KNOWLEDGE TO "GET" FROM TODAY'S CLASS MEETING

ASTR 105G Class Meeting #8, Friday, February 5th, 2016

1) Complete our discussion of SEASONS (*pages 32-39 of your text*)

2) SOLAR Day Length vs. SIDEREAL Day Length (*pgs 84-89*)

3) Moon Phases … if we have the time

4) … Earn a good grade on Quiz #2

LABS next Wednesday & Thursday (Feb 10th & 11th)
will be held at Aggie Memorial Stadium

We will <u>meet</u> at the northwest corner of the stadium (*you'll see a map in a moment*)

We will do some initial work while inside a building there, and then we will move down to the field to complete the **SCALE MODEL OF THE SOLAR SYSTEM** Lab exercise … numbered pages 79-88,

LAB03-SolarSystemScaleModel-Feb10-11

at

http://astronomy.nmsu.edu/murphy/ASTR105G-M040506-Spr2016/LAB-MANUAL

YOU SHOULD HAVE YOUR OWN PRINTED COPY OF THE LAB WITH YOU WHEN YOU ARRIVE AT LAB!! ***DOUBLE-SIDED PRINTING IS FINE***

Name:_____
Date:_____

6 Scale Model of the Solar System

6.1 Introduction

The Solar System is large, at least when compared to distances we are familiar with on a day-to-day basis. Consider that for those of you who live here in Las Cruces, you travel 2 kilometers (or 1.2 miles) on average to campus each day. If you go to Albuquerque on weekends, you travel about 375 kilometers (232.5 miles), and if you travel to Disney Land for Spring Break, you travel $\sim$ 1,300 kilometers ($\sim$ 800 miles), where the '$\sim$' symbol means "approximately." These are all distances we can mentally comprehend.

Now, how large is the Earth? If you wanted to take a trip to the center of the Earth (the very hot "core"), you would travel 6,378 kilometers (3954 miles) from Las Cruces down through the Earth to its center. If you then continued going another 6,378 kilometers you would 'pop out' on the other side of the Earth in the southern part of the Indian Ocean. Thus, the total distance through the Earth, or the **diameter** of the Earth, is 12,756 kilometers ($\sim$ 7,900 miles), or 10 times the Las Cruces-to-Los Angeles distance. Obviously, such a trip is impossible–to get to the southern Indian Ocean, you would need to travel on the surface of the Earth. How far is that? Since the Earth is a sphere, you would need to travel 20,000 km to go halfway around the Earth (remember the equation Circumference $= 2\pi$R?). This is a large distance, but we'll go farther still.

Next, we'll travel to the Moon. The Moon, Earth's natural satellite, orbits the Earth at a distance of $\sim$ 400,000 kilometers ($\sim$ 240,000 miles), or about 30 times the diameter of the Earth. This means that you could fit roughly 30 Earths end-to-end between here and the Moon. This Earth-Moon distance is $\sim$ 200,000 times the distance you travel to campus each day (if you live in Las Cruces). So you can see, even though it is located very close to us, it is a long way to the Earth's nearest neighbor.

Now let's travel from the Earth to the Sun. The *average Earth-to-Sun distance*, $\sim$ 150 million kilometers ($\sim$ 93 million miles), is referred to as one **Astronomical Unit** (AU). When we look at the planets in our Solar System, we can see that the planet Mercury, which orbits nearest to the Sun, has an average distance of 0.4 AU and Pluto, the planet almost always the furthest from the Sun, has an average distance of 40 AU. Thus, the Earth's distance from the Sun is only 2.5 percent of the distance between the Sun and planet Pluto!! Pluto is very far away!

The purpose of today's lab is to allow you to develop a better appreciation for the distances between the largest objects in our solar system, and the physical sizes of these objects relative to each other. To achieve this goal, we will use the length of the football field in Aggie Memorial Stadium as our platform for developing a scale model of the Solar System. A *scale*

Biology annex

Meet here for labs Feb 8th & 9th

PARKING available here ; *no need for an NMSU parking permit*

PARKING available across the street with any color NMSU parking permit

_____Lab's will start at *40 minutes after the hour* (rather than 30 minutes after the hour) to provide time for us all to get from campus to the stadium *Meet inside the northwest corner of the stadium*

QUIZ #3 WILL OCCUR next Fri, Feb 12th

Topics that will be covered:

1) **Kepler's 3 Laws of Planetary Motion**
2) **Phases of the Moon & Eclipses**
3) **Sidereal vs. Solar Day length (*and month*)**
4) **SEASONS: why do we experience them?**
5) **The 8+ planets in our solar system**
6) **Density, mass, volume, gravity**
7) **Radiant energy, Temperature, Spectra, Telescopes (Chapters 5 & 6).. *next week***

Read Chapter 5 for next week… start Chap 6

QUIZ #3 Study Aid

Seasons: *text pages 32-39*

end of chapter questions: Ch 2 #s 9, 10, 24, 30, 31

Phases of the Moon: *text pages 39-41*

end of chapter questions: Ch 2 #s 12, 26, 33, 38, 42, 43

Eclipses: *text pages 42-45*

end of chapter questions: Ch 2 #s 14, 35, 44, 45

The "Visuals Skills Check" questions at the end of Chapter 2 (page 50 in the 7th edition)

Radiant Energy (temperature effects): txt pgs 138-143, 150-155

end of chapter questions: Ch 5 #s 16, 19, 22, 27, 28, 35

Telescopes: *text pages 168-174*

end of chapter questions: Ch 6 #s 5, 19, 23

EXAM #1 occurs 14 days from today,
Friday, February 19th

An EXAM STUDY GUIDE will be distributed Monday during class……..

and will also available online in the STUDY-GUIDE folder at the class web site

PICTURE OF THE DAY

Earth image obtained from an orbiting satellite

What regions of the Earth are visible here?

Could this satellite image have been obtained on June 21, 2015?

Why or why not?

LET'S continue to TALK SEASONS:

We can, with a flashlight, illustrate the fact that when the Sun is NOT directly overhead (*say, for Earth's winter hemisphere*) that the received sunlight is 'SPREAD OUT' over a larger area, providing less heating per unit area

[**<u>This is not unlike the following</u>: I have $1,370 'per square meter' of money to hand out. I am going to spread this money out like sunlight on the Earth. Do you want the Sun be directly above the one meter you are standing on (so you will receive $1,370), or do you want to be <u>60 degrees of latitude</u> away from the 'sub-solar' latitude, where you will receive only:**

$685 per square meter ?

($1,370 x cosine(60 degrees)=$1,370 x 0.5 = $685)

SEASONS OCCUR HERE ON EARTH BECAUSE:

i) Earth's rotation axis is tilted 23.5 degrees (of angle) relative to a line perpendicular (*90 degree angle*) to the plane of Earth's orbit

ii) Earth's North Pole always points toward the same direction (seemingly toward some very distant star, the "North Star"; the South Pole always points in the opposite direction)

iii) As the Earth moves in its orbit around the Sun, *during half the year the North Pole* (and also the entire northern hemisphere) is more directly "angled" toward the Sun (during northern Spring and Summer); during this same ½ of the year, the South Pole is "angled" away from the Sun

iv) The Summer hemisphere receives sunlight from more directly overhead ('*the Noon Sun is high in the sky*') AND the *daytime duration from sunrise-to-sunset is longer during Summer*

The NORTH STAR

Earth's 23.5 degree axis tilt results in Las Cruces experiencing:

Summer in July

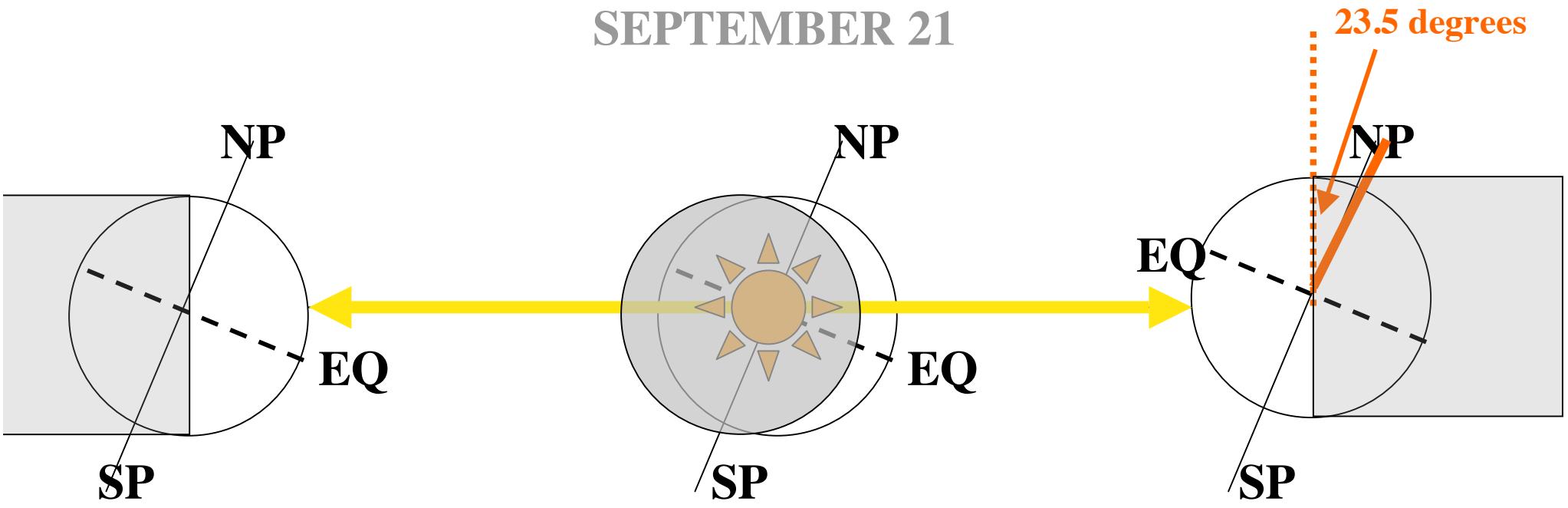
JUNE 21

Spring in April
Autumn in October

MARCH 21
SEPTEMBER 21

Winter in January

DECEMBER 21



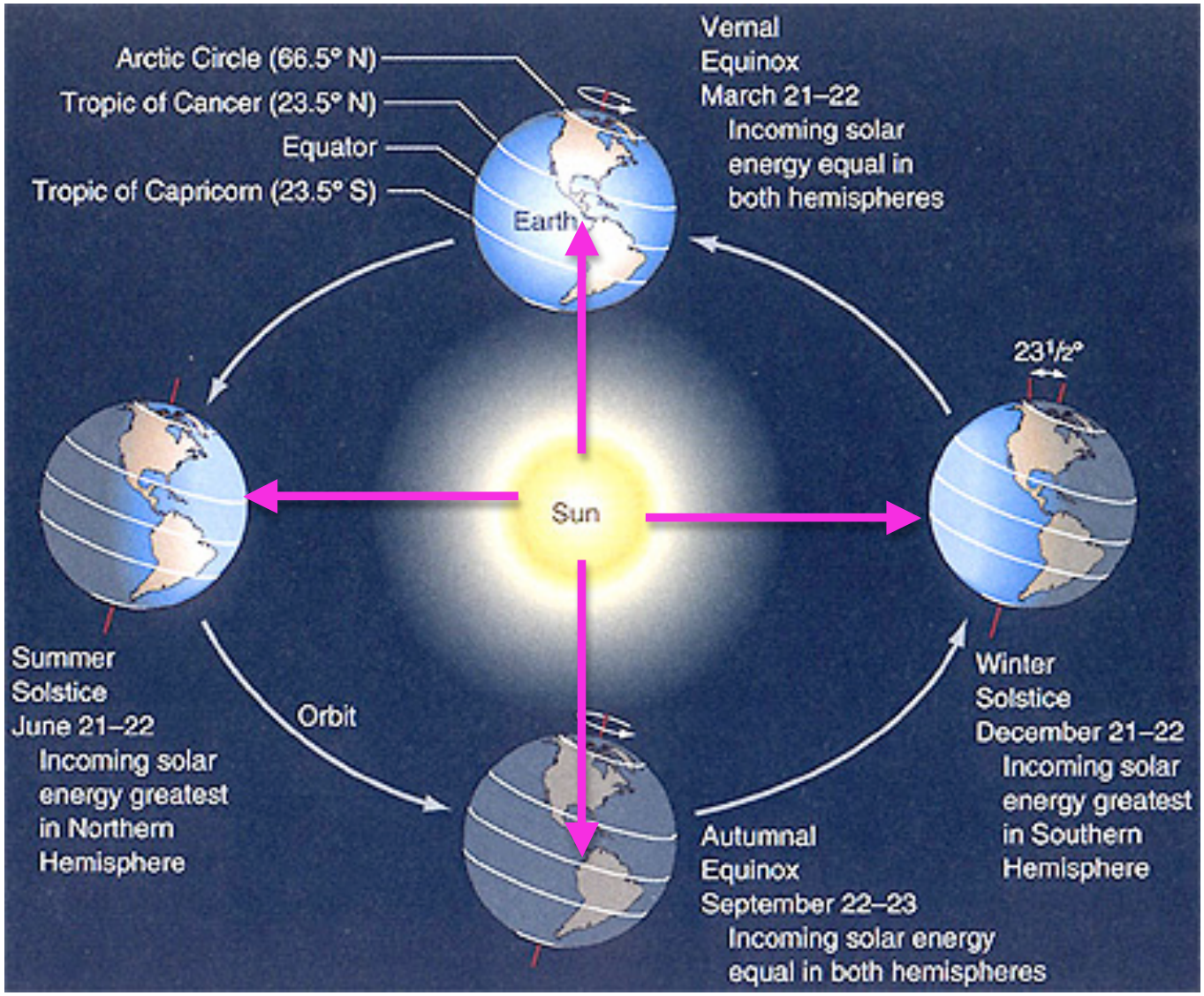
Sunlight 'more direct' in Northern hemisphere

Sunlight evenly distributed between northern and southern hemispheres

Sunlight 'more direct" in Southern hemisphere

SHADING in the figures above represents the NIGHTSIDE of Earth

Picture representations of SEASONS in textbooks, such as Figure 2.15 in your text, often have the following appearance:



.. which are not always the most useful illustrations of the concept.

For the planets in our Solar System, which ones DO NOT experience seasons?.. only Mercury does not experience seasons!

	Eccentricity	Axis Tilt (angle)
Mercury	0.20	0.0
Venus	0.007	177.3
Earth	0.017	23.5
Mars	0.093	25.2
Jupiter	0.048	3.08
Saturn	0.056	26.73
Uranus	0.046	97.92
Neptune	0.01	29.6
Pluto	0.25	112.5

NO SEASONS !!!

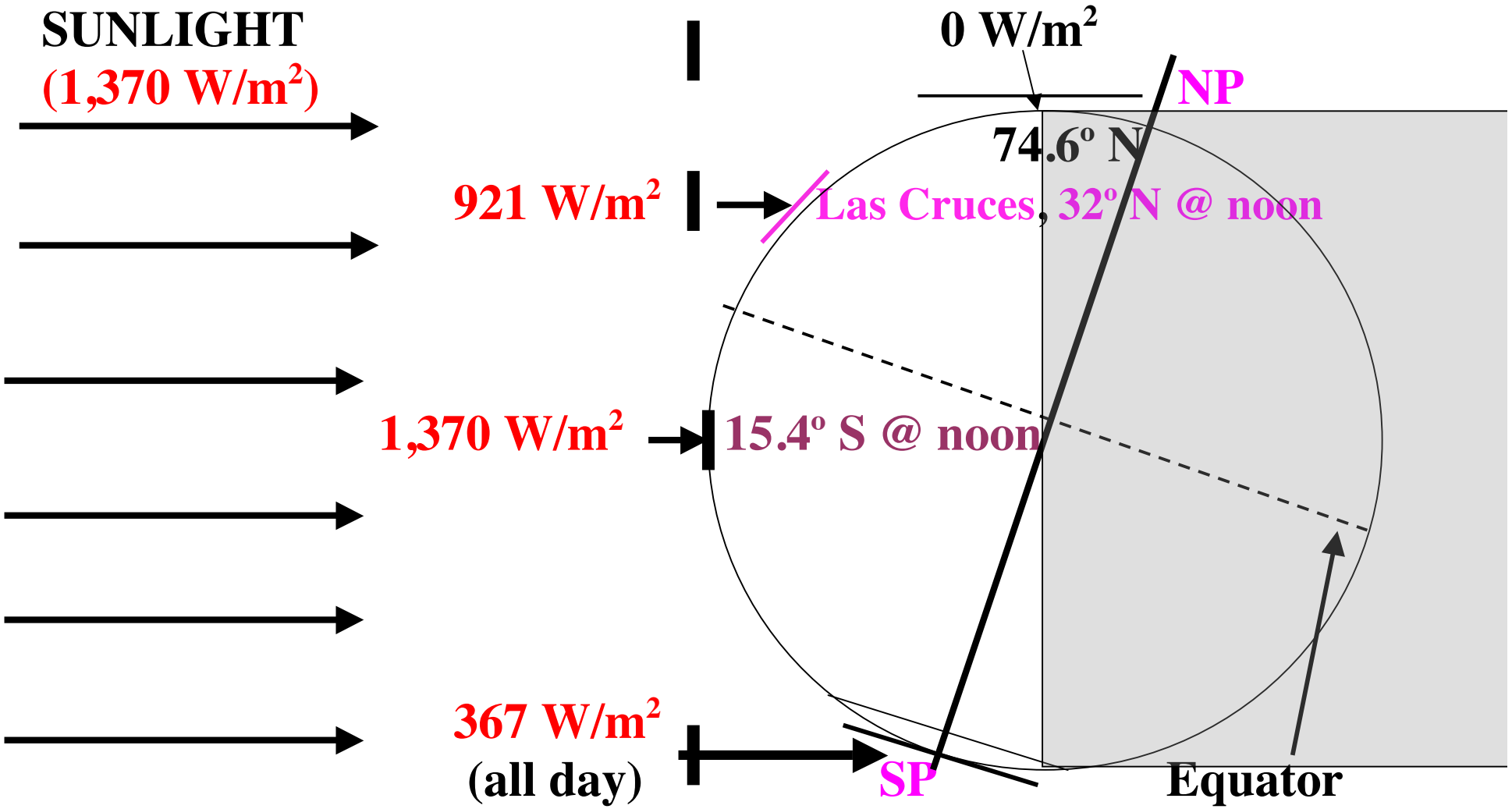
..least extreme of planet with seasons… why?

MOST EXTREME SEASONS!

The closer to 90 degrees the axis tilt is, the more extreme the seasons, since at 90 degrees axis tile, the North Pole (and then the South Pole) will be pointed DIRECTLY toward the Sun during Summer, and directly away from the Sun in winter…. On Earth, the North Pole is always 66.5 or more degrees of angle away from being pointed directly toward the Sun

Notice above that even though Mercury has a large orbit eccentricity (0.20), it DOES NOT experience seasons because its axis tilt is zero degrees

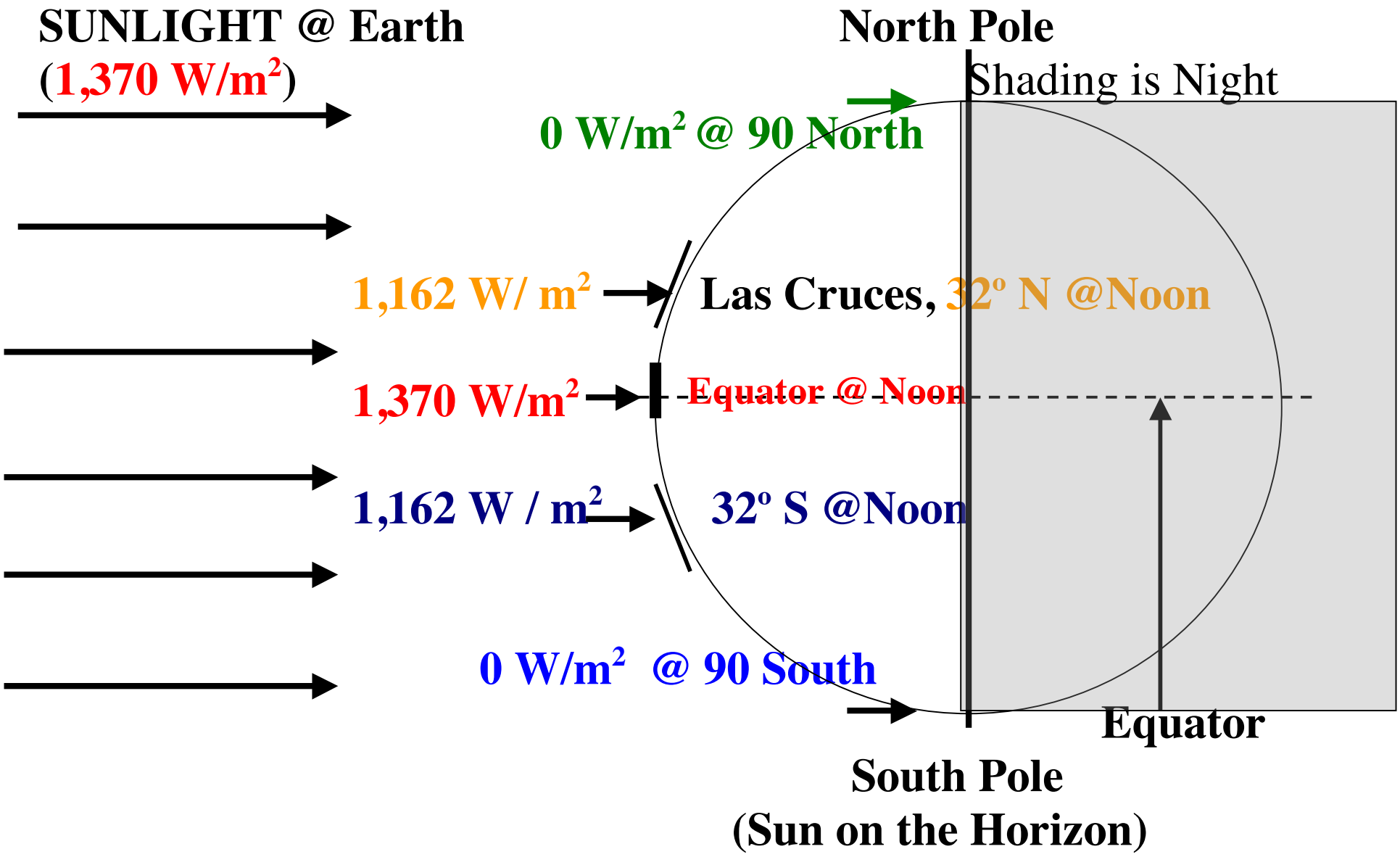
SUNLIGHT DISTRIBUTION ON THE EARTH: Feb 3rd, 2016



If the Sun is not directly overhead, the sunlight in one square meter of incoming light is spread out *over an area of the surface that is larger than 1 square meter*, so it's heating ability is reduced

