Astronomy 102, Fall 2004

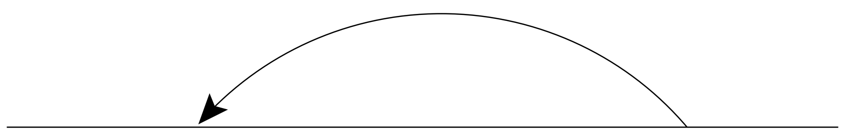
Exam 1 Solutions

1. You are between latitudes of 0° and 23.5°; you have to be at least a little bit above 0 degrees. degrees. The time of year has to be sometime between March 21 and September 21.

In the northern hemisphere, when looking north, northeast is to your right and northwest is to your left. Stars rising in the east and setting in the west will rise to your right, cross overhead, and curl down to the left. That's a counter-clockwise rotation. For the Sun to pass directly overhead, you have to be at a latitude less than 23.5°, the tilt of the Earth's axis relative to its orbit. If you're in the northern hemisphere, it must be the half of the year when the northern hemisphere of the Earth is tilted towards the Sun, i.e. around the time of the northern summer.

2. Yes. Above latitudes of $90° - 23.5°$, or 66.5°, and below latitudes of $-66.5°$, there are times of the year when the Sun never sets. In the northern latitudes, this happens around December 21; right at $+90°$, all the way from the vernal to the autumnal equinox this happens. As you go farther south, the number of days when this happens gets smaller and smaller. It is similar in the southern hemisphere, only it's June 21 that the dark days center around.

3. **(a)**



(b) North. (To see a star make a low arc in the sky from the Southern hemisphere, you need to be facing the direction of the equator, which is North of you. This also explains why the star is going "backwards" across the sky, compared to what we northern hemisphere residents have learned to expect.)

(c) Must be greater than 0. Stars on the equator will be up for 12 hours. If you're in the souther hemisphere, stars at negative declinations will be up for longer than 12 hours, and stars at positive declinations will be up for less.

4. There is no "dark side" of the Moon. Or, rather, there is, but what that side is changes. As the Moon goes around the Earth over the course of a month, it also rotates. There *is* a "far side" of the Moon, which is always pointed away from the Earth. But sometimes it's pointed towards the Sun (during the phase we call "new moon"), and sometimes away from the Sun (our "full moon"), so it's sometimes light and sometimes dark.

5. **(a)** No. For the Sun to be as high in the sky as it gets, it must be noon. For it to be full moon, the moon has to be in directly the opposite direction, which would be on the other side of the Earth, or below our horizon.

(b) Near the poles. Because there is a small (5°) tilt of the Moon's orbit relative to the Sun's orbit, you could get a Sun just off the horizon (say a little after March 21 on the Northern horizon), and the full Moon just off the horizon in the opposite direction.

6. Galaxies in the local group. Star are so amazingly far apart compared to their sizes that if you wanted to use something you could actually *see* to represent the stars (let's be absurd and shrink it all the way down to grains of sand), you'd have to put them tens of miles apart. Galaxies in the local group, however, are much closer together compared to their sizes; you could use frisbees that are only tens of feet apart, making it feasable to put together a scale model within one large room where each Galaxy is even big enough to paint pretty swirling spiral arms on it.

Note that the *absolute* distances between galaxies are much larger (hundreds of thousands or millions of light-years for galaxies, as compered to just light-years for stars). Galaxies are just closer *compared to their sizes* than stars are compared to *their* sizes.

7. (a)

$$A = \frac{l}{d}$$

In this case, l is 40 AU, and A is $0.002''$. To use this equation, we need A in radians, and l in the same units as we will be measuring distances. So, let's convert A to radians, and l to parsecs:

$$A = 0.002'' \left(\frac{1\,\mathrm{rad}}{206265''}\right) = 9.69 \times 10^{-9}\,\mathrm{radians}$$

$$d = 40\,\mathrm{AU} \left(\frac{1\,\mathrm{pc}}{206265\,\mathrm{AU}}\right) = 1.94 \times 10^{-4}\,\mathrm{pc}$$

For a given measured angle A, then, the distance we would calculate is:

$$d = \frac{l}{A}$$

The biggest distance then comes from the smallest possible angle we can measure:

$$d_{\mathrm{max}} = \frac{1.94 \times 10^{-4}\,\mathrm{pc}}{9.69 \times 10^{-9}}$$

$$\boxed{d_{\mathrm{max}} = 20,000\,\mathrm{pc} = 20\,\mathrm{kpc}}$$

(b) The Milky Way is about 30 kpc across, and we're about 8 kpc from the center You can *almost* get out to the far side of the Milky Way with your measurements; not quite, but close.

(b) What l do we need to measure a distance $d = 800\,\mathrm{kpc}$ if we can measure angles A to $0.002''$ (which is the same as 9.69×10^{-9} radians)?

$$l = A\,d$$

$$l = (9.69 \times 10^{-9})\,(800\,\mathrm{kpc})$$

$$l = (7.76 \times 10^{-6}\,\mathrm{kpc}) \left(\frac{1,000\,\mathrm{pc}}{1\,\mathrm{kpc}}\right) \left(\frac{206,265\,\mathrm{AU}}{1\,\mathrm{pc}}\right)$$

$$\boxed{l = 1600\,\mathrm{AU}}$$

(That's still less than 1/100 of the distance to the closest star.)