ASTRO 1050
Observing the Sky- Planetarium

ABSTRACT

Today we will be calibrating your hand as an angular measuring device, and then heading down to the planetarium to see the night sky in motion. We'll see how the motion of objects in the sky changes with your location on Earth, and how the path of the Sun changes with the seasons.

Materials

Meter sticks, rulers, red flashlights.

1. Angular sizes

The angular size, α, of an object depends on its linear (actual) size L and its distance D from you. The Moon and the Sun both have about the same angular size of $0.5°$. This is true because even though the Sun is 400 times larger than the Moon, it is also about 400 times farther away! For objects that are not too big (smaller than about $10°$), the angular size of an object is given by:

$$\alpha(radians) = \frac{Size(m)}{Distance(m)} = \frac{L}{D} \tag{1}$$

This is really just trigonometry ($sin(\alpha) = \frac{L}{D}$) with the small angle approximation applied to get rid of the *sine* function.

Since there are 57.3 degrees in one radian, we can also use:

$$\alpha(degrees) = 57.3 \times \frac{L}{D} \tag{2}$$

Make sure you pay attention to your units (as you always should)!! Now we can use these equations to calibrate our hands as angular measuring devices. You can then use your hand to do things like figure out your latitude (if you can find Polaris), estimate how long you have until the Sun sets, or estimate how far away objects are. We will calibrate both your fist at arms length and your pinky at arms length.

Hold your pinky finger up comfortably at arm's length. Have a partner carefully measure the distance between your eye and your pinky. Distance from eye to pinky: D = __________ centimeters.

Now measure the width across your pinky to the nearest tenth of a centimeter. Width of pinky: L = __________ centimeters.

Finally, use this information to compute the angular size of your pinky when held at arm's length. Angular size of pinky finger: $\alpha = 57.3 \times \frac{L}{D} =$ __________ degrees.

Next, make a fist and hold it at arm's length. Have a partner measure the distance between your eye and your fist. Distance from eye to fist: D = __________ centimeters.

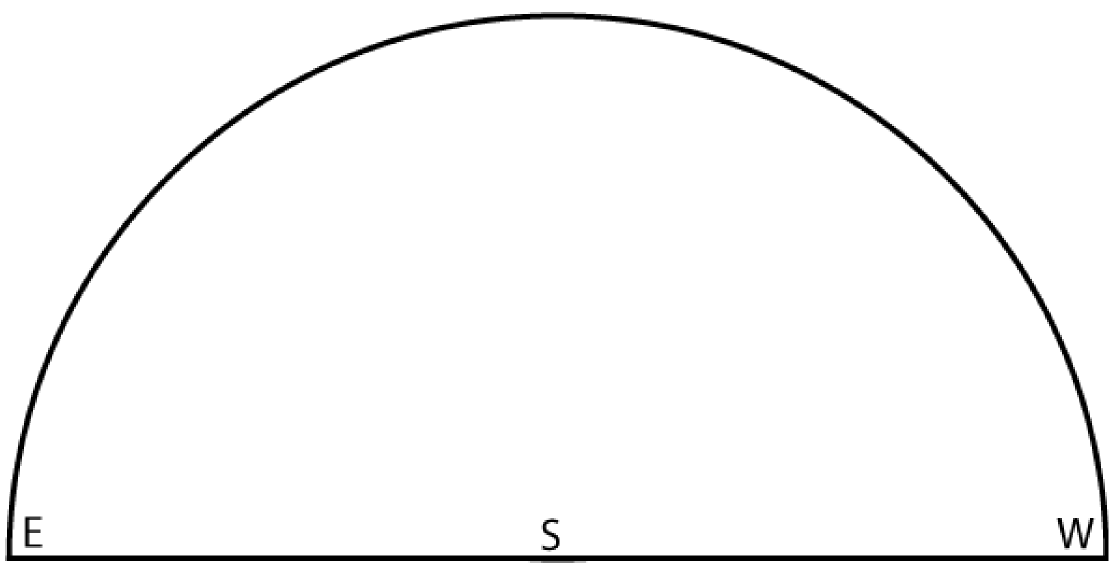
Now measure the width across your fist. Width of fist: L = __________ centimeters.

Now, use those measurements to calculate the angular size of your fist at arm's length. Angular size of fist: $\alpha = 57.3 \times \frac{L}{D} =$ __________ degrees. What would happen to the angular size of your fist or pinky if your arm were to suddenly become twice as long as it currently is? ______________________.

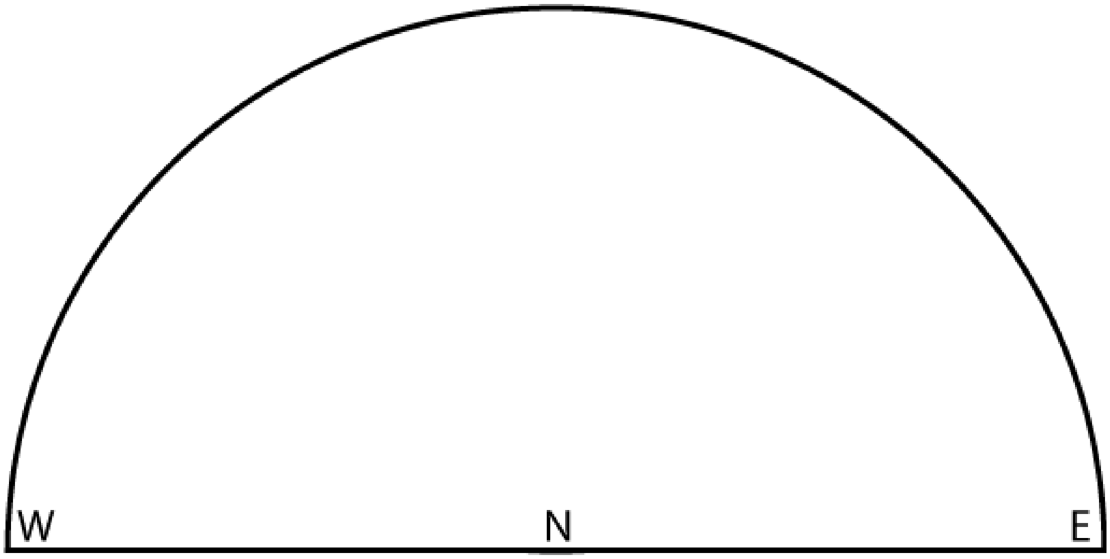
2. Motion of the Sky from Wyoming

With the planetarium set for the latitude of Wyoming, we now want to study the apparent motions of the stars as the Earth rotates. Let's suppose you take a backpacking trip in the Wind River Range. Since the weather is nice, you lay down on your sleeping bag outside your tent and watch the night sky as it passes.

First we will simulate the view looking south for about 12 hours. **(a)** Focus on the path of the stars (or one constellation) and sketch it. I will also show you a line marking the *celestial equator* and a grid marking the *celestial sphere*. Think of the grid as lines of longitude and latitude (as such lines are called on the Earth) projected onto the sky (where they are referred to as "declination" and "Right Ascension"). **(b)** Copy this coordinate system onto your drawing below.

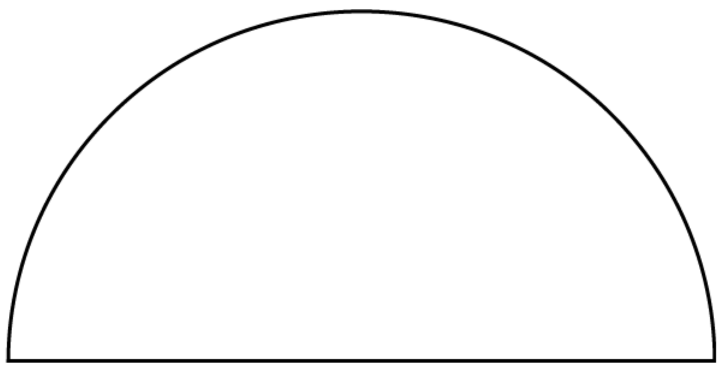


Now, let's simulate the view looking to the north. **(a)** Once again, sketch the paths of some bright stars or constellations across the sky for 12 hours. Pay particular attention to Polaris and the movement of the Big and Little Dippers. **(b)** Mark Polaris, then **(c)** sketch the Big Dipper at the beginning of the 12 hour period and at the end of the 12 hours.



3. Motion of the Sky from other Locations

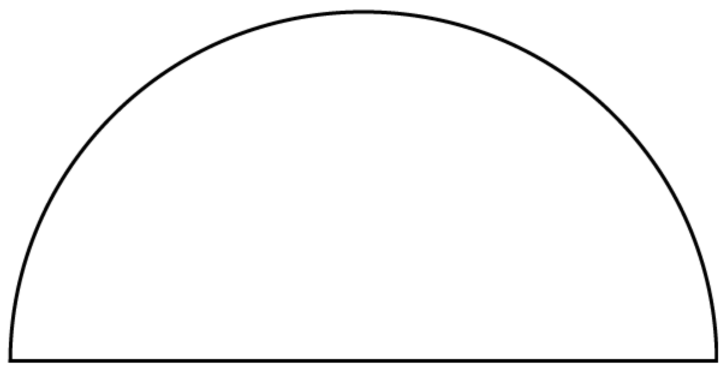
Now, predict how you think the motions of the stars will appear throughout the night if you were located at the Earth's **North Pole**. Think about where Polaris will appear to be as viewed from this location, and how the stars move relative to Polaris. **(a)** Draw the paths that you expect. **(b)** Be sure to mark Polaris and **(c)** the cardinal directions (East and West)!



Horizon

We will actually simulate the motion of the sky at the North Pole. **(d)** How close was your prediction?

Now try predicting how the motions of the stars would appear throughout the night if you were at a location on the Earth's **Equator**. **(a)** Draw the paths that you would expect at this latitude. **(b)** Be sure to mark Polaris and **(c)** the cardinal directions (East and West)!



Horizon

We will now simulate the motion of the sky at the Equator. **(d)** How close was your prediction?

4. Position of the Sun with Seasons in the Northern Hemisphere

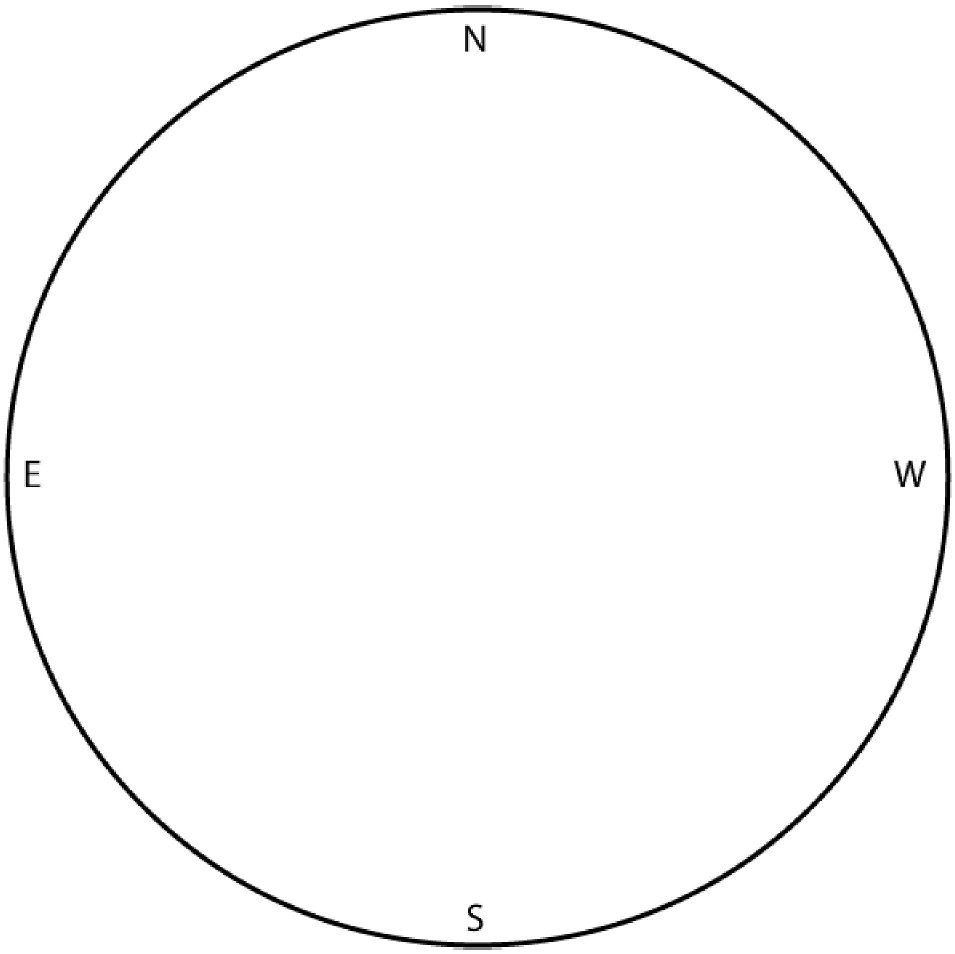
Now we'll position the planetarium to show the view from Wyoming again. Because of Earth's 23.5° tilt relative to its orbital plane, the Sun's height in the sky changes with the seasons. I will show you the location of the Sun at noon on **June 21**st (the summer solstice). Note that the Sun is 23.5° north of the celestial equator (this might be called "celestial latitude" but astronomers actually call it "declination"). Measure the altitude of the Sun above the southern horizon: ________________ **degrees.**

Now use this information to find your latitude. In general, from the northern hemisphere:

$$\boxed{Latitude(degrees) = 90^\circ + (declination\ of\ Sun)^\circ - (elevation\ of\ Sun\ from\ southern\ horizon)^\circ}$$

Latitude = 90°+ 23.5°- __________°= ___________° **(N or S?)**

Now we will watch a full day as the Earth rotates. **(a)** Draw where the Sun rises, **(b)** the path it takes across the sky, and **(c)** where it sets.



As seen from the northern hemisphere on the summer solstice, the Sun rises in the __________ and sets in the __________.

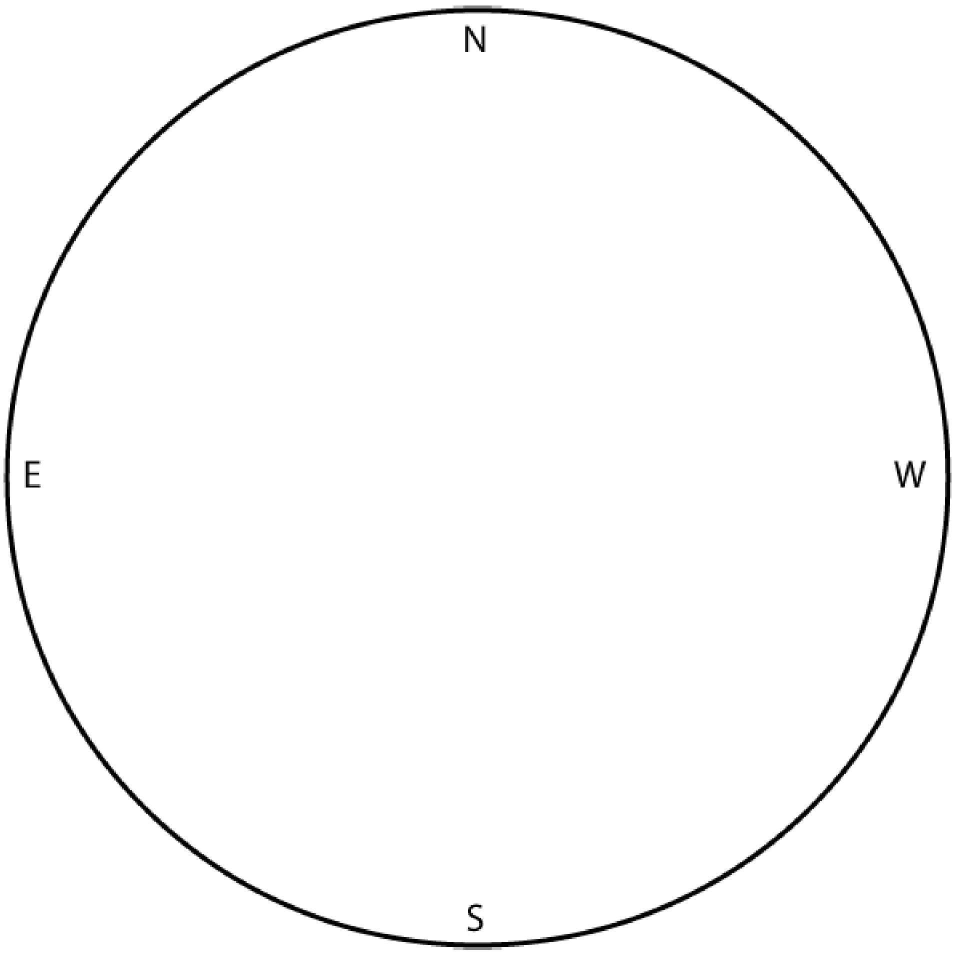
Now we will look at the location of the Sun at noon on **September 21st** (the autumnal equinox) or **March 21st** (the vernal equinox). Note that the Sun is at 0° north of the celestial equator (0° declination). Measure the altitude of the Sun above the southern horizon: _________________ **degrees.**

Now use this to find your latitude. Again, from the northern hemisphere:

$$\boxed{Latitude(degrees) = 90^\circ + (declination\ of\ Sun)^\circ - (elevation\ of\ Sun\ from\ southern\ horizon)^\circ}$$

Latitude = 90°+ 0°- __________°= ___________° **(N or S?)**

I will again show you a full day as Earth rotates. **(a)** Draw where the Sun rises, **(b)** the path it takes across the sky, and **(c)** where it sets. As seen from the northern hemisphere



on the equinoxes, the Sun rises in the __________ and sets in the __________.

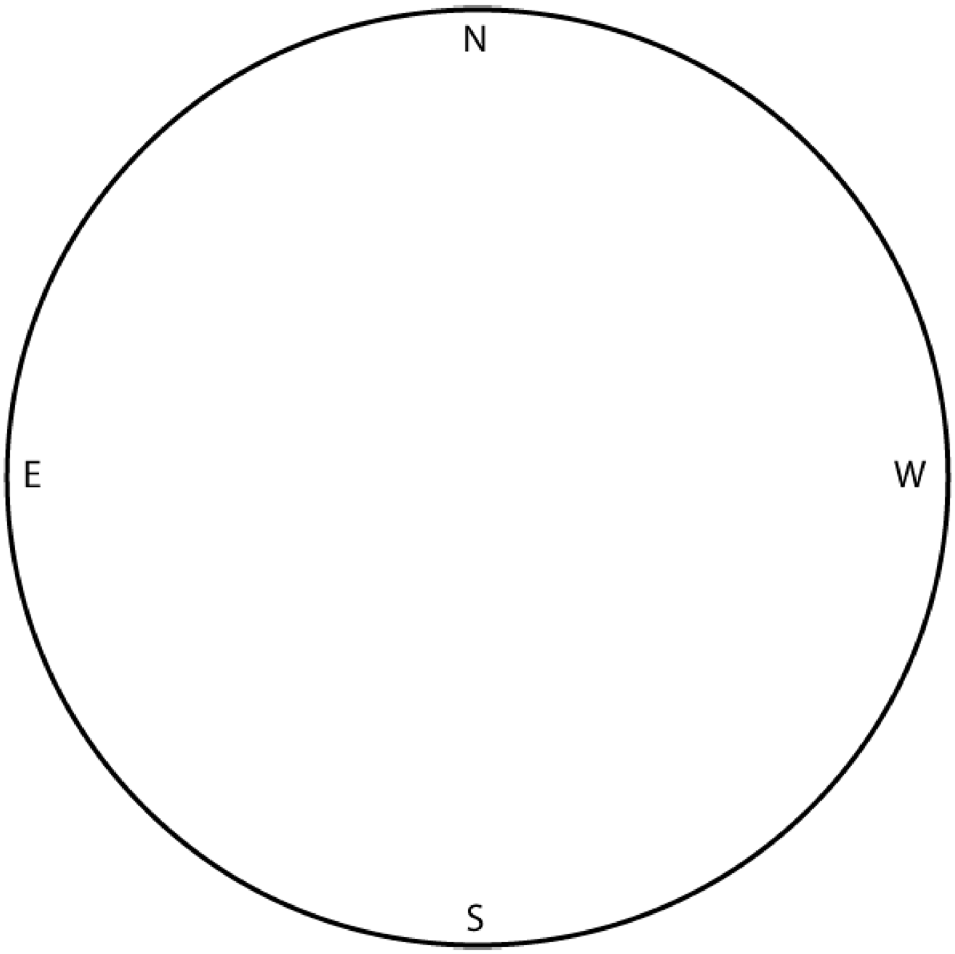
Finally, I will show you the location of the Sun at noon on **December 20th** (the winter solstice). Note that the Sun is 23.5° *south* of the celestial equator (-23.5° declination). Measure the altitude of the sun above the horizon: ______________ degrees.

Use this to find your latitude. Again, from the northern hemisphere:

$$\boxed{Latitude(degrees) = 90^\circ + (declination\ of\ Sun)^\circ - (elevation\ of\ Sun\ from\ southern\ horizon)^\circ}$$

Latitude = 90°- 23.5°- __________°= ___________° **(N or S?)**

Again, you will see a full day, and you should **(a)** draw where the Sun rises, **(b)** the path it takes across the sky, and **(c)** where it sets. As seen from the northern hemisphere on the



winter solstice, the Sun rises in the __________ and sets in the __________.