SACRAMENTO CITY COLLEGE
LOS RIOS COMMUNITY COLLEGE DISTRICT

WELCOME

Astronomy 310 – Lecture Spring 2023

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Sacramento City College
Astro 310

1 Charting the Heavens
1.1 Our Place in Space
1.2 Scientific Theory and the Scientific Method
1.3 The "Obvious" View
1.4 Earth's Orbital Motion
1.5 The Motion of the Moon
1.6 The Measurement of Distance

3

ASTRONOMY 310
SYLLABUS

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ASTRONOMY 310

Professor.Mallory@gmail.com

- This is a descriptive course covering the nature and evolution of the Solar System including exoplanets of stars beyond the Sun.

- Topics include the origins and characteristics of different types of planets, satellites, ring systems, asteroids, comets, and other debris.

- The Sun's role within the Solar System is discussed.

- Emphasis will be placed on how astronomers obtain and refine their knowledge of planets, and students will interpret the latest planetary discoveries in that context.

5

1

ASTRONOMY 310

Please forgive me…

I will be asking **"WHY"**

thought the semester

Sorry…

6

Roster / Attendance

7

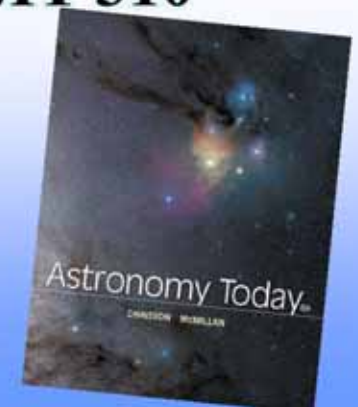## ASTRONOMY 310

Student Learning outcomes

- Assess the scientific process as it pertains to the astronomy of the Solar System and planets in general.
- Confirm astronomers' understanding of the processes that originated the Solar System.
- Rank recent discoveries about planets into a broad context amid the background of Solar System planets.
- Construct the processes that led to the present state of the Solar System.
- Integrate new knowledge from exoplanet discoveries with known planet qualities.
- Incorporate knowledge about other worlds into understanding the functionality of Earth.

8

ASTRONOMY 310

- The Book
  - Astronomy Today, by Chaisson McMillan 8th edition.
    - ISBN 10 digit 0-321-90167-3, 13-digit 978-0-321-90167-5 (Student edition) or
    - ISBN 10-digit 0-321-90971-2; 13-digit 978-0-321-90971-8 (Volume 1)

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ASTRONOMY 310

- Attendance   5%
- Quizzes   20%
- Tests   35%
- Final Exam   40%

Grade Breakdown

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ASTRONOMY 310

- Attendance   5%

- Attendance will be taken each class meeting and will count for 5% of your final grade.
- **If you do not attend this class, it is your responsibility to drop this class.**

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ASTRONOMY 310

- Quizzes   20%

- **Quizzes will be given after each chapter the following week and will count for 20% of your final grade.**
- The quiz questions will primarily come from the previous class lecture along with some questions from the book.
- The quizzes may consist of *True/False, Multiple Choice* and be given online along with *Fill in the Blank, Matching* and *Short Answer* questions given in class.

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ASTRONOMY 310

- Tests   35%

- Tests will be given up to four times during the semester and will count for 35% of your final grade.
- The test questions will *ONLY* be taken from the previous quizzes.
- **Tests will not be cumulative and will only consist of quiz questions since the previous test.**
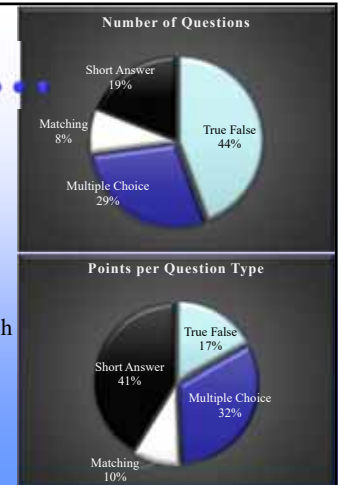
13

3

ASTRONOMY 310

•Final Exam   40%

- *The Final will count for 40% of your final grade.*
- *The final questions will **ONLY** be taken from the tests.*
- *The* final will be cumulative and cover all tests and the last quiz.
- **Failure to take the final exam will result in an automatic fail in the course.**

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A Typical Final…

- **True False**
  - 1 point each
  - 75 questions
  - 75 points
- **Multiple Choice**
  - 3 points each
  - 48 questions
  - 144 points

- **Matching**
  - 3 points each
  - 14 questions
  - 42 points
- **Short Answer**
  - 5 points or more each
  - 33 questions
  - 183 points

Number of Questions

Short Answer 19%
Matching 8%
True False 44%
Multiple Choice 29%

Points per Question Type

True False 17%
Short Answer 41%
Multiple Choice 32%
Matching 10%

15

ASTRONOMY 310

The grade you earn…

A	90% - 100%
B	75% - 89%
C	60% - 74%
D	45% - 59%
F	0% - 44%

I guarantee that you will receive at least the above grade if not higher due to modifications of the curve to fit the class performance.

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ASTRONOMY 310

Quiz Questions

Test Questions
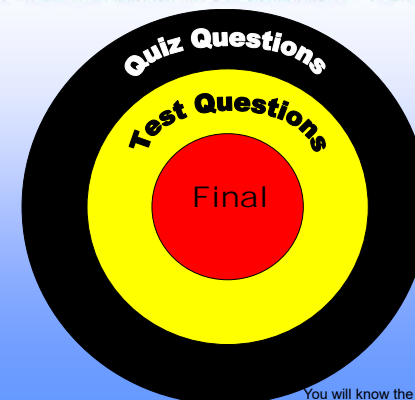
Final

You will know the final questions…

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ASTRONOMY 310

- Web
  - http://themalloryfamily.net/
  - Old quizzes, tests, handouts
  - Study guides
- Canvas
  - Old quizzes, tests, handouts
  - Study guides
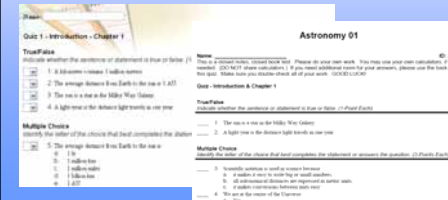
ASTRONOMY 310

How to fail...

It takes work, but it can be done.

Some Ground Rules...

- If you need to go to the bathroom, you do not need to ask for my permission.
- Please set cell phones either off or high frequency.
- Discussions are great (as long as they are related to the class). If they do not relate to the class, please go outside and talk.
- If you do not want to be here, you can leave, don't worry it wont hurt my feelings.
- If you do not understand something, **please ask**. Chances are that someone else does not understand also.

See Next Slice for Mosquito sound

Code of Academic Honor and Integrity

Students here are members of an academic community dedicated to the achievement of excellence and the pursuit of honor. We are all expected to meet high standards of personal, ethical, and professional conduct. **These standards require personal integrity and a commitment to honesty.**

The **Academic Code of Honor and Integrity** is an undertaking of the students, both individually and collectively, that they will:

1. Not give or receive unpermitted aid during exams, quizzes or assignments
2. Not give or receive unpermitted aid in assignments, reports or any other course work that is to be used by the instructor as a basis for grading.
3. Do their share and take an active part in upholding the spirit and letter of the Code of Academic Honor and Integrity.

Earn an extra 1% extra credit for your grade!

23

Please do not worry...

NEW TO ASTRONOMY

- My goal is to make sure that you will be able to succeed in this class.
- I will try to explain everything and help guide you through the class.
- Please let me know if you do not understand something or if I have made a mistake.
  - I do this sometimes on purpose
  - And sometimes by mistake

KNOW ASTRONOMY

- When I do not explain the latest knowledge and findings, please forgive me.
  - My goal is to take us from little to no knowledge to the latest findings. At times you might get frustrated, I hope that you will put up with me until I get up to your knowledge level and hopefully more.
- Your contribution to the class is invaluable. Please bring up topics that you feel are important.

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Astronomy

25

Time for Some Questions

How many planets are there in our solar system?

a. Seven
b. Eight
c. Nine
d. Ten
e. A Whole Bunch

DO YOU KNOW THEIR NAMES??