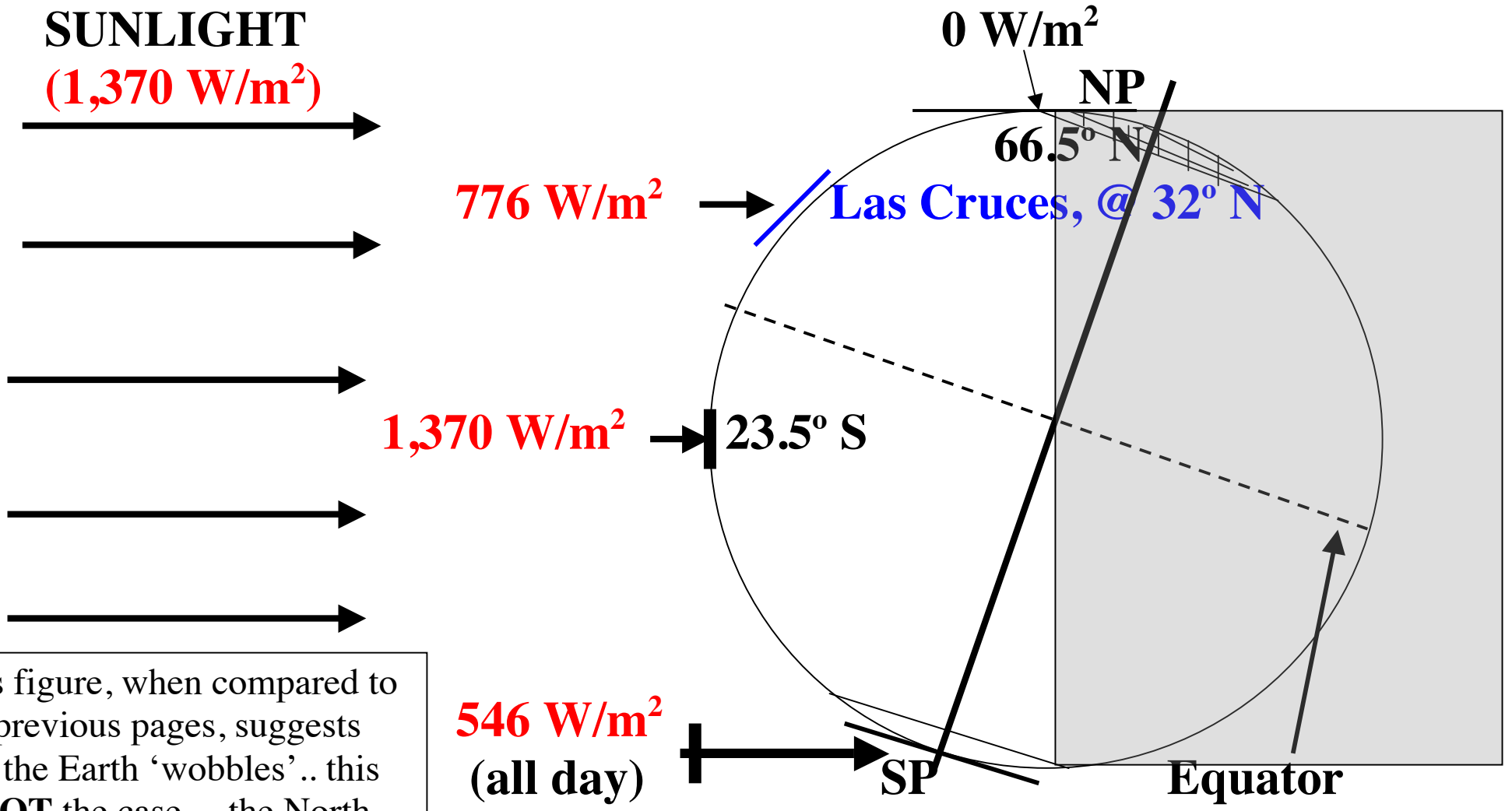
Length of time from sunrise-to-sunset in Las Cruces: 10 hrs 40 minutes

SUNLIGHT DISTRIBUTION ON THE EARTH: Sept 22nd or March 22



Length of time from sunrise-to-sunset in Las Cruces: 12 hrs 0 minutes

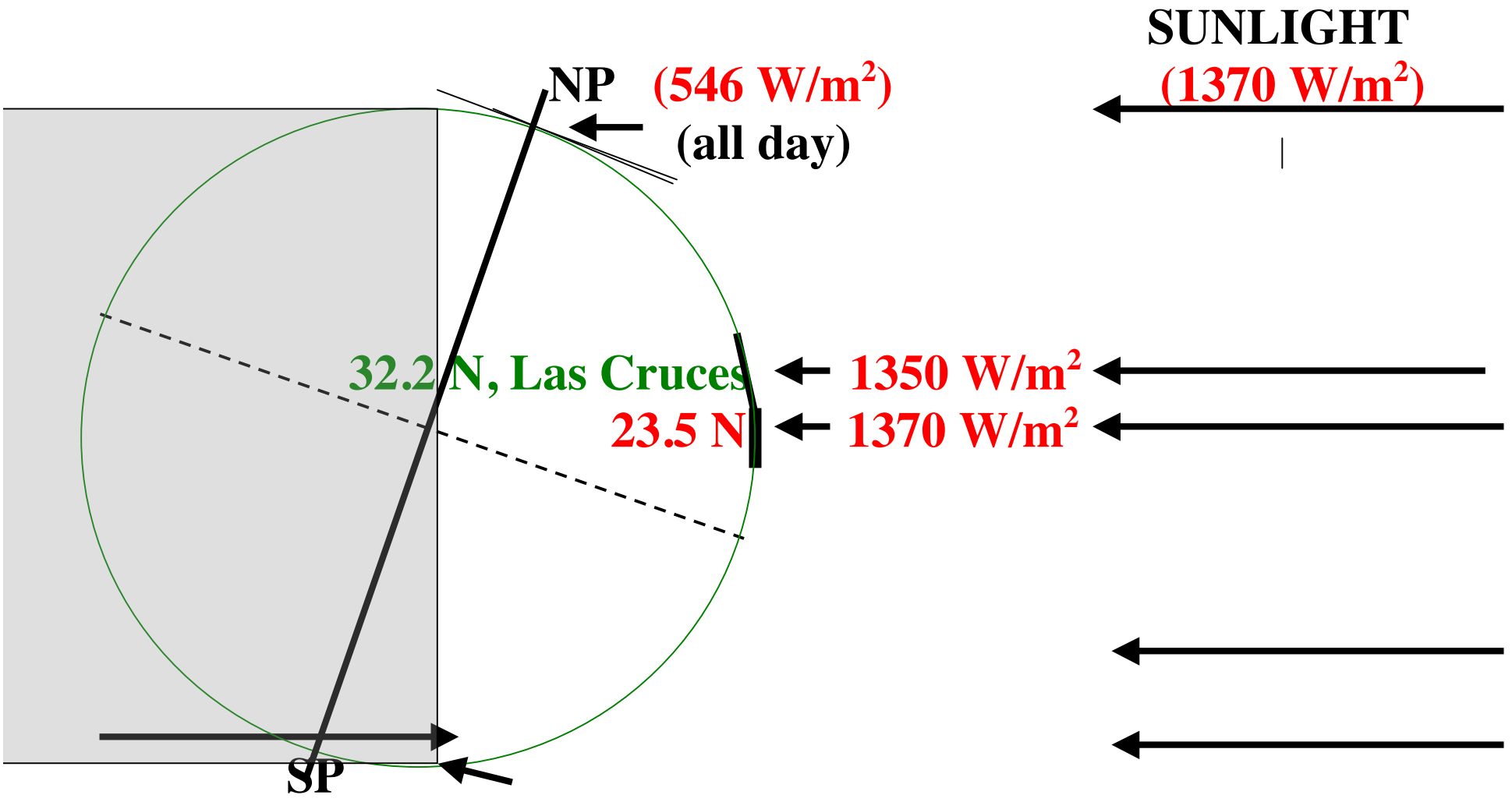
SUNLIGHT DISTRIBUTION ON THE EARTH: Dec 21



This figure, when compared to the previous pages, suggests that the Earth 'wobbles'.. this is **NOT** the case… the North Pole always points toward the same point in space

Length of time from sunrise-to-sunset in Las Cruces: 10 hrs 2 minutes

SUNLIGHT DISTRIBUTION ON THE EARTH: June 21



South 0 W/m² @ 66.5 S

Pole does not receive sunlight

Length of time from sunrise-to-sunset in Las Cruces: 14 hrs 16 minutes

A MADE-UP PLANETARY SYSTEM

(planets orbit a star with the same mass as the Sun)

	ORBIT			AXIS
PLANET	OSA (AU)	PERIOD (UNITS?)	ECCENTRICITY	TILT (angle)
ALBA	1.0	_____	0.0	28º
BILL	4.0	_____	0.6	0º
CELIA	10.0	_____	0.4	3º

1) What are the orbital periods of these planets?

