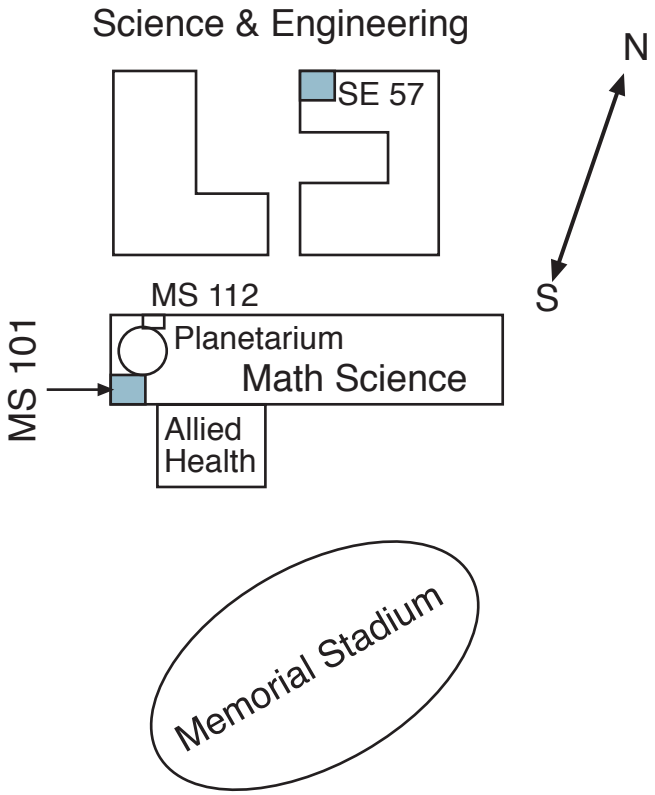


Spring semester
Instructor: Nick Strobel
Office: MS 101, 395-4526 (leave a message if I'm not there)
also: **nstrobel@bakersfieldcollege.edu**.
Department Office: SE 57, 395-4401 (another place to leave messages)
Lectures: MW 9:35 AM in the Planetarium for 85 minutes each
Office Hrs: TTh 12:10 – 1:40 pm in MS 101
Required Text: ***Astronomy B3 Student Guide*** at campus bookstore and ***Mastering Astronomy*** access code
"Opt-Req" Text: ***Astronomy Notes*** (2013 edition) at campus bookstore
Prerequisites: Reading Level 5 (college-level comprehension skill)
Recommended: First semester college algebra.
Astronomy class website: `http://inside.bakersfieldcollege.edu` and choose the ASTR B3 link for the current semester
Mastering Astronomy website for homework: `www.masteringastronomy.com`
Course ID = MASTROBEL93791. Purchased access code is valid for only ONE student. You can purchase Mastering Astronomy access code online. When registering your access code choose "Cosmic Perspectives **6th ed**" (careful of the correct edition!) as our textbook—Astronomy Notes is not in the list. Do NOT choose the 7th or 5th editions!

Course Overview:
A college-level survey of the solar system, from the everyday observations we make of the sky (and what they mean) to our ideas about the inner workings (**physics**) of the planets. **Equivalent to a university course** except: a) slower pace; b) instructor wants you to succeed and is much more available for questions; c) cost.

Throughout the course we will examine the process and philosophy of science from the astronomical perspective. We will use several examples from current research problems. Modern astronomy deals with some very mind-expanding stuff requiring sophisticated abstract and logical thinking so you will need to give your brain TIME to mull over and digest the concepts. If you take a look at any college astronomy textbook (not just mine) and any course outline for a college astronomy class, you will see that modern astronomy is mostly a "physics of the cosmos"—**how things work** and **how we know**. Astronomy is a visually beautiful and intellectually stimulating subject. We live in a beautiful universe on a gorgeous planet. Understanding how it became the way it is and how the parts interact with each other enriches and deepens our appreciation for the artistry around us. It is my hope that you will take the time and expend the effort to learn how our universe works.

Learning Outcomes:
At the end of the Solar System (Astr B3) course, the successful student **will be able to:**

1. Demonstrate a correct understanding of the cause of a given phenomenon, the physical nature of a given object, and the properties and processes of a habitable world [this is the "what we know" SLO]
2. Describe the scientific method, give the evidence for an explanation and describe the technique(s) used in determining either the property of something, how it interacts with its environment, or its

origin and history [this is the "how we know" SLO]

3. Solve word problems and apply concepts to new situations not given in the book or in lecture using logical, deductive reasoning.
4. Use a computer to locate information on the internet.

Grading: Your grade will be based on your performance on three exams (∼20% course grade) + final (∼22% course grade), 24 homework assignments posted on the *Mastering Astronomy system* (∼26% course grade), 11 quizzes (∼16% course grade), Skywatch (∼8% course grade), & in-class projects – classroom participation (∼8% course grade). All points will be added up and the sum divided by the maximum possible (excluding extra credit). **The course grade will be determined by the following percentage scale:**

90 – 100% = A, 80 – 89.9% = B, 65 – 79.9% = C, 50 – 64.9% = D, below 50% = F.

The *homework* assignments will stress **critical reasoning** (and some computation).There are 24 homework assignments due by the beginning of class time that will be done on the *Mastering Astronomy system*. Exam questions are drawn partly from the required homework assignments. All of the homework assignments have been already posted on the class website before the start of the semester. **No late (including tardy) homework assignments will be accepted. *Those who do all or a majority of the homework assignments, score on average at least one whole letter grade higher on the exams than those who do less of the homework assignments—the homework assignments really do help!***

Quizzes & exams are multiple-choice format. The *quizzes* will be every Wednesday except for exam weeks or Wednesday holiday. The exam material will be drawn from homework, quizzes, in-class projects, lectures, and the textbook review questions. The exams are *closed book*—no live or electronic help, except a calculator, is allowed. Dates for exams are given at the end of the syllabus and also on the class website. **There are no make-up quizzes or exams without hardcopy documentation of a medical or legal emergency from an officially-recognized neutral third party.** Any other reason, **including work schedules**, will ***not*** be accepted. You will need to do the quiz or exam make-up the week of your return. If you have another school/work activity or family event that prevents you from taking the exam or quiz on the given date, *you* will need to arrange with the instructor an alternate quiz/exam time that is **before** the given date.

The Skywatch assignment is due **May 5 (Monday)** and is worth 30 points. **No late Skywatch reports will be accepted—mark your calendar and hand it in early if you will not be able to turn it in on the due date!** Choose *one* of the Skywatch assignments described in chapters 4 and 5 of the Student Guide. The Skywatch requires a *hardcopy report* that will be turned in (or mailed or faxed) to me on campus—no emailed skywatch reports! The *hardcopy* typed, complete data *table*, star chart, and/or photos are due by **April 2 (Wednesday)** at the beginning of the class time (NOT emailed!). No late, untyped, incomplete data records accepted; hand in early if necessary! You must turn in the complete, typed data record by the due date &time and it must be COMPLETE or you will receive *zero* credit for the final report (not just the data record)! Therefore, **April 1** is the last possible date to complete your observations. If you mail me your data record or your final report, allow for at least 3 days mail transit time so that it arrives by the due date!

Your Role + Expectations:

Understanding how the solar system became the way it is and how the parts interact with each other enriches and deepens our appreciation for the artistry around us. However, it does mean that one has to confront and leave aside misconceptions and grapple with some complex (but manageable!) ideas. This class will be challenging but I hope you will find it rewarding and worth the time it takes to learn the subject so that at the end of the semester you will have that appreciation of our universe I spoke of above.

Your role: I expect you to take responsibility for your own learning. The expectations for a college class are a definite jump up from what you had in high school! The standard for minimum acceptable work, the *quality* and amount of study time, and the pace the material is covered will be a significant jump up from high school. This a voluntary college course that meets just two times a week for 85 minutes a lecture. Because of the limited time spent in class, you will need to spend **at least** 6 hours a week *outside* of class reviewing lecture material, reading the textbook, and doing the homework assignments. You will not pass if you only attend every lecture and do just the in-lecture-period work. Your grade is determined only by *your* performance on the required assignments not on "how well I feel you did". ***It is possible in a college course to get an "F" if your performance on the required assignments is below the "D" threshold regardless of the effort you put into the course.***

- **Be prepared to learn astronomy when you come to lecture.** Conversing with your neighbor about something unrelated to the topic of the class prevents you and them from learning the concepts and makes it

very difficult for other classmates to learn. Although I may not hear you conversing quietly with your neighbor, your other classmates will and they will find it hard to concentrate. Do not violate their right to an education.