26

Review of the Planets

My Very Educated Mother Just Served Us Nine Pizzas

My Very Enraged Mother Just Saw Us Naked

27

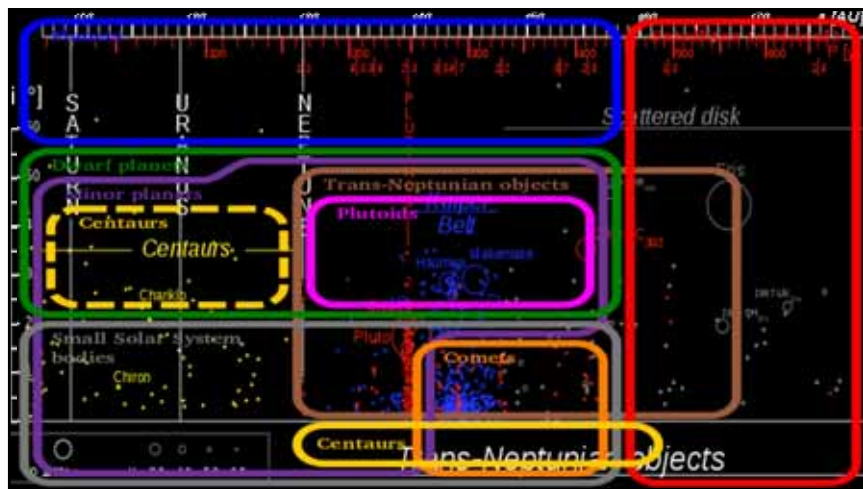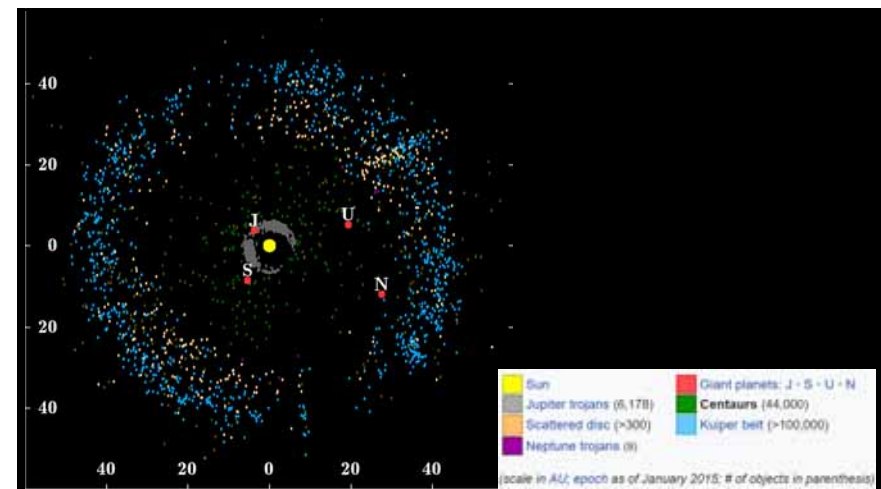---

Pluto

Lowell Observatory

Clyde w. Tombaugh

- Pluto was first discovered in 1930 by Clyde W. Tombaugh at the Lowell Observatory in Flagstaff Arizona.
- General Assembly of the International Astronomical Union, which was held from August 14 to August 25, 2006 in Prague, Czech Republic concluded that Pluto was a dwarf planet.
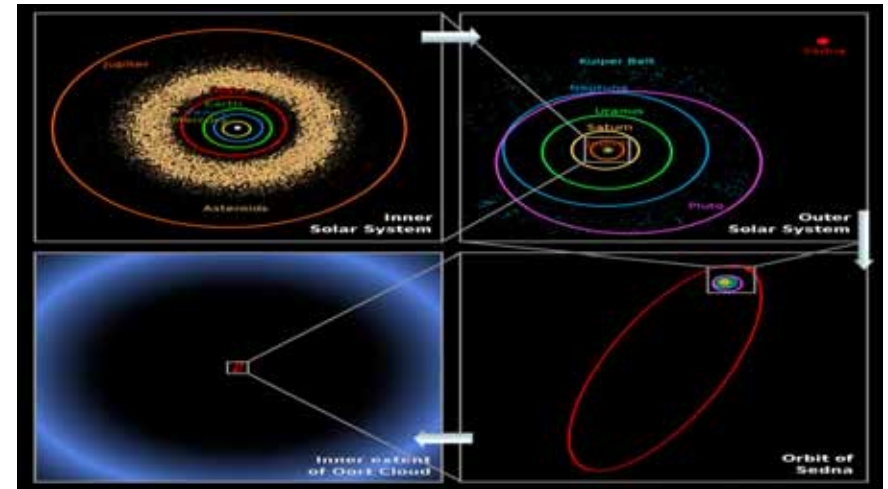
28

29

30

31

32

Time for Some Questions

– Are we at the center of the Universe?

– How big is the Universe?

– What is outside of the Universe?

– What is the Universe mostly made up of?

Definitions of the Universe
The totality of matter, energy, and space Everything that exists anywhere the aggregate of all existing matter, energy, and space the whole body of things and phenomena observed or postulated

33

What do you see when you look in the sky??

34

Something like this…

35

Night driving in clear conditions with low beams (Regular head lights):

Tyndall Effect

36

Smoke Visualization

Forward Scattering at Light

37

Tyndall Effect

38

How City Lights Affect the Night Sky

39

5,000 to 10,000 visible stars

40

Scale of the Cosmos

CHAPTER 1

41

How big is big?

The matter in the universe in 13 steps…
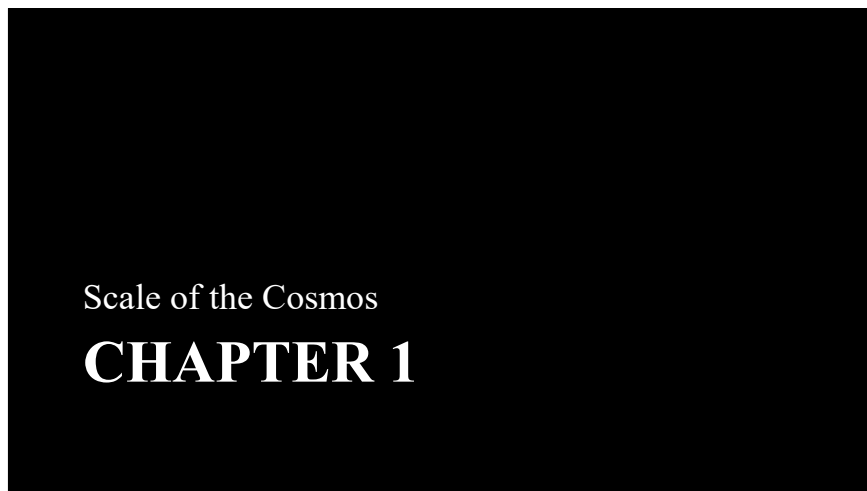
The Notorious B.I.G.

43

Slide 44

Chapter 1

- To understand the size of the universe
  - We will look at the known universe in 13 steps
  - Each step will be 100 times the previous step
    - For example…

My Cell Phone

0.52 feet

100 times

SACRAMENTO TOWER BRIDGE
THE OPERATORS HOUSE

52 feet

44

Slide 45
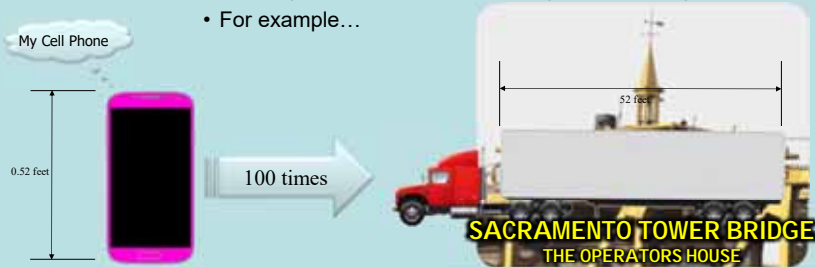
Step 1

52 feet x 52 feet

1. **Tower Bridge Operator's House**
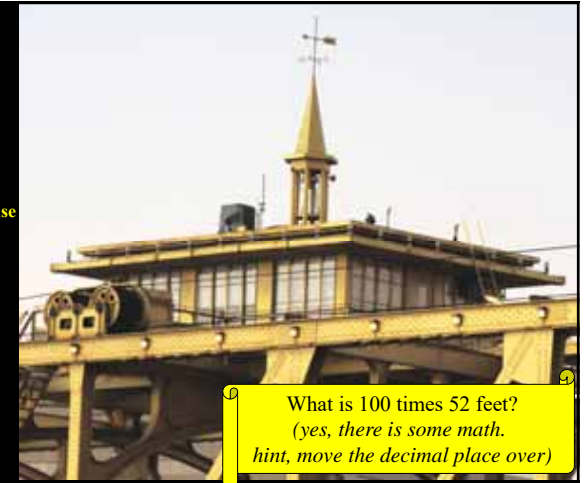
What is 100 times 52 feet?
(yes, there is some math.
hint, move the decimal place over)

45

Slide 46

Step 2

5,200 feet x 5,200 feet
or
0.98 miles x 0.98 miles

5,200 feet to yards??

