Celestial Sphere Lab

The purpose of this exercise is to help you understand the meaning of the celestial sphere and its components, and to help you visualize mentally the positions and motions of objects on the celestial sphere. You will also explore in some detail the motion of the sun relative to the stars and to the observer. Along the way you will learn to visualize the position of the ecliptic relative to the astronomical horizon.

Be sure to answer all the questions.

Part A

Definitions: *Locate and examine carefully the following parts of the celestial sphere globe. You do **not** have to write these definitions in your notebook, but you must be able to identify and define these items before you can do the exercise. Ask the teaching assistant for help if you are not absolutely sure of the definition of any of these items.*

a. Celestial Sphere
b. Zenith & Nadir
c. Astronomical Horizon
d. Cardinal Points
e. Celestial Equator
f. North & South Celestial Poles
g. Meridian

Set the globe, as it would be seen from various locations on Earth. (*REMEMBER: the **altitude** of the North Celestial Pole above the northern horizon is **equivalent** to the **latitude** of the location on Earth*). For each setting, rotate the globe and notice the changes in the sizes of the circumpolar caps (where the stars would be visible in the sky 24 hours per day or not visible at all) and also the area of the seasonal constellations (where the stars can only be seen for a portion of the night).

1) Consult the map page and using the predrawn circles for **each** of the designated locations on the Earth:
   a) draw in the horizon, celestial equator and indicate the position of the celestial poles, the cardinal points and the zenith & nadir. Label all the parts (*a to g in the above definition list*).
   b) At what latitude is the area of the circumpolar cap at its maximum size? at its minimum size?

2. Why are the constellations on the celestial globe mirror imaged?

3. For Deneb, give the equatorial coordinates (α, δ) (Right Ascension, α, should be accurate to 5 min. Declination, δ, should be accurate to 1°) **and** indicate whether or not the star is circumpolar for the location of Winnipeg.

4. At what latitude would the star in the previous question **first** become circumpolar?

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Part B

Definitions: *Locate and examine carefully the following parts of the celestial sphere globe. You do **not** have to write these definitions in your notebook, but you must be able to identify and define these items before you can do the exercise. Ask the teaching assistant for help if you are not absolutely sure of the definition of any of these items.*

a. Ecliptic
b. Vernal Equinox
c. Autumnal Equinox
d. Summer Solstice
e. Winter Solstice

5. What is the approximate daily rate of motion of the sun along the ecliptic? What are the **ecliptic longitudes** of the sun at the dates (b) through (e) in the above list? What regularity do you discern between the dates and the ecliptic longitudes? What are the **right ascensions** (α) of the sun at these times? What is the relation between the dates and the right ascensions? What are the **declinations** (δ) of the sun at these times? What regularity do you discern between the dates and the declinations? (Hint: *you might like to tabulate your results*).

6. Set the globe to provide the view of the sky as seen from the **latitude of Winnipeg**. What is the direction that the sun rises and sets on the horizon at the solstices? (*Give approximate compass directions using the cardinal points as well as **azimuths** for each of the four situations*).

7. With the globe still set as seen from the **latitude of Winnipeg** give the sun's **altitude** above the horizon at **local noon** for each of the following dates:
   a. Summer Solstice
   b. Winter Solstice

8. What is the length of the day at each of the dates in the previous question?

Optional:

Bonus Question 1: For the latitude of Winnipeg, **give the equatorial coordinates** of a star (also give the name if one is indicated) that can be seen in the sky for:

a. more than 12 hours but less than 16 hours
b. more than 4 hours but less than 6 hours

What is the actual length of time that each star is in the sky?

Bonus Question 2: With the celestial globe set for the latitude of Winnipeg, notice how the angle the ecliptic makes with the horizon varies with the rotation of the globe. For sunset, on what dates does the ecliptic make its greatest angle with respect to the horizon? Its smallest angle? What are the angles? Repeat the question for sunrise.

Bonus Question 3: Astronomical twilight ends when the sun is more than 18° below the horizon. For the **latitude of Winnipeg**, between what dates is the sun always **less than 18° below the horizon** at local midnight.

Bonus Question 4: Make a detailed sketch of the celestial sphere for the location of Winnipeg for the time of **sunrise** on the day of the **Autumnal Equinox**. Label your sketch. Use one of the predrawn circles on the page following the map page.

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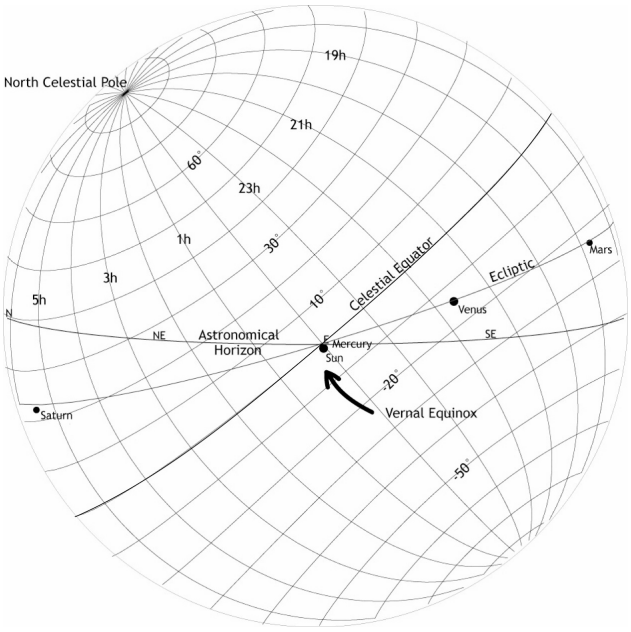
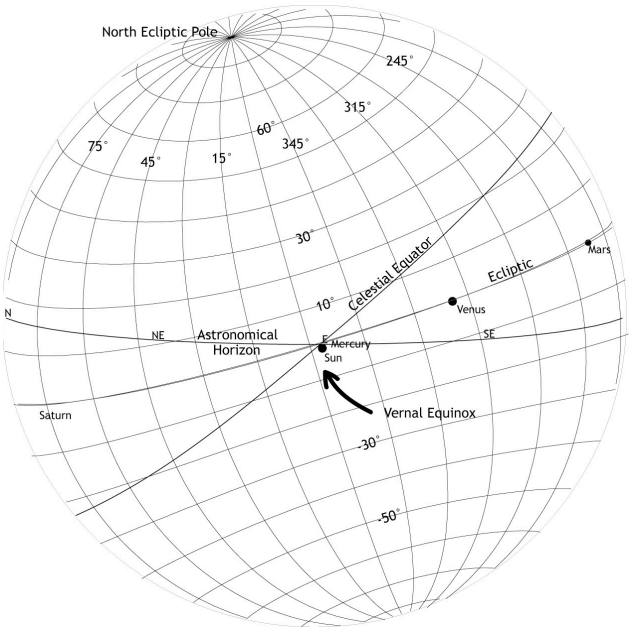
Equatorial Coordinate System



Ecliptic Coordinate System



Above: celestial sphere diagrams in the equatorial (left) and ecliptic (right) coordinate systems. Both diagrams are for sunrise on the day of the Vernal Equinox (March 21 or 22 of a given year).

Coordinate System Name	**Fundamental Reference Circle**	**Zero Point**	**Great Circles** (around, through pole)	**Small Circles** (parallel, above and below equator)	**Poles**
Alt-Azimuth	Horizon	North	Azimuth N-E-S-W-N 0-360°	Altitude ±90°	Zenith & Nadir
Equatorial	Celestial Equator	Vernal Equinox	Right Ascension (RA, α) W to E 0-24h	Declination (Dec, δ) ±90°	North & South Celestial Poles (NCP & SCP
Ecliptic	Ecliptic	Vernal Equinox	Ecliptic Longitude W to E 0-360°	Ecliptic Latitude ±90°	North & South Ecliptic Poles (NEP & SEP)

