Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Nightly Motions	**Purpose:** Track the motion of a constellation over the course of an evening **Instructions:** Find your **<u>eastern</u>** horizon using a compass. Sketch your view (buildings, trees, etc.) along the bottom of a blank piece of paper. The top of the paper should represent the point directly over your head (the "zenith"). Choose a group of stars (doesn't have to be a "recognized" constellation) that you will be able to find again that is low on the eastern horizon at the time you begin. The constellation Orion is a good choice if you are beginning in the early evening. Sketch the group of stars and its location and orientation relative to objects on the horizon. Come back in one hour and sketch again. Repeat each hour, for a total of four hours. Note that you do not need to make a new sketch each time. You can simply sketch the horizon once, and redraw the group of stars each time (hint: they will move!). Make sure to note on your drawing, next to the group of stars: (a) the time of each observation (b) your estimate for how high in the sky the constellation is as a percentage or fraction of the distance from the horizon to zenith (the point directly overhead). A few examples: "about halfway to zenith" or "20% of the way to zenith" **Questions:** At the end of your observation, answer the following questions in your observing notebook: (1) Which direction did the stars you chose move over the course of your observation? (2) Roughly what percentage (or fraction) of the visible sky did your stars move across over the course of your observation? Is this consistent with how much you would expect it to move over the course of one full day? Why or why not? (3) Based on how your stars moved with time, why were you asked to choose a constellation on the Eastern Horizon and not the Western horizon? (4) In what way did this observation either follow or differ from your expectations? **Extra Credit Option**: Observe hourly for longer than 4 hours. **Number of points:** 10	Once per hour for 4hr	1/29	No

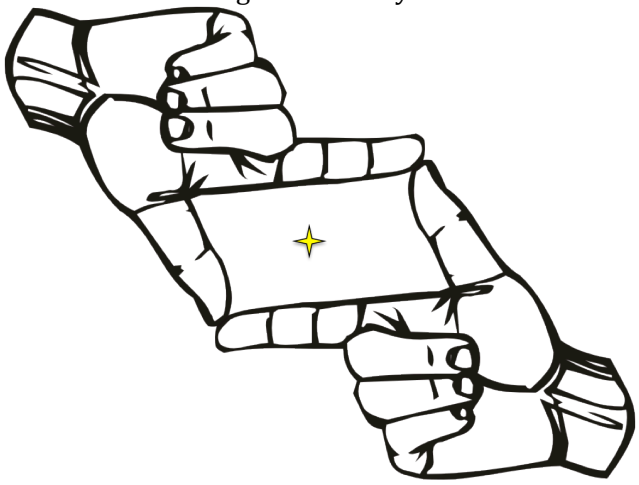
Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Sunset Position	**Purpose:** Mark the location of sunset on the horizon. You will repeat this observation three more times during the semester. Each observation **must be separated by at least 3 weeks** (unless you choose this option as a semester observing project, in which case you should repeat the observation once every 1-2 weeks). **Semester Observing Option:** If you choose this as your SOP, you will need to make this observation more frequently - once per week - and will answer additional questions and make additional measurements. See the full project description. **Materials:** compass, watch **Instructions:** ****DO NOT LOOK DIRECTLY AT THE SUN** without solar observing glasses, which you will be provided with by your instructor. Find a relatively unobscured view of the Western horizon. Choose your spot carefully so that it is free of big foreground obstacles (tall buildings, etc.) but has a recognizable background against which you'll be able to distinguish the location of sunset. A completely flat, featureless horizon won't work, while a mountain ridgeline is ideal. Choose the location where you stand carefully so that you can come back to the **exact same spot** when you complete further observations later in the semester. You will need to be in the same spot to within about 1 foot, so pick a landmark on the ground where you can put your feet and make a note of it in your journal so you'll remember. **For the first observation:** Sketch the horizon for about 45 degrees on either side of due West (which should be in the middle of your drawing). To do this, find due west using a compass (most smartphones can do this fairly accurately, but a real compass is better and can be borrowed from your instructor) and mark its exact location clearly on your sketch. *You will mark the location of sunset several times over the course of the semester, so take the time to sketch the horizon carefully this time. To leave yourself enough time, go out at least 30 minutes before sunset this time so that you can find a good spot and sketch the horizon before the sun sets.* **CONTINUED ON THE NEXT PAGE**	10-30min once per month	#1: 1/29, #2: 2/26, #3: 3/26 #4: 4/23	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Sunset Position continued	**For all four observations:** 1) Mark carefully the location on your sketch where the sun touched the horizon and label it with the date 2) In a table with the date in the first column, record the exact time that the sun first touches the horizon in the second column, and the time that the last bit of the sun disappears behind the horizon in the third column. In other words, record the start and end time of the sunset for each date. In a fourth column, write down any other notes about the observation (weather conditions, color of sunset, etc.). **Questions for after the final observation:** 1) Did the sun ever set due West? On what day was it closest to due West and why? 2) Outside at your observing point, use the fist and finger method and your sketch to measure the distance between the most southern and the most northern sunset locations that you observed. How much did the sun move along the horizon over the course of the semester? 3) Did the time it takes the sun to set (so the time between it touching the horizon and disappearing completely behind it) change over the course of the semester? Why or why not? 4) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation for what the cause of the trend you observed is. **Number of Points:** 40	10-30min once per month	#1: 1/29, #2: 2/26, #3: 3/26 #4: 4/23	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Path of the Sun	**Purpose:** Using a "Sun Sphere" borrowed from your instructor, track the daily motion of the sun over the course of one day. You will repeat this observation three times during the semester. **Timing Requirements:** You'll make this observation on three different days over the course of the semester. The first day must be before 2/3, the second day must be between 3/18 and 3/24 and the third day must be between 4/20 and 4/28. For each of the three day you choose, you must complete at least three observations: one before 10am, one as close to noon as possible, and one after 2pm. The observations themselves are quick (less than 5 minutes) so you could make them between classes or during a break at work. **Materials:** Sun sphere, sun sphere paper, compass, grease pencil **Instructions:** ****ONLY WRITE ON THE SUN SPHERE WITH GREASE PENCIL**** Find a flat piece of ground somewhere in the sun (not the shade). Lay down the sun sphere paper on the ground and the compass on top of it. Rotate the paper until the "North" label lines up with North on the compass. Lay the sun sphere on top of the paper so that the lines on the sun sphere line up with the lines on the paper. On the **inside** of the sun sphere near its "equator" (the flat part), label the line that points to North with an "N". Each time you come out to take another observation, you should line up the "N" on your sphere, compass and paper. Take the grease pencil and hold it just over the surface of the sun sphere. Move it around until the shadow of the pencil tip lines up with the cross at the center of the paper. Mark this location on the sun sphere with a small dot from the grease pencil. Pick up the sphere, and make a dot in the same place on the inside of the sphere. Label it with the time. After you have made all three observations for the day and moved the marks on the inside of the sun sphere, erase the marks on the outside of the sun sphere by wiping them away. **CONTINUED ON THE NEXT PAGE**	Once every 2-3 hours over the course of a day for three days spread over the semester	#1: 2/5, #2: 3/26, #3: 4/30	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Path of the Sun continued	**Extra Credit Option:** Complete 5 observations each day, two on either side of noon and one at noon (adding sunset and sunrise to the times above would give you very nice data). **Questions after each observation:** 1) Did the sun shine directly overhead (at zenith, or the place on the sun sphere where the lines cross) at noon today? 2) If you connect the dots of your observations (make sure to do this on the outside of the sphere so that you can erase it later), and extend the lines toward the horizon, where would you predict that the sun rose and set today relative to due East and due West? 3) Estimate how close the sun got to the zenith today as a percentage of the distance from the "equator" of the sun sphere to the top. **Questions after the final observation:** 1) How did the height of the sun at noon differ on these three days? 2) How did the predicted location of sunset/sunrise differ on these three days? 3) Was there anything special about any of your observations relative to the others? 4) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points:** 40	Once every 2-3 hours over the course of a day for three days spread over the semester	#1: 2/5, #2: 3/26, #3: 4/30	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Jupiter's Moons	**Purpose:** Track the motion of the moons of Jupiter over the course of an evening. **Timing Requirements:** You can make this observation yourself any night before 2/12. On the night in question, you will need to make at least three observations, separated in time by at least one hour, but the observations themselves should be quite short. Alternatively, you may participate in a group observation with a larger telescope during the star party on Friday, February 7 (subject to change) **Materials:** Galileoscope or binoculars(if completing on own) **Instructions:** Find Jupiter in your telescope or binoculars. Sketch any features you see on its surface (bands, great red spot, etc.). Just to the right and/or left of Jupiter, you should see several bright spots. Theses are the "Galilean" moons of Jupiter. Note their location relative to Jupiter and their relative spacing. Record the precise time of your observation. Repeat, making a new sketch each time, every hour for at least three hours. **Extra Credit Option:** Continue your observations for 5 hours or more or repeat the observation the following night and describe what you find. **Questions:** (1) Did the location and/or number of moons you saw change over the course of your observation? If so, how? (2) Did the moons move by different amounts over the course of the observation? Which one moved the most? Least? (3) If you saw features on Jupiter (the Great Red Spot for instance), did they change over the course of your observation? How? (4) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points:** 20	Once per hour for at least 3 hours	2/12	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Dark Adaption	**Purpose:** Test how your eyes adjust to darkness with time **Materials**: watch or timer, paper, assistant or red flashlight **Instructions:** You need to begin somewhere where you can step directly outside from a brightly lit room and see the sky in the dark (no outside lights). Alternatively, go out somewhere dark, shine a bright flashlight on a white piece of paper and look at it for ~5 minutes before you begin. This is a good time to set up a chart with three columns. The first column should have times from 1min to 15min at 1min intervals. The second column should be labeled number of stars, and the third is for other observations. Start a timer as soon as you step outside or turn off the white flashlight. At one minute intervals for 15 minutes total, write down the number of stars that you see in a "finger box" (see diagram below) held out at arm's length. You'll need to look at the same piece of sky each time, so to avoid having to hold your arms out for 15 minutes, center your finger box on the first bright star that you see and come back to the **same** star each time.  **CONTINUED ON THE NEXT PAGE**	15-30min	2/5	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Dark Adaption continued	Once you step outside or turn off the flashlight, you should not use any white light and you should avoid looking at any lights on the horizon (lit houses, street lights, etc.). It may help to bring along an "assistant" to tell you each time one minute passes and to whom you can call out the number of stars you see for them to record. If you don't have an assistant, just set a timer for 1 minute, record your number **using red light only** and then start the timer again and turn off the flashlight as soon as you're finished recording. Red cellophane can be obtained from your instructor, which you can use to cover an ordinary white flashlight. In the intervals between counting stars, scan the sky, paying particular attention to the colors of stars you see. Each time you see a new color, record it in the "other observations" column. Record the time that you first see the Milky Way as well. **Extra credit option:** Choose another bright star or two and repeat this sequence. Average the values at each time step before answering the questions. **Questions:** 1) Create a graph with time along the x-axis and number of stars seen along the y-axis. Make sure to label your axes and add a title to the graph. 2) Can you draw a straight line through your data, or do you need a curve? Does it "flatten" (stop increasing and stay constant) at some point? What does this tell you about how your eyes adjust to darkness with time? 3) What do you think would happen if you kept going for another 15min. Continue your x-axis out to 30min and draw your prediction as a dashed line. 4) Do a little Internet research about the cells that make up your eye (called "rods" and "cones"). Which are more sensitive to light? Which are more sensitive to color? How do they perform in the dark? Use what you find to explain your observations in one paragraph. **Number of Points:** 10	15-30min	2/5	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Planetary Motion	**Purpose:** Track the change in the location of Jupiter relative to background stars over the course of the semester. **Timing:** You will make this observation four times over the course of the semester. It can be made at any date/time, so long as Jupiter and the constellation Gemini are up in the sky. Your four observations must each be separated by at least three weeks and must be completed by the dates listed at right. **Semester Observing Option:** If you choose this as your semester observing project, you will need to make this observation more frequently - once per week - and will answer additional questions and make additional measurements. See the full project description. **Materials:** Monthly sky chart **Instructions:** The planet Jupiter is visible in constellation Gemini in the early evening all semester. You have been given a map of the region of the sky in which it is located. You simply need to find Jupiter and carefully add it to the map you were given. You should also keep a table with the following information: (a) the date and time of your observation (b) the distance (in fist and finger measurements) from Jupiter to each of the following bright stars, labeled on your map: Pollux, Procyon, Betelgeuse, Capella. **Questions after final observation:** 1) Connect the dots of your observations. Was Jupiter always moving in the same direction relative to the background stars? 2) Using a ruler, your sketch, and the dates of your observations, describe how Jupiter's rate of motion relative to the background stars changed over the course of the semester. When was it moving fastest/slowest? 3) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points:** 40	30-45min for first observation, then ~10min once per month	#1: 1/29 #2: 2/26, #3: 3/26, #4: 4/30	Yes

<table>
<tr><th>Name</th><th>Instructions</th><th>Duration</th><th>Note-book Check</th><th>Sem. Obs. Option</th></tr>
<tr><td>Moon Motion</td><td>Purpose: Observe the motion of the moon over the course of ~1-2 weeks.

Timing requirements: Since the moon is not always up at any given time, you'll need to plan ahead to choose when to start your observations. Use the tips below to get a rough idea of when to start, but there's no substitute for simply looking at the moon rise and set times over the course of the weeks that you want to do your observation. Use the rise/set calendar in the Observing Resources packet to make sure that the moon will be up at the time you want to observe <u>over the course of the whole 1-2 week interval</u>.

<table>
<tr><th>Desired Observing Time</th><th>Start your 1-2 Weeks at</th></tr>
<tr><td>6-9pm</td><td>New to first quarter</td></tr>
<tr><td>9pm-12am</td><td>First quarter to full</td></tr>
<tr><td>12-3am</td><td>Full to third quarter</td></tr>
<tr><td>3-6am</td><td>Third quarter to new</td></tr>
</table>

Materials: Astrolabe

Semester Observing Option: If you choose this as your SOP, you will need to make this observation every day for 2 weeks and will answer additional questions and make additional measurements. See the full project description.

CONTINUED ON THE NEXT PAGE</td><td>~10min
3 times per week for 1-2 weeks</td><td>2/19</td><td>Yes</td></tr>
</table>

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Moon Motion continued	**Instructions:** Make at least three observations of the moon over the course of ~1-2 weeks. The first and last observation should be separated by at least 5 days, and need to happen at **the same time each day** (to within 15 minutes). Each time, sketch the moon's location, shape and orientation relative to the horizon <u>on the same sketch</u>. To facilitate this, make sure that your first sketch includes the entire southern horizon all the way from east to west along the bottom of the page. The top of your paper should represent the point directly over your head (the zenith). Make a table that lists: 1) the exact date and time of your observation 2) the distance between the moon and the horizon (the elevation of the moon), measured using your astrolabe. Measure to the lowest illuminated point on the moon each time for consistency. 3) the phase of the moon 4) the constellation that the moon is in **Questions:** 1) Draw a line connecting your observations and use it to predict the path that the moon takes across the sky over the course of a month (when viewed at the same time). Draw a dashed line along this path and label it. 2) Estimate what percentage of this path the moon traversed over the course of your observations. Describe how you arrived at this estimate. 3) Write 2-3 paragraphs summing up your observation, including : (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points:** 20	~10min 3 times per week for 1-2 weeks	2/19	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Telescope Observing	**Purpose:** View celestial objects through a telescope. **Timing Requirements:** These observations can be done at any point during the semester if you own a telescope or can access one. You will also have an opportunity to "check out" a small telescope called a Galileoscope to complete these observations. Finally, there will be several "star parties" offered over the course of the semester, where larger telescopes will be set up for you to use. **Materials:** telescope, planisphere **Semester Observing Option:** If you choose this as your SOP you will need to make additional observations and some measurments. See the full project description. **Instructions:** Find and sketch at least one object in five of the six categories: (a) Nebulae (b) Double Stars (c) Open Clusters (d) Globular Clusters (e) Galaxies (f) Planets Before going outside to do these observations, you will want to do some internet research regarding good options in each category and how to find them. Some suggestions are below, but it is by no means an exhaustive list. There are many other good options. Remember that these "deep sky" objects will not generally appear on your planisphere, so you need to know where to look relative to stars that <u>are</u> on your planisphere. Before going outside to observe, answer question 1 for each object you intend to find. This holds true even if you are coming to a star party to observe, as you will be asked to choose objects and point the telescopes. In many cases, you will have to point your telescope in the right general area and slowly scan the sky in that area until you find it. **CONTINUED ON THE NEXT PAGE**	varies	4/2 and 4/9	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Telescope Observing continued	**<u>Suggested Objects, (constellation)</u>** **Nebulae:** Orion Nebula (Orion), Crab Nebula (Taurus) **Double Stars:** Alberio (Cygnus), Mizar (Ursa Major), The "double double"=Epsilon Lyrae (Lyra) **Open Clusters**: Pleiades (Pleiades), Hyades (Taurus), The Double Cluster h and chi Persei (Perseus) **Globular Clusters:** M13 (Hercules), M3 (Canes Venatici, near Bootes) **Galaxies:** Andromeda Galaxy (Andromeda), Whirlpool Galaxy (Canes Venatici) **Planets:** Saturn (in Libra Spring 2014), Mars (in Virgo Spring 2014), Venus (varies, but on eastern horizon just before sunrise throughout Spring 2014) **Questions:** (1) How will you find the object? Draw or describe its location relative to nearby stars/constellations. (2) Once you find an object, sketch what you see through the telescope. For each object, answer the following questions: (a) Do you see any color in the object? What color(s) do you see? (b) Can you see the object with the naked eye? If so, how does it appear differently through the telescope (c) Describe the object's appearance in words. Is there anything surprising about it? (3) Write a paragraph describing your reaction to these observations in general. What did you find particularly challenging, cool, over or underwhelming? **Number of Points:** 40	varies	4/2 and 4/9	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Lunar Eclipse	**Purpose:** Observe a total lunar eclipse **Timing:** There's no getting around it. The night of April 14/15 is the only time all semester you can do this observation. **Semester Observing Option:** If you choose this as your SOP, you need to observe the entire eclipse and make additional measurements. See the full project description. **Instructions:** Sketch the moon as it appears at 20 minute intervals starting at least 20 minutes before the start of partial eclipse at 10:58pm and lasting until at least 20 minutes after the start of the total eclipse (at 12:07am). This means that the minimum observing time is from ~10:30pm-12:30am. Exact timings for the eclipse are listed below. Each time you make an observation, sketch the moon as it appears relative to the horizon on the same sketch. Penumbral Eclipse Begins: 04:53:37 UT = 09:53pm MST (Tucson Time) Partial Eclipse Begins: 05:58:19 UT = 10:58pm MST Total Eclipse Begins: 07:06:47 UT = 12:07am MST Greatest Eclipse: 07:45:40 UT = 12:46am MST Total Eclipse Ends: 08:24:35 UT = 1:24am MST Partial Eclipse Ends: 09:33:04 UT = 2:33am MST Penumbral Eclipse Ends: 10:37:37 UT = 3:37am MST Questions: 1) How did the moon appear differently during the penumbral, partial and total eclipse phases? 2) Did the color of the moon change over the course of your observations? If so, how? 3) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points:** 30	~2-4hr on the night of 4/14-4/15	4/16	Yes