If you need to spend the time talking, doing assignments for other classes, or reading the newspaper or magazines, then do not waste your or my time by coming to lecture. **Turn OFF your cell phone in class!**

- **Take the initiative to seek clarification of the concepts.** As an adult, one needs to have the self-motivation to learn anything. I can only help you learn. I will present the material in as clear and logical way as I can and give assignments that require you to think critically about the concepts. Then it is up to you. I expect you to ask questions when you do not understand something, either in class or in office hours or via email. If you are doing poorly and you decide not to get help, I will honor your choice. Learning is a choice and requires a voluntary decision to spend extra effort and time.
- **Use the keys at the library reserve counter.** If you answered a question on an assignment incorrectly, you will need to take the initiative to find out why your answer is incorrect. Use the keys at the library reserve counter, ask a question in class or in office hours or via email.
- **Modern astronomy deals with some very mind-expanding stuff** requiring sophisticated abstract and logical thinking so you will need to give your brain **TIME** to mull over and digest the concepts. Finding sufficient **TIME** to study the concepts and think and synthesize the concepts is the greatest stumbling block to students. Students who try to cram their studying in the day before an assignment is due get D's and F's. Modern astronomy is mostly a "physics of the cosmos"—**how things work** and **how we know**.
- If you miss a lecture, I expect you to see me after class or in my office or check the class website (or email me) to find out what you missed. **If you miss four or more classes during the semester or an exam, you *MAY* be dropped from the course. *However,*** do not assume that I will automatically do this for you. If you wish to drop, then drop via InsideBC (`https://inside.bakersfieldcollege.edu`).
- **If you are tardy, I expect you to enter quietly and sit in the BACK of the room without disturbing anyone.**
- Use the study tips in the Student Guide. They include how to more efficiently and effectively use your textbook to succeed in the class and tried-and-true techniques for taking multiple-choice exams.
- Students with disabilities who believe they may need accommodations in this class are encouraged to contact Disabled Student Programs & Services in the Student Services Building, 1st Floor, Counseling Center, 661-395-4334, as soon as possible to better ensure such accommodations are implemented in a timely fashion.

- How will you succeed at BC this semester? What determines success is not circumstance, but habit. **Habits of Mind, It's POSSIBLE at BC** has many free tools intended to help you accomplish your goals in school. Only you can overcome the challenges you face this semester and in life. Start out successfully with these steps:

  1. Visit the **Habits of Mind** website: www.bakersfieldcollege.edu/habits-of-mind .
  2. Download the app for Habits of Mind at Bakersfield College for power in your palm.
  3. Ask for help, do the work, and refuse to quit.

  Success takes energy, planning, and strategies for both the expected challenges in school as well as the unexpected twists life can take. Ask your professor for more information. Now is the time to develop new habits.

Late Assignments

Absence for an exam or quiz will result in zero credit. In the event of an unavoidable and *documented* medical or legal emergency that prevents you from taking a quiz or exam, I will consider a make-up quiz or exam on an individual basis. **Work schedules are not valid excuses.** The documentation must be from an officially-recognized neutral third party. You must take the exam or quiz the week of your return. Abuse of this policy will void your privilege of a make-up exam or quiz. It is possible to take the exam or quiz *early* in the case of medical, legal, or job conflicts. Exam and quiz dates are given on the class website. The Final Exam will be comprehensive and will be on the date given in the printed class schedule. It is always possible to take an exam or quiz *early* but usually only within a couple of days early.

Required homework and Skywatch are due at the beginning of class on the given due date. **No late homework (including tardy!) will be accepted. No late Skywatch reports and no**

late, incomplete, or untyped data records accepted at all. If you are sick, have a classmate turn it in. **Assignments, including quizzes and exams, can always be turned in *EARLY.***

Homework assignments on the *Mastering Astronomy system* are due by **9:35 AM** sharp of the due day (not 9:36 or later!!). Tardy homework assignments will get zero credit on the system. The Skywatch & data record canNOT be emailed. If you do not do the homework, it is 99% likely that you will fail the course.

Absence of an in-class project (not pop quizzes, homework, or Skywatch) will result in half credit provided the work is made up within one week of the day when the project is given. Make-up of an in-class project requiring me to set something up will have to be done at a time that is convenient for *me*, the instructor. I will be lenient in the case of unavoidable and *documented* medical or legal reasons. Other miscellaneous (and missed) in-class activities that may contribute to your participation grade will be dealt with on an individual basis.

