Astronomy, Physics 1030: Observing Projects.

[revised 8/23/03, J.E.S.] [revised 8/28/01, A.T.J.]

On the following pages is a list of activities that may be completed as observing projects. The full details are available on the course web site. You should look these over carefully. Be sure to consult your instructor with any questions or concerns.

To receive full credit, your project should be presented as a report. In other words, you should describe the details of the project fully, so that anyone could read your report by itself and understand exactly what you did, what your results were, and what your results mean. Introduce the project so that the reader can understand exactly how you conducted your work. After the intro, describe what you did and what your results were so that if you had lost your report and it was picked up by some stranger, he or she could understand what you did without any other background information. In addition, each project has specific issues or questions that should be addressed in your report. Feel free to report all of the interesting adventures that you experience, such as getting funny looks while you peered through a toilet paper tube, getting lost while driving out to the middle of nowhere, etc.

Note that many of these projects take long periods of time to complete (as long as several months), so you should get started early. These projects are worth a significant fraction of your grade, so it would be wise to pay close attention to each project's requirements.

Some things to consider:

Safety: Many of these projects require going to places away from city lights. It would be best to do this as a group of 2 or more. You instructor is more than happy to announce in class who is working on what projects and if they want a companion. **Do not go alone if you do not feel safe.**

Many projects require a flashlight so that you can take notes or make sketches in the dark. A bright white flashlight will interfere with your night vision. To correct this, you might try taping a piece of red transparent cellophane or plastic over the flashlight. Or, you may already have a small keychain sized red light. Your eyes are less sensitive to the red light, and thus will not lose their adaptation to the dark.

You should record all observations as accurately as possible. This means that you should even record things that you might think are unimportant, such as counting "zero" stars in your view finder or recording the fact that the moon was obscured by clouds. This makes your data more believable and understandable.

Keep track of when the daylight savings/standard time switch occurs. If you are recording time-of-day for any ongoing project, you should account for the change in local time.

PLEASE turn in projects on standard (8.5x11), stapled paper. If this is not possible you should verify that it is OK with your instructor first. Unnecessary binders, covers, poster boards, etc. are difficult to carry and organize for grading and will simply annoy the person who is doing the grading. You may also elect to document your project as a web page – see your instructor if you would like to pursue this.

Keep in mind that the observation project is worth a large portion of your grade, and that a fair amount of effort is expected. Projects should be done thoroughly and should be well presented. It is to your advantage to be as descriptive and careful as possible. The projects will be graded according to the rubric on the backside of this page – you should read through this before you complete your project. Good luck, and have fun!

Grading rubric for astronomy projects

Description:	Score:	Grade equivalent:
This project was completed with an extraordinary amount of effort. Not only were all aspects of the project completed accurately and completely, but this project showed extra insight and clarity. This score is received on a small minority of projects.	5	100% = A+
This project was completed accurately and completely. Any errors in this project are mostly insignificant. Essentially, this score is reserved for projects which reflect total integrity and accuracy, and are generally more sophisticated than the average project. The student learned more from this project than most students in the class.	4	95% = A
This is a good project. It was complete and generally accurate; and, though it might contain errors, the point of the project is well conceived. This student put an adequate amount of work into the project and it is evident that s/he learned something from it.	3	85% = B
This project is mostly complete, but it might be missing a major component of the assignment. Or, this project might have several notable errors in it. Although the student completing this project probably learned something from it, s/he also may have missed some important points.	2	70% = C
This project probably has some major flaws. This may be due to incorrectly completing the project, or just a general lack of effort. This score is usually received by only a small minority of projects.	1	60% = D
This project was not completed, or did not satisfy enough project requirements to receive credit.	0	0 % = E

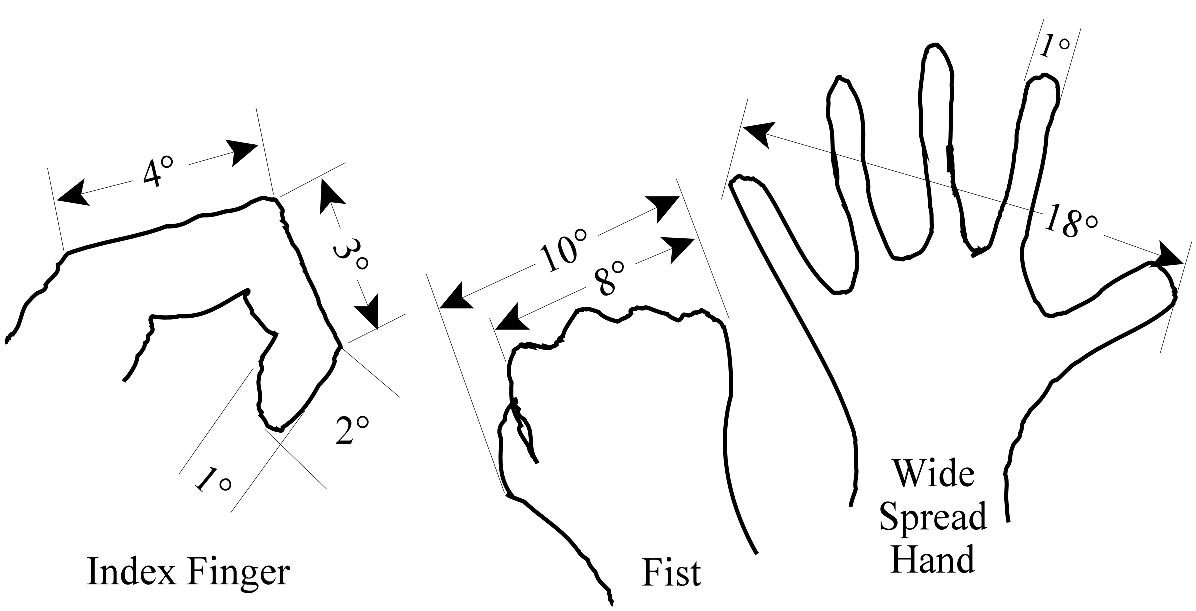

Figure 1. Measuring angles in the sky using your hand at arm's length. (Reference: Department of Physics, University of Colorado.)

List of Observing Projects

I. Position of the Setting Sun
(This is a longer term project requiring a few minutes a week for about 2 months.)
II. Phases of the Moon
(This project requires a few minutes every night for two weeks.)
III. Astrophotography
(This project can be done in one long night but requires prior approval and availability of personnel.)
IV. Observing Ursa Major (the Big Dipper) version I
(This version takes a few minutes one night every ten days for a month or two.)
V. Observing Ursa Major (the Big Dipper) version II
(This version takes all night long for one night.)
VI. Measuring the Size of the Earth
(This project requires traveling north or south for 150 miles or more. Do this if you're planning a trip.)
VII. Counting the Stars.
(This project can be done in one night but requires driving to different locations, including a dark one.)
VIII. Observing a Meteor Shower.
(This project takes one long night and only on certain dates. If it clouds up you'll need a backup project.)
IX. Observing the Motion of the Planets.
(This is a longer term project requiring a few minutes a week for about 2 months.)
X. Plotting the Moon's (or Sun's) Orbit.
(The Moon version of this project requires a few minutes every night for one month. The Sun option takes weekly observations for two months.)
XI. Star Atlas Creation
XII. Measure the Diameter of the Sun.
(This project can be done in a few hours on any sunny day.)
XII. Observe a Variable Star.
XIII. Use Sun Spots to Measure the Rotation of the Sun.
(This project requires a few minutes every day for two weeks or so.)
XIV. Tracking Artificial Satellites.
(This project requires about 15 minutes a night five or six nights almost whenever you want.)
XV. Design Your Own Project.

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The full document is available on the web via the course web site. Please do not print out the entire document. Print only the pages you are interested in and lets help save some trees and reduce waste!!