2) Do any of these planets experience seasons?

3) Which planet possesses the <u>least</u> circular orbit? Does this planet experience seasons?

A MADE-UP PLANETARY SYSTEM

(planets orbit a star with the same mass as the Sun)

	ORBIT			AXIS
PLANET	OSA (AU)	PERIOD (UNITS?)	ECCENTRICITY	TILT (angle)
ALBA	1.0	1 Earth yr	0.0	28º
BILL	4.0	8 Earth yrs	0.6	0º
CELIA	10	31.6 Earth yrs	0.4	3º

1) What are the orbital periods of these planets? *See Table*

2) Which, if any, of these planets experience SEASONS?

ALBA & CELIA; **both have non-zero or non-180 Axis Tilt**

3) Which listed planet possesses the least circular orbit? Does this planet experience seasons?

BILL, *since it has the largest orbit eccentricity*, BUT Bill does not experience seasons.. **it has zero degree axis tilt**

Planets which possess non-circular (*non-zero eccentricity*) orbits do experience variations in the intensity of sunlight they receive as they travel through their orbit,… BUT these variations, and the planet temperature variations that might result, are not considered SEASONAL VARIATIONS

No good word or phrase has been defined to explain these variations arising from a planet possessing an eccentric orbit

PICTURE OF THE DAY.. again

Earth image obtained from an orbiting satellite

What regions of the Earth are visible here?

So, this satellite image COULD NOT have been obtained on June 21, 2015 because *in July the South Pole does not experience any sunlight at all* !!

The satellite image must have been obtained during Northern Hemisphere winter when the North Pole is pointed away from the Sun while the South Pole is in sunlight during the entire day

ANY QUESTIONS REGARDING THE PHYSICAL PROCESS THAT CAUSES SEASONS?

Could you draw a picture that illustrates why it is

HOT in Las Cruces in June

and

COLD in Las Cruces in December?

.. A LAB in a few weeks will focus upon SEASONS

Let's now work through Part 2 of Lecture 07 In-Class Exercise ..

Now, on to EARTH ROTATION issues…

Question #1: How long is 'ONE DAY' ?

(where ONE DAY is 'Noon to Noon' from one day to the next)

Answer #1: ***'24 hours, that's easy!'***

OK, but……

Question #2: How long is one rotation (*one Complete 'spin' on its axis*) of the Earth?

Answer #2:'Gee, that should be 24 hours, also'

But, alas, it is not……

The Earth completes one rotation (one spin) on its axis, relative to the fixed pattern of stars, in a time of 23 hours and 56 minutes

What does this really mean?

It means that: if the Earth was standing still (not orbiting around the Sun), the star that is directly overhead right now would again be directly overhead 23 hours and 56 minutes from now, and then again 23 hours and 56 minutes after that, and so on….

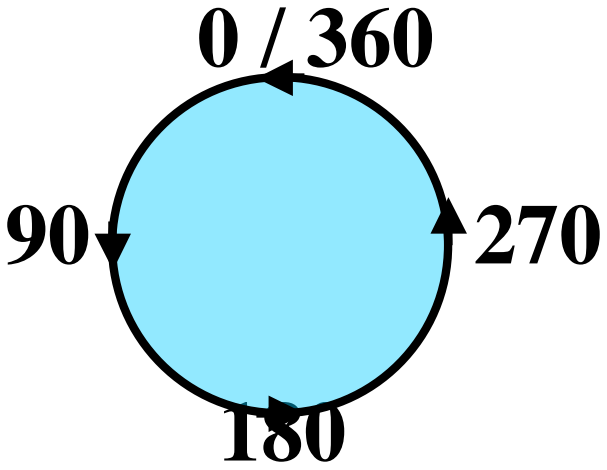
BUT

the Earth IS NOT standing still !!

…. it is orbiting around the Sun

Question: How many angle degrees does the Earth ROTATE through each 23 hours and 56 minutes?

Answer: 360 angle degrees (*which is the number of angle degrees in a circle*)



Question: How many minutes of time are required for the Earth to ROTATE 1 angle degree?

Answer =

$$\frac{\text{\# of minutes for one complete rotation}}{\text{number of angle degrees per complete rotation}}$$

$$= \frac{(23 \text{ hrs} \times 60 \text{ min/hr} + 56 \text{ min})}{360 \text{ angle degrees}} = \frac{1436 \text{ minutes}}{360 \text{ degrees}}$$

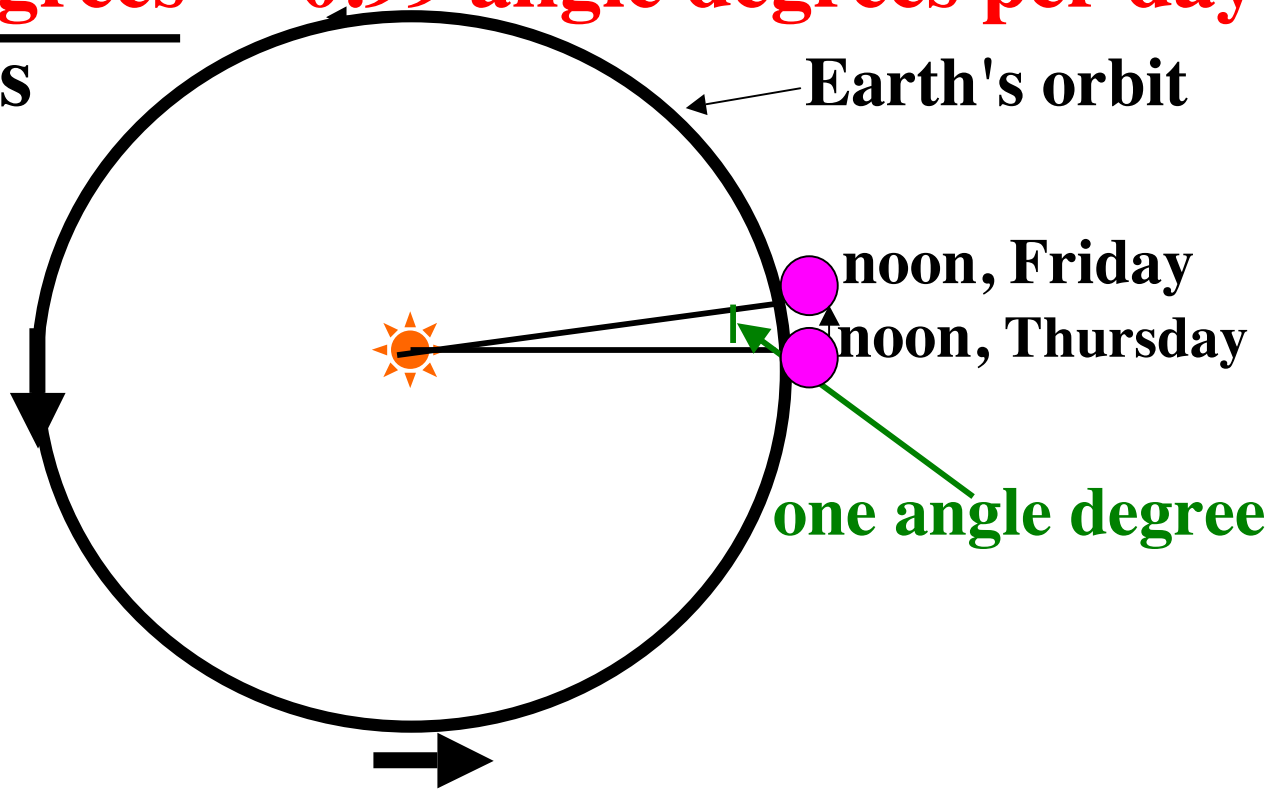
= 3.99 minutes of time per 1 degree of Earth rotation on its axis