Cheating: By cheating, you are being unfair to yourself and your classmates. Cheating is defined as not doing your own work on class assignments or on exams. There is a distinction between being helped by someone and copying someone's work. State your answers to the homework and Skywatch in your **own** words. Do NOT show your written (or electronic) copy of your assignment to other classmates. If you help someone out, be sure that they can articulate their response in their own words. **NO group solutions!** If copying is noticed by me, each person will get a fraction of the total group's solutions grade. Cheating on an exam will result in zero credit with no make-up possible. **Permitting someone to copy from you is just as bad.** It takes less effort to play fair than to devise clever ways of deceiving your instructor and classmates.

Exam Dates:

Exam 1: Wednesday, February 19. **Exam 2: Wednesday, March 19.**
Exam 3: Wednesday, April 23.
Final: *Monday*, May 12 at 10 AM for 1 hr 50 min. The final is "cumulative", "comprehensive" = over the entire semester's material.

Size+Time Scales and Scientific Method
Lecture outline -- 1

Reading: ***Astronomy Notes*** sections 1.1 through 1.4 and skim chapter 2

Vocabulary terms used:
astronomical unit—average distance between the Earth and the Sun (149.6 million kilometers). Used for inter*planetary* distances. Abbreviated with "AU".
light year—distance light travels in one year (9.461 trillion kilometers, over 63,000 AU!). Used for inter*stellar* distances.

model—an abstraction that is a simplified view of reality.
theory—a logical, systematic set of principles or explanation that has undergone testing or validation from careful observations and has stood up against attempts to prove it false. A scientific theory can be used to make a variety of predictions of what will happen under different circumstances**.**

Outline

Sense of Scale

Size (solar system models: campus + quarter coin)

If Pluto orbit fits in a quarter, nearest star is how far away:_____

Milky Way galaxy is how big in this scale model: _____

Time (cosmic calendar + walk through history)

If universe's history is put on the solar system model between the Sun and Uranus, then each big step (1 meter) would equal _____ years.

The solar system formed_____ steps beyond Saturn = _____ years ago.

Life began_____ steps beyond Saturn = _____ years ago.

All of human history_____

Figuring out how things work

Observe

Generalize

Model definition

What separates a scientific theory or model from other types of explanations:_____

"Theory" in everyday language vs. a "science theory" _____

Observe + experiment

Revise, expand, or reject the theory/model

What is the sole judge of scientific truth: _____

Assumption #1: _____

Assumption #2: _____

"Scientific truth" — _____

Self-imposed limitation: _____

Science – religion conflict? Not necessarily! _____

Communicate results in clear, logical fashion & Peer Review

Value of Astronomy

Why/how astro*logy* is *not* a science

Celestial Sphere, Solar Motion, Coordinates
Lecture Outline -- 1

Reading: ***Astronomy Notes*** sections 3.1 through 3.5

Vocabulary terms used:

celestial poles—points on celestial sphere directly above geographic poles.

celestial equator—circle around the sky directly above the Earth's equator.

zenith—point on the celestial sphere that is *always* straight overhead.

meridian—circle around the sky that goes through celestial poles *and* the zenith point. Separates the daytime motions of the Sun into "a.m." and "p.m.".

solar day—time between successive meridian crossings of the Sun. Our clocks are based on this.

ecliptic—the apparent yearly path of the Sun through the stars on the celestial sphere. It is the projection of the Earth's orbit around the Sun onto the celestial sphere.

vernal equinox—specific moment in the year (on March 21) when the Sun is directly on the celestial equator, moving north of the celestial equator.

autumnal equinox—specific moment in the year (on September 22) when the Sun is directly on the celestial equator, moving south of the celestial equator.

season—approximately three-month period bounded by an equinox and a solstice.

solstice—specific moment in the year when the Sun is farthest away from the celestial equator. The summer solstice is when the Sun gets closest to zenith at noon (on June 21 for U.S.). The winter solstice is when the Sun gets closest to the horizon at noon (on December 21 for U.S.).

latitude—used to specify position on the Earth, it is the number of degrees north or south of the Earth's equator.

longitude—used to specify position on the Earth, it is the number of degrees east or west of the 0° line going through Greenwich, England.

altitude—position on the celestial sphere that is the number of degrees above the closest horizon.

azimuth—position on the celestial sphere that is the number of degrees along the horizon away from the exact north point.

right ascension (RA)—position on the celestial sphere measured with respect to the celestial equator. It is a projection of longitude lines onto the sky and converted to time units. An object's RA is fixed throughout the night.

declination (dec)—position on the celestial sphere that measures the number of degrees north or south of the celestial equator/ It is a projection of latitude lines onto the sky. An object's dec is fixed throughout the night.

precession—slow wobble of an object's rotation axis or an object's orbit. For the Earth, precession is caused by the gravitational pulls of the Sun and the Moon on the Earth's equatorial bulge.

