Tuesday, 29 September, 2009

PHYS-1060 (2)

Fall 2009

3:30-4:45pm Tu Th 1104 Rood

Dr. Philip Edward Kaldon
Western Michigan University

Unit 1

First Contact – *Defying Gravity*

A Class of One

The Center of the Universe

- because the Earth is round
- because the Earth rotates
- because the Earth orbits the Sun
- we get time zones

3 time zones west

- late summer in L.A. = fire season
- Station Fire and Mt. Wilson
- The observatory used by Hubble
- Hubble realized the Universe… is not the Milky Way Galaxy
- And the size is MUCH bigger

A Tale of Two Hubbles

- Edwin Hubble (1889-1953)
- The Hubble Space Telescope (1990-)

Remember... To Join
Dr. Phil's Physics Class on Facebook

- You must (a) be Registered in PHYS-1060
- (b) Request to join the group
- and (c) NOT Friend Dr. Phil (grin).

Don't Fret About Quiz 1

- It's just an attendance thing

- Powers of 10 (magnitudes)

1 – ME, You, The Sun
10 – planets (in our solar system)
100 – years of life
1000 – miles to New York or Florida
-- years of Civilization
10,000 – kilometers size of Earth
100,000 – miles to the Moon
1,000,000 –
10,000,000 –
100,000,000 – population of US
-- miles to Sun
1,000,000,000 – pop of world
10,000,000,000 – years… ever…
100,000,000,000 – stars in Milky Way?

<u>Speed of Light</u>
186,000 miles per second
300,000,000 meters per second

If you missed class on Thursday 10 September 2009 *or* were there but did *not* fill out the Quiz 1 form, go to the class web page at

`http://homepages.wmich.edu/~kaldon/classes/ph106-2.htm`

and print out the Quiz 1A form and turn it in to Dr. Phil.

Thanks!

What Can We See?

- The Sky is Blue (day)
- The Sky is Black (night)
- Our Local Environment

About 4000 Stars (optimum)
… without technology

Our Neighborhood

- Earth-Moon
- Solar System
- Nearest/Brightest Stars

The Astronomical Unit

The distance from the Earth to the Sun
93,000,000 miles = 150,000,000 km
or 150,000,000,000 meters

There is a mistake on Quiz 2 part (h)

Should be ×, not ÷...

(h) Distance to Alpha Centauri in A.U.

= 4.4 Light Years × _____ A.U./LY = _____

Units are very important to numbers.

$100 is not £100 is not ¥100

$100 is not 100 feet

£100 is not 100 lbs.

Constellations (and Asterisms)

88 recognized Constellations
-- as seen from the Earth

Angular Size

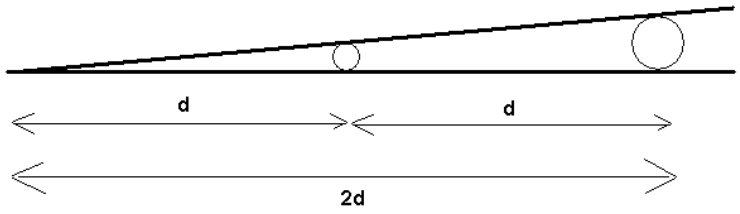
The circle is divided into 360°

Each 1° is divided into 60' (minutes)

Each 1' is divided into 60" (seconds)

3600" = 1° and 1,296,000" = 360°

Same Angle:



Hipparchus (c.190-120 BC)

First Magnitude – the brightest stars
Sixth Magnitude – the faintest stars we can see

Apparent Magnitude – Seen From Earth
Absolute Magnitude – From Standard Distance
10 parsecs = 32.6 LY

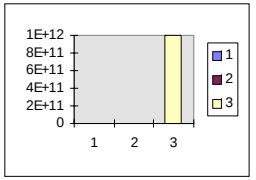
Magnitude is a Logarithmic Scale

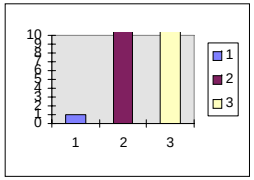
A Simple Log Scale Might Be Powers of 10

10^0 … 0 → 1
10^1 … 1 → 10
10^2 … 2 → 100
10^3 … 3 → 1000
…
10^{15} … 15 → 1,000,000,000,000,000

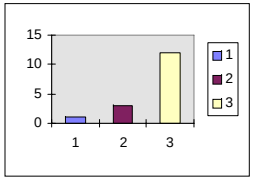
Suppose we want to graph 3 numbers:
1 1000 1,000,000,000,000

We can't get them to show up.





But if we show the exponents,
$10^0 = 1$
$10^3 = 1000$
$10^{12} = 1{,}000{,}000{,}000{,}000$



More Than Just 1 through 6…

Apparent Magnitude
is based on our observations

"Brighter" (lower number) means:

Closer and/or More Powerful in Actuality

$$mB - mA = 2.5\log(I_A / I_B)$$

$$I_A / I_B = 2.512^{(mB-mA)}$$

mB	mA	difference	×bright
6	6	0 (same)	1
6	5	1	2.512
6	4	2	6.310
6	3	3	15.85
6	2	4	39.82
6	1	5	100.0
6	5.25	0.75	2.00
6	4.50	1.50	4.00

Apparent versus True Values

We Classify Objects Based on:

- Size, Brightness, Color, Place, Association, Orientation, etc.

What Determines How Bright?

- Distance
- Size
- Luminosity (if glowing)
- Albedo (if reflecting)

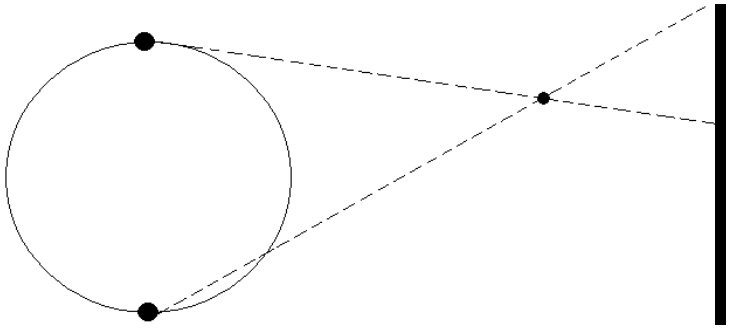
How Do We Measure Distances?

- Parallax (close)
- Comparisons With Similar Objects
  (Assumes stars and galaxies are similar in composition and nature)
- Standard Candles
- Red Shifts (distant)

How Does Parallax Work?
Test Your Binocular Vision

• • • • • • • • •
1 2 3 4 5 6 7 8 9

We Can Use Observations From Earth Six Months Apart (2 A.U.)
and Measure Angles
to Determine Distance

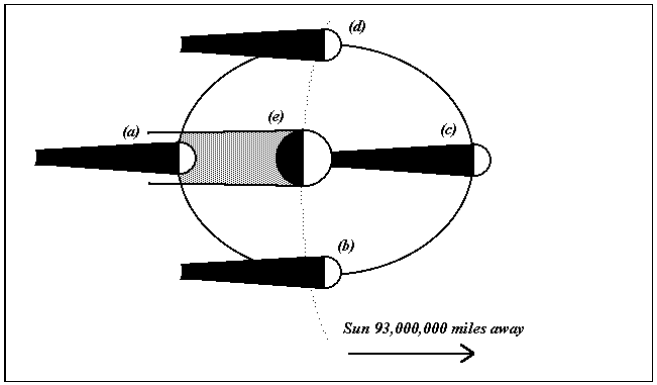


(Not to Scale)

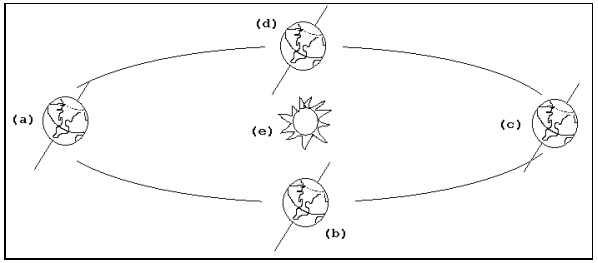
Used to be able to do this only for "near" stars. HST allows us to measure very small angles for more distant objects – parallax confirms results with other methods.

(Always nice in science to have more than one way to measure data.)

Eclipses:

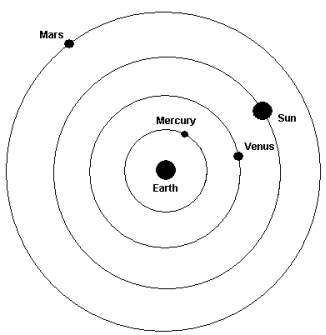


Seasons:

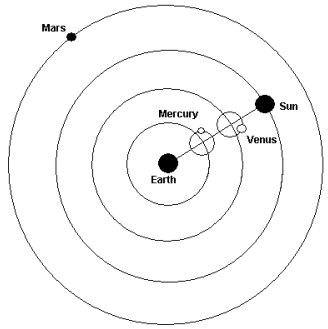


23½° angle of inclination

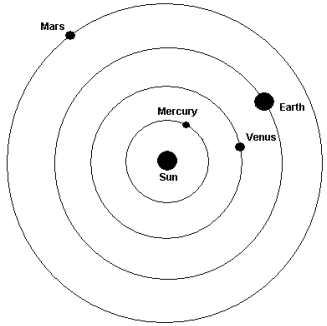
Some Models of the Solar System (Universe)



