newton's Law of Universal Gravitation

$$F = \frac{G M_1 M_2}{R^2}$$

F is for Force (measured in "Newtons")

G is just a number, $6.67 \times 10^{-11}$ $m^3$ $kg^{-1}$ $s^{-2}$

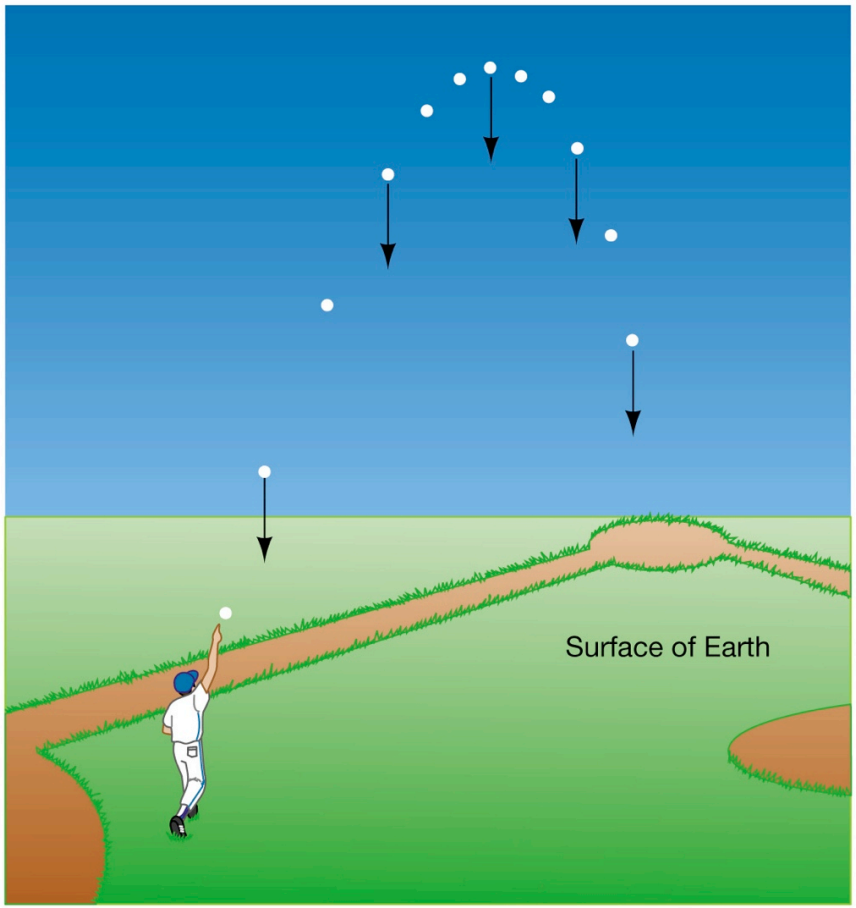
$M_1$ is the mass of object 1 (in kg).

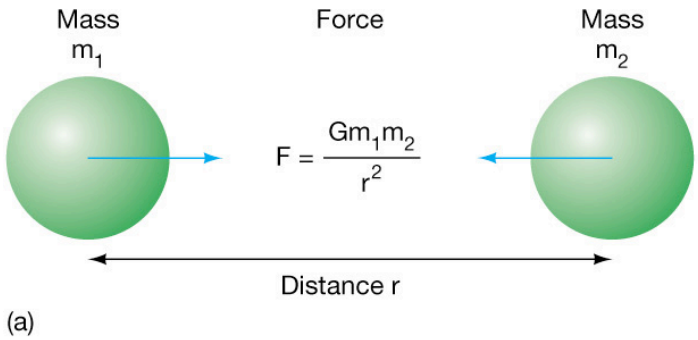
$M_2$ is the mass of object 2 (in kg).

R is the distance between $M_1$ and $M_2$ (in m).

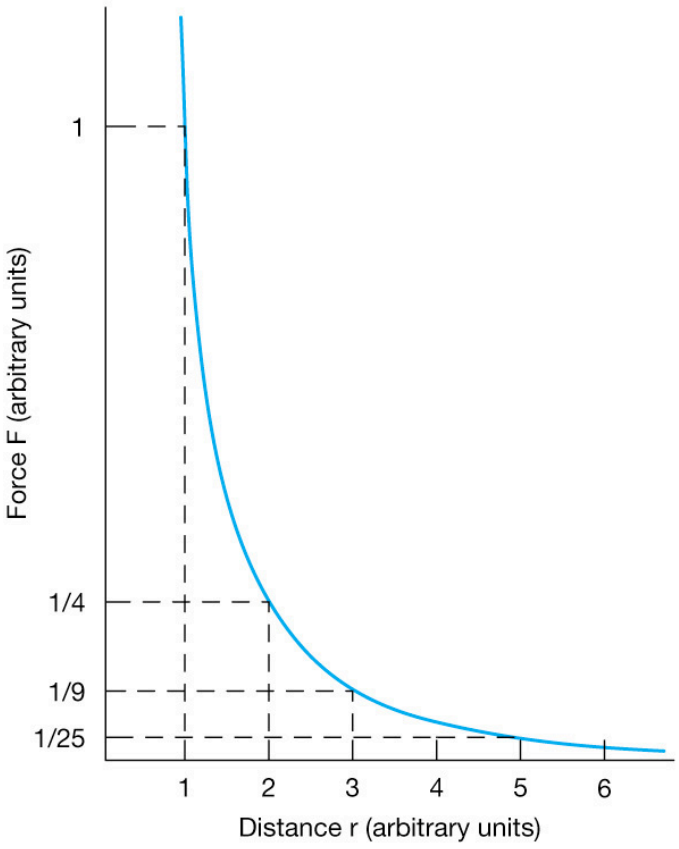
# Illustration of Newton's Law of Gravitation

$$F = \frac{G M_1 M_2}{R^2}$$




(a)




(b)

# Why does the Earth Orbit The Sun?