Celestial Sphere, Solar Motion, Coordinates
Lecture Outline -- 2

Outline

A look at the sky

Reference markers (definitions)

Motion of stars with respect to celestial equator_____

Points on horizon the celestial equator *always* goes through_____

Views from various places on the Earth.

Height of celestial pole above horizon = _____

Motion of the Sun

Ecliptic is tilted by _____ with respect to celestial equator

Places ecliptic and celestial equator intercept _____

Length of daylight when Sun on celestial equator _____

Where on horizon Sun rises and sets on those dates _____

How far Sun is from celestial equator at solstices: _____

Where on horizon Sun rises and sets in spring and summer _____

Why daylight is longer than 12 hours in spring and summer _____

Where on horizon Sun rises and sets in fall and winter _____

Why daylight is shorter than 12 hours in fall and winter _____

Coordinate Systems

Altitude-azimuth

Depends on _____

Azimuth of sunrise in spring and summer _____

Azimuth of local noon at any time of the year _____

Azimuth of celestial equator in east _____ and in west _____

Altitude of celestial equator where it crosses meridian _____

Altitude of Sun at local noon in spring and summer _____

Altitude of Sun at local noon in fall and winter _____

Celestial Sphere, Solar Motion, Coordinates
Lecture Outline -- 3

Right ascension-declination

Why used _____

Right ascension is like _____

How right ascension is measured (units) _____

Two stars that are 1 hour of RA apart will rise _____

Declination is like _____

How declination is measured (units) _____

Declination of Sun at equinoxes _____

Declination at solstices _____

Precession

How Earth is like a spinning top or gyroscope _____

Star positions over long time periods _____

3.1 Path of the Sun tutorial

Courtesy of Adams, Prather, Slater, and CAPER Team

Before doing this assignment, you must carefully read section 3.4 of Astronomy Notes! Figure 1 below shows more than half the sky as seen from the continental United States (U.S.). It shows the longest daily path of the Sun on the summer solstice (June 21st) and the shortest daily path on the winter solstice (December 21st). On the summer solstice the Sun reaches the maximum altitude in the southern sky above the horizon at about noon. Notice that the Sun never reaches the zenith (point directly overhead) for any observer in the continental U.S. Over the six months following the summer solstice, the altitude of the Sun at noontime moves progressively lower and lower until the winter solstice. After the winter solstice the noontime Sun altitude moves progressively higher and higher. **Therefore, the winter and summer solstice paths shown below are the lower and upper bounds of the Sun's motion.** For all of the other 363 days of the year, the Sun's daily arc is between the two arc paths shown.

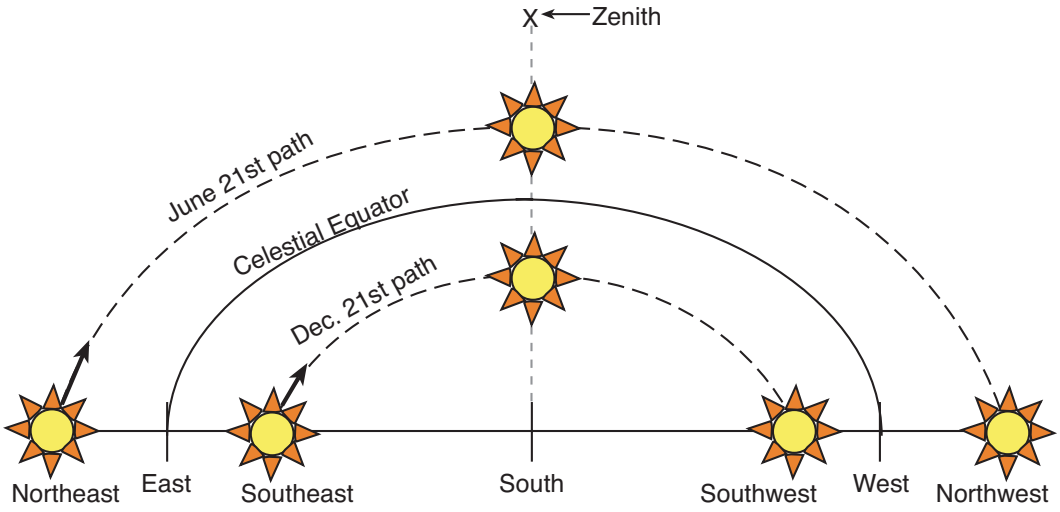


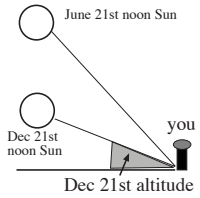
Figure 1

1. According to Figure 1, in which direction would you look to see the Sun when it reaches the highest position in the sky today?

