OUTSIDE LAB 6: Celestial Navigation

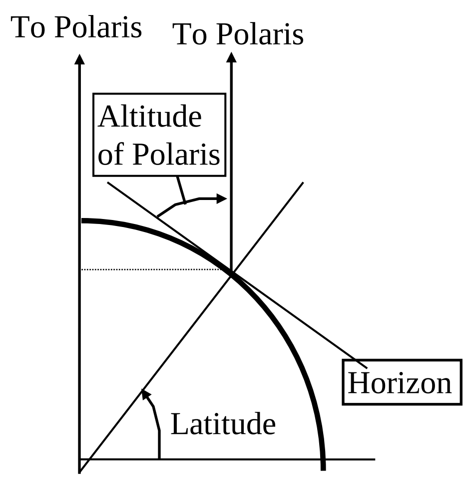
OBJECTIVE: *To find your latitude and longitude.*

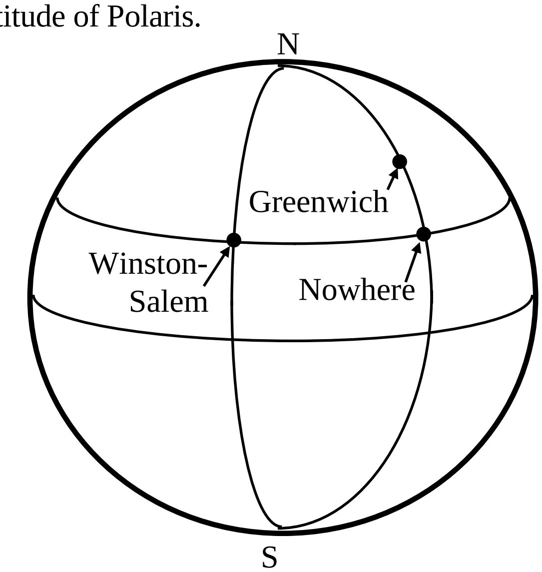
DISCUSSION:

To determine locations on the surface of the Earth requires the use of some kind of coordinate system. The system most commonly used is that of longitude and latitude. By means of a simple measurement it is always possible to determine your latitude. Longitude is more difficult. However you can also determine it in a straightforward manner if you have a way to know the time in Greenwich, England. This is called Greenwich Mean Time (GMT), or Universal Time, and is the standard time used throughout the world.

A. Finding latitude.

Finding your latitude is easy because, as can be seen from the following diagram, your latitude is equal to the altitude of the north celestial pole. In the southern hemisphere it would be the altitude of the south celestial pole. In the northern hemisphere the star Polaris is within one degree of the north celestial pole. So you can get a good estimate of your latitude simply by measuring the altitude of Polaris.





B. Finding Longitude.

This is harder because the zero of longitude is arbitrary. It is set as the half circle which goes through the poles and passes through Greenwich, England. You find your longitude by knowing what time it is locally (this is local time as measured astronomically, not the time in your time zone) and knowing GMT. Your longitude is just the difference in these times. So if the difference is 6 hours and you are East of Greenwich then you have longitude 6 hours E. If you are west of Greenwich and the difference is 9 hours then you are 9 hours W. Since there are 24 hours in a day and 360 degrees in a circle, each hour of longitude corresponds to 360/24 = 15 degrees.

EXERCISES:

EXERCISE 1:

Using a quadrant find the altitude of Polaris. Make five measurements and average them together. **The altitude of Polaris equals your latitude.**

Trial	**1**	**2**	**3**	**4**	**5**	**Average**
Altitude						

EXERCISE 2:

Next record the correct time in the box below. Check with your TA to make sure that it is the correct time. You won't get the correct answer for your longitude if the time on your wristwatch is incorrect. Then immediately measure the altitude of a bright star whose name you know. Make sure that the star is **not** one of those near the north celestial pole. It can be anywhere else in the sky. Again make several measurements and average them. Finally record the correct time right after you finish your measurements.

