ASTR 310 Tutorial 1: Sunrise and Sunset

The motion of the Sun, stars and planets across our sky in complicated problem becaues patterns related to Earth's daily rotation around its tilted axis and its annual revolution of the Earth around the Sun are mixed together.

Yet, centuries ago, astronomers watched the sky, figured out the patterns and built this "computer", called an armillary sphere ("armillary" refers to bracelets, hoops, and rings). With it, they could predict when and where the Sun and stars and planets would rise and set each day.
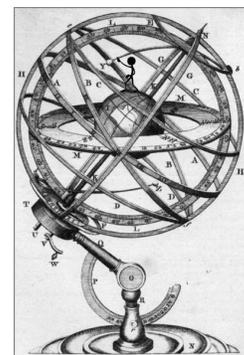
Part 1: Orientation

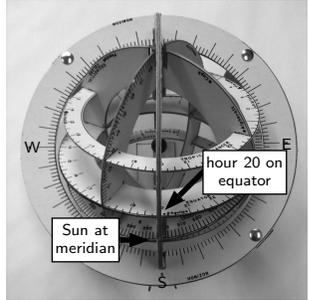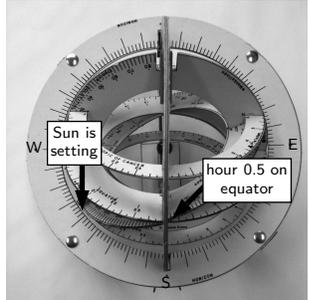| Features of the Armillary Sphere |
|---|
| Imagine that the little, round bead at the center of the sphere is the Earth. At all times, pretend you are standing on the top of the bead looking up into the sky. |
| The wooden dowel holding the bead is the axis of the Earth, stretching up and down into space. The dowel points up through the ARCTIC POLE to _____. |
| What is marked on the HORIZON ring? _____ |
| At any moment, the part of the sphere above the HORIZON ring contains the objects currently visible in the sky. Objects on the bottom half of the sphere below the horizon are not currently visible. |
| The MERIDIAN ring follows an imaginary line in the sky that runs from the Northern horizon, directly overhead and down to the Southern horizon. What units are marked on the MERIDIAN ring? _____ |
| The **blue** celestial EQUATOR ring is the extension of Earth's equator out into space. What is the range of the numbers marked on the EQUATOR ring? _____ What do they measure? |
| What's written on the **red** ECLIPTIC ring? _____ What do the dates indicate? |
| Check that the brass fastener is attached to the ECLIPTIC ring on JAN 20. Imagine that it's the Sun shining down on you on the bead. Rotate the inner sphere from East to West. What is the fastener showing? |
| The Sun reaches the highest point of the day when it crosses the meridian. What time of day is it when that happens? _____ |
| In the morning the Sun is *ante meridiam* (a.m., "before the meridian") and in the afternoon, the Sun is *post meridiam* (p.m., "after the meridian".) |

Part 2: The Path of the Sun Across the Sky

The Sun rises in the East and sets in the West. How does it get there? Follow along with your TA to see how to use the armillary sphere to compute the path of the Sun on January 20.