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Lyrid Meteor Shower	**Purpose:** Observe a meteor shower **Timing Requirements:** The Lyrid meteor shower will be visible from the nights of April 19 to 25th, but they will peak around the night of the 22nd/23rd. You may complete your observations any time in this window. Lyra rises around 10pm on those nights, so you will need to make your observations sometime after that. **Instructions:** Find a dark place where you can sit or lie down comfortably and where your Eastern horizon is fairly unobstructed. Sketch your view towards the east, including some of the brightest stars in the region. Start a timer for 1 hour. Looking east towards the constellation Lyra, watch for shooting stars. Each time you see one, mark its path across the sky, including where it "started" and "finished", and note the time next to it. **Questions:** 1) Describe your observation in 1-2 paragraphs. How many did you see? Were they evenly spaced in time? Did the brightness and length vary from one to the next? Did they appear to originate or point toward a particular place in the sky? 2) Do some Internet research and write one paragraph about the cause of meteor showers in general and this shower in particular. Why does it happen the same time every year? Why are there more meteors some years than others? **Number of Points:** 20	1hr after 10pm any night 4/19-25	4/23	No

Name	Instructions	Duration	Note-book Check	Sem. Obs. Option
Light Sources	**Purpose:** Observe the spectra of light sources around town **Timing Requirements:** May be done any time between receiving the spectrographs in class on 2/24 and the 3/5 journal check. **Materials:** Spectrograph **Instructions:** Find the following types of light sources and sketch their spectra using your spectrograph. In each case, be careful to capture the relative brightness, spacing and colors of any lines that you see. Use colored pencils or label the colors. (1) The sun (do not look directly at it, but off to the side) (2) The sun through glass (3) At least two "neon" signs of different colors (4) A streetlight – the yellower the better **Questions:** (1) Was there any difference between the spectrum you observed for the sun and for the sun through glass? (2) For each neon light, use the website http://www.tinyurl.com/SpecDb and your sketch to identify the element in the tube. If you think there is more than one candidate, describe your dilemma. (3) Was the spectrum of the streetlight completely continuous? Most streetlights in Tucson aren't! Describe how it differed in words. If any lines appeared in its spectrum, use the website above to identify the element(s) causing them. (4) Write 2-3 paragraphs summing up your observation, including: (a) what you learned from it (b) anything that you found surprising or puzzling about it and (c) your best explanation, using specifics from your observations, for what the cause of the trend you observed is. **Number of Points**: 20	~5min per light source between 2/24 and 3/5	3/5	No