Gee, this answer of approximately 4 minutes of time is the same time length as the DIFFERENCE between the rotation "with respect to the stars" period (called the SIDEREAL DAY) and the length of the noon-to-noon day (called the SOLAR DAY)
(*pages 894 - 89of your text !*)

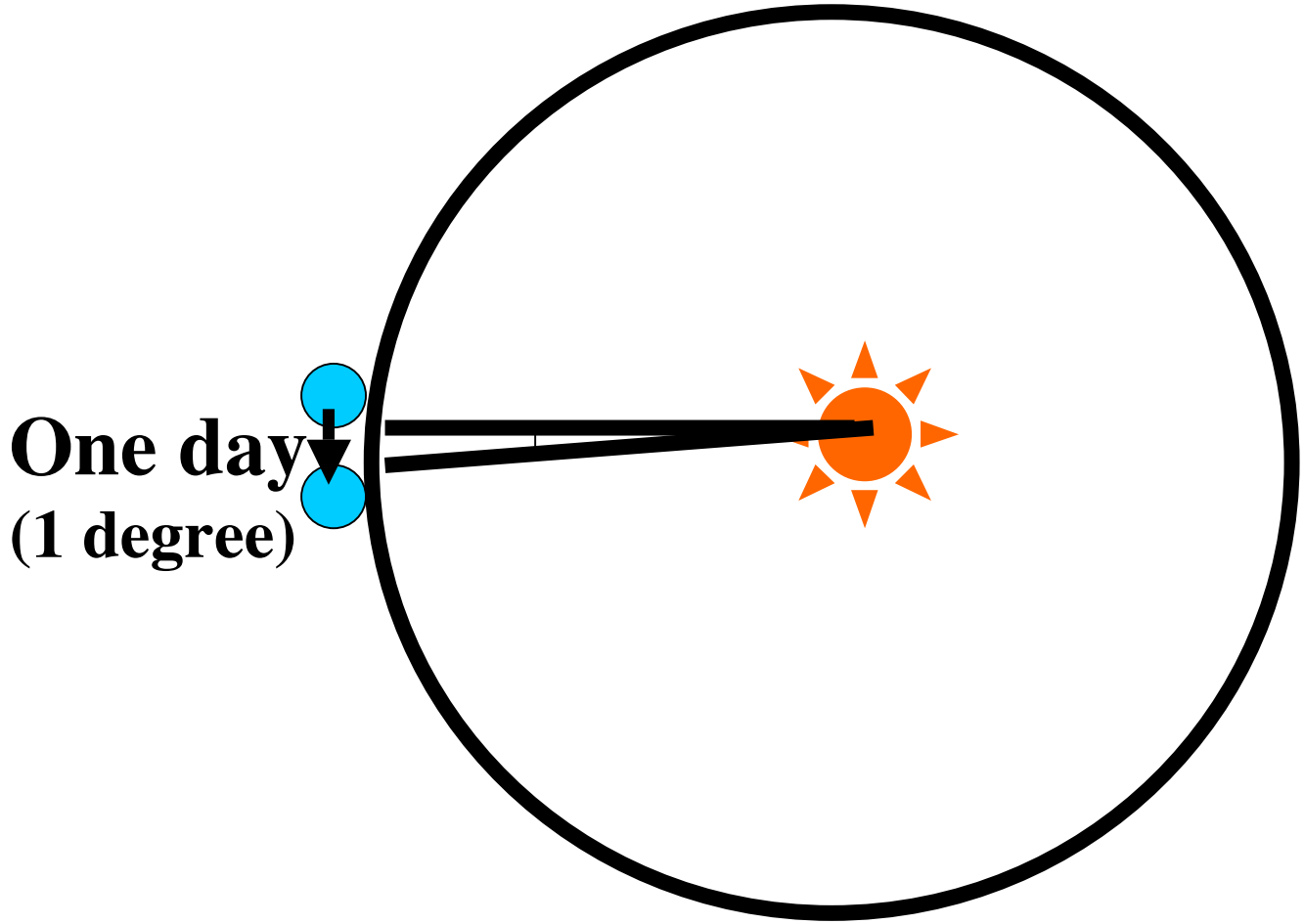
WHAT IS THE DISTINCTION BETWEEN A SIDEREAL DAY and a SOLAR DAY??

How many degrees of angle does the Earth ORBIT (travel around the Sun) **each DAY** (365.25 days per year) **on average?**

$$\frac{\textbf{360 angle degrees}}{\textbf{365.25 days}} = \textbf{0.99 angle degrees per day}$$

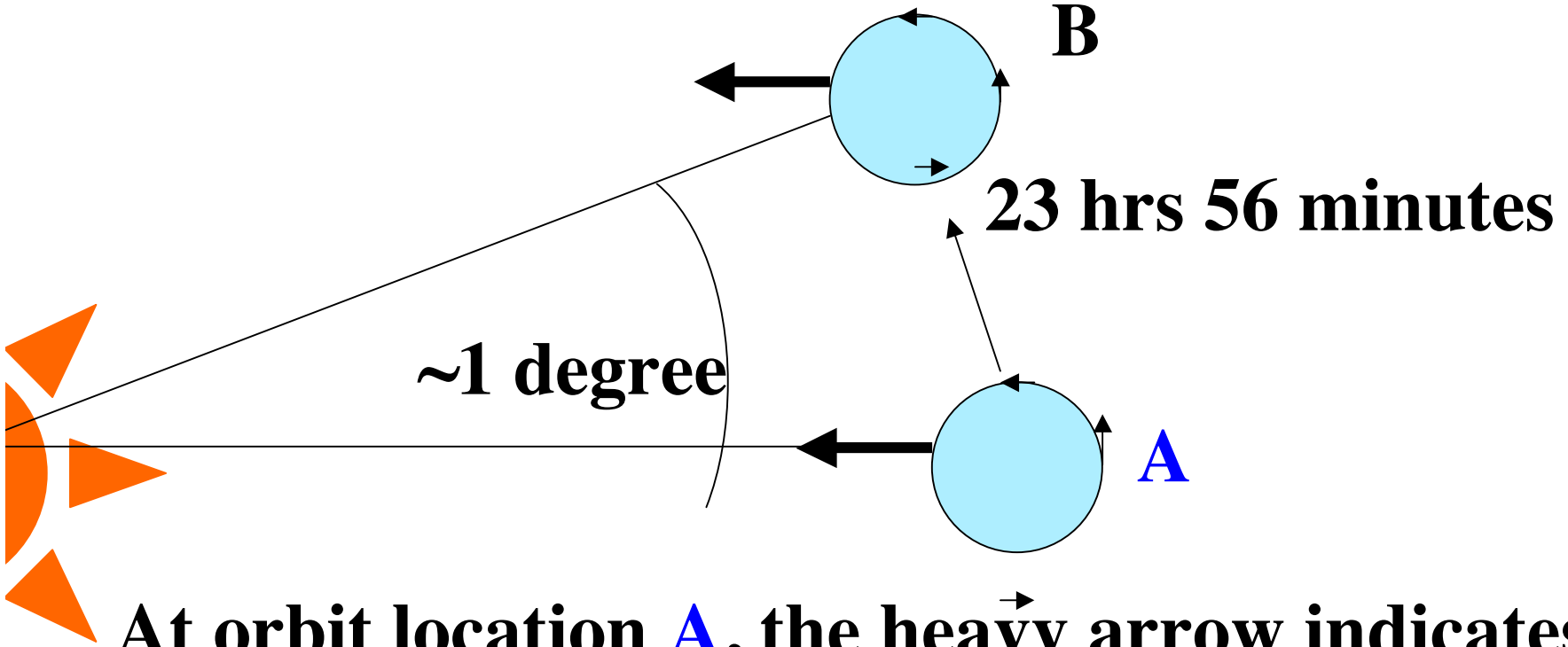


Earth's orbit around the Sun



Let's COMBINE ROTATION & ORBIT

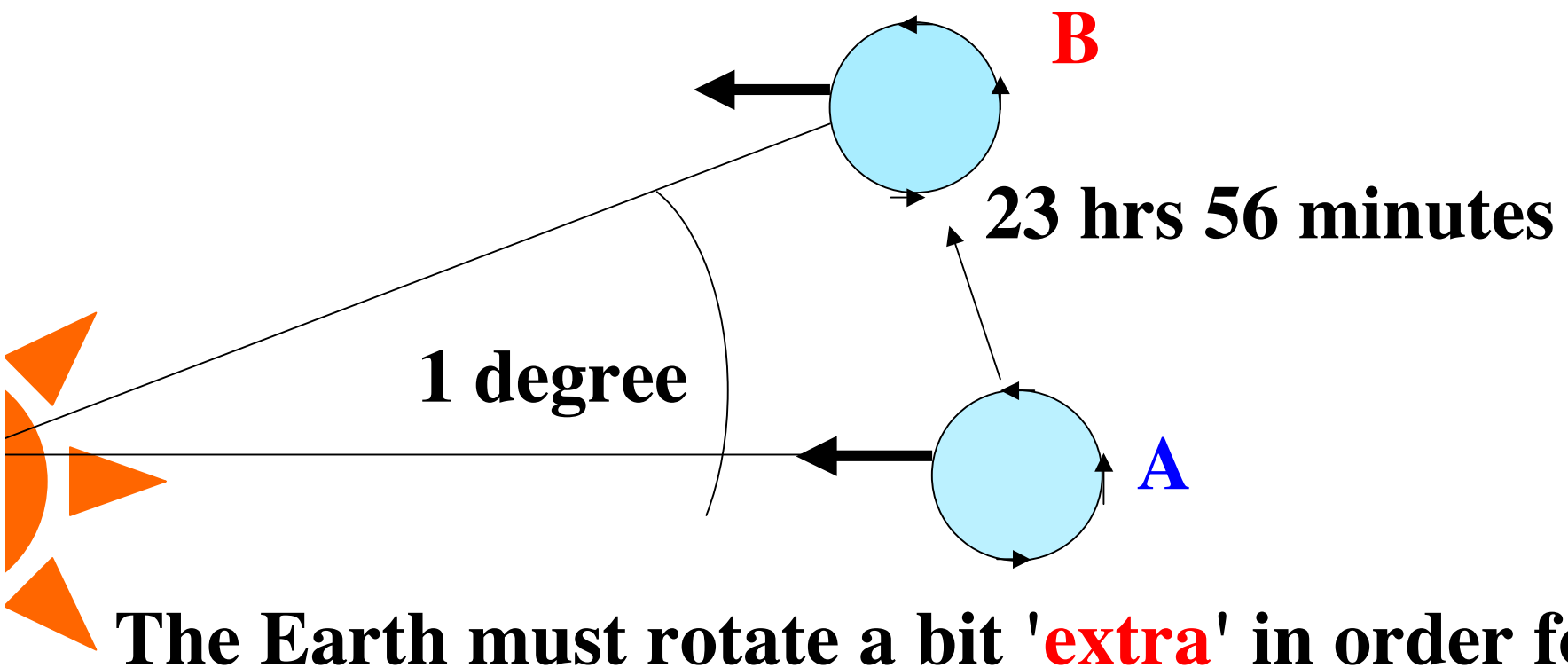
23 hours and 56 minutes of Earth's orbit



At orbit location A, the heavy arrow indicates that Las Cruces is facing the Sun.. it is Noon

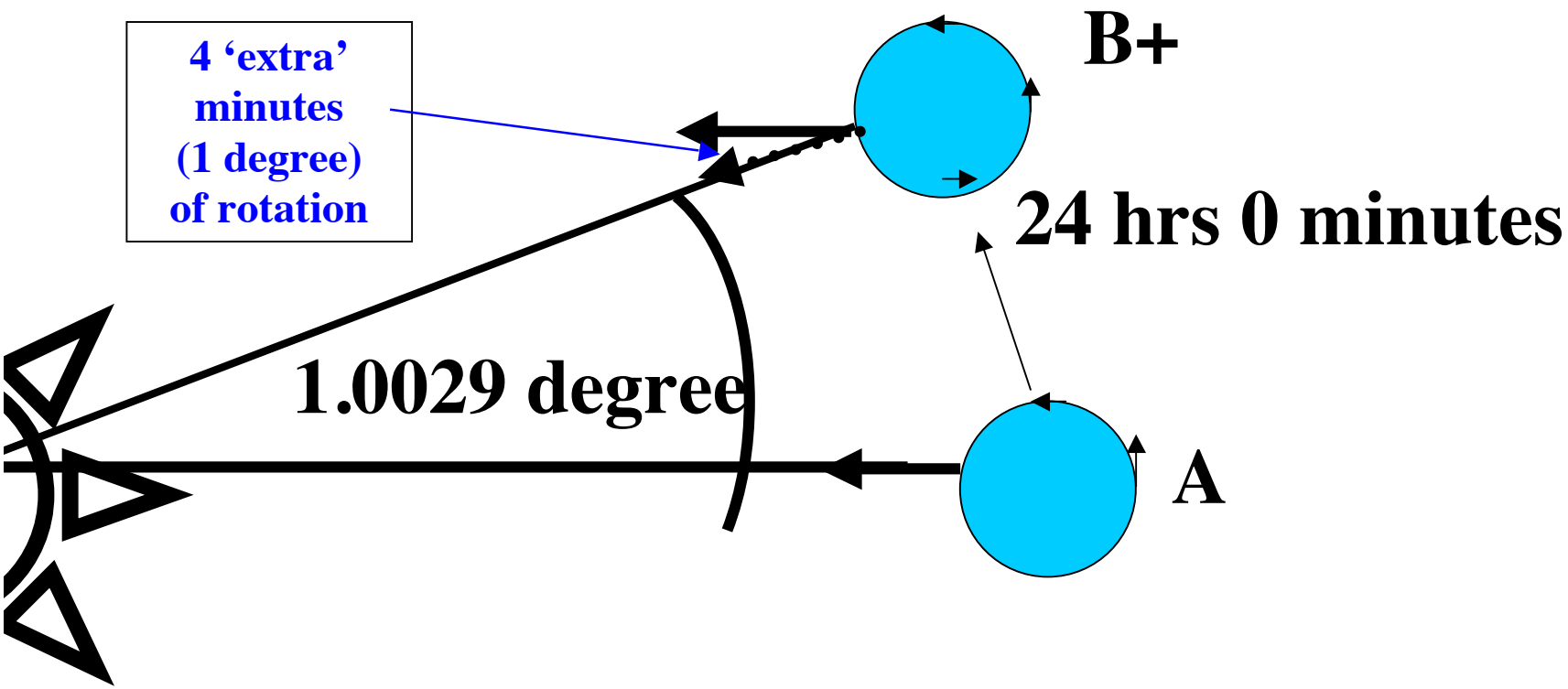
After 23 hrs, 56 minutes, is it again noon in Las Cruces (does the arrow point to the Sun?)

NO, at orbit position B the arrow is not yet pointing back toward the Sun



The Earth must rotate a bit 'extra' in order for Las Cruces to again be pointed toward the Sun

Since the Earth has ORBITED ~1 angle degree during the 23 hour and 56 minute rotation interval, the Earth must ROTATE an additional one angle degree to have the 'NOON' arrow once again point toward the Sun



We already showed that one angle degree of ROTATION is a 4 minute time interval, so:

The time from noon-to-noon =

23 hour + 56 minute SIDEREAL ROTATION time

PLUS

4 minutes of 'EXTRA' rotation time

=

24 hours and 0 minutes

So, the 4 minute difference in the length of the
SIDEREAL (rotation period) DAY
[23 hours and 56 minutes]
VS. the
SOLAR (noon-to-noon) DAY
[24 hours and 0 minutes]

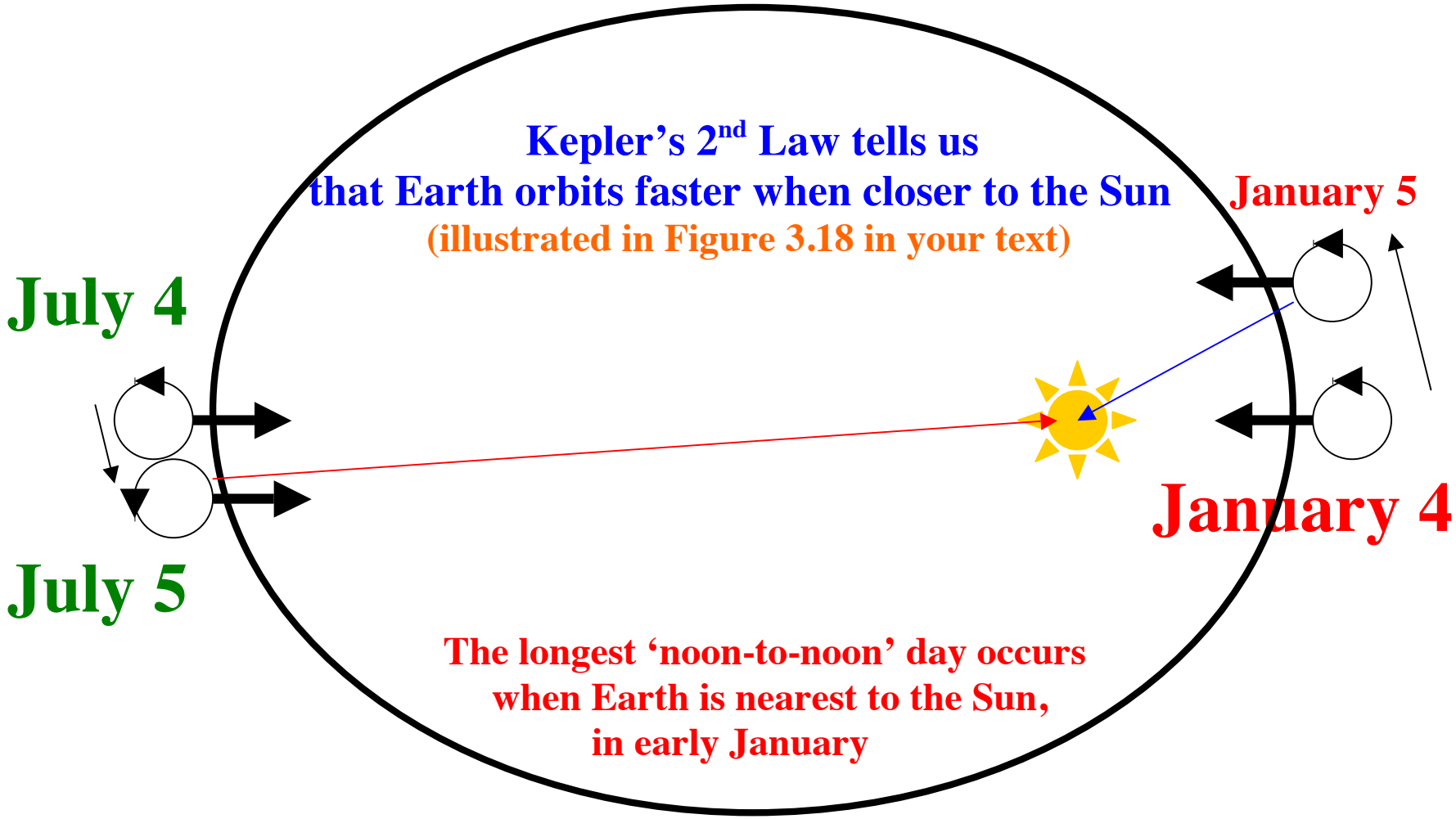
is due to the fact that Earth completes ~1 angle degree of orbit each 23 hours and 56 minutes

If the Earth orbited the Sun twice as fast (2 degrees of angle per day) as it actually does (*which would require a smaller OSA OR a more massive Sun*), how long would a SOLAR DAY (noon-to-noon) be?

Since the rotating Earth would need to 'catch up' two angle degrees rather than one angle degree per rotation, the solar day length would be:

23 hr +56 minutes + 4 minutes + 4 minutes = 24 hours and 4 minutes

During what part of Earth's year (orbit around the Sun) does the longest 'noon-to-noon' Solar Day length occur?



ANY QUESTIONS REGARDING SEASONS,
or
THE LENGTH (Time Duration) OF A 'DAY'

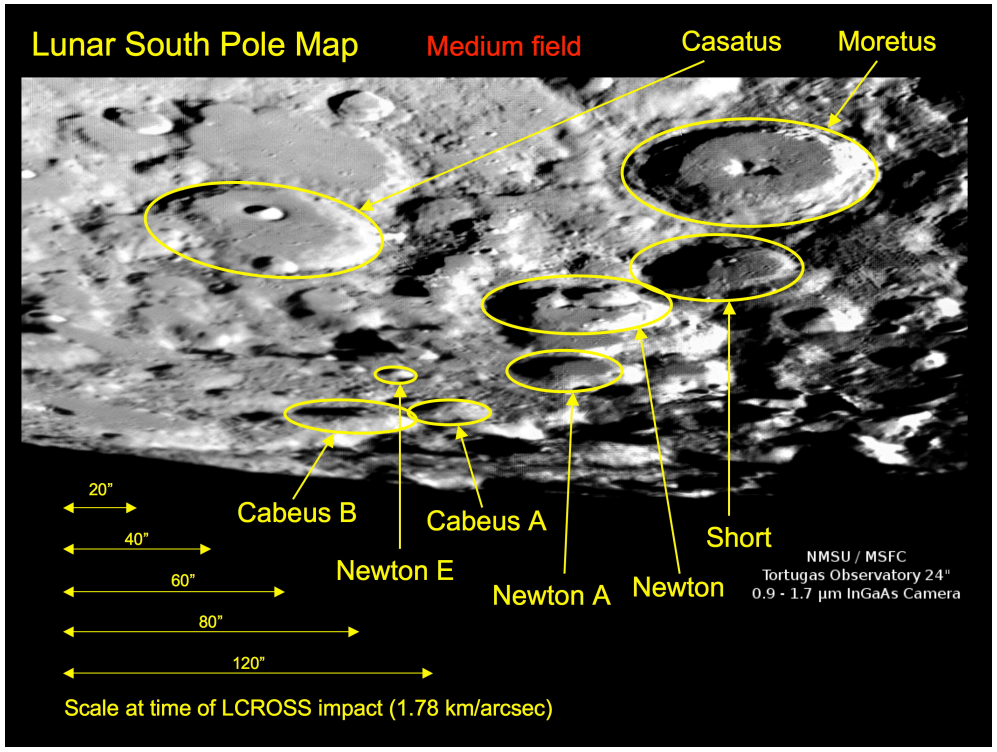
Solar Day VS Sidereal Day?

Our next topic of discussion is
MOON PHASES
which refers to the day-by-day changes in the Moon's appearance and position in the sky during a 29.5 day cycle…

PICTURE(S) OF THE DAY #1

The Moon's changing appearance during ~30 days as seen from here on Earth's surface.. MOON PHASES

An image of the Moon's South Pole, obtained from NMSU's A-Mountain Observatory; the 'left-over' part of a rocket struck the surface in CABEUS-A crater on the morning of Oct 09, 2009.



if we have time we'll conduct an In Class exercise to aid us in understanding Moon Phases….