$5{,}200 \; feet \; x \; \dfrac{1 \; yard}{3 \; feet} = 1{,}700$ yards

still big..

5,200 feet to miles??

$\dfrac{1 \; mile}{\quad feet} = 0.98$ miles

The statute mile of 5,280 feet originated in the Roman *mille* passus, or "thousand [...] measured 5,000 Roman feet. A Ro[...] 5 Roman fee[...], measured from[...] heel of one foot was raised to[...] was set down again after an in[...] other foot. Around the year 15[...] divided into 8 furlongs, with each fu[...] 625 feet. Later, under Queen Elizabeth I, the Statut[...] of 1593 confirmed the use of a shorter foot, which made the length of a furlong 660 feet, adding another 280 feet to the mile.

This is a large number; can we convert it to another unit for a number that is easier to recognize?

46

Slide 47

Step 2

5,200 feet x 5,200 feet
or
1700 yards x 1700 yards
or
0.98 miles x 0.98 miles
or
1.6 km x 1.6 km

1. Tower Bridge Operator's House
2. **Neighborhood**

What is 100 times 1.6 km?

47

Step 3

160 km x 160 km

1. Tower Bridge Operator's House
2. Neighborhood
3. **Mountains**

What is 100 times 160 km?

48

Step 4

16,000 km x 16,000 km

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. **Earth**

What is 100 times 16,000km?

49

Step 5

1,600,000 km x 1,600,000 km

or

1.6×10^6 km x 1.6×10^6 km

Unfortunately, there is are no units that are appropriate for this conversion.

In science when we are faced with this issue, we use scientific notation which reduces the chance in error with data transcriptions.

so for 1,600,000 kilometers (notice that there are six digits after the first digit...)

This is a large number; can we convert it to another unit for a number that is easier to maintain? It works out that six is the exponent in scientific notation or

1.6×10^6 kilometers

50

Step 5

1,600,000 km x 1,600,000 km

or

1.6×10^6 km x 1.6×10^6 km

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. **Earth and Moon**

zoomed

What is 100 times 1.6×10^6 km?

51

Slide 52

Step 6

1.6×10^8 km x 1.6×10^8 km

We have a unit that is defined as the average distance between the Earth and Sun.

The average distance between the Earth and Sun is defined as one Astronomical Unit.

so, 1.6×10^8 kilometers equals 1 AU.

This is a large number; we can Now convert it to another unit for a number that is easier to recognize.

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. **Inner Solar System**

Slide 53

Step 6

1 Astronomical Unit x 1 Astronomical Unit

1 AU x 1 AU

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. **Inner Solar System**

Enlarged to show relative size

What is 100 times 1 AU?

Slide 54

Step 7

100 AU x 100 AU

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. **Solar System (Pluto too!)**

What is 100 times 100 AU?

Slide 55

Step 8

10,000 AU x 10,000 AU

or
10^4 AU x 10^4 AU

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. **Solar System**

First time that there is no change!

Step 8

10,000 AU x 10,000 AU

or
10^4 AU x 10^4 AU

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. **Solar System**

Sun ━●━

What is 100 times 10^4 AU?

Step 9

10^6 AU x 10^6 AU

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. Solar System
9. **Local Stars**

Sun

Step 9

10^6 AU x 10^6 AU
or
17 ly x 17 ly
Light Years

We have a new unit to talk about, the
Light Year

This is a large number; can we
convert it to another unit for
a number that is easier to recognize?

In 1638, Galileo Galilei proposed an experiment, with an apparent claim to having performed it some years earlier, to measure the speed of light by observing the delay between uncovering a lantern and its perception some distance away. He was unable to distinguish whether light travel was instantaneous or not, but concluded that if it were not, it must nevertheless be extraordinarily rapid.
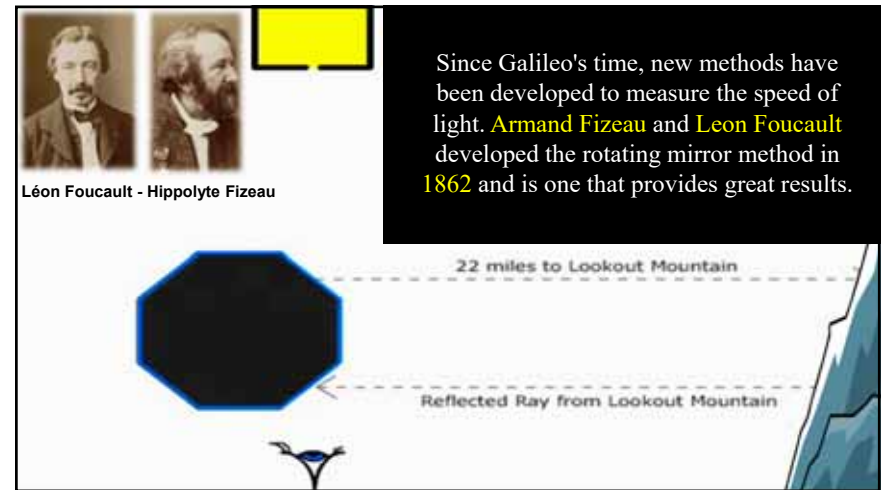
In 1667, the Accademia del Cimento of Florence (Academy of Experiment) reported that it had performed Galileo's experiment, with the lanterns separated by about one mile, but no delay was observed.

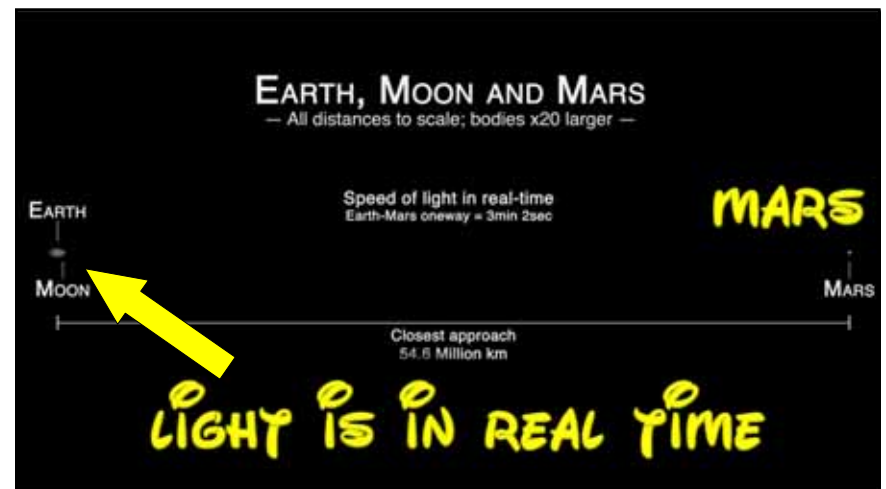*The actual delay in this experiment would have been about 11 microseconds.*

Slide 60

In 1638, Galileo Galilei's experiment, he was unable to distinguish whether light travel was instantaneous or not, but concluded that if it were not, it must nevertheless be extraordinarily rapid.

Finish Count

Sees the light

One Mile Apart

Slide 61

Léon Foucault - Hippolyte Fizeau

Since Galileo's time, new methods have been developed to measure the speed of light. Armand Fizeau and Leon Foucault developed the rotating mirror method in 1862 and is one that provides great results.

22 miles to Lookout Mountain

Reflected Ray from Lookout Mountain

Slide 62

Date	Author	Method	Result (km/s)
1676	Olaus Roemer	Jupiter's satellites	214,000
1726	James Bradley	Stellar Aberration	301,000
1849	Armand Fizeau	Toothed Wheel	315,000
1862	Leo		000
1879	Alb		910
1907	Ros		788
1926	Alb		796
1947	Essen, Gorden-Smith	Cavity Resonator	299,792
1958	K. D. Froome	Radio Interferometer	299,792.5
1972	Evenson et al.	Lasers	299,792.4574
1983		Adopted Value	299,792.458

