Lecture 4: August 30, 2010

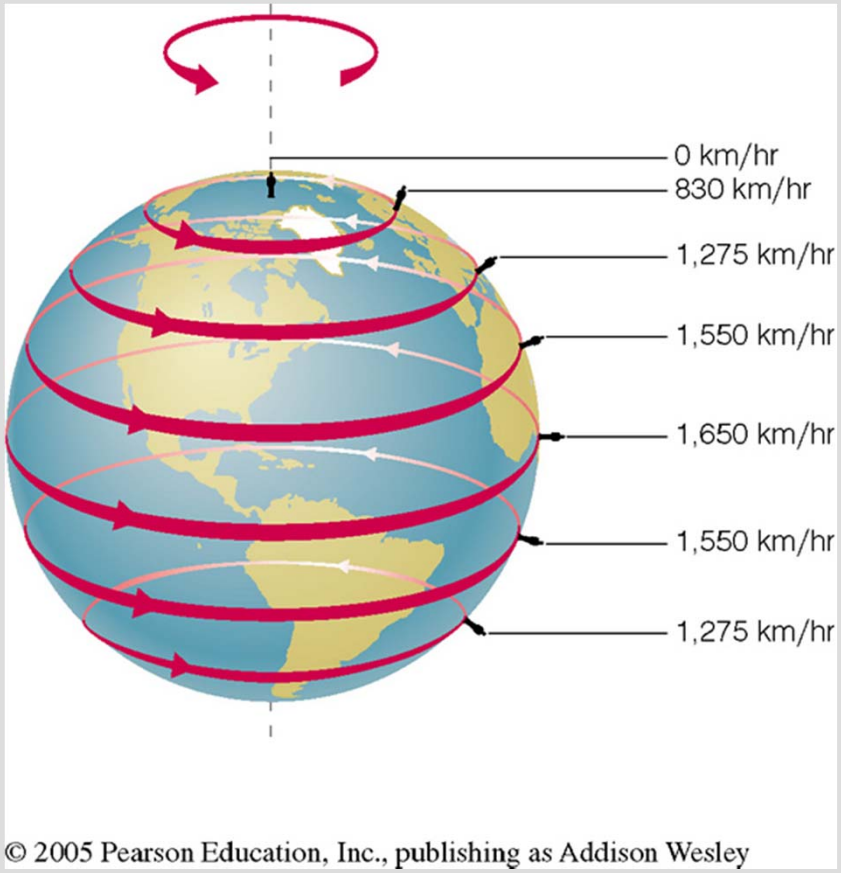
- How many hospitals are there in the USA?

Announcements:

First homework has been posted
Due Friday (10th)
First Observatory Opportunity Thursday Night
September 2, 8:30pm
Will meet at Fiske Planetarium on Friday 9/17

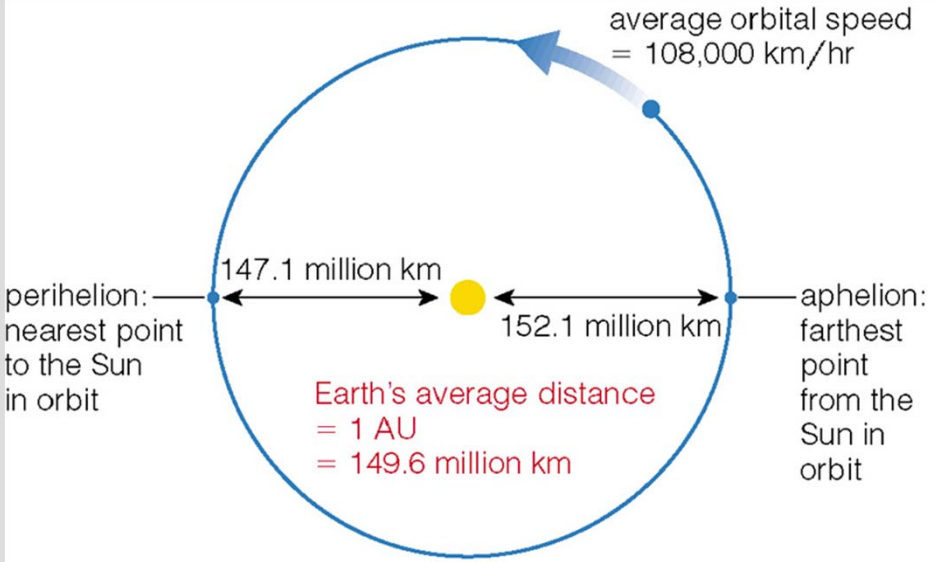
A Universe in motion

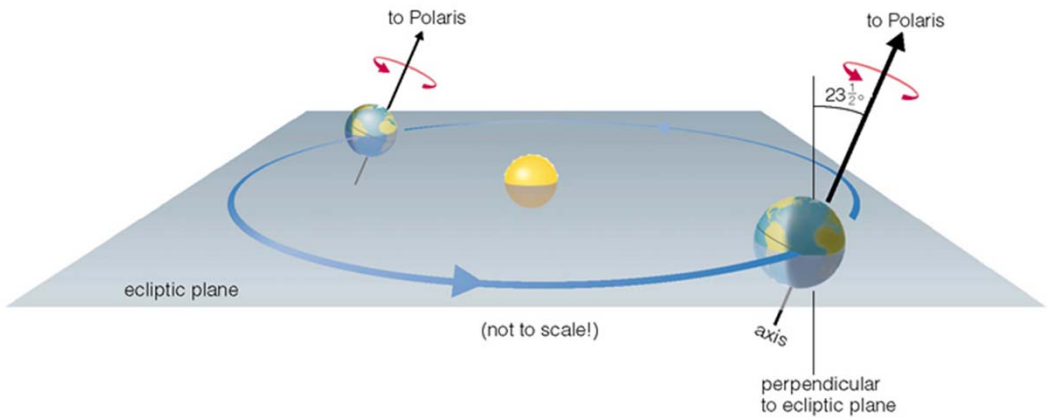
- Contrary to our perception, we are not “sitting still.”
- We are moving with the Earth.
  - and not just in one direction