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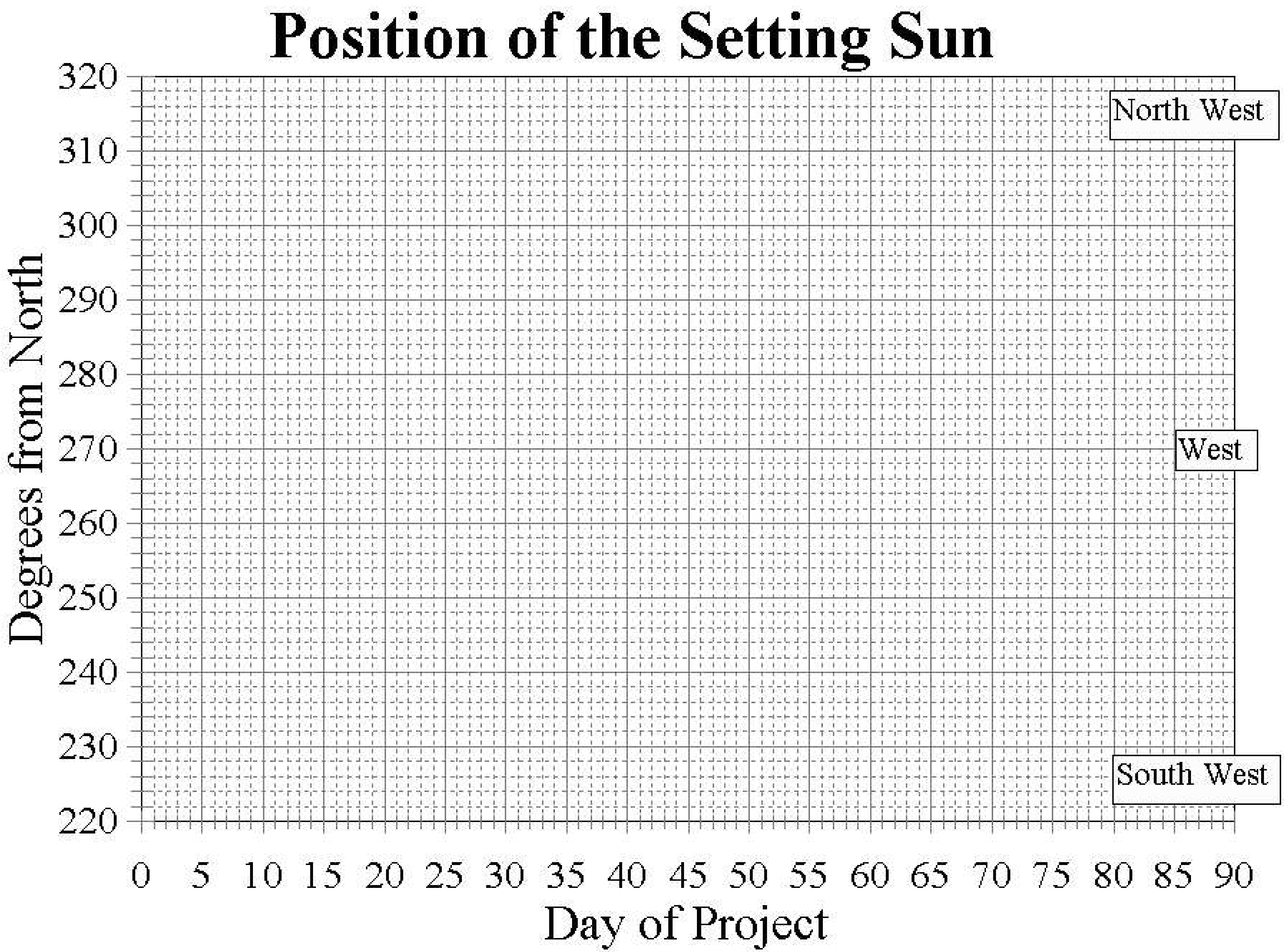
I. Position of the Setting Sun

1. Choose a location with a good view of the western horizon from which you can clearly observe the Sun at sunset. It is important that you make all of your observations from *exactly* the same location. Make a careful drawing of the western horizon. This drawing should be large enough to run most of the length of a standard sized sheet of paper. You should include a fairly large angular range along the horizon. You can substitute a photograph of the horizon to make your marks on. However, take that photo in the middle of the day *not at sunset*. Make a large print (at least 5X7, 8X10 is much better) then mark the sunset positions right on the photo with a fine tip marker.
2. Optional for photographers: You may choose to photograph the setting Sun also. However, you must still mark its setting position on your sketch or horizon photo too. We have seen hundreds of bad photographs of the setting sun for this project. It is very challenging to get the exposure just right so as to see both the last tip of the Sun and the horizon clearly too.
3. Once every 4 to 6 days, indicate the position of the top of the setting Sun's disk - just before it disappears - on your drawing or photograph of the horizon. Also, record the date and time of each sunset. If it is too cloudy to observe a specific sunset, then do the following day's sunset instead.
4. You should record at least 7 sunsets over at least 30 days to complete your observing project. Two months of observing would be even better.
5. You should record the location that you made your observations *from*, e.g. Layton, Ogden, etc.
6. Plot your data on the graph shown on the next page. On this graph, predict the location of sunset for the first day of exam week. Clearly mark that position on the graph.
7. A. How many degrees along the horizon has the position of the sunset moved during the course of your observations? (Refer to Figure 1 on page 2 for suggestions of how to measure angles using your hands.) B. How much has the time of sunset changed during your study? (Don't forget to correctly account for daylight savings time changes.) C. Does the Sun move the same amount along the horizon from sunset to sunset, or does the amount of motion speed up or slow down? D. Write a short paragraph describing the results of your observations.
8. Reminder: you may supplement your chart with individual photos of sunsets, but that is not the primary data display. You must have a full page sized sketch or good sized photo of the horizon with the dates and times marked on it. One good way is to draw arrows down to the point along the horizon where the sun set, then number the arrows. Include a separate data table that has the date and time for the sunset matched with the numbers for each arrow.



Position of the Setting Sun
Degrees from North
320
310
300
290
280
270
260
250
240
230
220
North West
West
South West
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
Day of Project

II. Phases of the Moon

1. With the page sideways (i.e., long side horizontal) make a full page drawing of the horizon from east through the south to the west. Make the sketch small enough that you have plenty of room above it to mark the position of the Moon. You will need enough details to be able to accurately locate the Moon on this sketch later. Alternatively you can take several photographs and tape/glue them together to make a panoramic view of the horizon.
2. For at least 14 days, starting from the date of the new moon carefully sketch the position of the Moon each day on your horizon sketch. You must make each observation at exactly the same time. The time you choose should be between sunset and 30 minutes after sunset, but use the exact same time each night. If you have a few cloudy days here and there don't worry, just make a note that it was cloudy. For this project to work you must have at least 7 or 8 clear nights during the two weeks. Your sketch must be carefully done showing not only the accurate position of the Moon but also the shape, orientation and size.
3. As you make your sketch, record the date and time of each observation. Also record the position of the Moon in the sky by giving the direction (west, southwest, south, southeast, east) and the approximate number of degrees above the horizon. (90° is at the zenith, 45° is halfway from the horizon to the zenith, etc.) See Figure 1 on page 2 for methods of measuring angles with your hands at arm's length.
4. Your report should include a general description of your results. In particular, answer the following questions: A. What was the general pattern of the motion and the phases? B. How far (in degrees) did the Moon move each day? C. Which direction do the "horns" of the moon's crescent point relative to the position of the Sun just below the horizon? D. Is it ever possible to see the moon during the day?

III. Astrophotography

1. You do not need to own any equipment for this project! All you need is an interest in photography. *If you are interested in this project, you must contact the instructor within the first five days of class*. More detailed instructions will be given to you. In brief, you will be teamed with a member of the Ogden Astronomical Society who will provide access to a computerized camera and telescope.
2. Take at least two images of deep sky objects. (You will probably take many more than this.) An image of the Moon and of a planet would also be nice when possible. The astronomer working with you will help you select these objects.
3. Print out copies of these images on a laser printer. (You can do this in the Natural Science Learning Center, SL 228.) Describe each image including: name and location of object, size of telescope, length of exposure, and what image processing you did.
4. Write a description of the process and your experiences in obtaining these images.

IV. Observing Ursa Major (the Big Dipper) version I

(This version takes a few minutes one night every ten days for a month or two.)

1. Pick a time well after sunset when the sky is dark and the Big Dipper and Polaris (the North Star) are clearly visible. It is important that you make all of your observations at *exactly* the same time. (You might have to adjust for daylight savings time.) Make sure that you have a good clear view of a low horizon from your observing location.
2. Using the special polar graph paper provided by the instructor, carefully record the position of the seven stars that make up the Big Dipper. Note that the stars should not change their distance away from one another or away from the North Star; rather, they should seem to rotate around together in a circle. Repeat this observation at least four times at ten day intervals. (The longer span of time used for this project, the better. You might make observations over two months, if possible.) Record the date and time of each observation.
3. Special note to photographers. If you have a ***good*** camera you might try mounting it on a tripod and taking timed exposures of the sky. Make sure you include Polaris, Ursa Major and some foreground object like a tree or house (for reference later) in the field of view. Depending on the speed of your lens, film/CCD you might try exposures of 10, 30 and 60 seconds. It would be wise to also make a sketch, both to help you with the pictures and in case the pictures don't turn out.
4. Using your graph paper, measure the total number of degrees that the Big Dipper has rotated around Polaris. Divide 360° by the number of degrees that the Big Dipper has rotated. Next, multiply the result by the number of days between your first and last observations. If you have been careful, your answer should be close to the number of days in a year.
5. Is your result close? If not, why not?

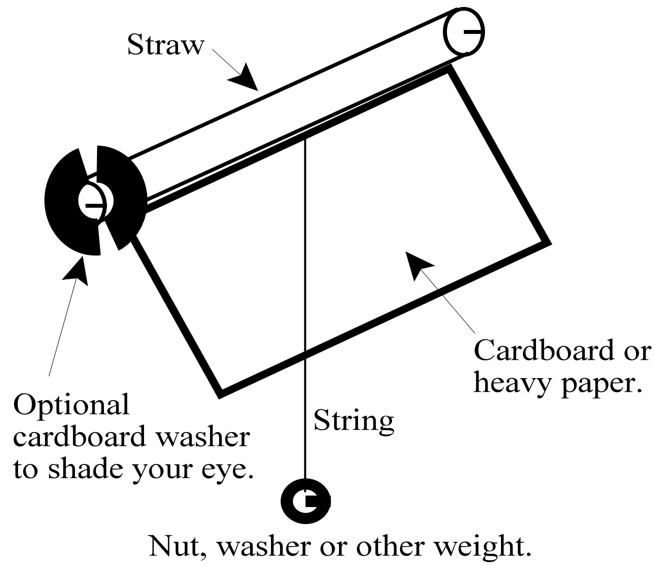
V. Observing Ursa Major (the Big Dipper) version II

(This version takes all night long for one night.)