1 Light Year = 5,879,000,000,000 Miles

1 Light Year = 63241 Astronomical Units

Slide 63

EARTH, MOON AND MARS
— All distances to scale; bodies x20 larger —

EARTH

MOON

Speed of light in real-time
Earth-Mars oneway = 3min 2sec

MARS

MARS

Closest approach
54.6 Million km

LIGHT IS IN REAL TIME

Step 9

10^6 AU x 10^6 AU

or

17 ly x 17 ly
Light Years

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
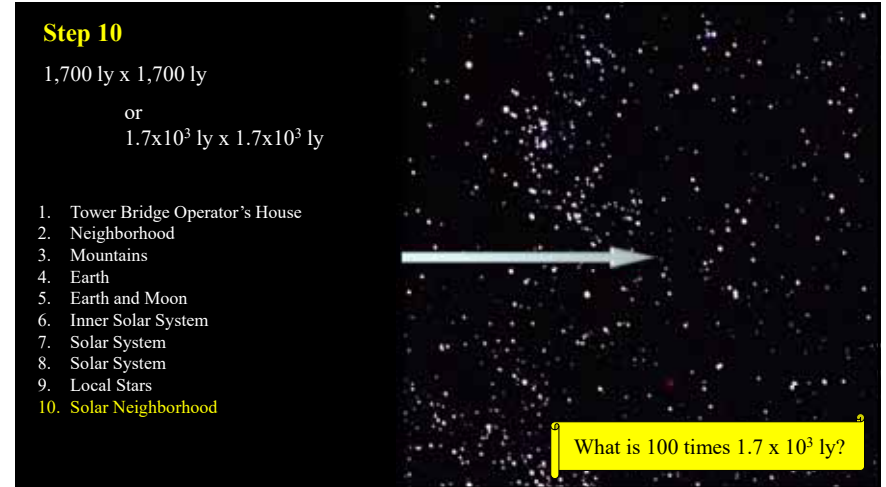8. Solar System
9. **Local Stars**

http://themalloryfamily.net/
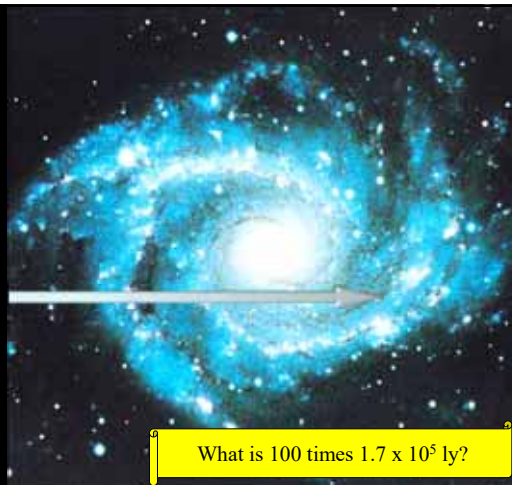
Sun

What is 100 times 17 ly?

64

Step 10

1,700 ly x 1,700 ly

or

1.7×10^3 ly x 1.7×10^3 ly

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. Solar System
9. Local Stars
10. Solar Neighborhood

What is 100 times 1.7×10^3 ly?

65

Step 11

170,000 ly x 170,000 ly

or

1.7×10^5 ly x 1.7×10^5 ly

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. Solar System
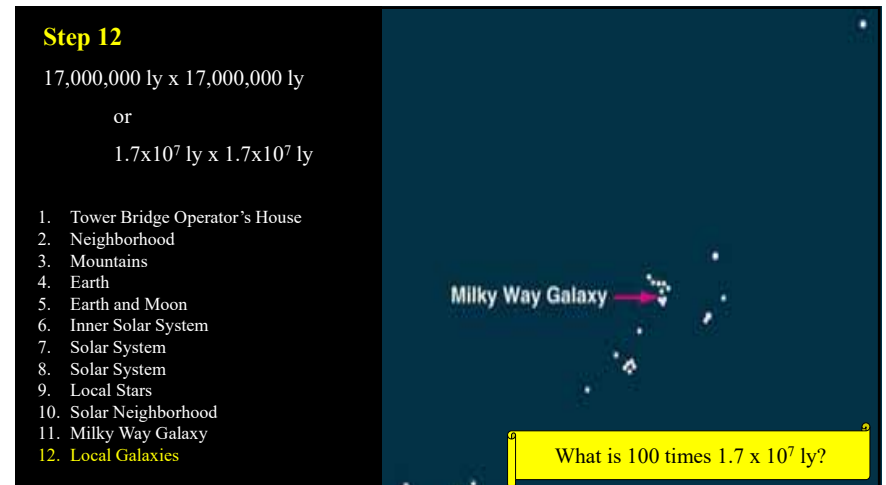9. Local Stars
10. Solar Neighborhood
11. Milky Way Galaxy

What is 100 times 1.7×10^5 ly?

66

Step 12

17,000,000 ly x 17,000,000 ly

or

1.7×10^7 ly x 1.7×10^7 ly

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. Solar System
9. Local Stars
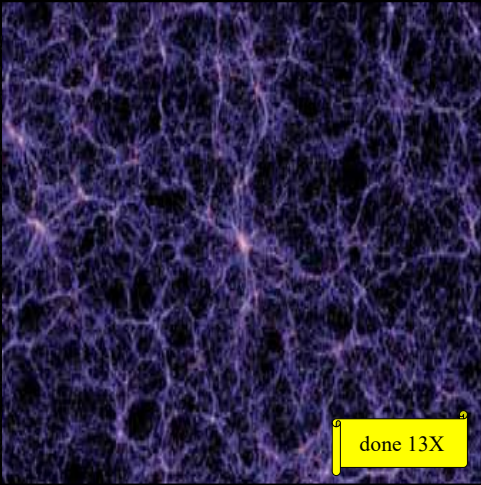10. Solar Neighborhood
11. Milky Way Galaxy
12. Local Galaxies

Milky Way Galaxy

What is 100 times 1.7×10^7 ly?

67

Step 13

1,700,000,000 ly x 1,700,000,000 ly

or

1.7×10^9 ly x 1.7×10^9 ly

1. Tower Bridge Operator's House
2. Neighborhood
3. Mountains
4. Earth
5. Earth and Moon
6. Inner Solar System
7. Solar System
8. Solar System
9. Local Stars
10. Solar Neighborhood
11. Milky Way Galaxy
12. Local Galaxies
13. Filaments and Voids

done 13X

The Universe in 13 Steps

1. Tower Bridge Operator's House (feet)
2. Neighborhood (miles)
3. Mountains (kilometers)
4. Earth (kilometers)
5. Earth and Moon (kilometers)
6. Inner Solar System (astronomical units)
7. Solar System (astronomical units)
8. Solar System (astronomical units)
9. Local Stars (light years)
10. Solar Neighborhood (light years)
11. Milky Way Galaxy (light years)
12. Local Galaxies (light years)
13. Filaments and Voids (light years)

Metric Units

Scientific Notation
Astronomical Units

Empty Space
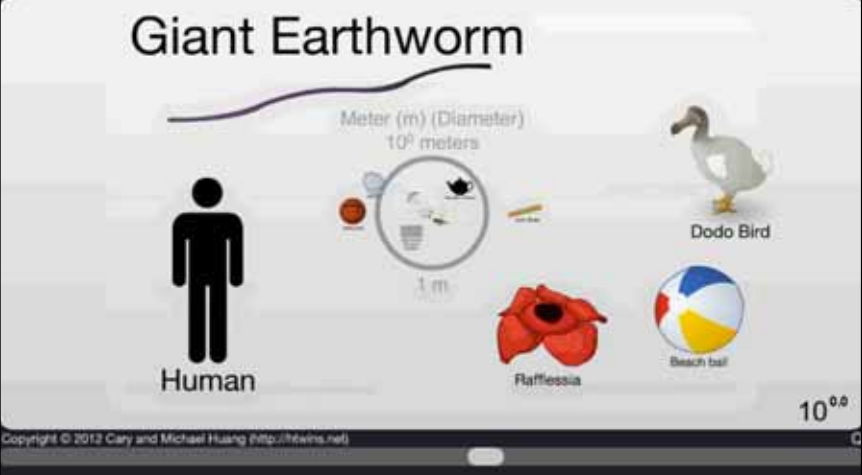*Light Years*

Beginning of Time

How Big is The Universe

- 13.6 billion Light Years for matter
- Composed of
  - Bright Matter
  - Dark Matter
  - Dark Energy ...together
    ...ps to expand things
- What else is out there... *lets take a flight*

Even though the universe is estimated to be around 13.8 billion years old, the light from the most distant objects that we can observe has been traveling through space for much longer, up to 93 billion years, due to the expansion of space.

Giant Earthworm

Meter (m) (Diameter)
10^0 meters

Human

Dodo Bird

1 m

Rafflesia

Beach ball

$10^{0.0}$

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My Very Enraged Mother Just Saw Us Naked

72

The Scientific Method

- Observations (forming the question)
  - Idea / Thought
    - When a horse gallops, what is the minimum number of feet touching the ground at any one time?

73

The Scientific Method

- Observations (forming the question)
  - Idea / Thought
    - When a horse gallops, what is the minimum number of feet touching the ground at any one time?

- Hypothesis (The guess)
  - Explain the observation, mathematically if possible
    - If a horse gallops, then two feet are always touching the ground.