   Circle one: East Southeast South Southwest West

2. If it is wintertime right now (just after the winter solstice), how does the altitude of the Sun at noon change as summer approaches?

   Circle one: increases ———- (arc gets higher) stays the same ———- decreases (arc gets lower)



3. If Figure 1 is a reasonable representation for any observer in the continental U.S., is there ever a time of year when the Sun is directly overhead at the zenith (looking straight up) at noontime? If yes, on what date does this occur? (Read that first paragraph again! Do any of the arcs go through the zenith point in the drawing?)

4. During what time(s) of year would the Sun rise:

   (a) north of east?

   (b) south of east?

   (c) directly in the east? (Hint: It is on only which TWO *dates* of the year?)

5. Does the Sun always set in precisely the same location throughout the year? If not, tell where the sun will set throughout the year.

6. If the Sun rises south of east on a given day, where will it set on that day?

Shadows are long when the Sun is *low* in the sky and short when the Sun is high in the sky. All shadows everywhere in the universe always point directly away from the light source.

Figure 2 shows a small, vertical stick which casts a shadow while it rests on a large piece of paper or poster-board.

For two different days of the year, the very top of the shadow has been marked with an "x" every hour throughout the day. Although this sketch is somewhat exaggerated, these *shadow plots* indicate how the position of the Sun changes in the sky through the course of these two days. The following questions are designed to show the relationship between Figure 1 above and Figure 2 at right.

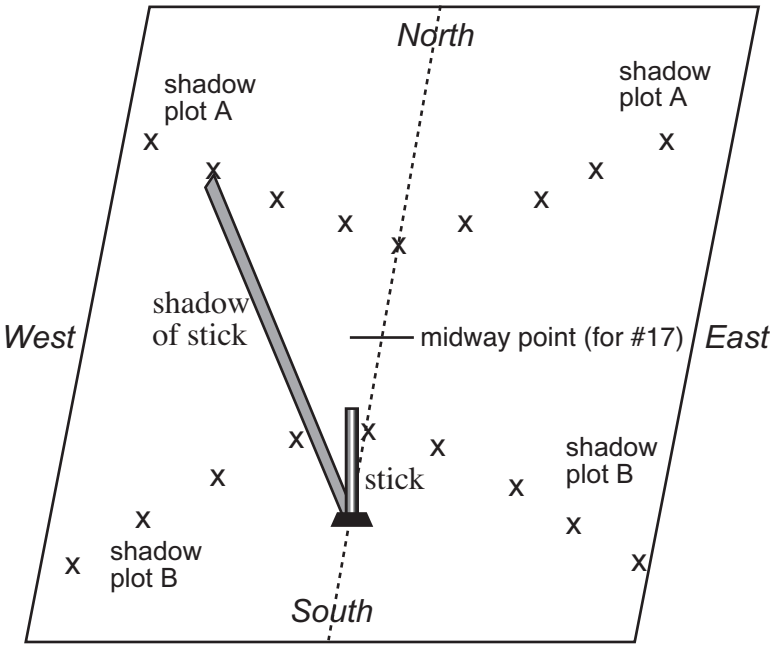
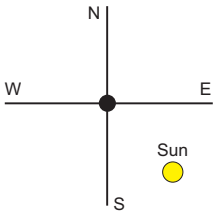


Figure 2



7. Using Figures 1 and 2, in what direction would the shadow of the stick be cast on the poster-board if the Sun rises in the southeast? Remember that any shadow points directly away (or opposite) the light source, so if the Sun is southeast, the shadow points...

   Circle one: West Northwest North Northeast East Southeast

8. Clearly circle *and label* the × for the shadow that corresponds to the time of noon for plot A and for plot B.

   b Are shadows long when the Sun is high in the sky or when the Sun is low in the sky nearer the horizon?

   c As the Sun gets higher in the sky, the shadow lengths _____. (Hint: recall the length of your own body's shadow near sunrise or sunset vs. near noon.)
   Circle one: get shorter stay the same get longer

9. Compare the position of the × that corresponds to noon for shadow plots A and B. Which shadow plot (A or B) goes with a *noon* Sun at its highest position? Explain your reasoning.