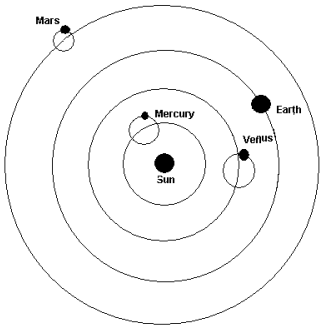
Earth-centric Model…



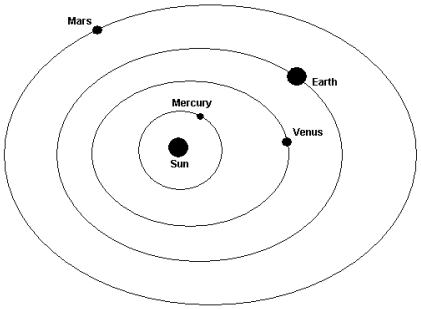
with Mercury & Venus locked with Sun



Heliocentric (Sun-centered) Model…



with epicycles



Kepler's Model with exaggerated ellipses

Kepler's Laws

1st Law: Planetary orbits about the Sun are ellipses and the Sun lies at one of the foci of the ellipse.

Quiz 3 – You May Be Working Too Hard

(a) Star A is 10 parsecs (32.6 LY) from Earth and has an apparent magnitude of mA = 6.00 . What is its absolute magnitude?

To know the absolute magnitude, you need to know the standard distance for a "police lineup" comparison of stars.

(b) Star B is just like Star A, except that it is 20 parsecs (65.2 LY) from Earth. What is its apparent magnitude? What is its absolute magnitude?

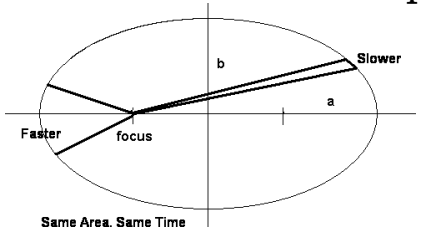
Star A and Star B are twins. Except Star B is twice as far away. So it appears one-fourth the size in area. That would make it one-fourth as bright.

No formulas needed, just need to know what change in magnitude will give you a factor of four change in brightness. (see handy table above)

We'll accept Quiz 3 until 1pm Monday 28 September 2009.

Kepler's Laws

1st Law: Planetary orbits about the Sun are ellipses and the Sun lies at one of the foci of the ellipse.

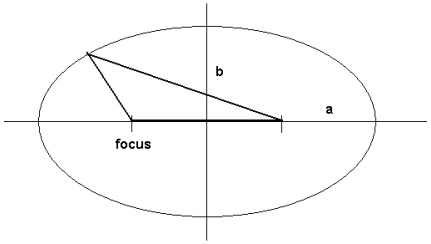


2nd Law: A line connecting the Sun and planet sweeps out equal areas in equal times.

3rd Law: p^2(years) = a^3(AU)

p = period (time to go around once)
a = semi-major axis (half of the long side of an ellipse)

An Ellipse



The Eccentricity of an ellipse tells you how stretched out it is.

A circle is a special case of an ellipse with an eccentricity = 0
or a = b. *

Planetary orbits turn out to be pretty close to circular… but just elliptical enough to matter.

*(this was erroneously = 1 in class)

Because orbits are Elliptical, there are two important points in an orbit:
apogee and **perigee**

ap·o·gee (ăp′ə-jē) *noun*
1. **a.** The point in the orbit of the moon or of an artificial satellite most distant from the center of the earth. **b.** The point in an orbit most distant from the body being orbited.

French *apogée*, from New Latin *apogaeum*, from Greek *apogaion*, from neuter of *apogaios*, far from the earth : *apo-*, apo- + *gaia*, earth.]
— ap′o·ge′an (-jē′ən) *adjective*

per·i·gee (pĕr′ə-jē) *noun*
1. The point nearest the earth's center in the orbit of the moon or a satellite.
2. The point in any orbit nearest to the body being orbited.