74

The Scientific Method

- Observations (forming the question)
  - Idea / Thought
    - When a horse gallops, what is the minimum number of feet touching the ground at any one time?

- Hypothesis (The guess)
  - When the horse gallops, all feet come off the ground.

- Experimentation (The Data)
  - By independent analysis to confirm hypothesis
    - Take pictures and analyze the pictures

June of 1878

Retest

Revise Hypothesis

Edward James Muggeridge

Amasa Leland Stanford

75

18

The Scientific Method

- **Observations** (forming the question)
  - Idea / Thought
    - When a horse gallops, what is the minimum number of feet touching the ground at any one time?
- **Hypothesis** (The guess)
  - Explain the observation, mathematically if possible
    - When the horse gallops, all feet come off the ground.
- **Experimentation** (The Data)
  - By independent analysis to confirm hypothesis
    - Take pictures and analyze the pictures
- **Theory / Law** (accepted truth)
  - Proven over time
    - Verify by analyzing lots of horses over a sufficiency long period of time.
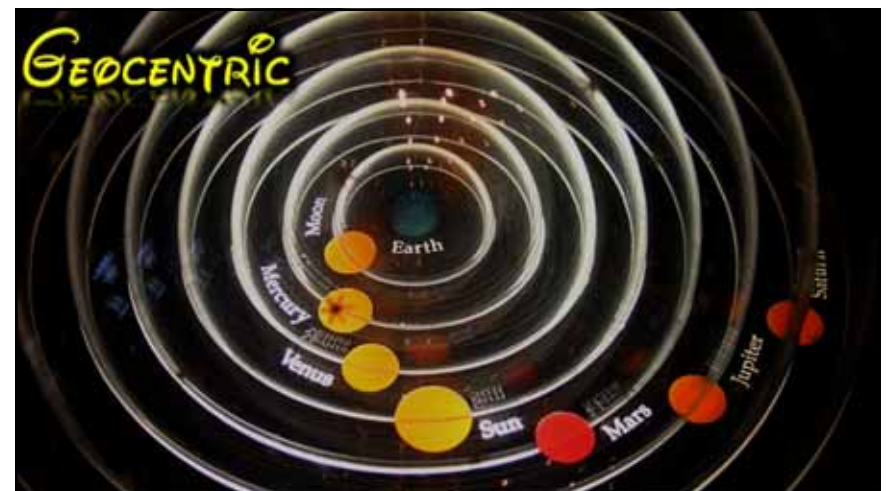
76

The Scientific Method

- Is Science always, correct?
  - No
- Does Science correct it's self when it knows it is wrong?
  - Yes
- Do people believe in the finding of Science?
  - Not always, but the good news is that people die and the next generation will typically accept the findings of Science.
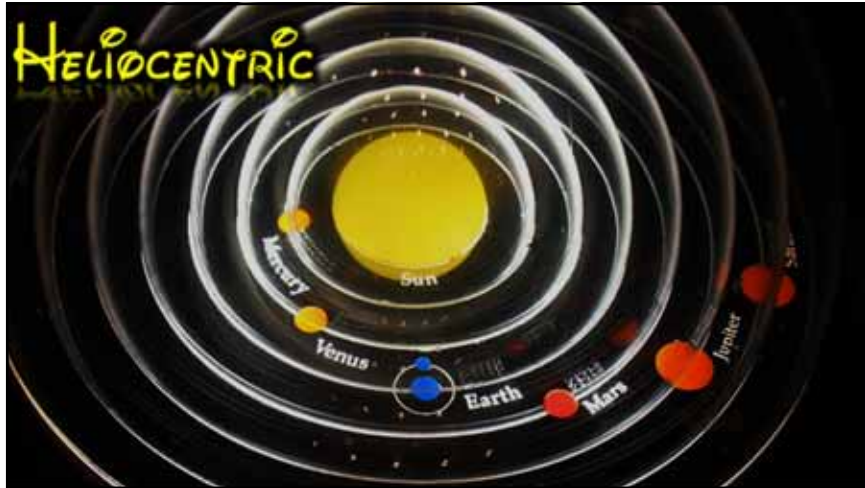
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Reference Points

- Astronomy classes will help you understand that you can have different reference positions.
  - Sun rising in the east and setting in the west = Geocentric
  - Planets going around the sun in almost a circular path – Heliocentric
  - Sun going around the center of the Milky Way galaxy – Galxocentric?
- Your point of reference is, simply put, *a model to understand how things work.*
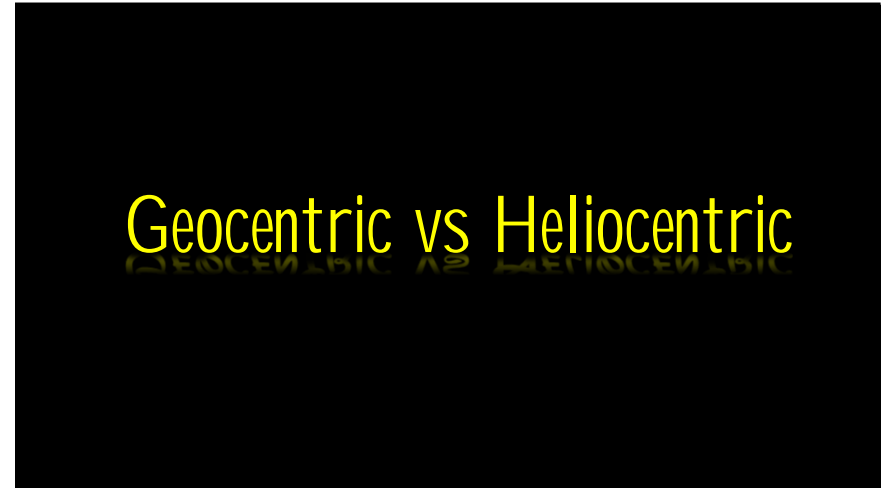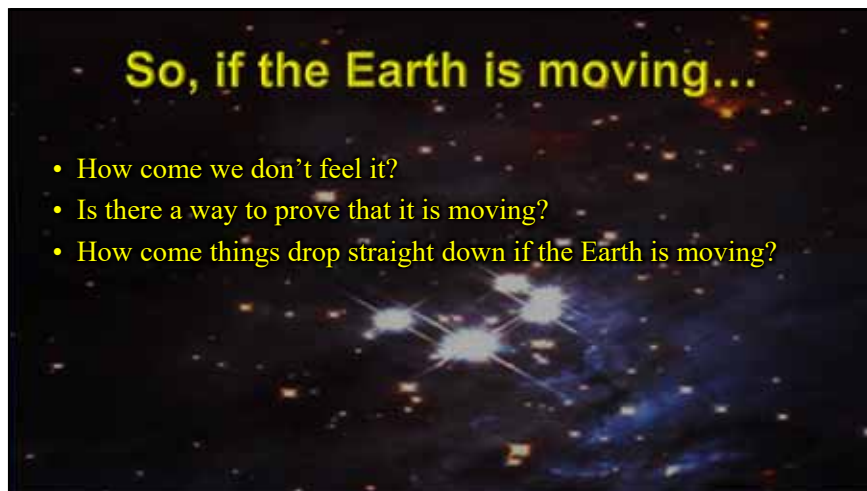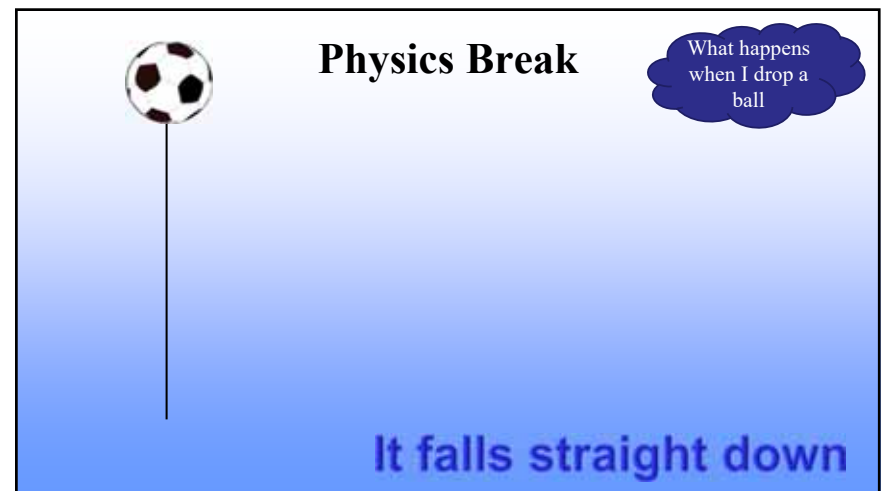
81

82

83

Geocentric vs Heliocentric

84

So, if the Earth is moving…

- How come we don't feel it?
- Is there a way to prove that it is moving?
- How come things drop straight down if the Earth is moving?