10. What do the ×'s in the shadow plots mean? Are they the position of the Sun or the top of the shadow? (Circle which one—look at the figure caption again before answering this.)

11. Which shadow plot has the longer shadows around noon time? Which shadow plot has the shorter shadows around noon time?

12. Which shadow plot (A or B) is most closely *associated with* the Sun's path through the sky during the summer and which is *associated with* the winter? Explain your reasoning. (Does winter have long shadows or short shadows? Does the Sun get high in the sky during the summer or does it stay low?) Make sure your reasoning is logically consistent with #8bc, #9, & #11.

13. On Figure 2, sketch the Sun's position at sun*rise* in the summer AND label the × that the stick's shadow would make at this time.

14. Based on the shadow plots in Figure 2, during which time of the year (summer or winter) does the Sun rise south of east? Explain your reasoning *using shadow lengths and* **directions**. Make sure your reasoning is logically consistent with #7 & #12.

15. If shadow plot A corresponds to the stick's shadow on the day of the winter solstice (double-check answer to #12, #14!), is it possible that there would ever be a time when the stick would cast a shadow longer than the one shown along the north-to-south line that indicates the Sun's position **at noon**? So compare the winter solstice noon shadow with noon shadows at other times of the year. Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page.)

16. If shadow plot B corresponds to the stick's shadow on the day of the summer solstice (double-check answer to #12, #14!), is it possible that there would ever be a time when the stick would cast a shadow shorter than the one shown along the north-to-south line that indicates the Sun's position **at noon**? So compare the summer solstice noon shadow with noon shadows at other times of the year. Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page.)

17. Mark the top of the stick's shadow with an × where it should be placed along the north-to-south line to indicate the Sun's position at noon *today*. Clearly explain why you placed the × where you did. (Hint: The equinox noon is exactly midway between plot A's noon and plot B's noon. So is today between the equinox and summer solstice date or is it between the equinox and winter solstice date? THEN answer: is today closer to the equinox or to the solstice date?)

18. Will the stick ever cast a shadow along the north-to-south line that extends to the south of the stick in the continental U.S.? Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page—is the *noon* Sun ever in the north direction in the continental U.S.?)

19. Is there ever a clear (no clouds and no total solar eclipse) day of the year in the continental U.S. when the stick casts no shadow? If so, when does this occur and where exactly in the sky does the Sun have to be? (Double-check your answer to #3!)

Every 2 / = 0.25; every 1 O = 0.25;
1 O (18 C) ⇒ 4.75, 17 C ⇒ 4.5, 16 C ⇒ 4.25, 15 C ⇒ 4, 14 C ⇒ 3.75, 13 C ⇒ 3.5, 12 C ⇒ 3.25, 11 C ⇒ 3, 10 C ⇒ 2.75, 9 C ⇒ 2.5, etc.

Seasons and Time
Lecture outline -- 1

Reading: ***Astronomy Notes*** section 3.6

Vocabulary terms used:
solar day—time between successive meridian crossings of *the Sun*. Our clocks are based on this interval of time (on Earth, one solar day = 24 hours *on average*).
sidereal day—time between successive meridian crossings of *a star*. It is the true rotation period of a planet (on Earth, one sidereal day = 23 hours 56 minutes).
time zone—interval of longitudes 15 degrees wide in which every clock is set to the same time (e.g., every clock in the Pacific time zone will give the same time).

mean Sun—imaginary object that moves uniformily eastward along the celestial equator such that it completes one 360˚ circuit of the sky in one year. The average solar day is the time between successive meridian crossings of the *mean Sun.*
perihelion—closest point of an orbit around the Sun.
aphelion—farthest point of an orbit around the Sun.
Equation of time—a relation that describes the difference in time between the meridian crossings of the mean Sun and the actual Sun.

Outline

Seasons

Tilt model explanation for seasonal temperature changes.

Two effects _____ + _____

Why popular Sun distance model does not work

Three predictions that are proven wrong _____

Sidereal day vs. solar day

Why there is a difference between the two "days" _____

Figuring out how much difference there should be:

The Earth *revolves* in its orbit _____ per day on average, so the Sun drifts eastward _____ per day on average.

The Earth *rotates* on its axis _____ per day or _____ per hour = _____ degrees per minute.

[Figure on page 45 of textbook is key for this concept]

A star (constellation) will rise _____ on the next night = _____ in 30 days (one month).