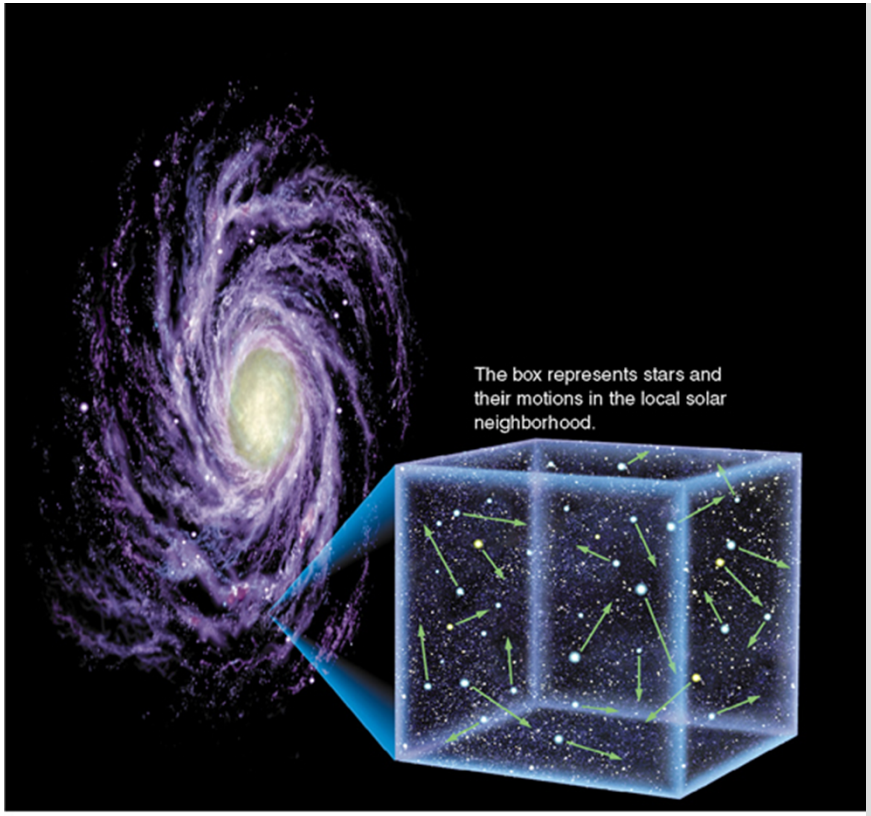
The Earth rotates around it’s axis once every day!

The Earth orbits around the Sun once every year



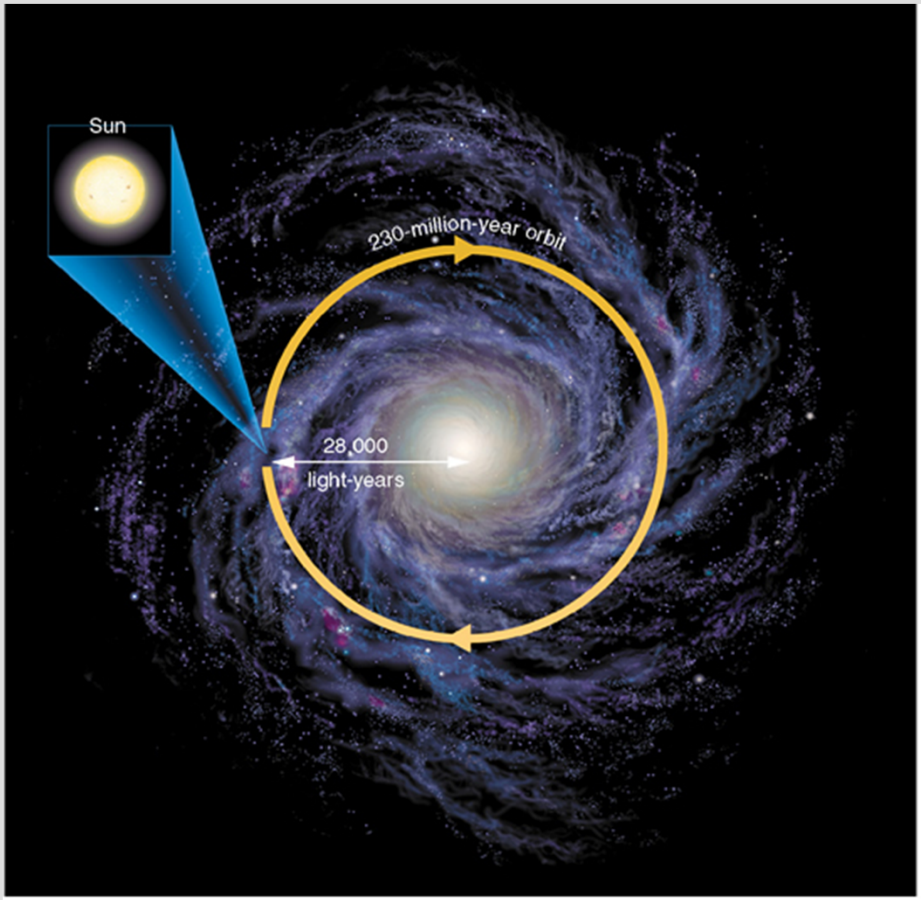


The Earth's axis is tilted by 23.5^{o}

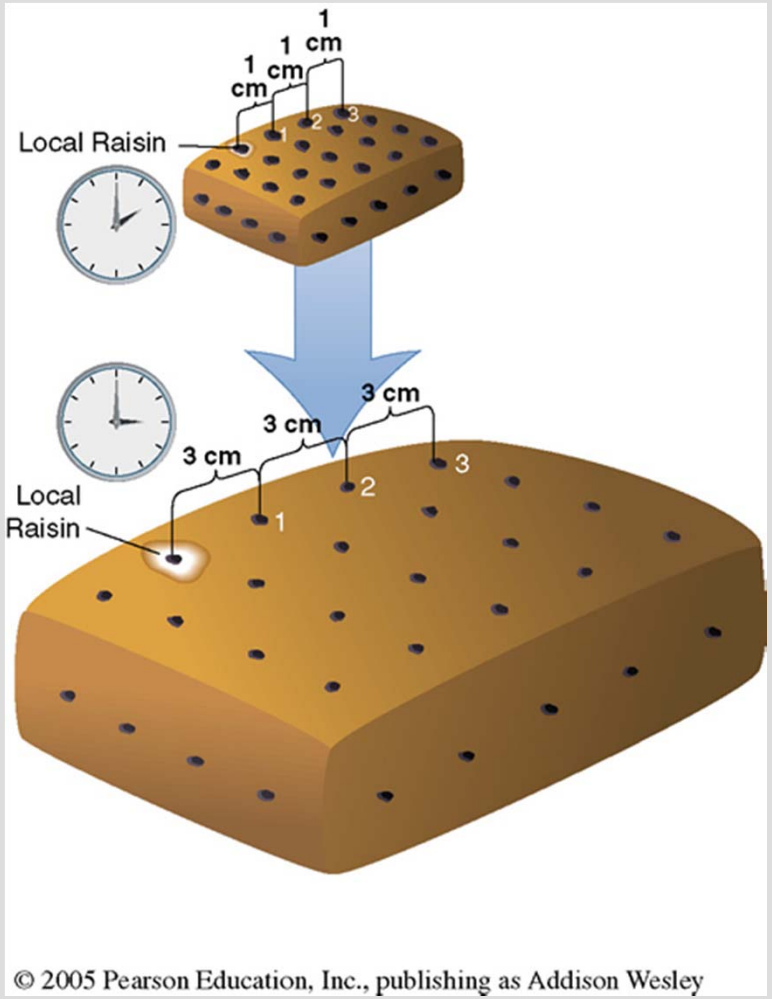


Our Sun and the stars of the local Solar neighborhood orbit around the center of the Milky Way Galaxy every 230 million years

Our Sun moves relative to the other stars in the local Solar neighborhood



The Milky Way moves with the expansion of the Universe!



- Mostly all galaxies appear to be moving away from us.
- The farther away they are, the faster they are moving.
  - Just like raisins in a raisin cake; they all move apart from each other as the dough (space itself) expands.

What have we learned?

- What is our physical place in the Universe?
  - Earth is a planet in a solar system, which is one of some 100 billion star systems in the Milky Way Galaxy, which is one of about 40 galaxies in the Local Group, which is part of the Local Supercluster, which is part of the Universe.
- Describe our cosmic origins and why we say that we are “star stuff.”
  - The Universe began in the Big Bang, which produced only two chemical elements: Hydrogen & Helium. The rest have been produced by stars, which is why we are “star stuff.”

2. Discovering the Universe for Yourself

(what we see when we look up)

1 Patterns in the Sky

⬇ Motions in the Sky

2 The Circling Sky *day*

> the rotation of the Earth about its axis

3 The Reason for Seasons *year*

> the Earth's orbit around the Sun

4 Precession of the Earth's Axis

> the wobbling of Earth's axis

5 The Moon, Our Constant Companion *month*

> the Moon's orbit around the Earth

6 The Ancient Mystery of the Planets *week*

> the various planets' orbits around the Sun

2.1 Patterns in the Sky

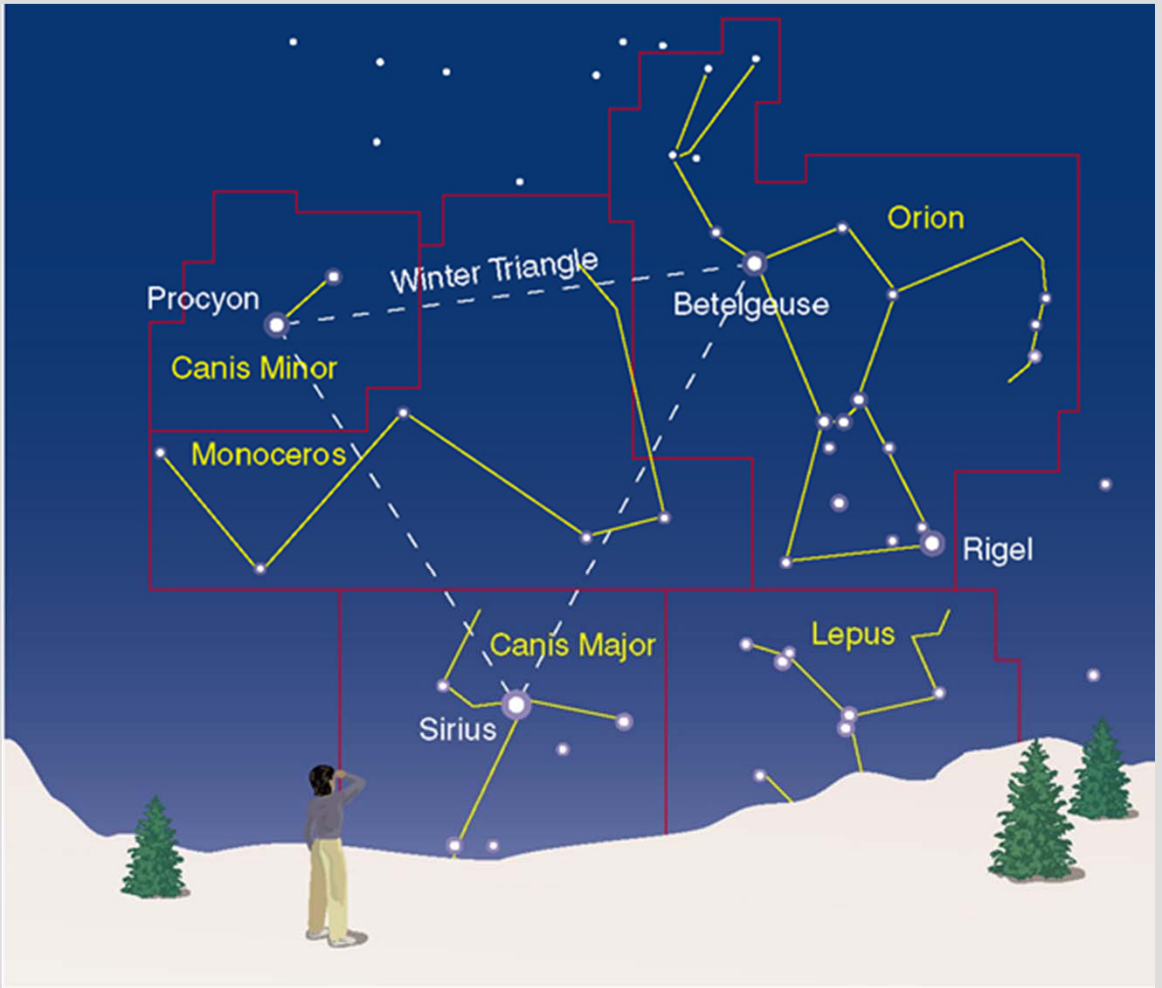
Our goals for learning:

- What is a **constellation**?
- What is the **celestial sphere**?
- Why do we see a band of light called the *Milky Way* in our sky?

A Constellation is…

… a *region* of the sky, within official borders set in 1928 by the IAU.