85

Physics Break

What happens when I drop a ball

It falls straight down

86

87

88

89

90

The Celestial Sphere

91

92

The Celestial Sphere

- Zenith = Point on the celestial sphere directly overhead
- Nadir = Point on the c.s. directly underneath (not visible!)
- Celestial equator = projection of Earth's equator onto the c.s.
- North celestial pole = projection of Earth's north pole onto the c.s.

94

The Celestial Sphere (II)

$90^\circ - \ell$

- From geographic latitude ℓ (northern hemisphere), you see the celestial north pole ℓ degrees above the horizon;

- From geographic latitude $-\ell$ (southern hemisphere), you see the celestial south pole ℓ degrees above the horizon.

• Celestial equator culminates $90^\circ - \ell$ above the horizon.

95

Latitude

Have you ever wondered where 360° for a circle came from?

90 degrees

96

Example:

New York City: $\ell \approx 40.7^0$

north celestial pole

Celestial Equator

40.7^0

49.3^0

Horizon

North

Horizon

South

The south celestial pole is not visible from the northern hemisphere.

97

Sextant

98

Apparent Motion of the Celestial Sphere

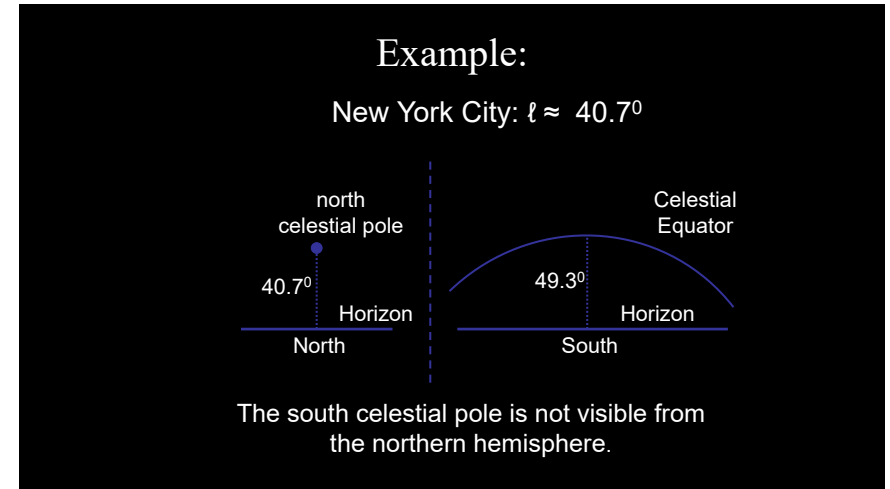North celestial pole
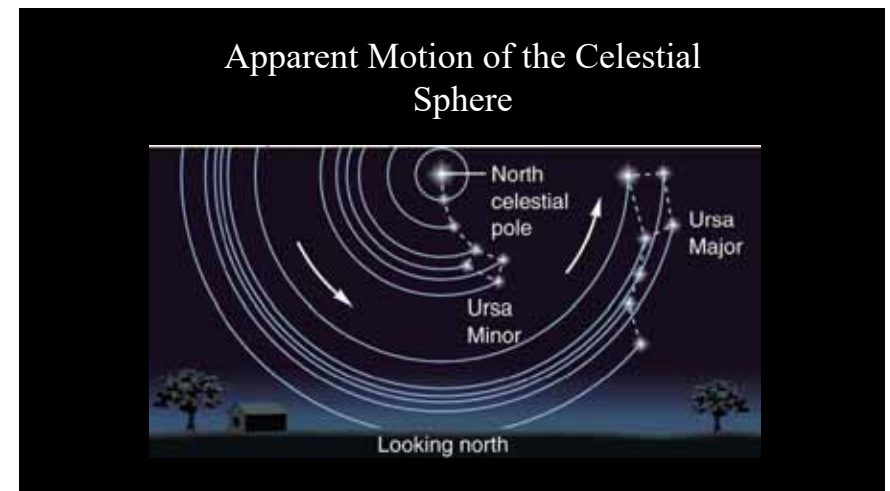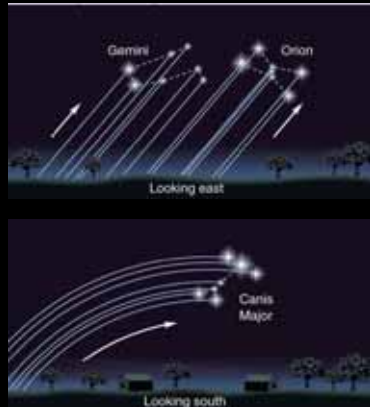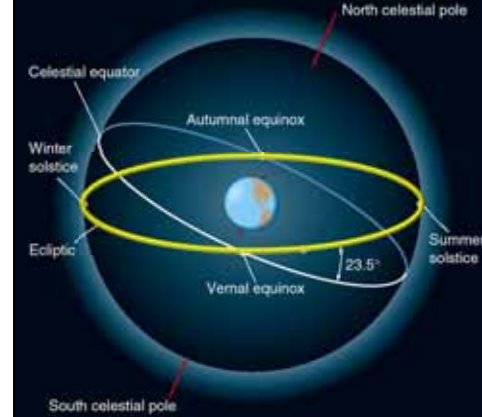
Ursa Major

Ursa Minor

Looking north

100

23

Apparent Motion of the Celestial Sphere II

101

The Ecliptic

Earth's equator is inclined against the ecliptic by 23.5°.

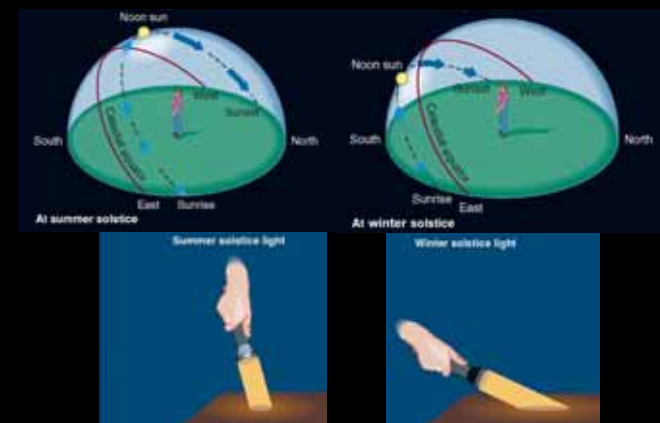The different incidence angle of the sun's rays is causing the seasons on Earth:

102

the seasons

103

The Seasons

104

24

The Seasons

Summer solstice light — Winter solstice light
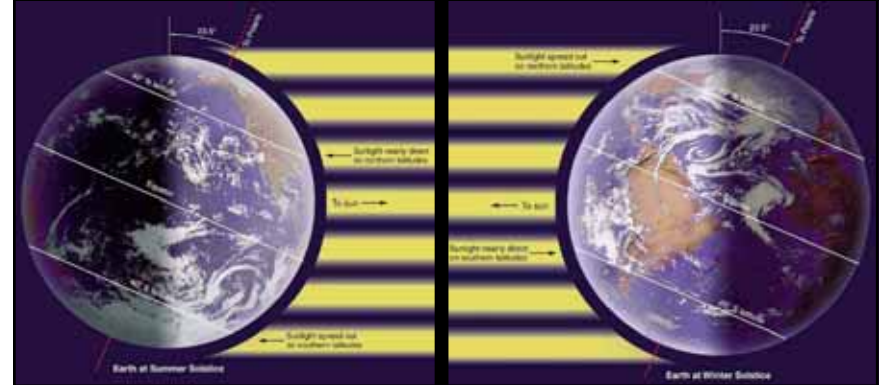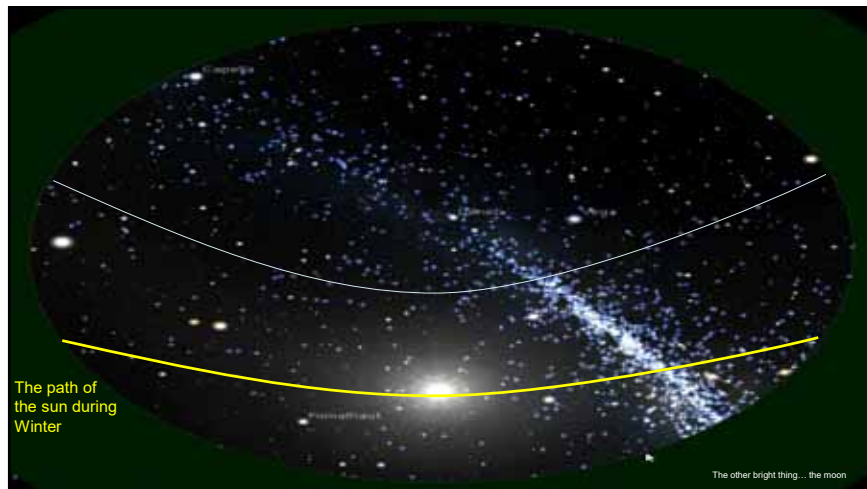
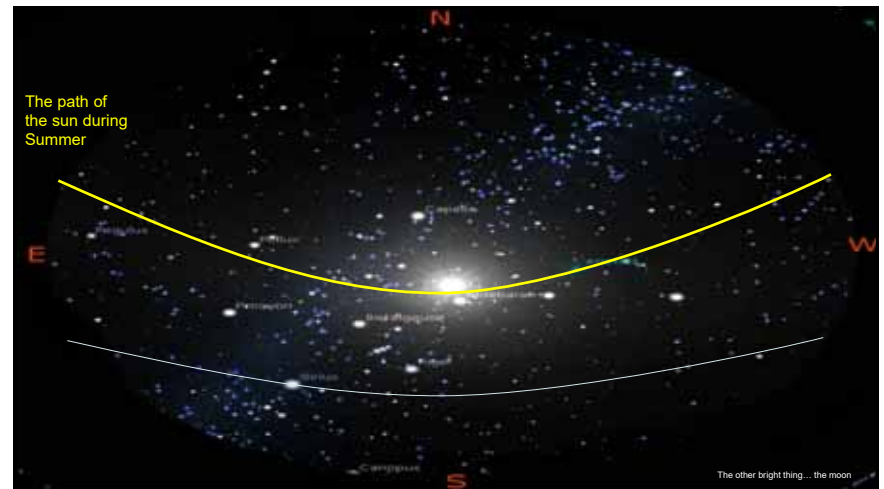Light over 1 division

Light over 2 divisions

105

The Seasons (III)

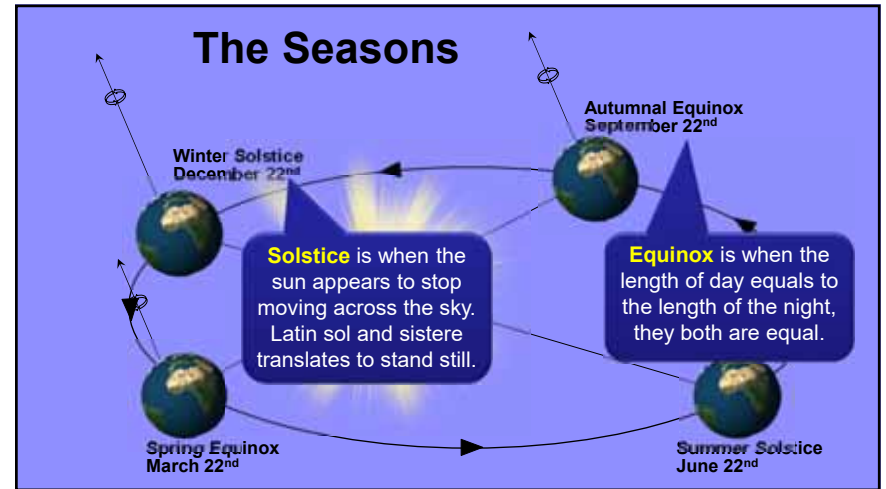Northern summer = southern winter   Northern winter = southern summer

106

The path of the sun during Winter

The other bright thing… the moon

107

The path of the sun during Summer

The other bright thing… the moon

108

25

At Noon

109

The Seasons

Winter Solstice
December 22nd

Autumnal Equinox
September 22nd

Solstice is when the sun appears to stop moving across the sky. Latin sol and sistere translates to stand still.

Equinox is when the length of day equals to the length of the night, they both are equal.

Spring Equinox
March 22nd

Summer Solstice
June 22nd

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The Seasons

Winter Solstice
December 22nd

Autumnal Equinox
September 22nd

Perihelion
January 3rd

Aphelion
July 4th

Spring Equinox
March 22nd

Summer Solstice
June 22nd

111

Off tangent… Just a thought…

What is the difference between…
Part
Apart

?

112

26

The Seasons

Earth's orbit (eccentricity greatly exaggerated)

Earth in January

Earth in July

sun

Earth's distance from the sun has only a very minor influence on seasonal temperature variations.

113

---

19. (10 points) Show the equinox's and solstice's of the Earth/Sun system clearly showing the following information:
   a. The relative distances of the Earth and the Sun (winter vs summer).
   b. The name of each of the four positions and the date.
   (The same as I drew on the board.)

Vernal Equinox
March 22

Winter solstice
December 22

Summer solstice
June 22

Autuminal Equinox
September 22

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Sacramento Airport Average Temperatures (°F)

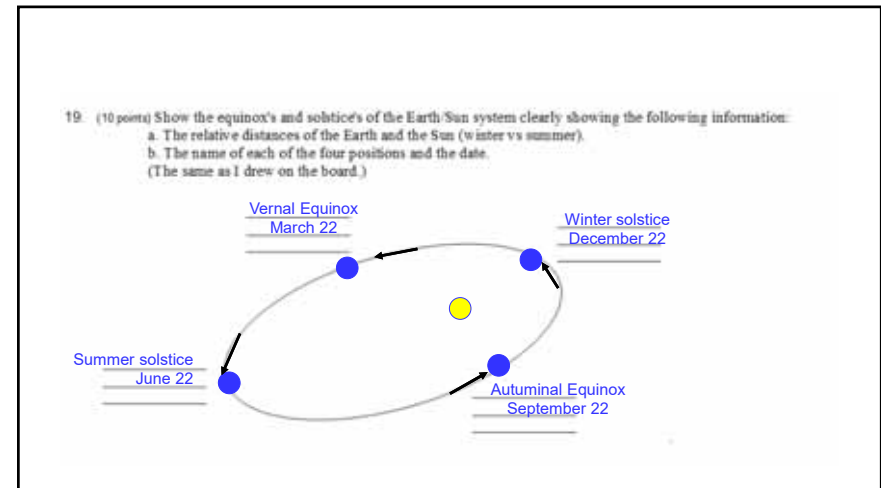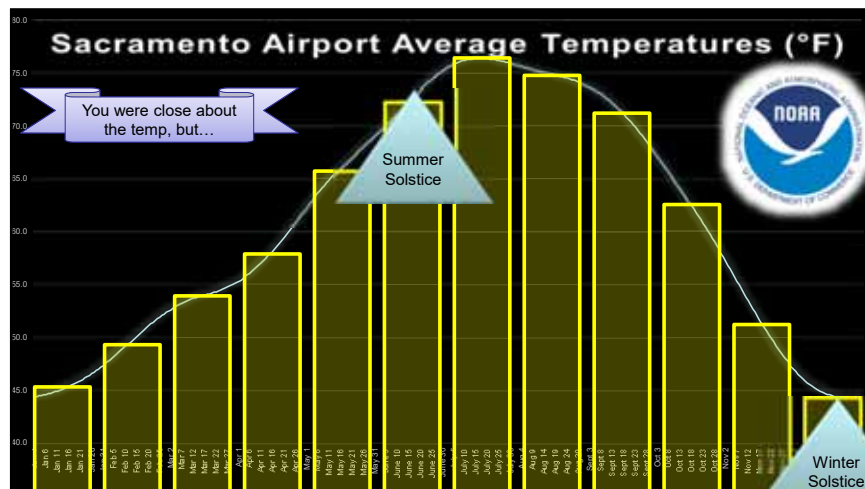You were close about the temp, but…
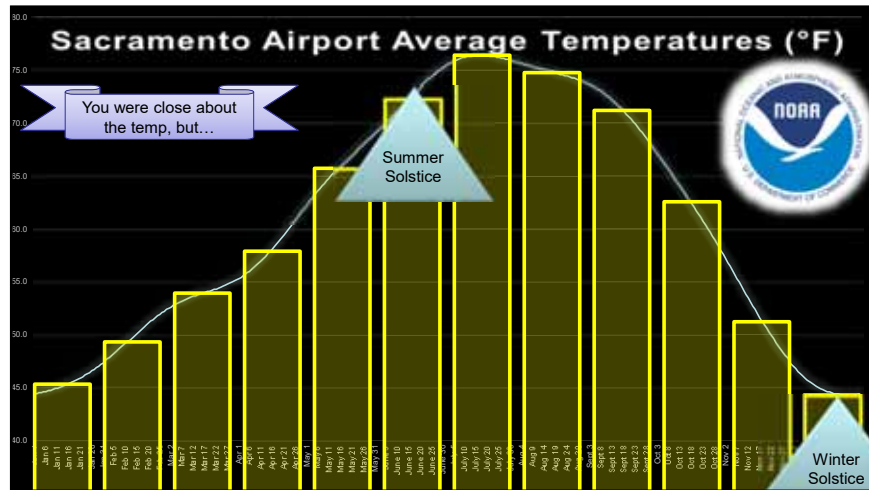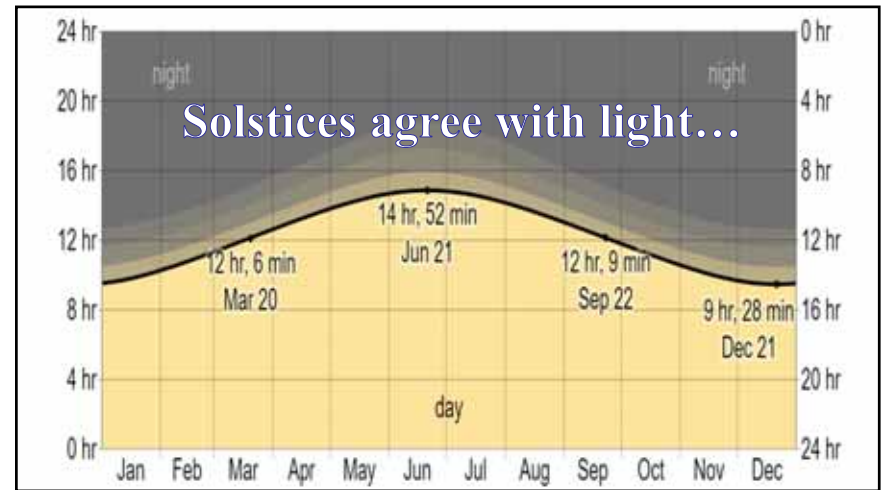
Summer Solstice

Winter Solstice

115

So why are the solstices not the warmest and coldest time of the year???

To answer this, we need to take a break and discuss something called specific heat
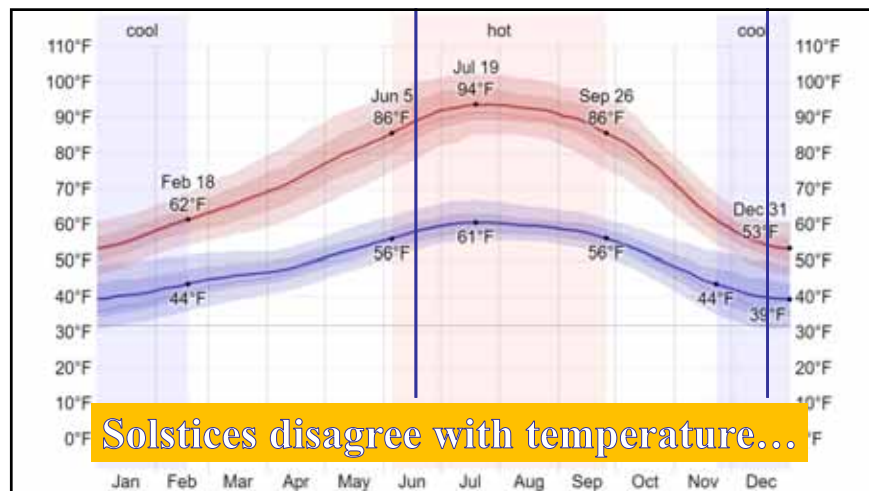
116

117

118

119

What is Specific Heat?
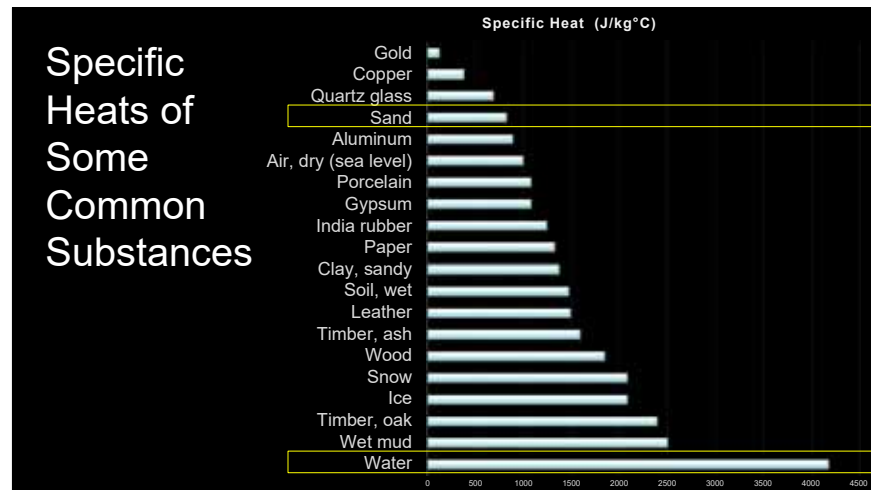
- Descriptions
  - The amount of heat required to change the temperature of a substance
  - The resistance to temperature change of a substance
- The units are energy per (mass times temperature)
  - Typical Units
    - Calories/gram·°C or $\frac{Calories}{gram \times °C}$ or $\frac{C}{g°C}$
    - Joules/kilogram·°C or $\frac{Joules}{Kilogram \times °C}$ or $\frac{J}{kg°C}$

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Slide 121

Specific Heats of Some Common Substances

Specific Heat (J/kg°C)

Substance
Gold
Copper
Quartz glass
Sand
Aluminum
Air, dry (sea level)
Porcelain
Gypsum
India rubber
Paper
Clay, sandy
Soil, wet
Leather
Timber, ash
Wood
Snow
Ice
Timber, oak
Wet mud
Water

(bar chart x-axis: 0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500)

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Slide 122

Sand (700 J/kg-C°) & Water (4186 J/kg-C°)
Sand changes temperature faster than water

122

Slide 123

So…

Why isn't the Solstices the warmest and coldest times of the year?

Because of the heat capacity of the ___ als on Earth. Specifically the la___ er which resists the cha___ ___ ___ ade up of various materia___ ___ eat will retain that heat when heat is no longer be___ ___ ___ and objects have this same property where the heat takes time to be either loss or gained over time. Now all I am ___

Thermal Lag

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Slide 124

Precession (I)

Gravity is pulling on a slanted top. => Wobbling around the vertical.

The sun's gravity is doing the same to Earth.

The resulting "wobbling" of Earth's axis of rotation around the vertical w.r.t.
the ecliptic takes about 26,000 years and is called precession.

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Precession (II)

As a result of precession, the north celestial pole follows a circular pattern on the sky, once every 26,000 years.

It will be closest to Polaris ~ A.D. 2100.

~ 12,000 years from now, it will be close to Vega in the constellation Lyra.

There is nothing peculiar about Polaris (neither particularly bright nor nearby

125

Bringing Everything Together

126

Due to Earth's revolution around the sun, the sun appears to move through the zodiacal constellations.
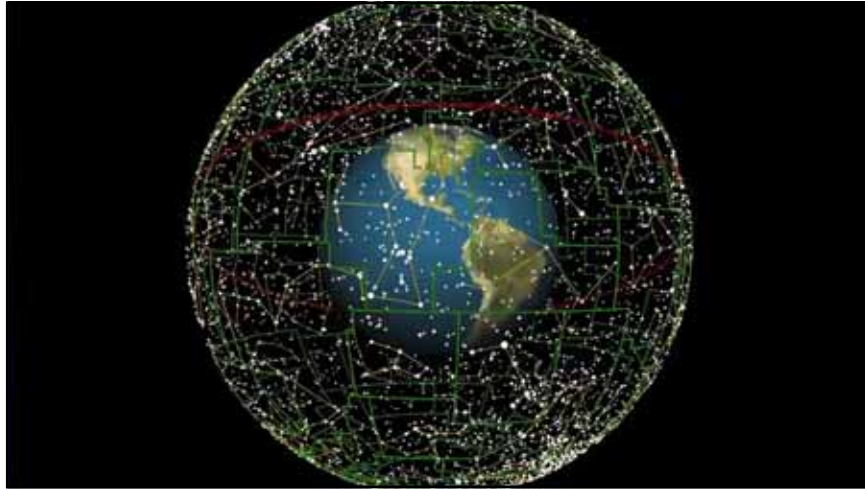
The sun's apparent path on the sky is called the **ecliptic**.

Equivalent: The ecliptic is the projection of Earth's orbit onto the celestial sphere.

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Sacramento City College
Astro 310

End of Chapter 1

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