Trial	**Start Time**	**1**	**2**	**3**	**4**	**5**	**End Time**	**Average Time**	**Average Altitude**
Altitude									

EXERCISE 3:

The next task is to determine Greenwich time. To do this simply take the (correct) time on your wristwatch and add 5 hours to it if you are going by Eastern Standard Time (November through March) or add 4 hours to it if you are going by Eastern Daylight Time (April through October). Do this for the time at which you took your measurements of the altitude of the star.

GMT time: _________________

EXERCISE 4:

Having determined Greenwich Mean Time it is now necessary to determine the local solar time. Recall that your longitude is given by the difference in these two times. The trick is to note that two observers at the same Latitude see the same sky, *but at different times*. If the two observers are at the same place, they will of course see the same thing at the same time. If one observer is at Greenwich and a second is one-fourth of the way around the Earth to the West from Greenwich then the second observer will see the same sky six hours later than the first observer. (Note to really be precise we would need to be working with Sidereal time which differs from solar time by four minutes each day. However we can get a very good approximation to our longitude without taking this complication into account.) We will measure the altitude of a star as viewed by us and will simply compare this with a hypothetical second observer at the same longitude as Greenwich. To accomplish this all you have to do is to use Starry Night to go to the location where the longitude is zero and the latitude is your latitude. Then find the time at which the star has the same altitude and is in the same part of the sky as where you observed it.

To do this, start "*Starry Night."* click on the "Viewing Locations" section and select "Other…" from the menu that pops up. Select the "Latitude/Longitude" tab. For latitude type the latitude you measured. Set the longitude and time zone to zero. Now, by clicking on the "Go to Location" button, you are positioned due south of Greenwich observatory at the latitude of Winston-Salem. Finally, make sure that Daylight savings time is *not* being used to ensure that the clock displays GMT. You do this by clicking on the small "Sun" icon at the left of the left of the area displaying the date and time.

Next find the star that you observed and change the time until it has the same altitude and is in the same part of the sky as you measured. This can be a bit tricky. First find your target star by pressing **Ctrl-F** (or clicking the "Find" tab at the left edge of the sky window) and typing in the name of the star. It is fine if the computer has to change the time to make it visible. Now try increasing or decreasing the time until the star is in the approximately correct direction. Now you need to fine tune the time to get the altitude of the star just right. There are two ways to check the object's altitude. One way is to position the mouse over the star until its info appears. Another way is to **Right-Click** and choose "Show Info" from the pop-up menu. The altitude and azimuth can be found under the "Position in Sky" section in the "Info" window. Once you have it just right, check the local time.

Local Time: _______________

Finally subtract your local time from the GMT at which you made the measurement. That is your longitude in hours and minutes. Is it East or West? Convert it to degrees. Each hour is 15 degrees, and each minute is ¼ of a degree.

Longitude: ________________ In degrees: _____________

EXERCISE 5:

Starry Night gives you the latitude and longitude of Winston-Salem. Compare your results with the correct ones. You can obtain the correct ones by resetting Winston-Salem as your current location and pressing **ctrl-L** again. How accurate are they? Are they as accurate as you would expect them to be? Why or why not?

Position of Winston-Salem:

Winston-Salem	**Latitude**	**Longitude**
Your Measurements		
Actual Values		

Comments:

EXERCISE 6:

Early navigators had an additional problem. They could measure local time by doing something similar to what you did. But without good portable clocks, they did not know GMT. Imagine that your watch was only accurate to 20 minutes a day. On any given day that is not so bad but if you set it to Greenwich time at the beginning of your voyage, then two months later you would not have any accurate knowledge of what time it was according to Greenwich mean time. What early voyagers had instead of accurate watches were almanacs that gave the times at which certain celestial events occurred at familiar places such as Greenwich, England. Given that they were able to determine their local time, how would they have been able to use the times of these events to determine Greenwich mean time and therefore their longitude? What types of celestial events would be useful for this?

Answer: