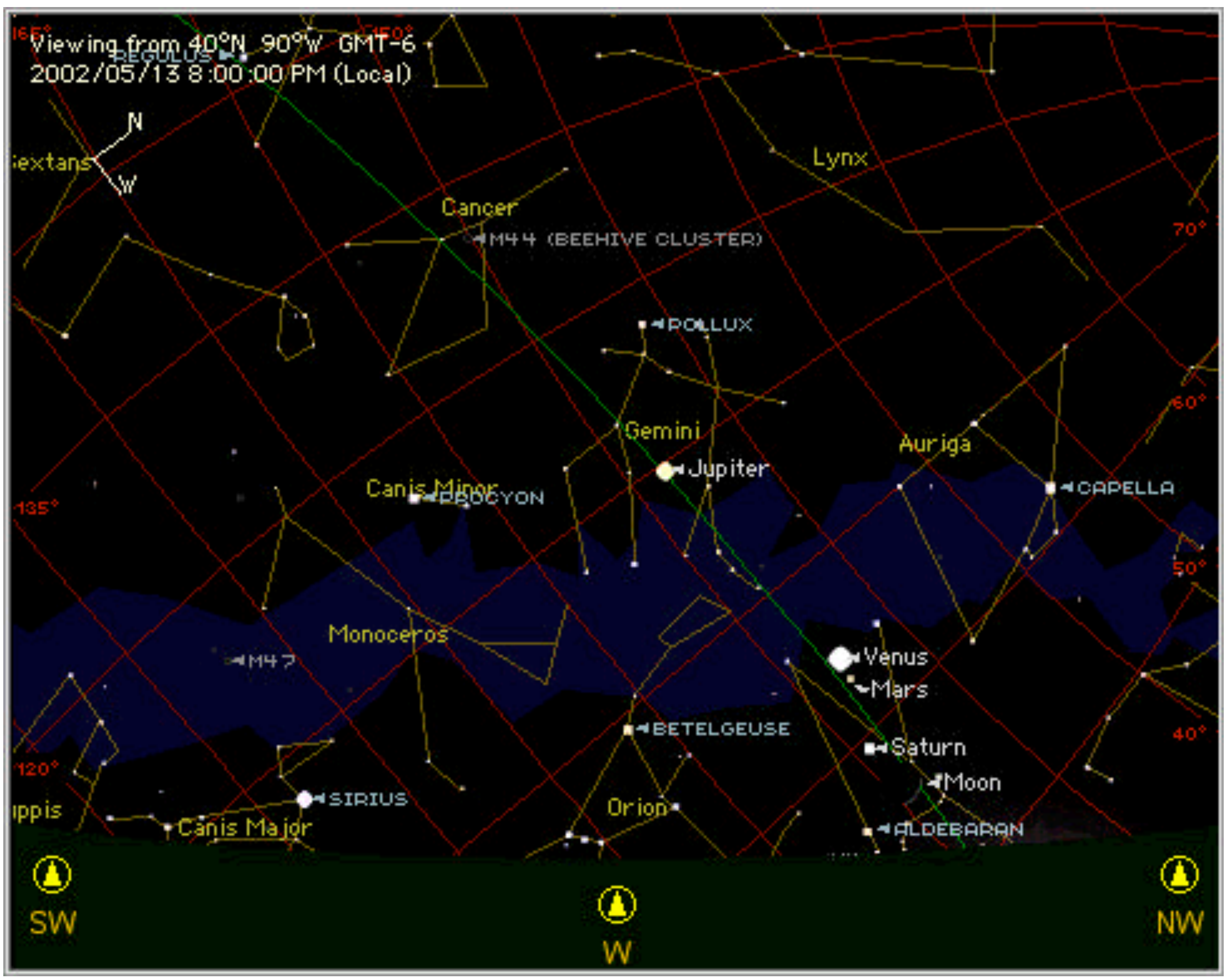
Plotting the Moon – Altitude and Azimuth

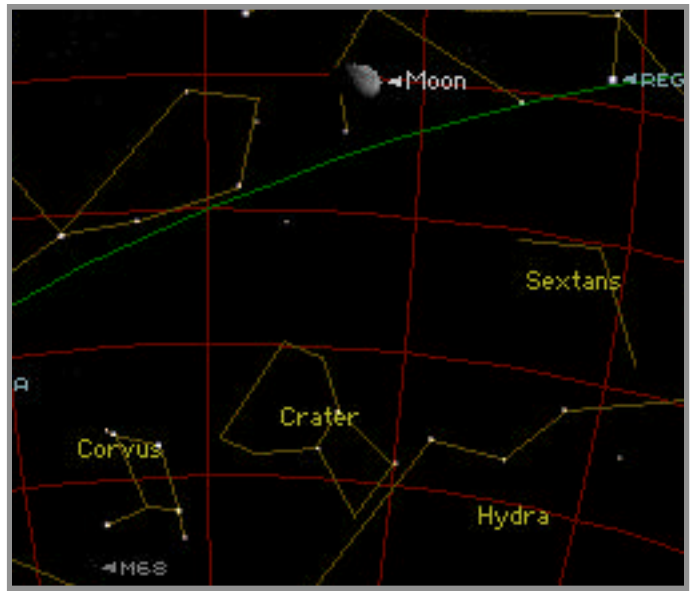
Your Challenge:
The Moon's position changes in both altitude and azimuth from day to day. You will take data on the position of the Moon, plot it and see what kind of relationship the data has - is it linear?

Discovering:
First do the activity "A Month of Moons" to discover the Moon's changing location in the sky over the course of a month. Now, let's go back and get the altitude and azimuth for the Moon for each day from the crescent new moon to the full moon. Find the day of the earliest crescent you can see in the western sky: __________. (Any month is OK; the images here show the month starting May 2002). Now, look at the bottom of the chart to see the direction in the sky. You'll see a "W" in the middle, for West, a "NW" at the right for "Northwest", and a "SW" on the left, for "Southwest". These are the directions you would look to see the horizon on this chart. We use "azimuth" to make a measurement of just how East or West the stars (or in this case, the Moon) is, measured along the horizon. Imagine yourself standing outside and facing North. How many degrees do you have to turn clock-wise (towards your right) until you face East? Answer: 90° (degrees), or a right angle. We define the term "azimuth" to be the number of degrees of rotation around the horizon, measured clockwise from North. So, the direction East is an azimuth of +90 degrees. You need to turn another fourth of a circle to face South. So South has an azimuth of +180 degrees. To face West, turn again another 90 degrees, so it's +270°. Back to North brings you to 360°(a full circle). (West is sometimes written -90°)

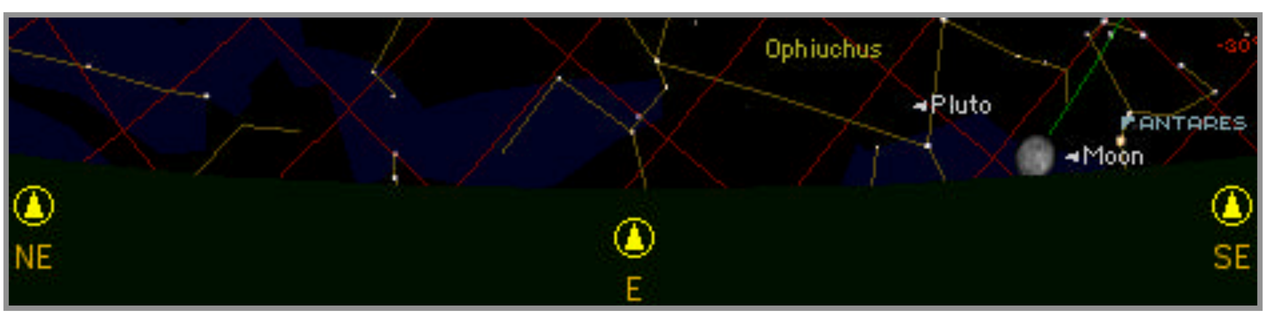


Since West is 270°, what is the azimuth of Southwest? (hint - it's halfway between South and West). What is the azimuth of Northwest? Now, turn on the "sky grid" button at bottom right. There are now white lines going straight up from the horizon, curving at the top. These are lines of constant azimuth. The line going straight up from "W" is the 270° line. Note that there is another line at "NW". How many lines are in between W and NW? So, what is the spacing of these lines? Each line corresponds to a change of ____ degrees (hint: not 10°). (check the scale at the top to test yourself) Now, notice that there are also faint white lines going across the picture. These are lines of altitude, each separated by ten degrees. Zero degrees of altitude is the horizon, and each ten degrees of altitude is higher in the sky by just about the angle of your fist at arm's length. After about 9 fists, you get ninety degrees, which is straight up. How many degrees of altitude does this plot cover? (It does not go all the way to the zenith - to see those stars, choose the "up" button). Notice that the lines are really curved. That's the problem with trying to put a curved star field onto a flat piece of paper! In this example, then, the moon is seen at an azimuth of about 293° and an altitude of about 5°. Make a chart of the Moon's position every day for two weeks. Put on the chart the day, the azimuth, and the altitude, plus a little sketch of the Moon's shape each day.

Day	Azimuth	Altitude	Shape



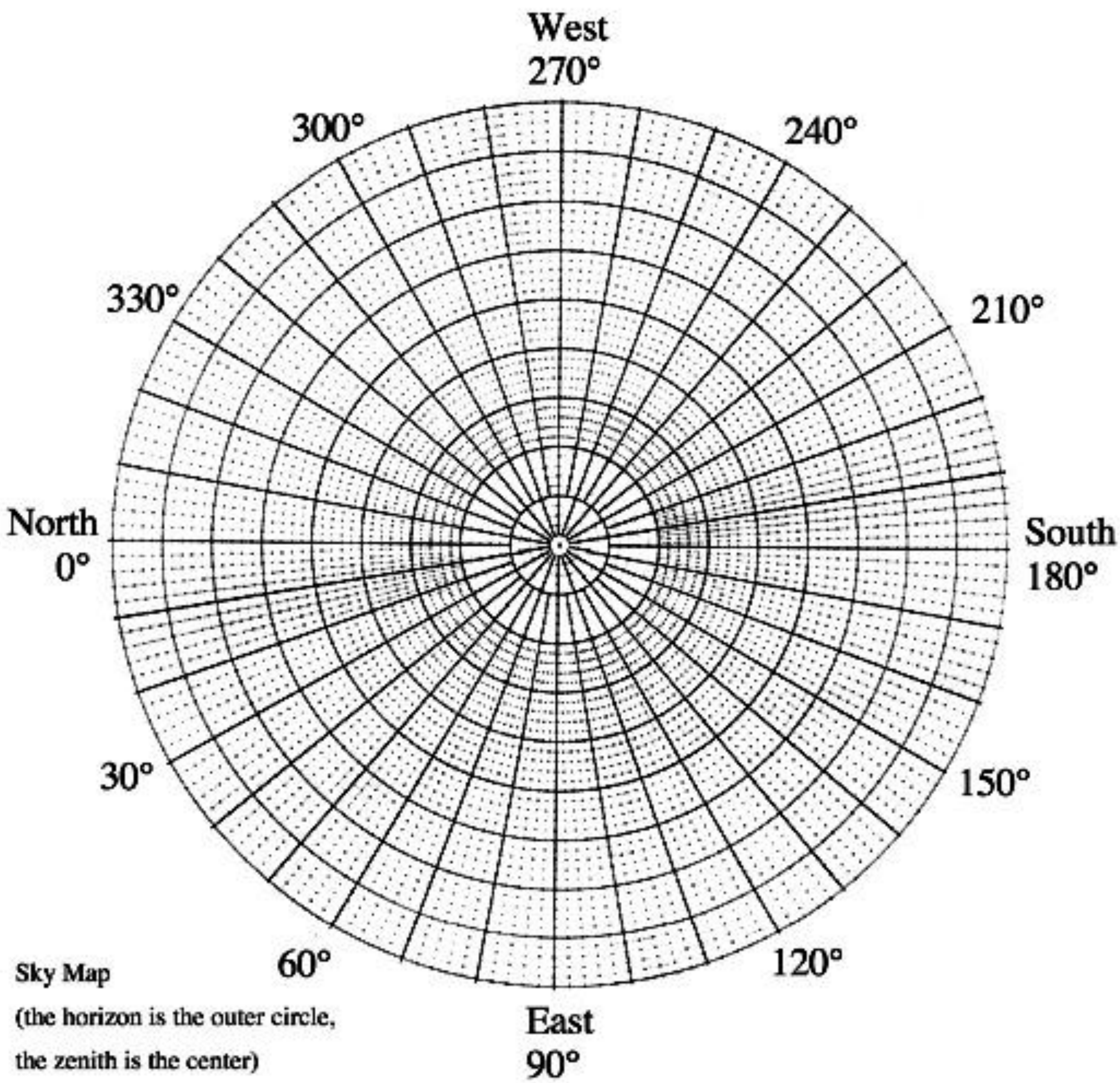
Note that after a few days, the Moon can't be found in the West any more. Look in the South direction, as for 5/20 above. (For some times of year, you may have to look "up" to the "Z"!). For the last few days, look in the East). Is the Moon's azimuth getting larger or smaller? Is its phase getting more full or less full?