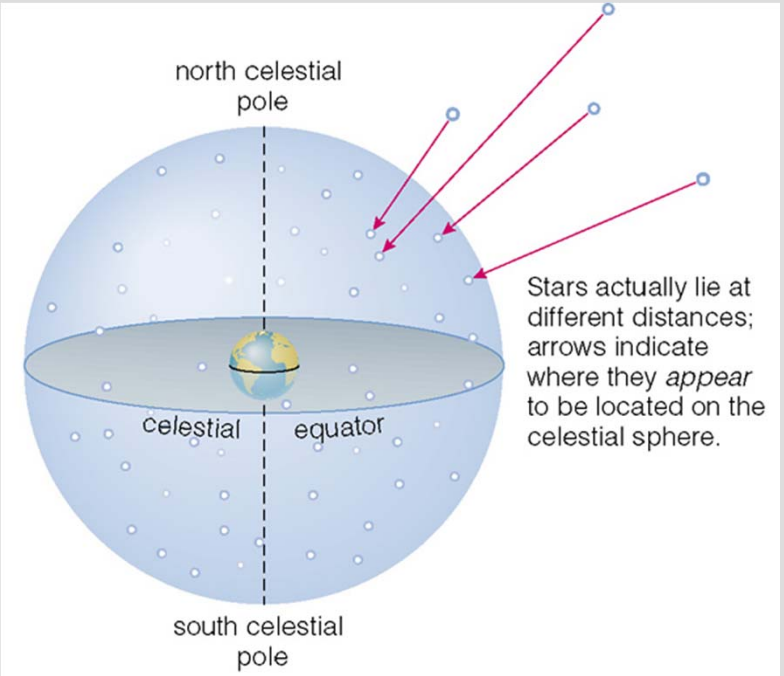
- Often recognizable by a pattern or grouping of stars.
- Some patterns, like the Winter Triangle, span several constellations.



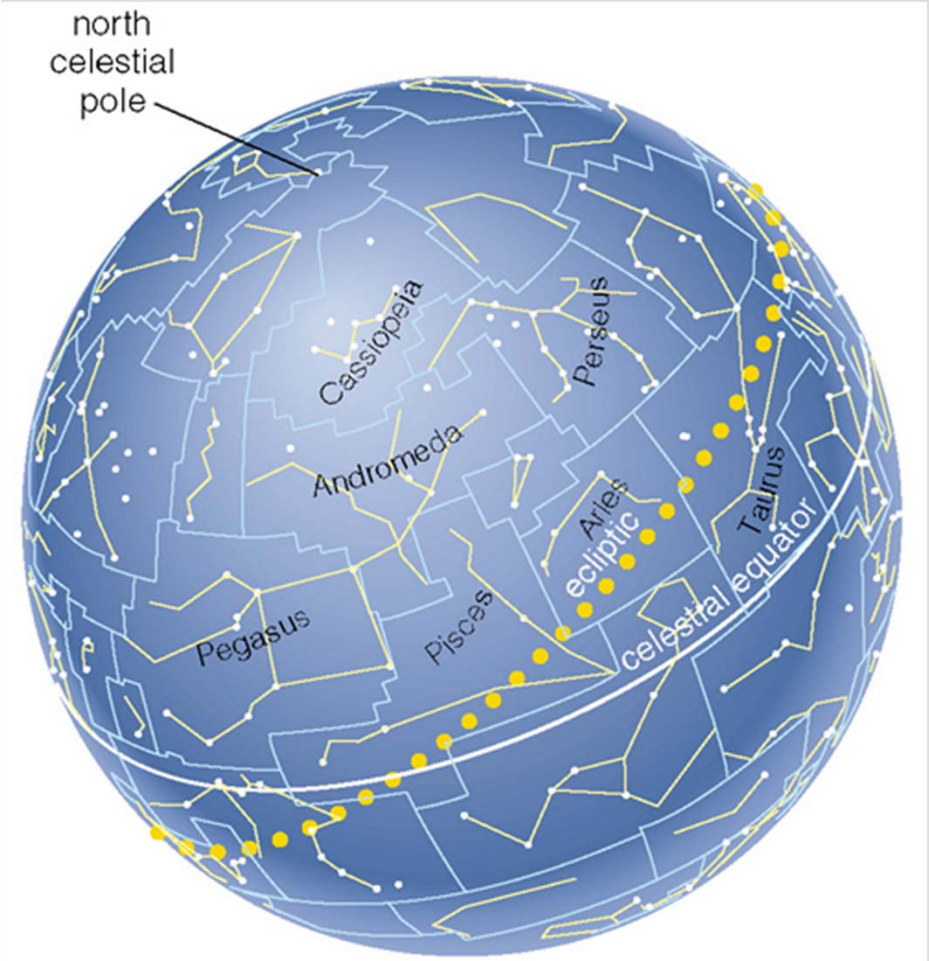
Constellations

- Most official constellation names come from antiquity. Some southern hemisphere constellations were named by European explorers in the 17th & 18th centuries.
- The patterns of stars have no physical significance! Stars that appear close together may lie at very different distances.

- Modern astronomers use them as landmarks.



The Celestial Sphere



- The sky above looks like a dome…a hemisphere..
- If we imagine the sky around the entire Earth, we have the **celestial sphere**.
- This a 2-dimensional representation of the sky

← Because it represents our view from Earth, we place the Earth in the center of this sphere.

The Celestial Sphere

North & South celestial poles

the points in the sky directly above the Earth's North and South poles

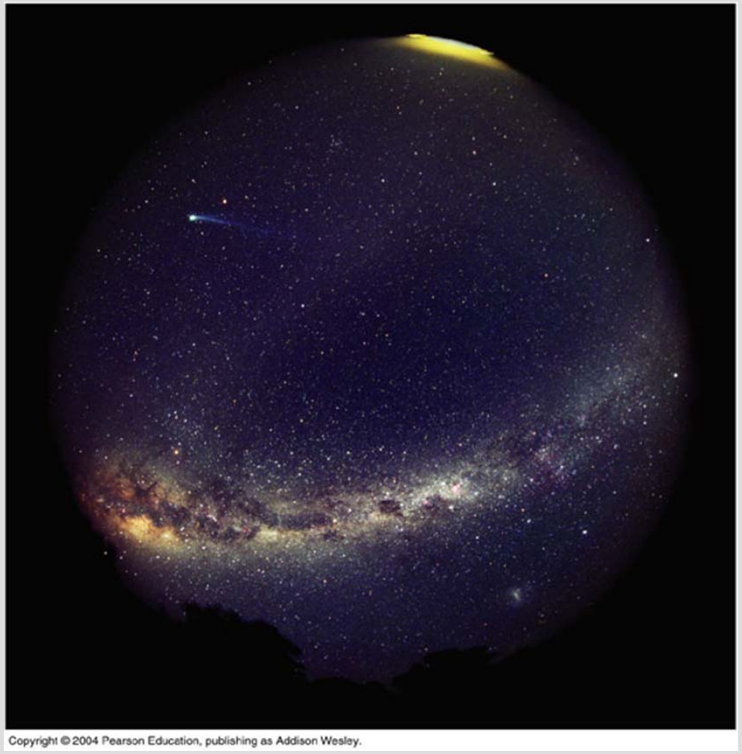
celestial equator

the extension of the Earth's equator onto the celestial sphere

ecliptic

the annual path of the Sun through the celestial sphere, which is a projection of ecliptic plane

