Astron 299/L&S 295 Problem Set 2

Given: Sep 14. Due: Wednesday, Sep 21 at the beginning of class

Homework Policy: You can consult class notes and books. Always try to solve the problems yourself; if you cannot make progress after some effort, you can discuss with your classmates or ask the instructor. However, you cannot copy other's work: what you turn in must be your own. Make sure you are clear about the process you use to solve the problems: partial credit will be awarded.
Reading: Kutner Chapters 5.3, 5.4, 22.1

Problem 1 The Height of the Sun

We saw in class how the seasons are caused by the tilt of the Earth's axis relative to the plane of its orbit. This results in the Sun appearing to change altitude from one season to another, with it high in the summer and low in the winter.

a. Assume that the latitude of Milwaukee is 43° N. What is the altitude (i.e., how many degrees above the horizon) of the Sun at noon on the summer solstice? The winter solstice? The equinoxes? [Hint: the Sun is far away, so a line from the center of the Earth to the Sun is parallel to a line from Milwaukee to the Sun.]

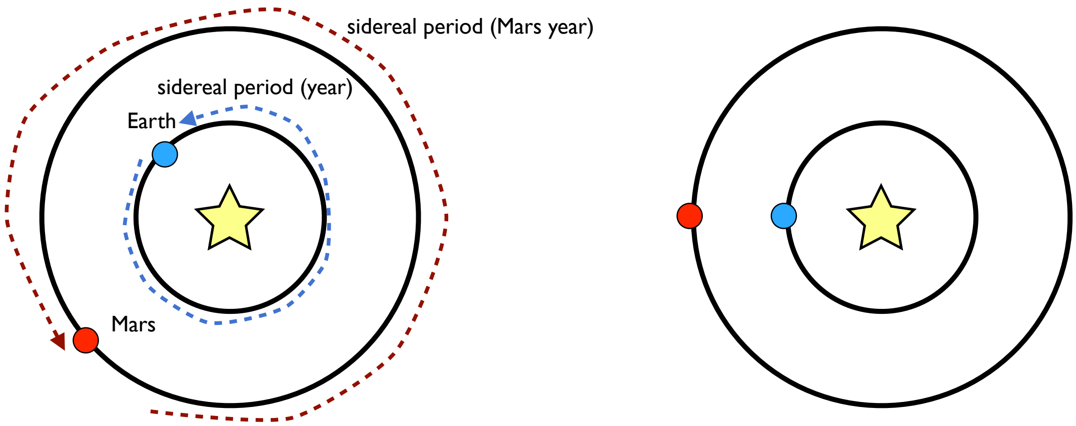
b. Assume that the latitude of the US research post McMurdo Station on Antarctica is 78° S. What is the altitude of the Sun at noon on Dec. 21? Jun. 21?

c. What about McMurdo at midnight on Dec. 21 and Jun. 21? What do these results imply for the lengths of day and night at different times of the year?

Problem 2 Synodic Periods

The *sidereal period* is the time between when a planet is at the same point in its orbit relative to the Sun. So for the Earth this is 365 days, or one year. The *synodic period* is the time between when two planets are closest to each other in their orbits (without looking at where the Sun is). See discussion in Kutner 22.1 for a slightly different way of writing things.

So in the figure, the sidereal period for each planet is how long it takes them to go all the way around the Sun (*left*). In contrast, the synodic period is how long it takes them to return to the same *relative* alignment (*right*).



In class we showed that, when considering the synodic period S (the time between when Earth and another planet are closest together) of Venus (whose orbit is inside that of Earth), the result was $1/S = 1/P_{\rm Venus} - 1/P_{\rm Earth}$.

a. Derive this result for Mars, whose orbit is *outside* that of Earth.

- Start by writing $\theta_{\rm Mars}$ and $\theta_{\rm Earth}$, which are the angles that each planet makes relative to some starting point in their orbits.
- Each of these is a function of time t. When time gets to $P_{\rm Earth}$, $\theta_{\rm Earth}$ will be 2π (in radians). So we can write $\theta_{\rm Earth} = 2\pi t/P_{\rm Earth}$. What is $\theta_{\rm Mars}$ in terms of $P_{\rm Mars}$?
- When they start at $t = 0$, $\theta_{\rm Earth} = \theta_{\rm Mars} = 0$. So they are at the same angle and they are close together. Then will again be close together after a synodic period. But there is no other solution to $\theta_{\rm Earth} = \theta_{\rm Mars}$, since the Earth goes around faster. So instead they will be close together when the Earth has done an extra time around the Sun, i.e., $\theta_{\rm Earth}$ will be 2π more than $\theta_{\rm Mars}$. Write this, and solve for the time at which that happens. This will be the synodic period.

b. The observed synodic periods of Venus and Mars and 583.9 days and 779.9 days, respectively. Calculate their sidereal periods.

Problem 3 Kutner 5.13

Problem 4 Order of Magnitude

Two quick problems. Remember, the point is not to be exactly right, but to make reasonable estimates and back up your estimates. Be explicit about what you do. If you find information online or in books, please give citations.

a. How many full-sized pages of paper could you carry, if they were bound up in boxes (try not to look this one up online, but make estimates based on things that you are familiar with, like books)?

b. How many liters of fluid have you drunk in your lifetime?