Make a Plot:
Now, use the data which you have collected and make an **x-y plot**, using the azimuth as the x-axis and the altitude as the y-axis. Does the plot make a straight line? If not, what kind of curve does it look like? (You may use graphing calculators or printed regular rectangular graph paper). (Advanced: use the fitting function of

your graphing calculator to fit the data to a quadratic curve. What do you get? Would you get the same fit for October Moons as you would for January Moons? Try it!)

We can also plot the data on a **polar plot**. Polar graph paper is where one coordinate (in this case, azimuth) is measured in concentric circles. To use this kind of plot, put 90°altitude in the center (for the zenith), and 0° altitude in the outside edge (for the horizon). Put the Moon on its proper location for each day. (Hint: turn the paper upside down to plot the West views - note the 10° azimuth spacing on this graph paper, which is different from the azimuth spacing in the Sky Tonight movies)



Sky Map
(the horizon is the outer circle,
the zenith is the center)

Celestial Coordinates

Notice that through the month, the Moon is always close to the **green** line. That line is the ***ecliptic***, and the Sun is always found *exactly on* that line. The Moon and planets are always found *near* that line (May 2002 is an especially pretty lineup of planets in the evening sky). The ecliptic is the plane of the Earth's orbit projected onto the sky.

On the sky maps are also faint **red** lines. These are the celestial coordinates of the stars and planets. The red lines all come to a point at the North Celestial Pole (NCP), which is near Polaris, the North Star. That location is 90° North celestial latitude. The circles are lines of celestial latitude, which we call "**Declination**", marked in 10-degree steps. The scale of declination is labeled on the right edge.

The coordinate of the stars which is most similar to a longitude is called "**Right Ascension**". It's easiest to see those coordinates if you look at the "North" view. Hit the "play" button and watch the stars rotate around the NCP through the year (they also rotate around the NCP through the night). (Of course, this apparent motion is caused by the Earth's rotation – the stars don't really move!) Note that the Big Dipper (Ursa Major) and Cassiopeia are on opposite sides of the North Celestial Pole. So they have different Right Ascensions, although their declinations are similar. The lines of Right Ascension (RA) all meet at the North Celestial Pole. How many lines come out from the North Pole? ____ This makes their spacing ____ degrees, which is equal to the number of degrees which the Earth rotates in an hour. This plot has Right Ascension marked in degrees (on the top and right edge), but it is often labeled in hours (1 hour = 15 degrees). The zero of RA is where the green ecliptic crosses the celestial equator heading North (the location of the Sun at the spring equinox). This is not shown on this plot (find it!). Zero RA on this plot is the red line which is nearly horizontal, marked "meridian", just over the top of Cassiopeia. What RA is the line nearly through Dubhe (one of the "pointer stars" in the bowl of the Big Dipper)? ____. How many "hours" is that? _____