Exercise set two

1 Indoor: Learn to use a sextant

Materials

sextant, sextant manual, ruler/tape measure

Instructions

A sextant is a device for accurately measuring the angle between the horizon and a celestial object (and other angles, too). This angle is called the “altitude” of an object. This is the fundamental measurement of celestial navigation, as you will learn in several later exercises.

Refer to the directions in the sextant manual to learn to adjust the mirror and read the vernier. Make sure you understand how to rock the sextant to achieve an accurate measurement.

Stand at the threshold of the library. Practice using the sextant by measuring the vertical angle subtended by the door at opposite end of the end of the hallway outside the library (bring the image of the top of the door in the mirror down to the base of the wall). Each person should adjusted the mirror and then make the measurement as precisely as possible. **Record your measurement and the precision with which you think you made it.** Now measure the height of the door and compute the distance from where you made your observation to the door. **Record door height (and precision), sketch the geometry of the problem, and show your calculations.** Measure the length of the hallway. **How far off were you? What is the difference between the angle you should have gotten and the one you got? Were you within the precision you quoted?**

2 Indoor: The sidereal day

Materials

lab notebook, optional: globe

Instructions

The sidereal day is the (average) time it takes for the Earth to make exactly one full rotation (360 degrees). The solar day is the (average) time it takes the Earth to rotate far enough for the Sun to be over the same longitude on the Earth.

Do the following in your lab notebook:

Draw the Earth’s orbit around the Sun looking down from the North Celestial Pole. Which direction does the Earth rotate on it’s axis? Which direction does the Earth orbit the sun? Draw points on the orbit representing the locations of the Earth on two successive days (you can exaggerate how far it would have moved). How many degrees does the Earth move it it’s orbit in 24 hours? How many degrees does the Earth have to rotate in 24 hours for the Sun to be over the same spot on the Earth? What is the difference between the length of the solar and sidereal day? Which is shorter? How long is the sidereal day?

3 Outdoor independent: Length of sidereal day

Materials

lab notebook, appropriate vantage point, watch which indicates seconds

Time frame

You will have three weeks to complete this project. You need to get at least 4 observations. Your first and last observation should be at least 14 days apart, but you have to allow for weather, so start as soon as you can. You may need to spend an hour or so finding a star and vantage point the first night, but after that observations should only take 10-20 minutes each.

Observations

The sidereal day is the time it takes for the Earth to make exactly one full rotation. We know that the solar day is 24 hours, meaning, on average, it take 24 hours for the sun to return to the same position in the sky. The sidereal day, however, is *not* exactly 24 hours. Here is how you will measure this difference.[1]

We need a way to tell when the Earth has completed one full rotation. You need a way to mark the position of a star in the sky and come back the next night to see when it is in the same place, and how much solar time has elapsed. Fortunately the time we use everyday is based on the mean solar day, so we can just read the solar time interval off a watch.[2].

You will use the edge of a tall building to define out fixed spot in the sky by recording the exact time when a star disappears behind the building (i.e. is "occulted" by the building). This can either be a star passing the vertical edge of the building or setting behind its rooftop. You need to make sure you're in exactly the same spot each night, or the edge of the building won't be in the same position in the sky. So make sure to pick a vantage point you can find again fairly accurately. Picking a distant building minimizes this problem, but you still need one close enough that it sticks up into the sky pretty far so you can easily find a bright star to pass behind it that won't be lost in the glow of city lights.

The authors of the lab on which this one is based have the following suggestions

> For example, if you think you can from night to night reproduce your observing location (position of your eye) to within 1 meter the building should be at least 100 meters distant; for 1/2 meter, at least 50 meters distant, etc.

It's also easiest if your building lies in a southerly direction. Buildings to the east won't work well, but you could record the time a star sets behind whatever defines your western horizon. Just make sure the rooftop you choose to the west is fairly horizontal.

I will give you a hint that the time at which the occultation occurs will get *earlier* by something like an hour and a half over the course of the three week period, so be aware of that when picking the first time to go out. Make sure the time you pick is at least that long after dark, for instance. Pick a suitable building and a bright star somewhat to the east of it. You may have to spend an hour or so watching the motions of the stars and selecting a good building-star pair. Make sure not to forget to **record the exact time of the occultation** while you're picking a star out. Identify the star you are using, if you can and **describe and sketch the vantage point and building you are using**.

[1] This exercise is adapted from
`http://www.astro.washington.edu/labs/clearinghouse/labs/Skywatch/LengthOfSiderealDay.htm`

[2] Make sure your watch is keeping good time by checking this website before you go out
`http://tycho.usno.navy.mil/cgi-bin/timer.pl`

Another hint: Make sure you go out early enough to catch the occultation on subsequent nights. For each day past the last observation, make sure to get to your spot at least four or five minutes earlier. For instance, if it's been 5 days since your last observation, get to your vantage point at least 20 minutes before the time of the last occultation.

You need to get at least four observations, and your first and last observation should be at least 14 days apart, if possible. Each time you go out **record the time of the occultation to the second**.

Analysis

If you have four observations then you have six different pairs of observations. **Using each pair of observations, calculate the length of the sidereal day.** Hint: start by calculating how much earlier, in seconds, the later occultation occurred. Convert that to a number of seconds earlier per day. **Do you trust some pairs more than others. Why?** Look up the accepted value of the length of the sidereal day and compare it to your answer.

4 Discussion: Motion of the ISS

From the *Sky and Telescope* Observing Almanac[3]:

> International Space Station Visibility Predictions
>
> ```
> Date, Time, Duration     Appearing        Max.Elevation  Disappearing
> 2005/10/04 6:13am 5 min. 13deg above SSW  28deg abv SE   12deg abv ENE
> ```
>
> The table shows nighttime passes of the ISS over your location during the next 5 days, if any. Time is listed for your time zone. Duration indicates the length of each sighting in minutes. Max. Elevation is how high the ISS will get above your horizon (90 overhead). To see the spacecraft, at a given Time look in the direction indicated by Appearing. You should see a bright, slowly moving "star" (weather permitting). The Disappearing entries indicate where the ISS will be when it vanishes from sight.

Answer the following questions: What direction is the ISS going (roughly)? Where, then, (roughly) does the it rise and set. Why does it move this way? Why does it appear and disappear above the horizon?

[3] http://skyandtelescope.com