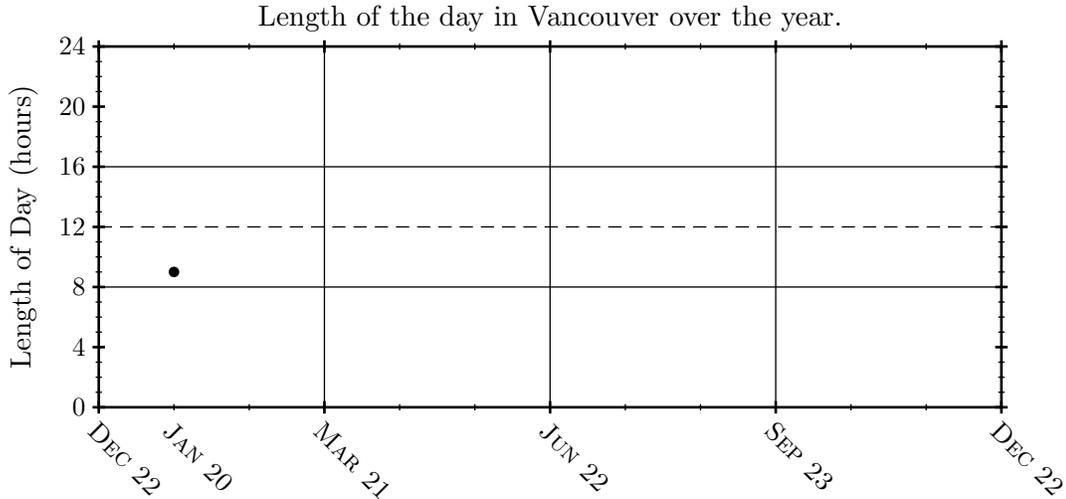## How to use the armillary sphere

Quantity	How to find it
Sun's location at sunrise	Rotate the inner sphere until the Sun (the brass fastener) is crossing the Eastern horizon. Read off the horizon ring how many degrees North or South of East the Sun is. On JAN 20, the Sun rises about 30° South of East.
Sun's highest point of the day	The Sun reaches the highest point of the day at noon when it crosses the meridian. Rotate the inner sphere until the Sun crosses the meridian. Read off the meridian ring how many degrees above the Southern horizon the Sun is. At noon on JAN 20, the Sun is about 22° up.
Sun's location at sunset	Rotate the inner sphere until the Sun (the brass fastener) is crossing the Western horizon. Read off the horizon ring how degrees North or South of West the Sun is. On JAN 20, the Sun sets about 30° South of West.
Time of sunset	One complete rotation of the inner sphere represents the motion of the celestial sphere for 1 day. The EQUATOR ring of the armillary sphere is divided into 24 intervals, so rotating the sphere by 1 interval means 1 hour has passed. Each hour is divided into four 15-minute subintervals. For example, this picture shows the sphere at noon on Jan 20 because the brass fastener, attached on Jan 20, is crossing the meridian. The hour written on the EQUATOR ring at the point where it crosses the meridian is about 20. Now the armillary sphere shows sunset on Jan 20 because the sphere is rotated until the brass fastener is on the Western horizon. **Look back to the meridian:** the point on the EQUATOR ring where it crosses the meridian is about 0.5. The sphere rotated 4.5 intervals which means the Sun sets 4.5 hours after noon, or at 4:30 p.m.
Time of sunrise	Keep watching the EQUATOR ring **where it crosses the meridian** to see how many intervals (and hours) it takes to rotate the sphere from sunrise to noon. On Jan 20, sunrise is about 4.5 hours before noon, or around 7:30 a.m.

Your task is to **draw 2 paths** on the diagram showing the Sun's path on 2 special times of year. For each date, find the locations on the horizon where the Sun rises and sets and the Sun's highest point in the sky. Use these three points to draw the path. Then find the time of sunrise and sunset and add them to the diagram.

	Jan 20	Winter Solstice Dec 22	Autumnal Equinox Sep 23
Sun's location on horizon at sunrise (degrees North or South of East)	30° South of East		
Sun's highest point of the day (degrees above Southern horizon)	22°		
Sun's location on horizon at sunset (degrees North or South of West)	30° South of West		
Time of sunset	4:30 p.m.		
Time of sunrise	7:30 a.m.		
Draw the Sun's path	☑	☐	☐

Part 3: Questions   Please hand in this worksheet when you are finished.

1. Use the sunrise and sunset times from your sky diagram to find the length of the day (the number of hours the Sun is up) throughout the year. Put the values on this graph and draw a smooth curve between them. January 20 is already on the graph.

Length of the day in Vancouver over the year.

2. Suppose you win a trip to Los Angeles (at latitude 34N) for the Summer Solstice (Jun 22). The armillary sphere can be adjusted for any latitude on Earth. Take the clips off the MERIDIAN ring and gently slide the holder so that the NCP/Acrtic pole drops to 34 degrees above the Northern Horizon. Using the armillary sphere, determine:

   a. Sun's location at sunrise on that day in Los Angeles _____

   b. The Sun's highest altitude on that day in Los Angeles _____

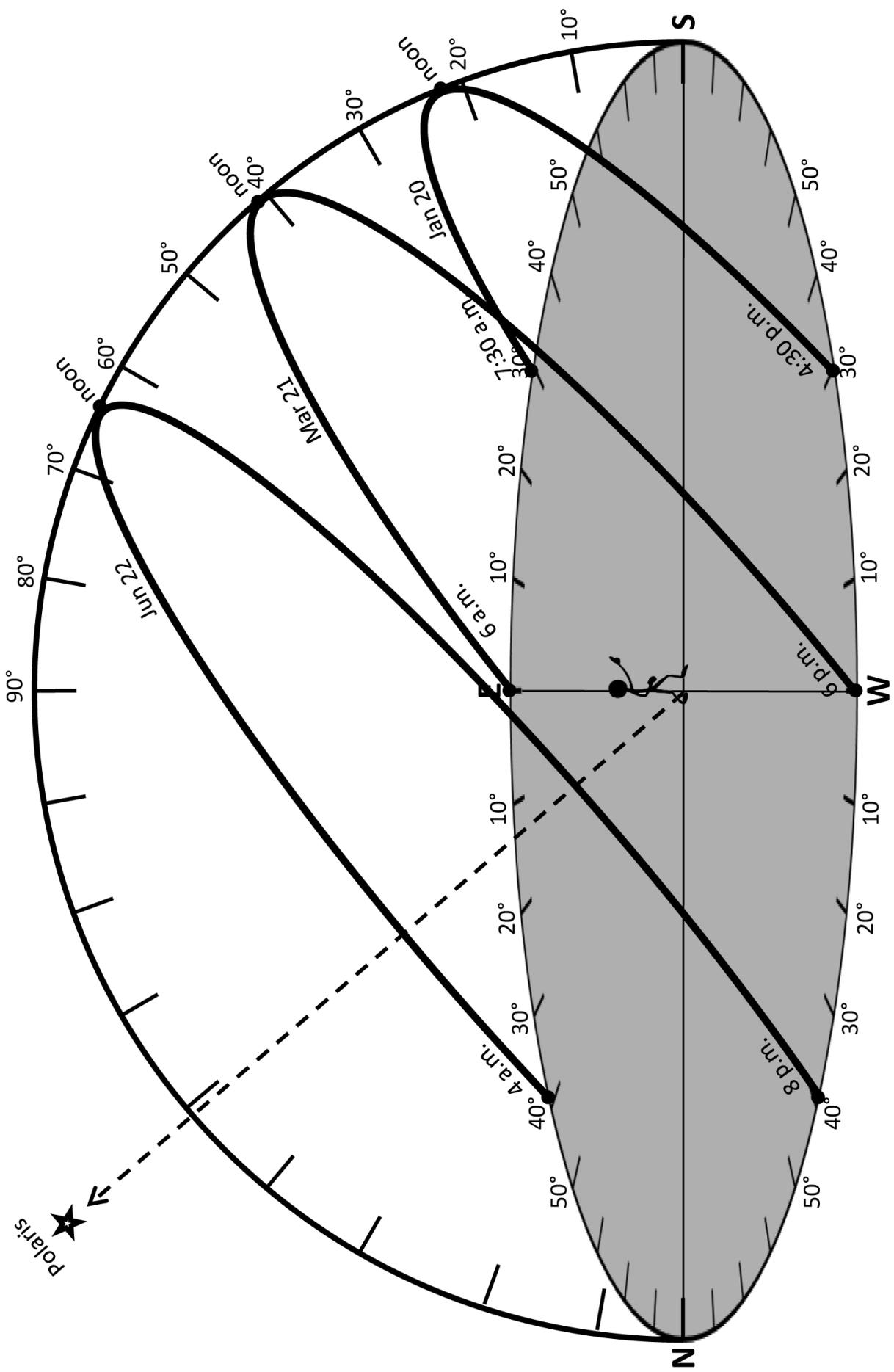   c. Compare these result with that of Vancouver on the same day:

3. Take the clips off the MERIDIAN ring and slide the armillary sphere inside the holder so the ARCTIC POLE is straight up. The sphere is set to show the motion of the celestial sphere for observers **at the North Pole**.
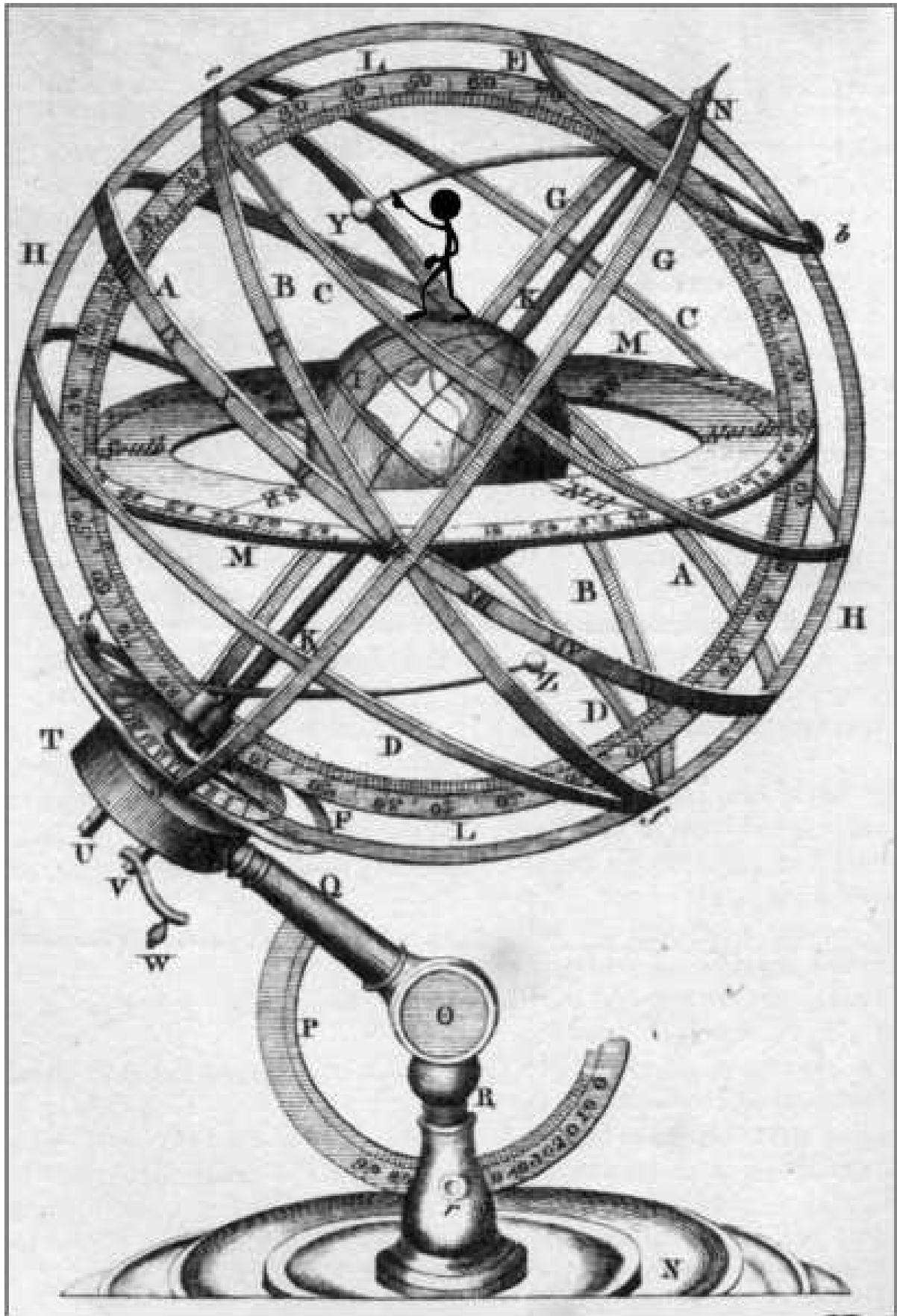
   What time does the Sun rise on Jan 20? _____

   What time does the Sun rise on Jun 22? _____

   When does the Sun rise at the North Pole? _____

4. Do not forget to draw the path of the sun for the Winter Solstice and Autumnal Equinox on the sky diagram at the back of this sheet.

S

10°

20°

30°

40°

50°

noon

noon

noon

Jan 20

Mar 21

Jun 22

7:30 a.m.

6 a.m.

4 a.m.

30°

40°

20°

10°

50°

4:30 p.m.

6 p.m.

8 p.m.

50°

40°

30°

20°

10°

10°

20°

30°

50°

W

E

50°

60°

70°

80°

90°

Polaris

N

When did the Sun rise this morning?

 A 6:30 a.m.

 B 7:50 a.m.

 C 8:00 a.m.

 D I don't know...