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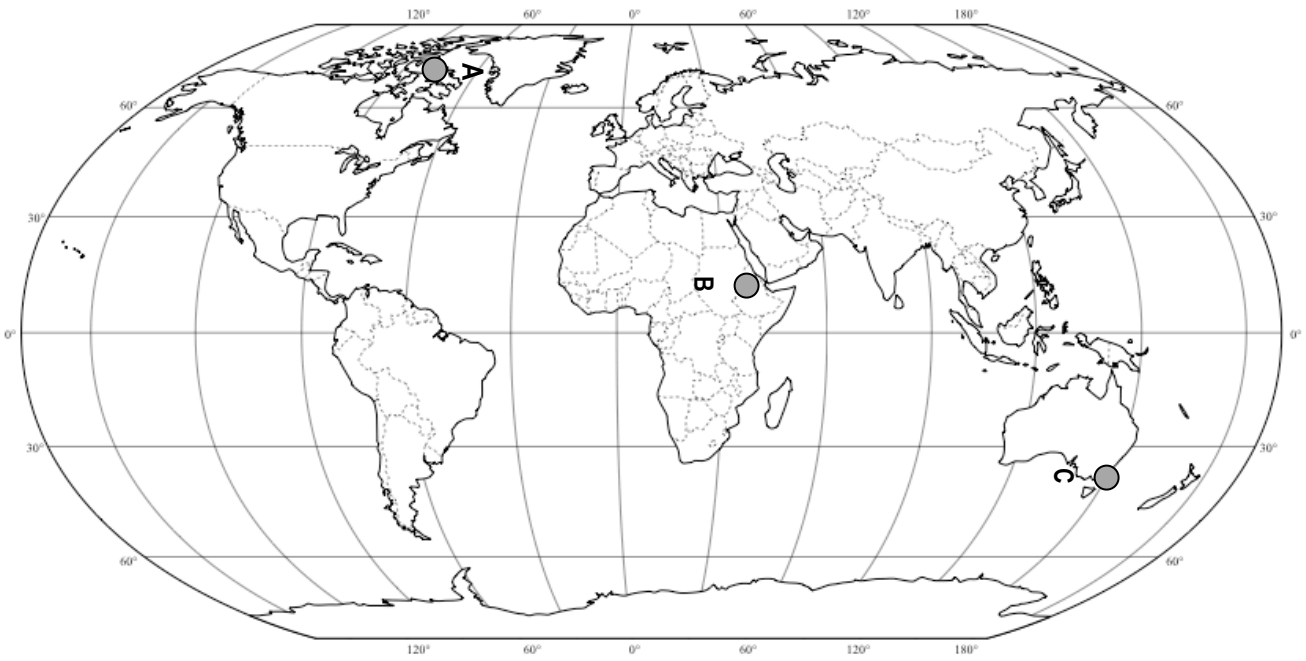
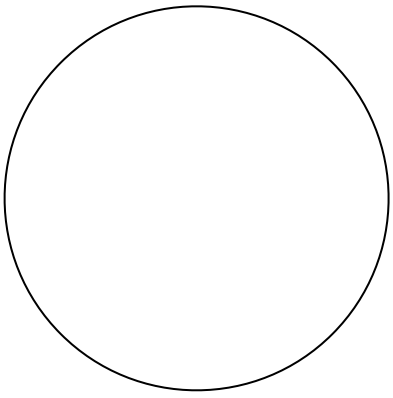
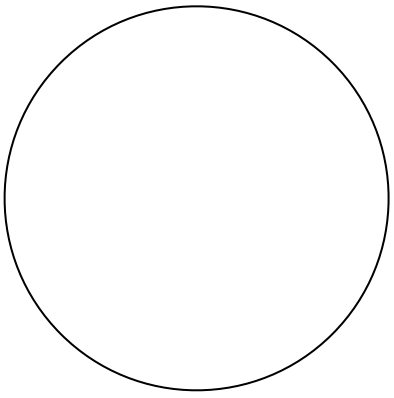
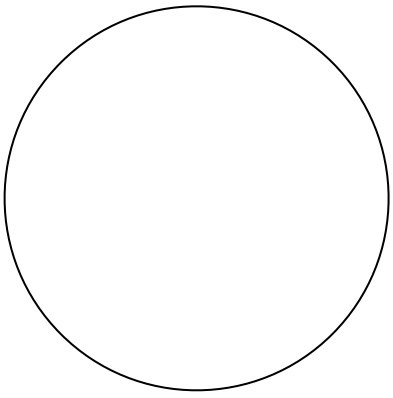




A



B



C

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