1. Pick a time well after sunset when the sky is dark and the Big Dipper and Polaris (the North Star) are clearly visible. You will be making measurements all night long, so pick a night with no clouds in the forecast.
2. Using the special polar graph paper provided by the instructor, carefully record the position of the seven stars that make up the Big Dipper. Note that the stars should not change their distance away from one another or away from the North Star; rather, they should seem to rotate around together in a circle. Repeat this observation every two hours all night long until nearly sunrise. Record the date and time of each observation.
3. Special note to photographers. If you have a ***good*** camera you might try mounting it on a tripod and taking timed exposures of the sky. Make sure you include Polaris, Ursa Major and some foreground object like a tree or house (for reference later) in the field of view. Depending on the speed of your lens, film/CCD you might try exposures of 10, 30 and 60 seconds. It would be wise to also make the careful sketch noted above, both to help you with the pictures and in case the pictures don't turn out.
4. Determine the average number of degrees of motion per hour. If you have been careful it should be close to 15° per hour. Now, multiply your result by 24 hours this will predict the angle that Ursa Major rotates through in one day. It is highly unlikely that a single night's measurements will be accurate enough to get exactly the correct answer. The correct answer is 359° *not* 360°. Discuss why the correct answer is 359° in your report.
5. Discuss your results in the report and why you think they might be off from the expected results.

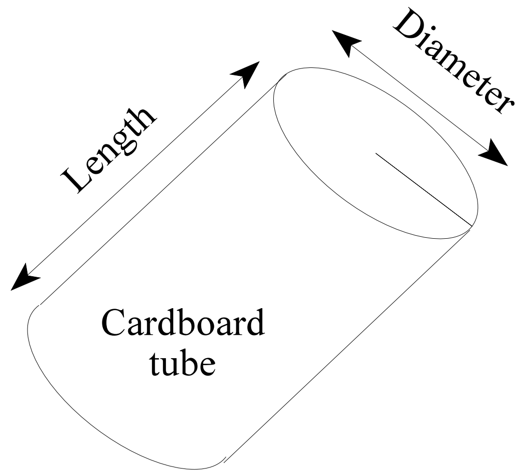
VI. Measuring the Size of the Earth

1. If you are going to be traveling 150 miles or more due north or south this semester (the farther the better), you can measure the size of the Earth. The two observations needed should be done at about the same time of night within about a week or two of each other. (This is because Polaris really does move a small amount.) The measurements of this project can give surprisingly good results for the size of the Earth, but you must be very careful in measuring angles (below).
2. Tape a soda straw firmly to a piece of cardboard. On a clear night at the northernmost location, hold the cardboard vertically and sight Polaris (the North Star) through the straw. Now, <u>*without moving the cardboard*</u>, draw a vertical line on the cardboard. This may be most easily done by hanging a small weight (such as a stone) from a string. (An assistant helps here too!) Hold the string up along the cardboard, and then draw a line with a ruler lined up along the string. Do the same thing at the southernmost location using the same piece of cardboard. You should have two vertical lines that cross at a small angle. Record which line is which, and be sure to record the date, time, and location for each measurement. (See the instructor for any clarifications regarding this procedure.) When you turn in your project, include the cardboard-string-washer device, along with the lines and notes you drew on it.



3. Record the <u>north-south distance</u> between your two observing locations. The north-south distance should be measured using a map. This will be less than your actual travel distance, unless you traveled straight north or south.
4. Using a protractor, measure the angle between the two vertical lines. (The lines cross because the direction of "vertical" — measured relative to the stars — has changed as you moved around the Earth's surface. The angle between the lines is the number of degrees of latitude that you have moved.) Divide 360 degrees by the number of degrees between the two vertical lines and multiply the result by the north-south distance between the two locations where you made your observations. Your answer should be close to the *circumference* (the distance *around*) of the Earth.
5. Look up the circumference of the Earth in your textbook; or, calculate it from looking up the radius or diameter of the Earth. (Be careful! Remember that the circumference is the distance *around* the Earth, while the diameter is the total distance *through* the center of the Earth, and the radius is half the diameter.) How well does your answer agree with this value? Explain how well your answer agrees and why.

VII. Counting the Stars.



1. To count the number of stars in the night sky that are visible to the naked eye, you will use a small cardboard tube. The center tube of a roll of toilet paper is ideal. On a clear, dark, *moonless* night, hold the tube up to your eye then count and record the number of stars that you can see through the tube. Hold the tube steady, with your eye at the center of the tube's opening, during each star count. Do this eight times, choosing random areas of the sky to measure. Be sure to sample all directions equally.
2. Add your eight star counts and record the total number of stars in your sample.
3. Now you will estimate the total number of naked-eye stars visible in the entire night sky by multiplying the total number of stars in your sample times the ratio of the area of the entire night sky to the area of the sky you saw through you tube. In other words, divide the length by the diameter, square the result and then multiply by the total number of stars in your sample. Your answer is an estimate of the total number of stars in the night sky that are visible to the naked eye.
4. Follow this procedure three times: once in a city, once in a rural location away from city lights (back in Ogden Valley, for example) and once in a location of your choosing. Make sure you record the locations, dates, and times of your three sets of observations. In which location can you see the most stars? Explain (in some detail) why. Why are astronomers concerned about the effect of light pollution from cities near their telescopes? How big of a problem is light pollution, and what could be done to alleviate the problem?

VIII. Observing a Meteor Shower.

1. In order to observe a meteor shower you must go to a **dark** site (e.g. Monti Cristo, the back side of Antelope Island, the Golden Spike National Monument, etc.). You must also choose a time and date that coincides with **both** a new Moon and the peak time for the meteor shower. The Moon must be between old thin crescent Moon (visible just before sunrise) and first quarter. Many calendars will have this information shown on them. Check with your instructor before you attempt this project to make sure your times are correct. The table below shows those meteor shows that occur during academic terms.

Potential meteor shower	**Date of Maximum**
Lyrids	April 22
η Aquarids	May 6
δ Aquarids	July 29
Orionids	October 22
Taurids	November 5
Leonids	November 17

   This project is easiest if you work in pairs – one to observe and one to record. You should switch roles during your observations.

2. Choose a meteor shower to observe and *prepare ahead of time* by making a star chart of the constellation (and those that surround it) from which the meteors will radiate. (The location of the radiant is based on the name of the shower, i.e. the Orionids radiate from the constellation of Orion.) The star maps in the back of your textbook should be useful for making the sketch. Even better would be to buy a Star and Planet Locator from a bookstore, or ask the instructor for further advice.
3. Go to your dark location far from city lights. Start your observations when the sky is dark with no light from the Moon. The best time to observe a meteor shower is very late at night – after midnight is optimal. You will need to observe for *at least* two hours, four or more is best. Dress warmly and bring something comfortable to lie down on! The observer will watch for meteors and the recorder will record the time of each meteor and draw the path of each meteor through the sky on the star chart. The red flashlight described on the first page is essential for this job since you don't want to lose your night vision!
4. Divide the total number of meteors you observed by your total observing time in hours to find the number of meteors observed per hour. Also, trace backwards all the meteor paths on your drawing to determine the location of the radiant point.

IX. Observing the Motion of the Planets.

(This is a longer term project requiring a few minutes a week for about 2 months.)

1. With care you can chart the motion of the planets through the heavens. If you are lucky, your planet will start or end a retrograde loop during your observation and you will have personal experience with the funny motions in the sky that so mesmerized our ancestors for thousands of years! You will need a detailed star chart which you can get from your instructor. You will have the best luck with the closest planets (Venus and Mars) which are close to both the Earth and Sun, although Jupiter and Saturn will work as well. (To do Jupiter and Saturn you will need to be very accurate with your measurements!) If you have a camera on which you can hold the shutter open for long periods of time, then you can also do this project astrophotographically. See your instructor before you attempt this method.
2. Plot the position of the planet(s) on your star chart at least once a week. Be sure to date each recorded position.
3. In what general direction (East or West) does the planet move relative to the stars? Is the motion constant in speed? If not, why not? If you where able to plot two planets, which one moved faster and why?

