Astronomy 210 Spring 2011
Homework Set #1

Due in class: Friday, Jan. 28
Total Points: 50 points + 10 bonus points

Note: Your homework solutions should be legible and include all calculations, diagrams, and explanations. The TA is not responsible for deciphering unreadable or illegible problem sets! Also, homework is graded on the method of solution, not just the final answer; you may not get any credit if you just state the final answer!

1. *SOHO and the Angular Speed of the Sun: a Web-Based Exercise.*

   (a) **[5 points]** Calculate the average angular speed of the Sun's motion with respect to the celestial sphere, as observed from Earth. Express your answer in units of degrees per day. You may simplify the problem by assuming that the Earth's orbit is perfectly circular.

   (b) **[5 points]** Go to the website for the NASA space mission SOHO, which you can find from the course `links` page or the page for Lecture 3. Look at the real-time movie from the LASCO C3 camera (the blue LASCO images); note that in each image, a circle indicates the location and size of the Sun's disk, which subtends an angle of about 0.5° in diameter. Compare two or more images showing the same star, and find the Sun's present angular speed with respect to the celestial sphere. Show your work. Compare your answer to your estimate in part (a), and comment on the agreement or lack thereof.

2. Viewed from the Moon, the Earth shows phases. This is in an image of the Earth taken by the Apollo 8 astronauts. If the Earth appears as shown to an observer on the Moon, then:

   (a) **[5 points]** What phase does the Earth have? Is the Earth waxing or waning for an observer on the Moon?

   (b) **[5 points]** Given this phase of the Earth, what phase does the Moon have to an observer on the Earth?

3. **[5 points]** If Venus is at conjunction, what does this mean? When Venus is at conjunction, at what time of day or night will the planet rise? Set?

4. **[5 points]** At what time of day or night does the waning crescent Moon rise? set?

5. **[5 points]** What is the altitude (angular height above the horizon) of Polaris as viewed from latitudes of 90°, 60°, 40°(Chambana's latitude), 30°, and 0° (the equator)?

6. **[5 points]** Astronomical twilight ends (the sky is completely dark) when the Sun is 18° below the horizon (distance from zenith 108°). At the summer solstice, the Sun is 23.4°above the celestial equator. At that time, above what latitude does twilight *never* end? That is, at what latitude is the Sun at midnight just 18° below the northern horizon?

7. *Circumpolar and Invisible Stars.*

   (a) **[5 points]** As discussed in class, circumpolar stars never set, that is, never go below the horizon. Consider an an observer at latitude ℓ in either the northern or southern hemisphere. For such an observer, find the maximum angle $\delta_{\max}$ from the celestial pole of the same hemisphere, at which all stars are circumpolar. *Hint*: you may treat the celestial sphere as very distant compared to the size of the Earth.

Check your result for an observer at the equator ($\ell = 0$), and the north and south poles ($\ell = 90°$), and explain why these answers make sense. Finally, give $\delta_{\rm max}$ for an observer in Chambana with $\ell = 40°$.

(b) **[5 points]** For an observer at latitude ℓ, some stars never *rise*, that is, never go *above* the horizon and thus are not ever visible. Again consider an an observer at latitude ℓ in either the northern or southern hemisphere. For such an observer, find the maximum angle $\theta_{\rm max}$ from the celestial pole of the *opposite* hemisphere, at which all stars are are invisible (always below the horizon). Check your result for an observer at the equator ($\ell = 0$), and the north and south poles ($\ell = 90°$ N or S), and explain why these answers make sense. Finally, give $\theta_{\rm max}$ for an observer in Chambana with $\ell = 40°$.

8. *Measure the Angular Size of the Moon.* **[10 bonus points]** You will need at least one partner (non-ASTR 210 civilians are welcome) to do this assignment, along with

- some means of taking a digital picture (camera, cellphone, etc.)
- one ball or spherical object, and
- a means of measuring lengths.

Your mission is to measure for yourself the angular size of the Moon. To do this, go outside with your partner(s) when the moon is up during the day. From the course `links` page you can find a lunar calendar which can help determine when this will be–that is, you can find the lunar phase, and then ask yourself when and during which phases is the Moon up during the day.

When conditions are right, go outside with your occulting sphere, otherwise known as a ball. One partner will be an observer/photographer, the other(s) the occulting sphere operator(s). The observer and sphere operator should arrange themselves so that the occulting sphere (ball) is held up *next to the Moon*, and has the *same apparent angular size*. This may require clever use of photographic angles and/or stairs; have fun but please be safe!

When you have successfully reproduced the angular size of the moon with the occulter, the photographer should take a picture which will demonstrate this by showing the Moon and occulting sphere side-by-side, and also the fearless sphere operator. Measure (perhaps by pacing off) the distance d between the camera and the occulting sphere.

For completeness, also take *two* other pictures: (a) one in which the occulting sphere has a smaller angular size than the Moon, so that it makes an annular eclipse of the Moon, and (b) one in which the occulting sphere has a larger angular size than the Moon, so that it appears size-by-side but would clearly more than cover the entire lunar disk. Hamming it up for the camera is recommended but not required.

After your successful expedition, return to a suitable environment for number crunching. Write a brief description of the time and place of your observations, and how you measured the length d. Then using the distance d you measured, and the radius r of the ball, calculate the angular diameter θ of your occulting sphere, and thus of the Moon. Compare your result with published values. Briefly comment on the experiment and the accuracy of your results.

For this problem you are welcome to work in groups of up to 3 students. Each group member should *appear in at least one photo* to get credit. For this reason, please put *labels* or include *captions* in your writeup that identify group members in the photos.

Each member of the group should *separately* post this assignment on Compass to receive up to 10 bonus homework points, anytime up to class time on **Friday Feb 18**.