**Ch. 2b *Celestial Mechanics***

I. **Kepler’s Laws of Planetary Motion** (Sec 2.4)

A. !st Law –the Law of .

1 Planets orbit the Sun with **elliptical**

orbits, as do comets, asteroids, etc...

2, The eccentricity of an orbit is a

measure of how -shaped it is.

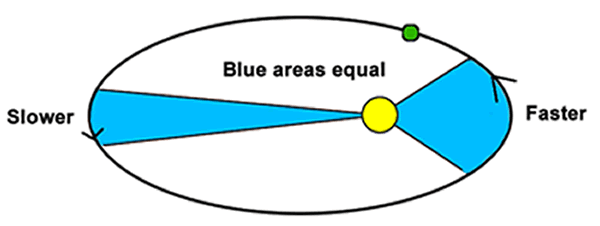
a. e = 0 indicates a 

b. All planets have an orbit w e > 0

B. 2nd Law –Law of Equal .

1. Planets “carve out” equal areas of an

orbit in an equal amount of .



2. For this to be true, planets must

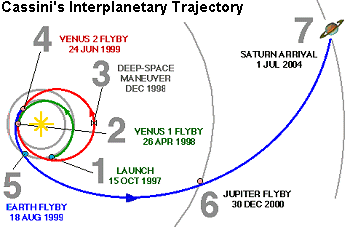
  close to the Sun!

3. NASA calls this the

  and has

used it on numerous missions such as

Cassini and New 



C. 3rd Law – Law of 

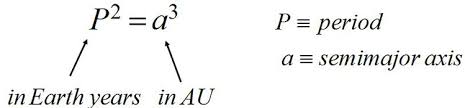
1. The square of a planet’s period is

proportional to the cube of its \*radius

2. The period is measured in 

3. The radius is measured in 

Name 



Example Problems:

1. Neptune is 30.6 AU from the Sun.

How many Earth years does it take

Neptune to orbit the Sun? 

2. Mars orbits the Sun in 1.87 Earth

years. How far is Mars from the Sun?

Answer: 

3. Venus orbits the Sun in 223 days.

How far is Venus from the Sun?

Answer: 

II. **Newton’s Laws of Motion** (2.5)

A. 1st Law- Law of 

1. An object at rest will stay at rest

until acted on by an overall force.

Ex/ 

2. An object that is moving will keep

moving in a straight  at

constant  until acted on

by an overall force (push or pull).

Ex/ 



B.2nd Law –Law of 

FNET = ma

1. For the same amount of mass,

applying greater Force will result in

 acceleration.

Ex/ 

2. For the same amount of force, greater

Mass will result in 

Acceleration.

Ex/ 

C. 3rd Law - ACTION / REACTION

For every force, there is an 

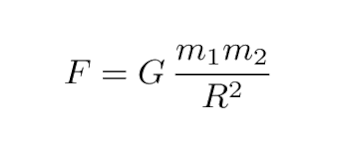
and  force.

Ex/ 



III. **Newton’s Law of Gravitation**

(Sec 2.6)



A. The amount of gravity between ANY

objects only depends on their 

and the  between them.

It is the distance between the

of the 2 objects.

B. The universal gravitation constant,

**G**, is the same everywhere. It is a

very small number, indicating that

gravity is a very  force.

Example Problems

4. If the Earth was the same size as now, but had 5 x its current mass, how would its surface gravity compare to now?

5. If the Earth had its same mass as now, but had 3 x its current radius, how would its surface gravity compare to now?

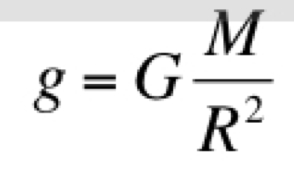
6. If you fly your spaceship 6 x farther from the center of a planet, by how much would the force of gravity on you ship change?

IV. **Acceleration Due to Gravity**

A. Newton’s Law of Gravity leads us to

an equation for the rate at which

objects accelerate as they fall.



B. “Little g” for the Earth is  m/s2.

This means that an object’s speed

will increase by about 20 mph for

every second that it falls.

(without air resistance)

Example Problem

7. Calculate the acceleration due to

gravity on the surface of the Moon.

Mm = 7.3 x 1022 kg

Rm = 1700 km

G = 6.67 x 10-11

8. Calculate the acceleration due to

gravity 2,000 km above the Moon.

V. **Center of Mass**

A. Gravity acts as a 

force. Ex/ A rock on a string

B. Celestial bodies actually orbit a

common  of .

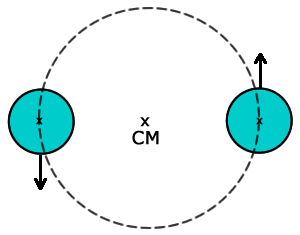
1. If 2 objects are of EQUAL MASS,

then their center of mass will be

exactly halfway between them. They

will both orbit that point in the center

of that system.

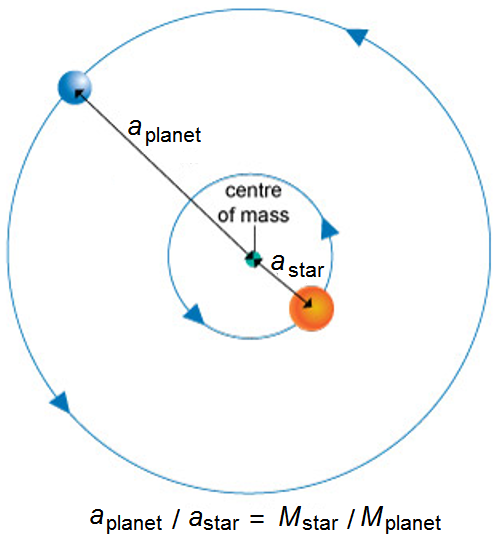


Ex/ 

2. If the objects are of slightly different

masses, the center of mass will be

closer to the heavier object.



Ex/ 

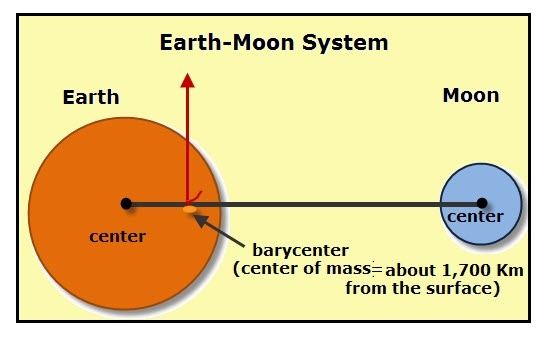
3. If the object have very different

masses, the center of mass of the

system may fall  the

heavier object.

Ex/ 



VI. **Orbit and Escape Velocity**

A. In Newton’s book *The Principia*, he

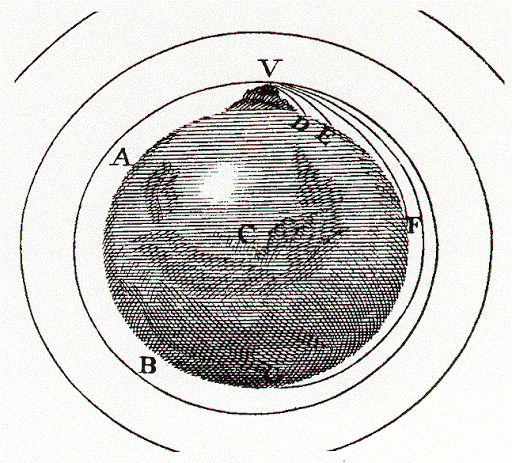
amazingly showed how fast objects

would need to be launched to both

orbit the Earth and to escape Earth

all-together. In other words, he

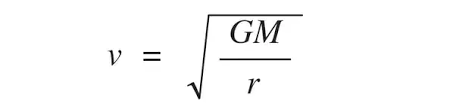
figured out satellites in 1685 (!!).



B. Newton derived an equation to

calculate the velocity needed to orbit

any celestial object (Orbital Velocity)



C. For the Earth, the orbital velocity is

 mph. This is only for

objects in a nearby orbit – L.E.O., or

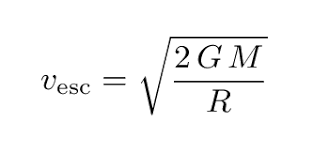
**Low Earth Orbit**.

D. Newton then derived an equation to

calculate the speed needed to escape

any celestial object. (escape speed).

For the Earth, vesc ~ 25,000 mph!



Example Problems

9. What is the orbital velocity of the

Moon?

10. What is the escape velocity of the

asteroid Ceres?

11. What is the orbital velocity of the

Earth at an altitude 5,000 km above

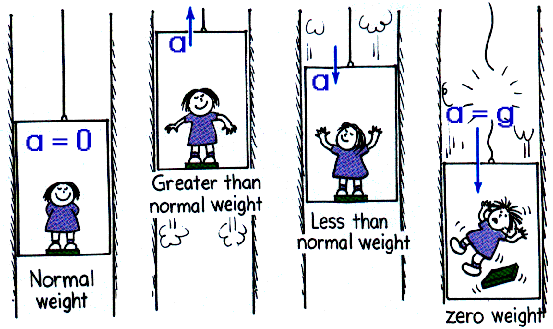
the Earth’s surface?

VII. **Microgravity**

A. Microgravity is weightlessness due

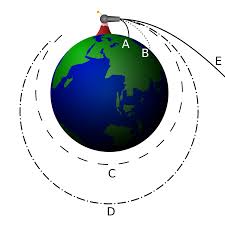
to  . When an

object is falling, it weights nothing!



B. A satellite is actually falling – it is

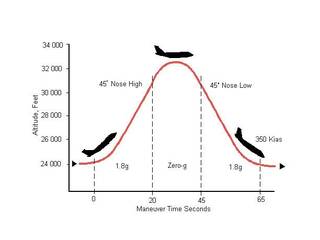
falling  the Earth!



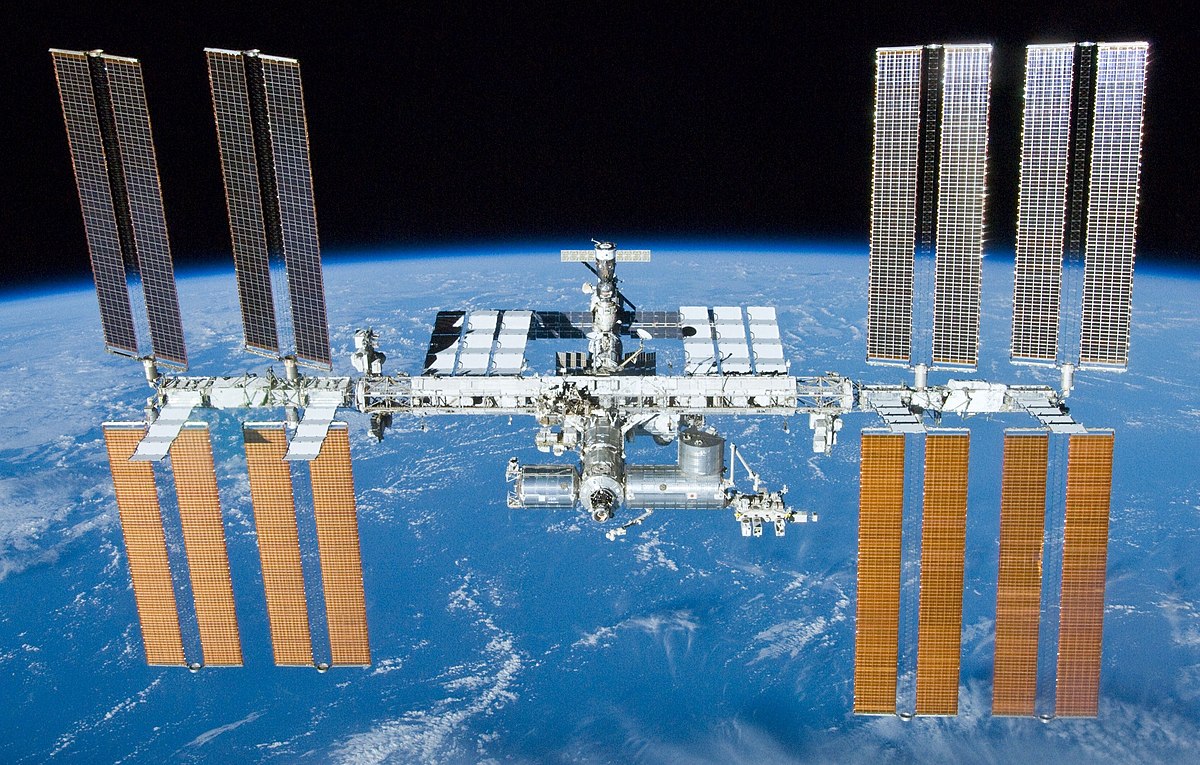
Ex/ High dive demo

Tower of Terror





The I.S.S.



C. Effects of Microgravity

1. Candle flame



2. Water



3. People