X. Plotting the Moon's (or Sun's) Orbit.

1. This project will take a few minutes each night for a month. Obtain a star chart from your instructor or make your own if you feel confident in doing that. (There is an option of observing the Sun's motion listed below too.)
2. Once each night carefully record the position of the Moon on your star chart. Note that during part of the month you will need to do this in the evenings and part of the month in the early mornings. You will need to make very careful measurements of the Moon. You will need to do triangulations to get the position of the Moon correctly. Measure the position of the Moon in degrees of arc from three bright stars and then use a drawing compass to record the exact position of the Moon on your star chart. See Figure 1 on page 2 for hints on how to measure angles in the sky using your hands. See your instructor for more details on how to triangulate the position of the Moon on your chart. See your instructor for other hints and suggestions.
3. Describe the motion of the Moon. How many days does the Moon take to get back to the same position relative to the stars? (I.e., what is the period of the Moon's orbit?) What direction (East or West) does the Moon move relative to the background stars? How many degrees the does the Moon move in 24 hours relative to the background stars?
4. As an alternative you can plot the Sun's apparent motion against the background stars as caused by our point of view from Earth orbiting the Sun. This is a bit more challenging since you will have to estimate where the Sun is after sunset and once enough stars appear to plot against. You will need to make measurements about once a week for about two months to complete this option. See your instructor for help and hints if you'd like to try this observing option. This sort of thing was done by ancient astronomers thousands of years ago.

XII. Measure the Diameter of the Sun.

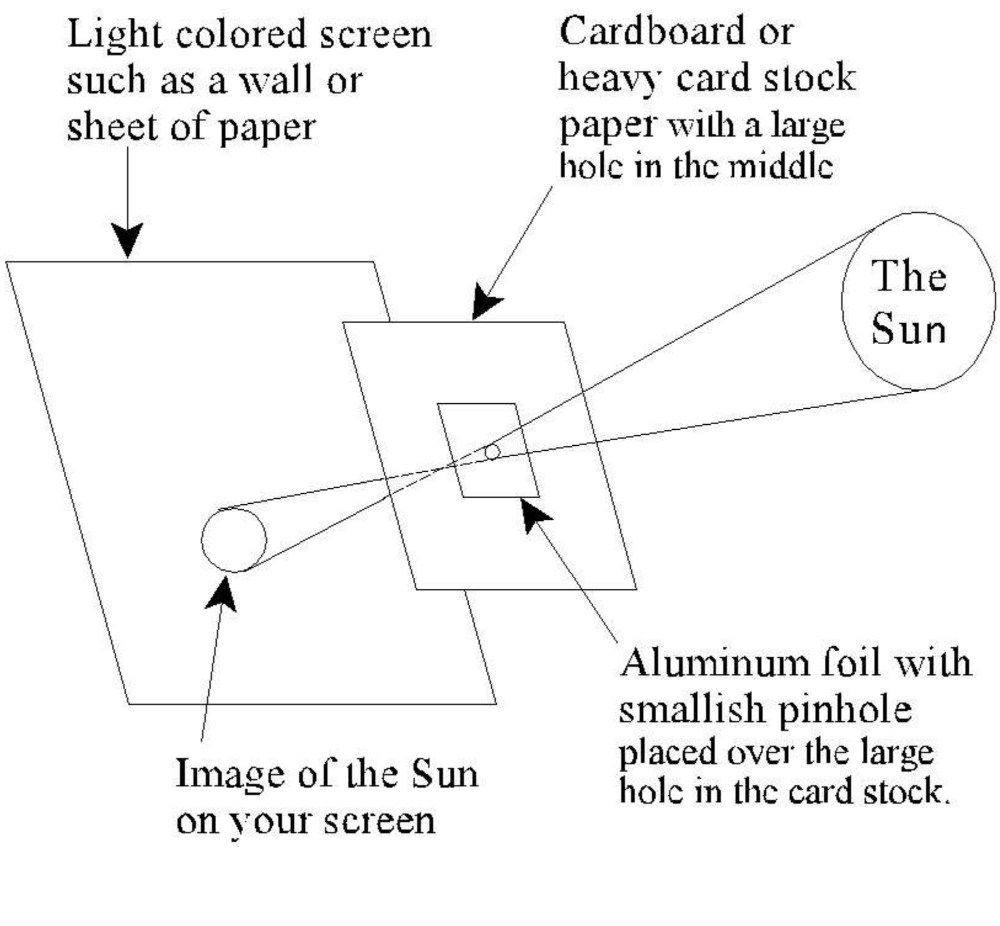
1. You will need to work carefully to get good results. It would probably be good to have a helper. In no case should you ever be looking at the Sun! Do not look at the Sun through the pinhole.
2. On a clear day when the Sun is high in the sky use the pinhole to cast an image of the Sun on your screen. Measure the diameter of the image and the distance from the pinhole to the image. Because you have two similar triangles, geometry says that the ratios distance to diameter are the

$$\frac{\text{Diameter}_{\text{Sun}}}{\text{Distance}_{\text{Sun}}} = \frac{\text{Diameter}_{\text{Image}}}{\text{Distance}_{\text{Image}}}$$

same. In other words, or

$$\text{Diameter}_{\text{Sun}} = \frac{\text{Diameter}_{\text{Image}}}{\text{Distance}_{\text{Image}}} \text{Distance}_{\text{Sun}}$$