[French *périgée*, from Medieval Latin *perigæum*, from Late Greek *perigeion* : Greek *peri-*, peri- + Greek *gē*, earth.]
— per′i·ge′al (-jē′əl) or **per′i·ge′an** (-jē′ən) *adjective*

About the Sun:
aphelion and **perihelion**

a·phe·li·on (ə-fē′lē-ən, ə-fēl′yən) *noun*
plural **a·phe·li·a** (-lē-ə)
The point on the orbit of a celestial body that is farthest from the sun.
[From New Latin *aphēlium* : Greek *apo-*, apo- + Greek *hēlios*, sun.]

per·i·he·li·on (pĕr′ə-hē′lē-ən, -hēl′yən) *noun*
plural **per·i·he·li·a** (-hē′lē-ə, -hēl′yə)
The point nearest the sun in the orbit of a planet or other celestial body.
[Alteration of New Latin *perihēlium* : peri- + Greek *hēlios*, sun.]
— per′i·he′li·al (-hē′lē-əl, -hēl′yəl) *adjective*

<u>Motion</u>

Position – where you are

Speed – a change in position

Direction – where you are heading

Acceleration – a change in speed and/or direction

Mass – how much stuff you are

Weight – mass under gravity

Momentum – mass times speed

The only way to change your momentum is to use a **Force**.

Newton's Laws

The Zeroeth Law:
There is such a thing as mass.

The First Law:
An object in motion tends to stay in motion, *or*
an object at rest tends to stay at rest, *unless*
acted upon by a net external force.

The Second Law:
F = m a
Force = mass × acceleration

The Third Law:
For every action (force) there is an equal and opposite action *acting on the other object*.

A pushes on B, so B pushes on A

How Do We Know It Is So?

Observation

Hypothesis

Theory

Testing

(Refinement)

Most people don't use the word "theory" to mean what it means in science. As a result, many arguments about "theories" don't make any scientific sense.

Forces

Contact Forces

"Action at a Distance" – Gravity

Newton's Law of Universal Gravity:

$$F_G = \frac{GM_1M_2}{r^2}$$

G = universal constant
M_1 and M_2 are masses of 2 objects
r = distance between their centers

Inverse Square law (1 / r^2)
Yet Again!

Double the distance – ¼th the force

Double one mass – twice the force

Relax… Exam 1 is Over

NOTE:
I am likely to curve X1 as needed

Quizzes

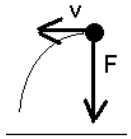
- Turn in, even if Blank (worth 3000)
- Put Commas in Long Numbers (10,000,000,000,000,000)
- The Numbers you write down should match any equation you write down.
- Please – Show All Work
- Read the QUESTIONS (grin)

- Q3 – Minimum scored bumped up to 7000/15,000 unless you didn't do the whole quiz.

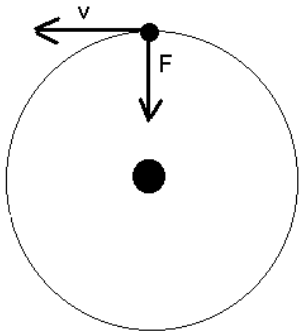
Updated Class Web Pages

Still Have 3 Names
Trying To Join Facebook Group
Which Don't Match Class Roster

Falling Near The Earth

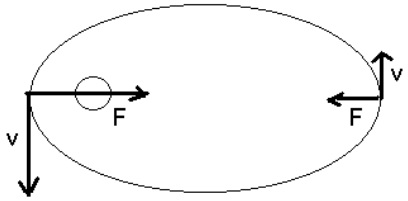


Falling Around The Earth or Sun
(Orbits)



In Either Case, if v = 0, Then Falls Straight Towards Earth or Sun

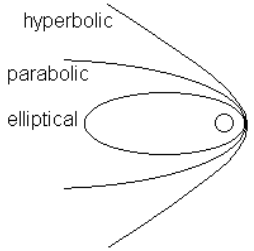
Kepler was right – Elliptical Orbits for *Bound* orbits



Newton showed that there were two kinds of *Unbound* orbits:

parabolic and hyperbolic

Grazing orbits which pass by and never come back.



Energy

Kinetic Energy – motion
Potential Energy – stored
Radiative Energy – light

Orbital Energy = KE + PE

Conservation Laws – momentum, energy

Angular Momentum

$m \times v \times r$

Ice Skating – spinning (Conservation of angular momentum)

Gravitational Encounters
- Change orbits
- Slingshot effect

Escape Velocity – the speed at which gravity cannot bring you back

For Earth:
11,000 m/s or 25,000 mph

Voyager 2 Probe has reached solar escape velocity – it is leaving the solar system and is not coming back

Chapter 5 on Light

We've discussed some parts of Chapter 5, but will pick it up again after Exam 1,

and then go into Unit 2.