Astronomy 102, Spring 2003

Homework Set 1 Solutions

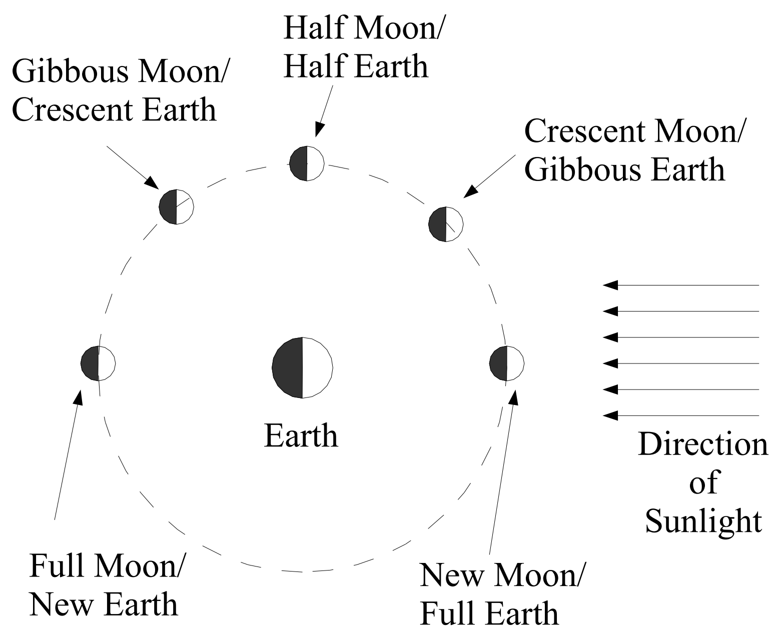
1. On the equator, the day is always exactly 12 hours long, June 21 or any other day. Thus, there is no shortest day. (The horizon cuts the Celestial Sphere so that exactly half of any circle of constant declination is above it, and half below it.)

2. The sun varies between +23.5° and -23.5° declination. The declination at the zenith is the same as your latitude, thus the sun can be at the zenith if your latitude is $-23.5° < l < +23.5°$.

3. *Assume that the Moon's orbit is circular. Suppose you are standing on the side of the Moon that faces Earth. How would Earth appear to move in the sky as the Moon made one revolution around Earth? How would the "phases of Earth" appear to you, as compared to the phases of the Moon as seen from Earth?*

The moon rotates with the same period as its orbit around the Earth, thus the same side of the Moon faces the Earth at all times. This means that to an observer on the Moon, the Earth does *not* appear to move across the sky. However, the Earth may be seen rotating, since its rotational period (24 hours) is much shorter than the orbital period.

The Earth would show phases from the Moon, precisely for the same reason the Moon shows phases from the Earth. Depending on whether the Sun is behind you (and thus lighting the face of the Earth you can see), or on the far side of the Earth from you (and thus lighting the face of the Earth you can't see), you will see a "full Earth" or "new Earth". The phases of the Earth as seen from the Moon are exactly opposite the phases oft he Moon as seen from Earth:



4. *Many U.S. cities have main streets laid out in east-west, north-south alignments. Why are there frequent traffic jams on east-west streets during both morning and evening rush hours within a few days of the equinoxes? On this basis, if you work in the city during the day, would you rather live east or west of the city?*

The primary effect here is that on the equinoxes, the sun is crossing the celestial equator (i.e. it is at $\delta = 0°$). This means that it will set *due west* and rise *due east.* (The celestial equator crosses the horizon due east and west, at any latitude.) Thus, if you're driving due east or due west, you're driving right into the sun, and the glare is at its worst. At other times of the year, the sun will set further north or south, and won't be as directly in your eyes.

A number of people identified the 12-hour length of the day as the problem, stating that sunrise and sunset tend to come near rush hour on the equinoxes. This is only a secondary effect; depending on your latitude, the time of year, whether or not daylight savings time has happened, etc., you may be driving into or away from work near sunrise at other times of the year.

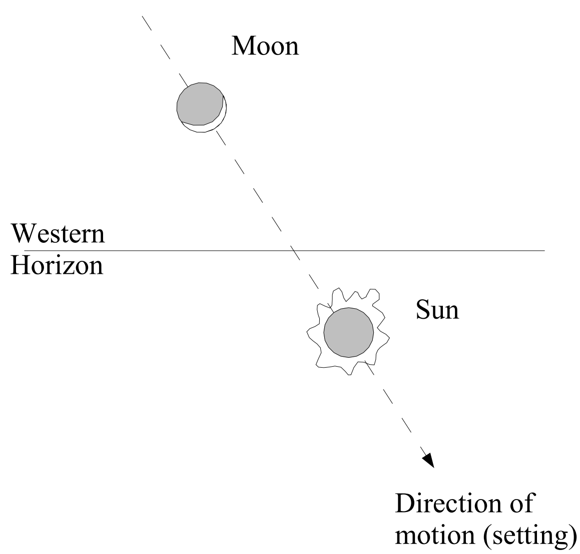
5. *Sometimes artists paint the horns of the crescent moon pointing toward the horizon. Is this realistic? Explain.*

Assuming that this is a night scene being painted, no, this is not realistic. There are two important points here.

First point: if the moon is crescent, it means that to an observer on the Earth, the angle between the moon and the Sun in the sky is fairly small (less than 90°). (If the angle were more than that, you'd have a gibbous or even full moon.) Thus, to be visible at night, the moon will either set not too long after the sun, or will rise not too long before the sun. A setting crescent moon will be over the western horizon just after the sun has gone beneath it, and a rising crescent moon will be over the eastern horizon just before the sun comes up over it

Second point: the crescent is on the side of the moon that is towards the sun, since the sun is what is lighting up that part of the moon. (Most of the lit side of the moon is away from us when the moon is a crescent; the difference in the angle to the Sun and moon lets us see a bit of the lit edge, which looks like a crescent to us.)

At a latitude similar to Nashville's in the northern hemisphere, the situation would look something like the picture below; the horns aren't pointing straight up, but they are pointing more up than down. At the equator, the sun would be setting straight down, and the moon would be (at most) at a 5.2° angle to the Sun, often less. The "horns" would in fact be pointing almost straight up.



6. *The Moon's orbit is tilted by about 5° relative to Earth's orbit around the Sun. What is the highest altitude in the sky that the Moon can reach as seen in Nashville (latitude 36°)?*

There are two ways to do this. The easier way is to recognize that the declination of the zenith is the same as our latitude, 36°. The altitude of the zenith is always 90°, at a right angle to the horizon. The highest declination the Sun reaches is 23°, which is $36° - 23° = 13°$ *less* than the declination of our Zenith (when it's due south on the summer soltices). At this time, the Sun's altitude is $90° - 13° = 77°$ (the altitude of the zenith minus the difference between the zenith and the Sun). If the angle between the Moon and Sun is 5°, then the Moon can be at most 5° closer to the zenith than the Sun, and thus can be at the highest altitude of 82°.

The harder way to do this is just to add the angles directly. First, recognize that at latitude 36°, the angle between the horizon and the celestial equator is $90° - 36° = 54°$, as shown in the picture below. (The angle from horizon to zenith is 90°, so horizon-to-equator plus equator-to-zenith must be 90°.) Due south, that is the altitude of the equator. The Sun gets to a maximum angle of 23° above the equator, or a maximum altitude of $54° + 23° - 77°$. The Moon can be at most another 5° away from the Sun's highest point, or $77° + 5° = 82°$.