Mean Sun vs. the actual Sun [may not be covered in lecture—read in textbook]

Two processes at work to make actual Sun "fast" or "slow" _____

Phases and Eclipses
Lecture outline -- 1

Reading: ***Astronomy Notes*** section 3.7

Vocabulary terms used:

sidereal period—the period of revolution of one object around another measured with respect to the stars (e.g., for the Moon, it is 27.3 days).

synodic period—the time required for a planet or moon to go from a particular configuration with respect to *the Sun* back to that same configuration (e.g., for the Moon, it is the time to go from a given phase back to the same phase—29.5 days).

solar eclipse—when the Moon covers up part of or all of the Sun at exactly new phase; the Moon's umbra and/or penumbra reaches the Earth.

lunar eclipse—when the Earth's umbra and/or penumbra strikes the Moon at exactly full phase.

umbra—region of total shadow; the light source is totally blocked.

penumbra—region of partial shadow that is outside of the umbra; the light source is partially blocked.

refraction—the bending of waves when they pass from one transparent medium (or vacuum) to another (e.g., sunlight bending as it passes through the Earth's atmosphere).

Outline

Motions of the Moon

Moon's *rotation* :

Phases (see table section 3.7.1 of ***Astronomy Notes***)

Cause of the phases of the Moon [demo in class]

Phase	**Position vs. Sun**	**Time behind/ahead of Sun**	**Moon rises (eastern sky)**	**Moon crosses meridian (southern sky**	**Moon sets (western sky)**
New Moon	< 5º	Within few minutes	Sunrise	Noon	Sunset
First Quarter					
Full Phase					
Third Quarter					

Each major phase is _____ apart

Why popular Earth shadow model is wrong _____

Phases and Eclipses
Lecture outline -- 2

Eclipses

Why eclipses are rare _____
(another reason why Earth shadow model for phases is wrong)

Why eclipses do not happen at the same time every year _____

Lunar eclipse

Phase _____
Why the Moon still has some sunlight reaching it _____

Why the Moon gets redder _____

Solar eclipse

Phase _____
Total vs. annular solar eclipse

Planet Motions + History
Lecture outline -- 1

Reading: ***Astronomy Notes*** sections 3.8 through 4

Vocabulary terms used:

retrograde motion—when a solar system object (e.g., a planet) moves "backward" (westward) with respect to its normal eastward drift against the stars. It happens when the Earth is closest to the object.

paradigm—a general agreement of belief of how the world works; what could be called "common sense".

instrumentalism—a way of viewing scientific theories and models that says they are merely tools or calculation devices and are *not* to be interpreted as reality.

realism—a way of viewing scientific theories and models that says they truly characterize the way the universe operates; they represent reality (contrast with instrumentalism).

geocentric universe—model of the universe with the Earth at the center and all other objects moving around it.

epicycle—a device in geocentric models that makes a planet execute a small circular motion around a point that is itself in a circular orbit around the Earth. An epicycle explains retrograde motion in a geocentric universe model.

Occam's Razor—a way of approaching the development of a scientific model based on the belief that "the best model is the simplest one—the one requiring the fewest assumptions and modifications in order to fit the observations" (i.e., nature prefers the simplest most elegant solution).

heliocentric universe—model of the universe with the Sun at the center and all other objects moving around it.

Outline

Planet motions

Constraint of motion _____
Tells us how orbits are aligned _____

Special constraint of Venus and Mercury _____
Why _____

When Venus and Mercury are visible _____
Why _____
When other planets are visible _____

Venus and Mercury phases _____
Condition for crescent phase _____
Condition for gibbous phase _____

Why other planets always in gibbous or full phase _____

Peculiar motion of planets _____

Planet Motions + History
Lecture outline -- 2

Ancient History

Importance of Greeks _____

Pythagorean paradigm:

- Orbit shapes _____
- Speed of planets in orbits _____
- Position of the Earth _____

Aristotle

Ptolemy's model

Type of model _____
Why use **epicycles** _____
Other complications ("fixes") _____

Modern History

State of Ptolemy's model by time of Renaissance _____

Occam's Razor and Ptolemy's model

Copernicus' model

Type of model _____
Why develop this type of model _____

Orbit shapes + speeds _____
Position of Earth _____ position of Sun _____
How explain retrograde motion _____

Accuracy of Copernicus' model vs. Ptolemy's model _____

Major observation against Copernicus' model _____

Galileo

First person to _____
Discoveries _____

Observation that disproved geocentric model and why _____

How Galileo changed the method of science _____