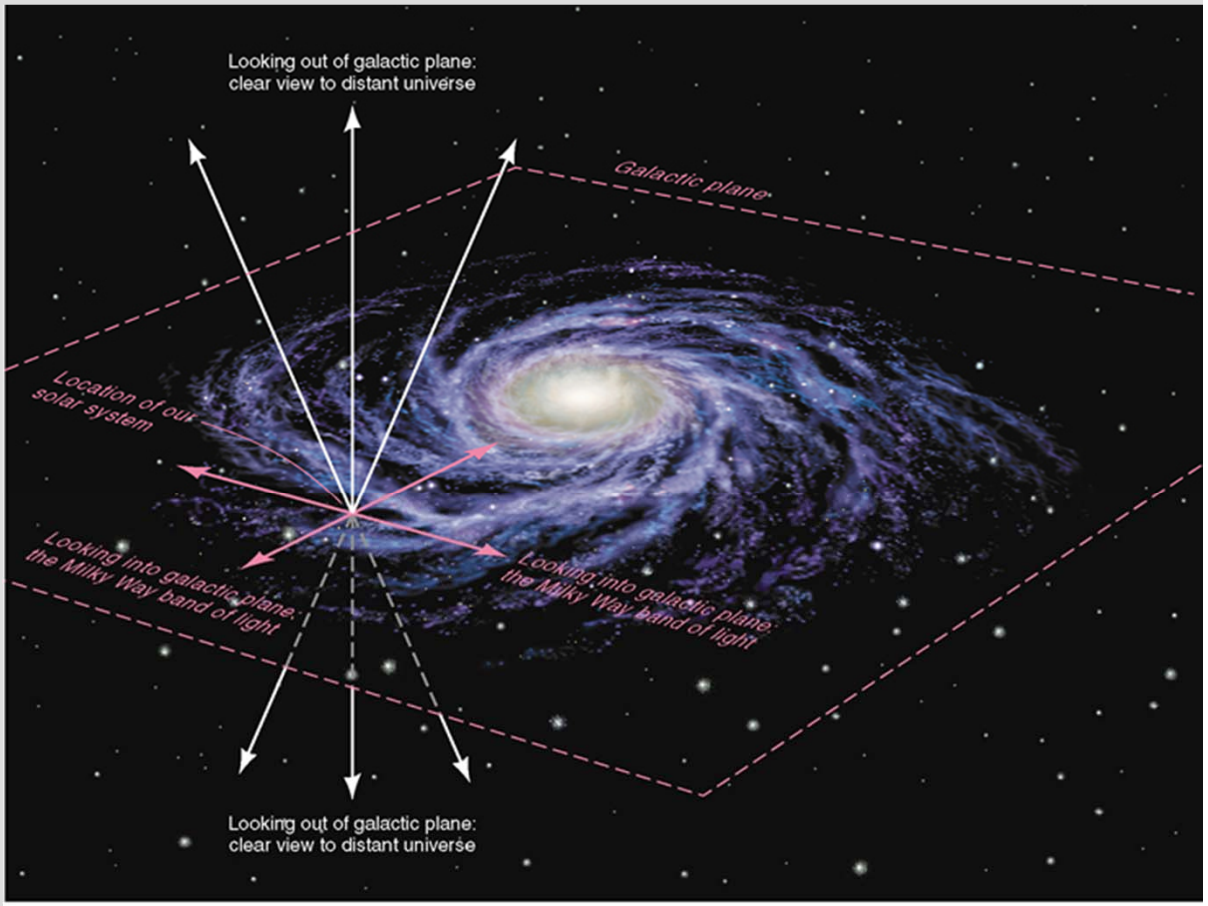
The Milky Way



You've probably seen this band of light across the sky.
What are we actually seeing?

The Milky Way

- Our Galaxy is shaped like a disk.
- Our solar system is in that disk.
- When we look at the Milky Way in the sky, we are looking along that disk.



2.2 The Circling Sky

Our goals for learning:

- Describe the basic features of the local sky.
- How does the sky vary with latitude?
- Why are some stars above the horizon at all times?
- How does the night sky change through the year?

Measuring the Sky

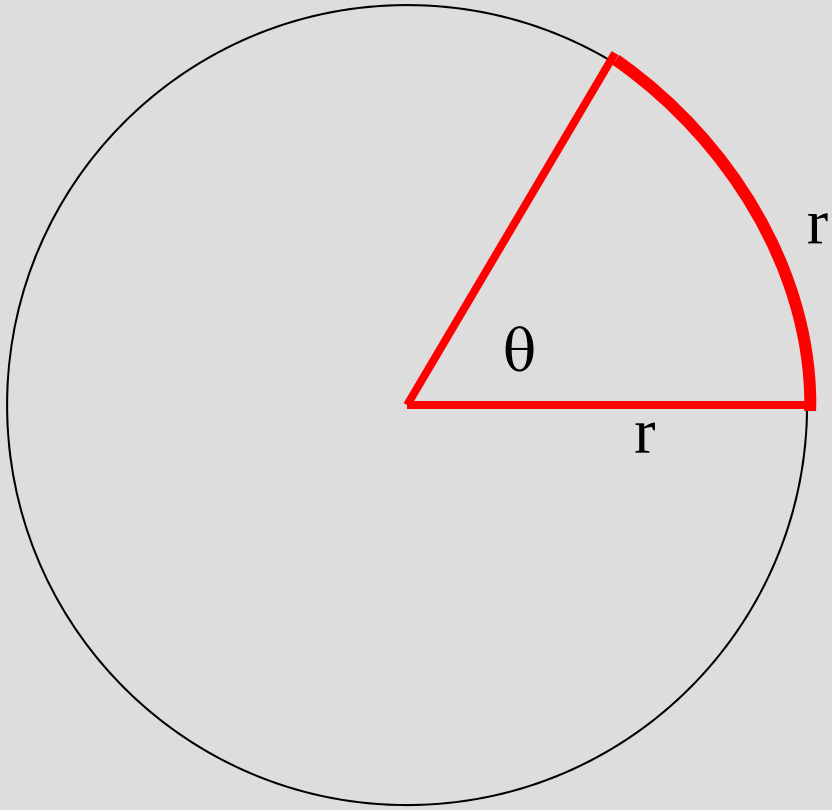
We measure the sky in *angles*, not distances.

- Full circle = 360º
- 1º = 60 arcmin
- 1 arcmin = 60 arcsec

The Radian

- 2π radians in a circle
- Ratio of distances

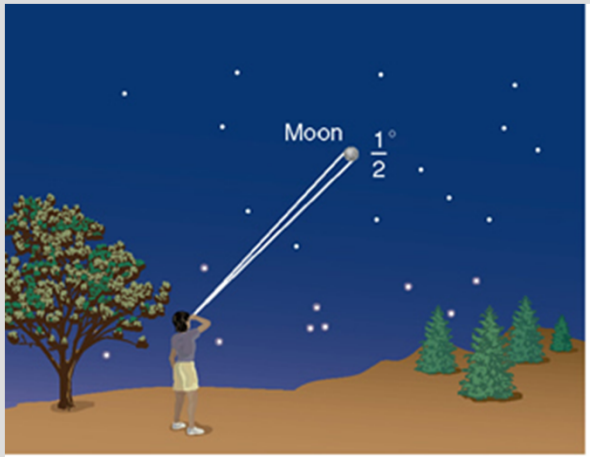
$1\text{rad} = 360/2\pi = 57.3\text{degrees}$

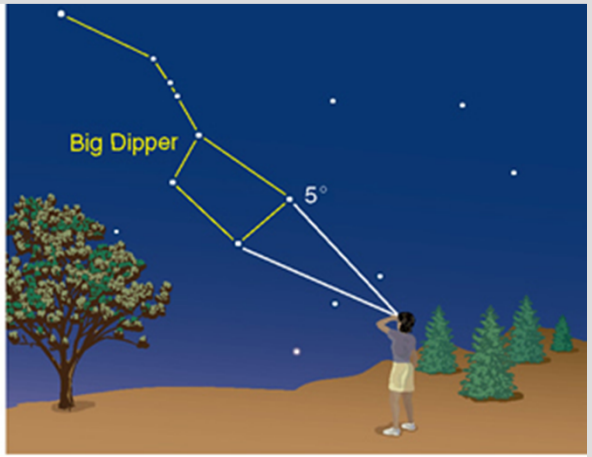


$\sin\theta \approx \theta$

If $\theta << 1$

Measuring Angles in the Sky





The Local Sky

zenith

the point directly above you

horizon

all points 90° from the zenith

altitude

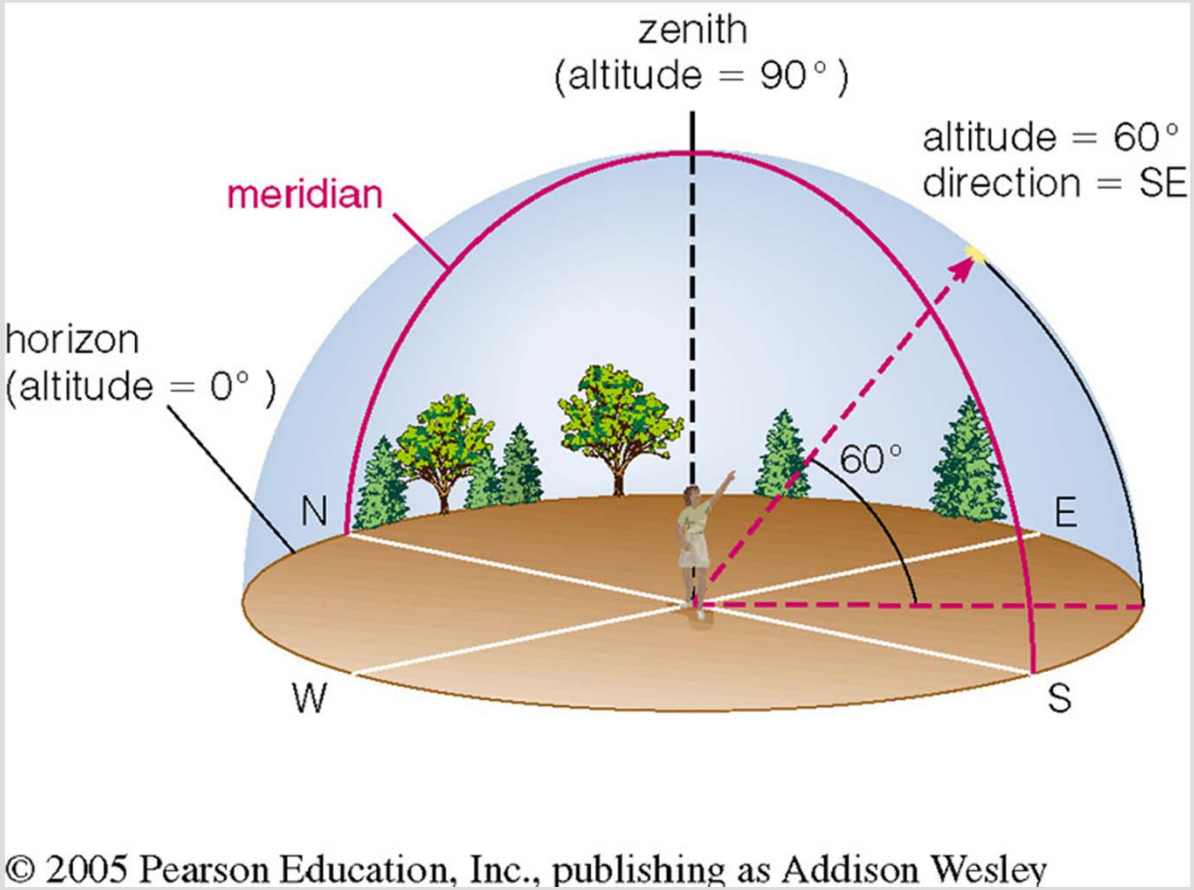
the angle above the horizon

meridian

due north horizon ⇒zenith ⇒due south horizon

To pinpoint a spot in the local sky:

Specify altitude and
azimuth along the horizon



Coordinates on the Earth

- Latitude: position north or south of equator
- Longitude: position east or west of prime meridian (runs through Greenwich, England)

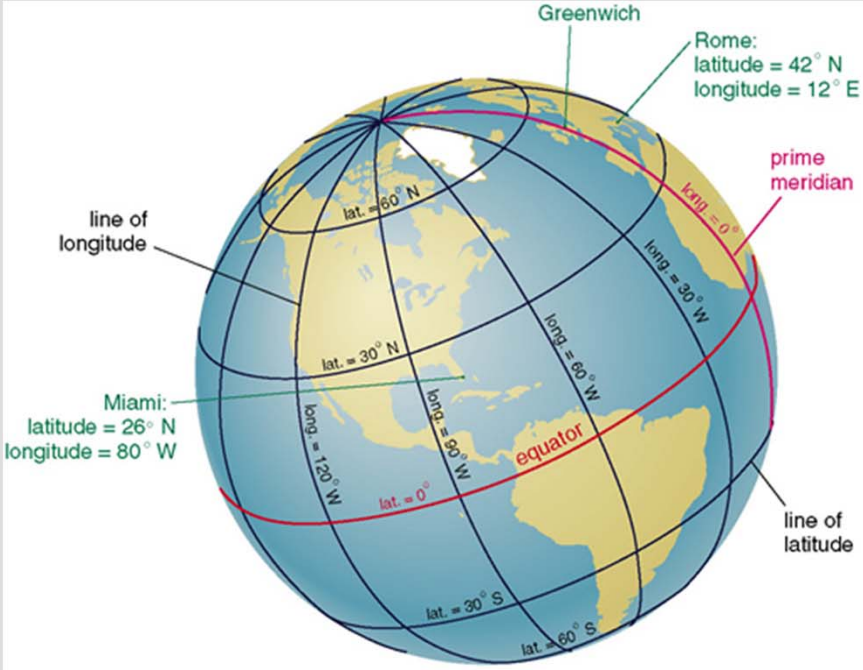
Denver

Lat.:

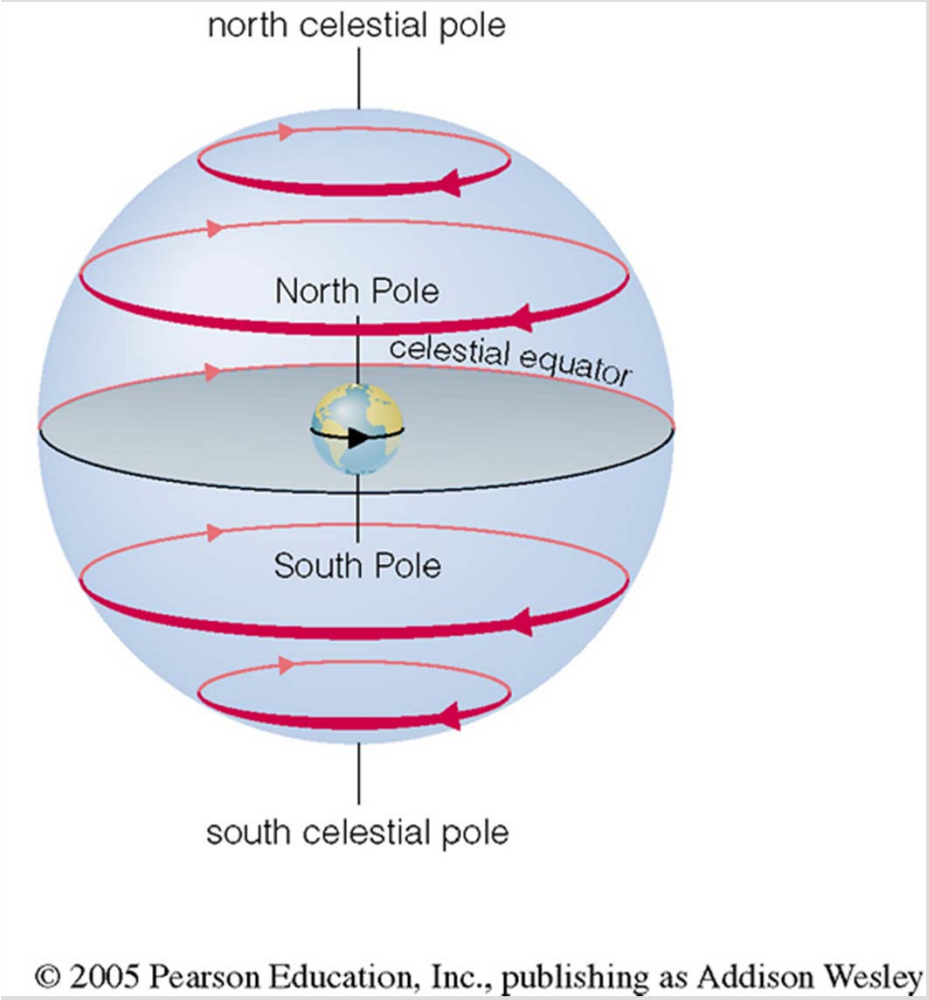
39° 43’ 35” N

Long.:

104° 57’ 56” W



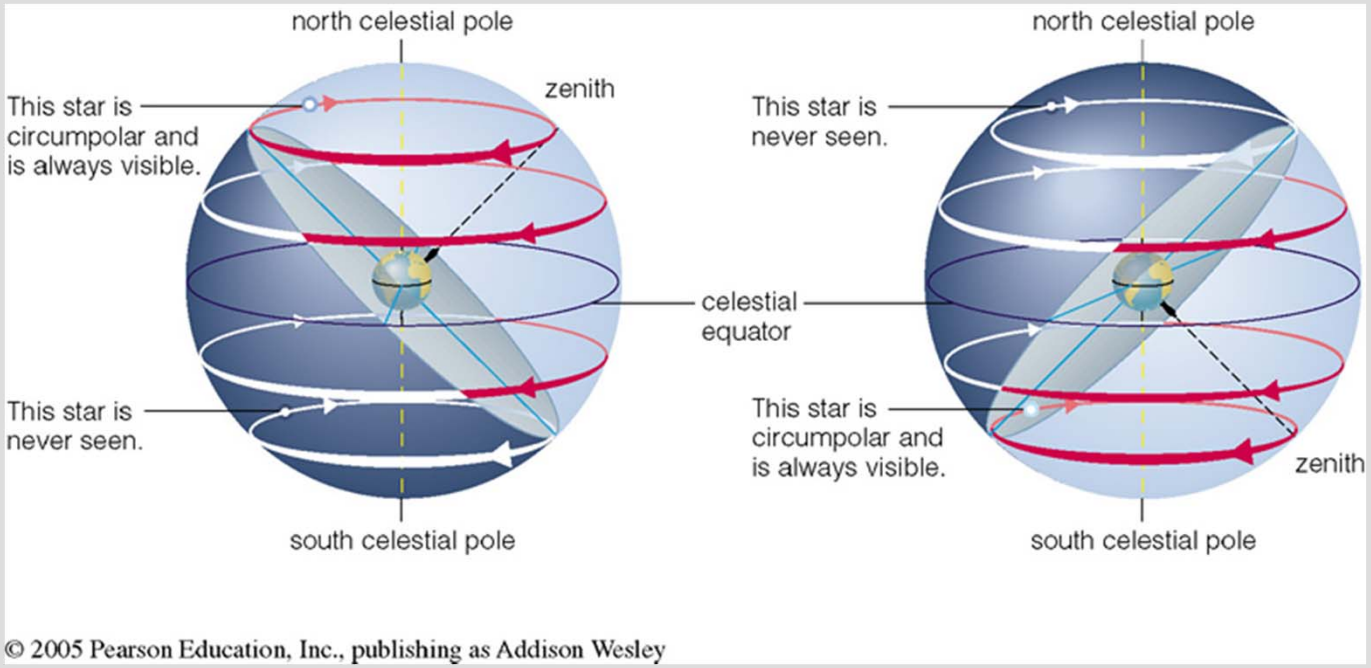
The Daily Motion



- As the Earth rotates, the sky appears to us to rotate in the opposite direction.
- The sky appears to rotate around the N (or S) celestial poles.
- If you are standing at the poles, nothing rises or sets.
- If you are standing at the equator, everything rises & sets 90° to the horizon.

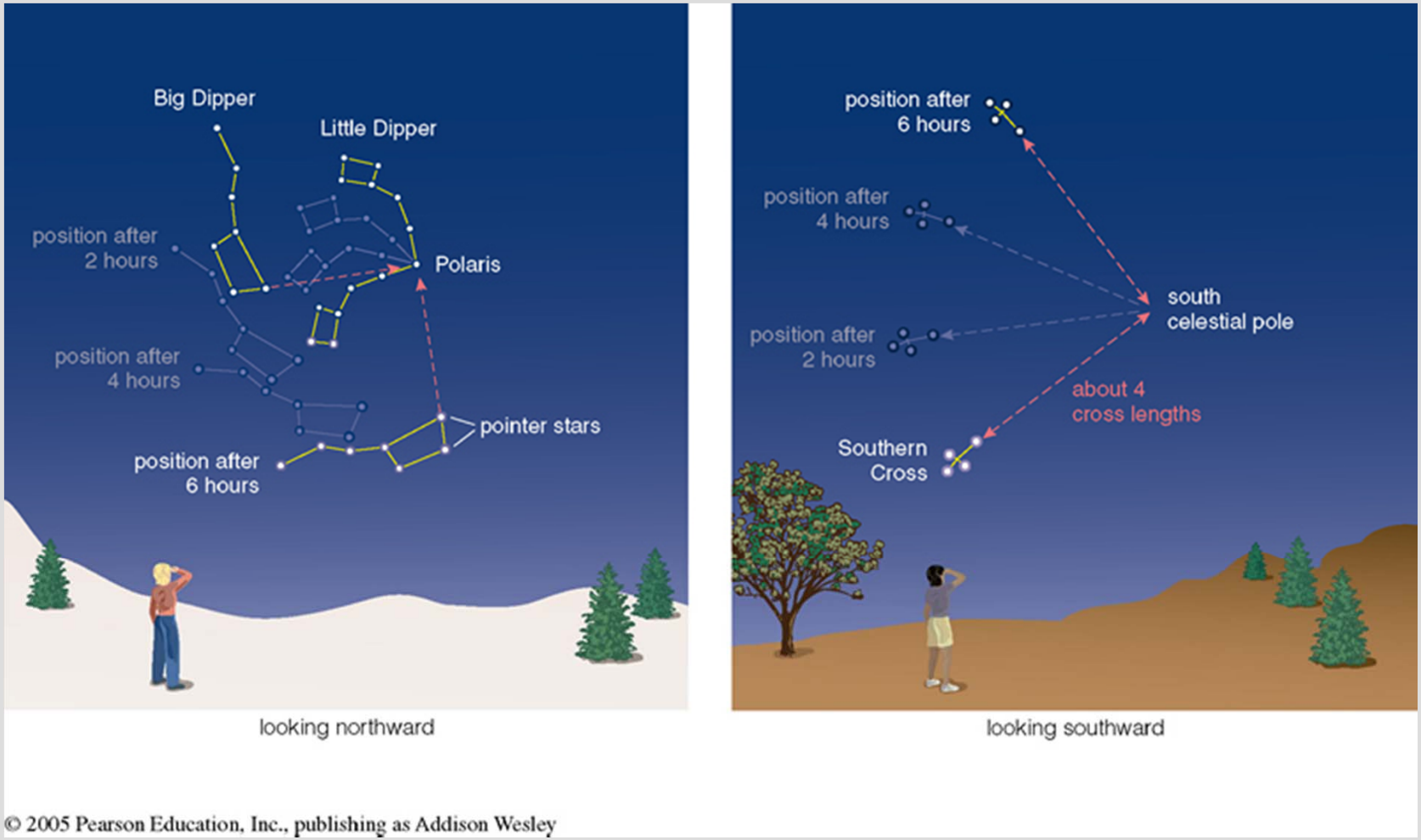
The Daily Motion

- The altitude of the celestial pole = [your latitude].
- All stars at an angle < [your latitude] away from:
  - your celestial pole never set. (**circumpolar**)
  - the other celestial pole are never seen by you.
- Other stars, (& Sun, Moon, planets) rise in East and set in West at an angle = [90° – your latitude].



The Daily Motion (IF 2.13)

daily circles --- CCW looking north, CW looking south



Time Exposure Photograph:

- Estimate time
- Which direction did stars move?

Annual Motion (IF 2.14)

- As the Earth orbits the Sun, the Sun appears to move eastward with respect to the stars.
- The Sun circles the celestial sphere once every year.