3. Be sure that you collect several (at least 3, but preferably more) different measurements for the size of the Sun. Compare these not only to one another, but also to the known diameter of the Sun. Use the known distance to the Sun from your textbook. Be careful to use the same units of measure - all in meters for example.
4. **Your measurements will be most accurate if you project the image onto a screen that is at least 1 foot (30 cm) away from the pinhole.** You may adjust the size of the pinhole in order to get a better projected image. Smaller pinholes work best for short projections, while larger pinholes may be necessary for longer projections.
5. Again, do not look directly at the Sun itself. Staring at the Sun ***will*** *cause permanent eye damge!*



XII. Observe a Variable Star.

1. Measure the brightness variations of a variable star. There are many stars for which this will work, including Algol, Delta Cephei, Delta Scorpii, Mira. Measure a brightness both from the naked eye and using a small telescope or binoculars if you don't own or have access to a telescope. To measure a brightness, compare how bright it is to nearby stars (e.g., same brightness as star A, twice as bright as star B, etc.), but make sure you clearly highlight the stars that you are using to compare with (find out their names if you can). You will need to use a star map to determine the visual magnitudes of those stars. In your report you must express the star's brightness in units of magnitudes. You'll have to figure out how to find the star (start with the internet). Your instructor can help you here and can provide you with custom star maps.
2. Monitor it for 4 times an hour, twice a week, for at least 3 weeks. Make a plot of the brightness as a function of time.
3. Your report should include the star map you used to find the star along with the comparison stars clearly marked. You also must include the plot of brightness and a short analysis of your observations.

XIII. Use Sun Spots to Measure the Rotation of the Sun.

1. You will need access to a small telescope equipped with a good quality solar filter or a method of safely projecting the Sun's image. (Pretty much any telescope or even binoculars can be used to project the Sun's image onto a screen.) Under no circumstances should you ever view the Sun through a telescope or binoculars without proper safety equipment. Total blindness will result. If there is any doubt whatsoever about your equipment, please bring it in for the instructor to see and check out.
2. Monitor the Sun once every few days until you see a nice sun spot near the edge of the Sun.
3. Make careful drawings of the Sun with the position of the sun spot carefully drawn on the image. Determine how many days it takes to move across the disk of the Sun. If your sun spot started part way across the Sun you will need to account for the offset from the edge. Your instructor can help you with this. From this information you can determine how long it takes the Sun to rotate on its axis (at that latitude).
4. Your report should include a careful description of the project, how you took your data and what your results were. Look up the actual rotation period of the Sun and compare that with your results.

XIV. Tracking Artificial Satellites.

1. Artificial, Earth orbiting satellites are visible on pretty much any clear night. You can obtain accurate predictions of visible satellite passes from the Heavens-Above website: www.heavens-above.com Spend some time at the web site getting familiar with how it works. Your instructor can help you.
2. Once you have selected a satellite to observe you can have the web site produce a star chart for you. Go outside and observe the pass. Describe all details (brightness, speed, colors, random aircraft, etc.) as you watch. The easiest satellite to observe is the International Space Station since it is one of the brightest objects in the sky.
3. Make at least 5 separate observations of satellites using predictions from the web site.
4. Include in your report the name of the satellite, the predicted magnitude, times, directions and maximum elevation of passage and your estimated actual times, directions, and maximum elevations of passage. You can do this easily by using the print out from the web site and making your observations and notes directly on the print out.

XV. Design Your Own Project.

If you are experienced with telescopes or have a special interest in some aspect of astronomy that you would like to observe for yourself, then see your instructor about possibly making up a special project. Your project must include some aspect of actually observing the sky. There are numerous things that you can do. Examples include:

- Using a telescope to monitor the positions of the moons of Jupiter.
- Watching eclipses of Jupiter's moons.
- Watching Earth's lunar or solar eclipses.
- Observing deep space objects.
- Observe and track asteroids.
- Build a telescope.
- Make an accurate sundial.
- Photograph or sketch the Moon in detail labeling the major craters and maria.
- Measure the ellipticity of Moon's orbit: use a small telescope to measure Moon's diameter over a month.
- Are you a law enforcement employee or health care worker? Why not plot the phase of the moon against "strange" human behavior. See your instructor for hints and ground rules.
- Plot part of an analemma, the Sun's actual path in the sky against the "mean Sun's path."
- There are thousands of other things you might try if you want. Literally, the sky's the limit. ☺

You can get loads of ideas off of the internet too. See your instructor if you have an idea or for suggestions.