Geomatics Engineering Department

Second Year Geomatics

Geodesy 2 (GED209)

Lecture No: 13

Geodetic Astronomy – Part II

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Overview Of Previous Lecture

- Why to Study Geodetic Astronomy
- The Solar System and The Celestial Sphere
- Reference Circles on the Surface of the Earth and Celestial Sphere
- Observation Circles Linking The Terrestrial And The Celestial Spheres

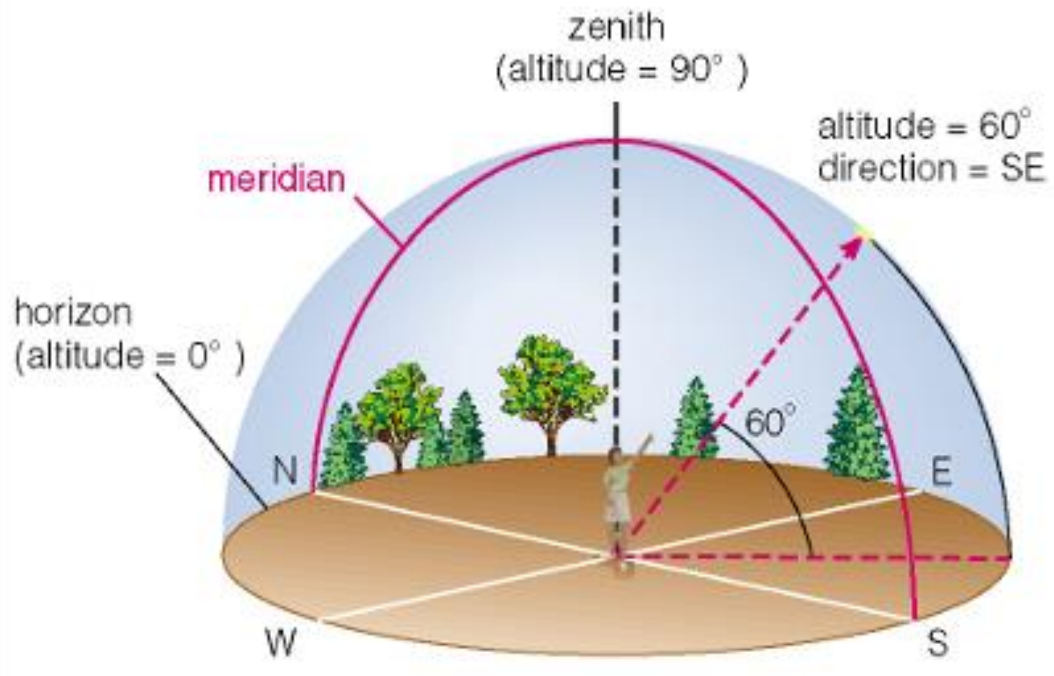
Overview Of Today's Lecture

- Overview
- Stars and Seasons
- Latitude and Longitude Determination
- Course Assessment

OVERVIEW

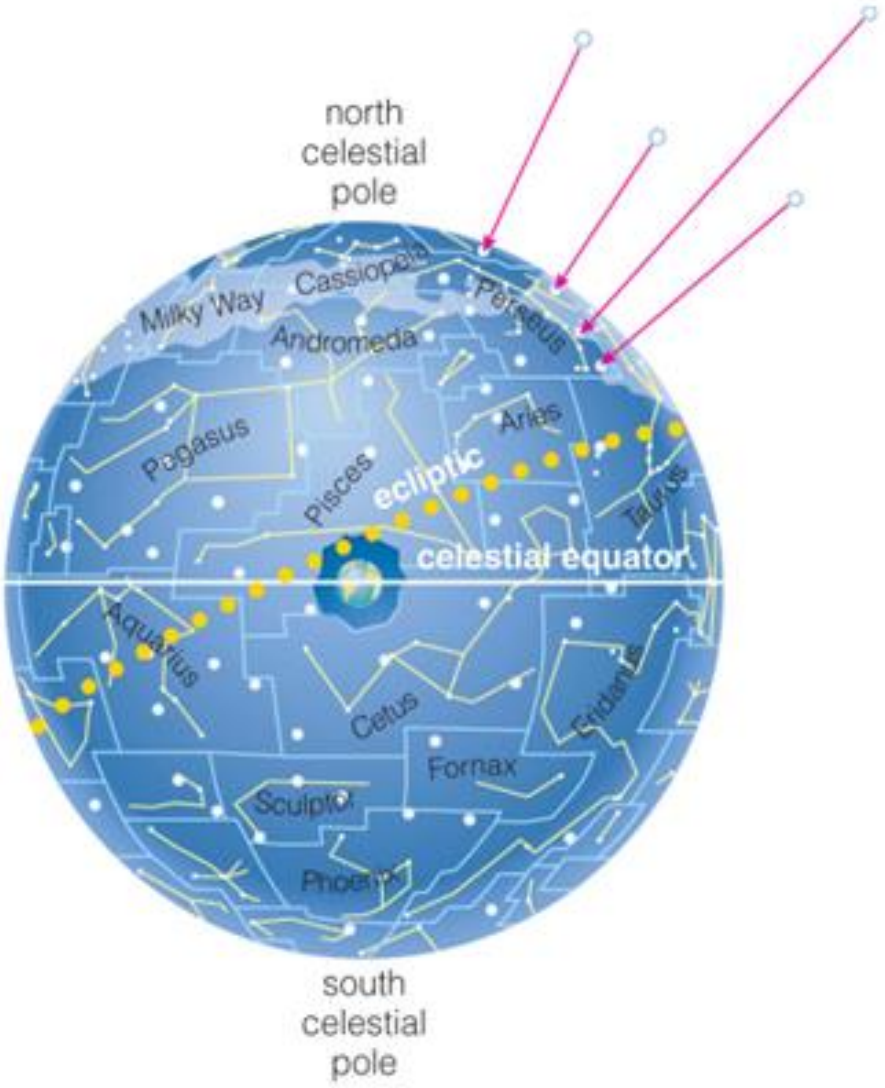
The Local Sky

- **Zenith**: The point directly overhead
- **Horizon**: All points 90° away from zenith
- **Meridian**: Line passing through zenith and connecting N and S points on the horizon.
- An object's altitude (above horizon) and azimuth (direction around horizon) can also specify its location in the sky at a specific time: North – 0, East – 90, South – 180, West – 270



The Celestial Sphere

- Stars at different distances appear to lie on the celestial sphere, an imaginary sphere we look up at from inside.
- A ***constellation*** is a region of the sky surrounding an ancient historical figure.
- In the 20th century, astronomers divided the sky into 88 official constellations in the entire sky.

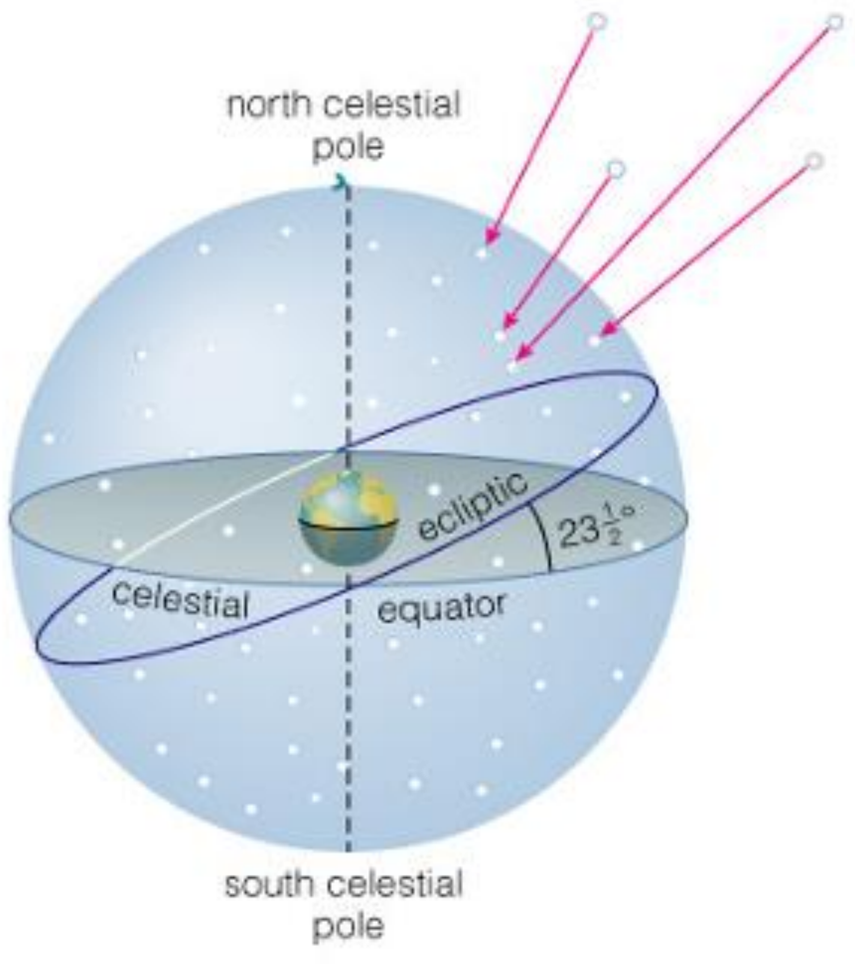


THE CELESTIAL SPHERE

- **North & South Celestial Pole**: extensions of Earth's poles.
- **Celestial Equator**: extension of Earth's equator.
- **Ecliptic**: -

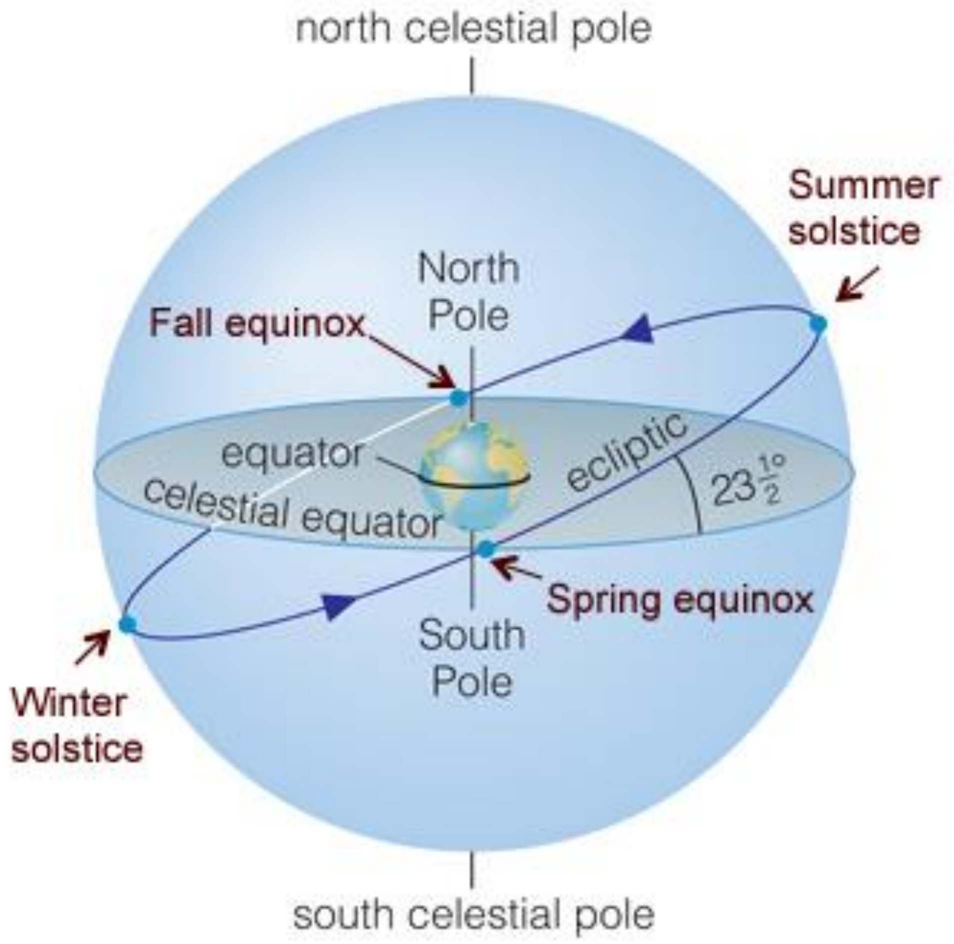
a. The Sun's apparent path around the celestial sphere.

b. It is also the path of the Earth around the Sun



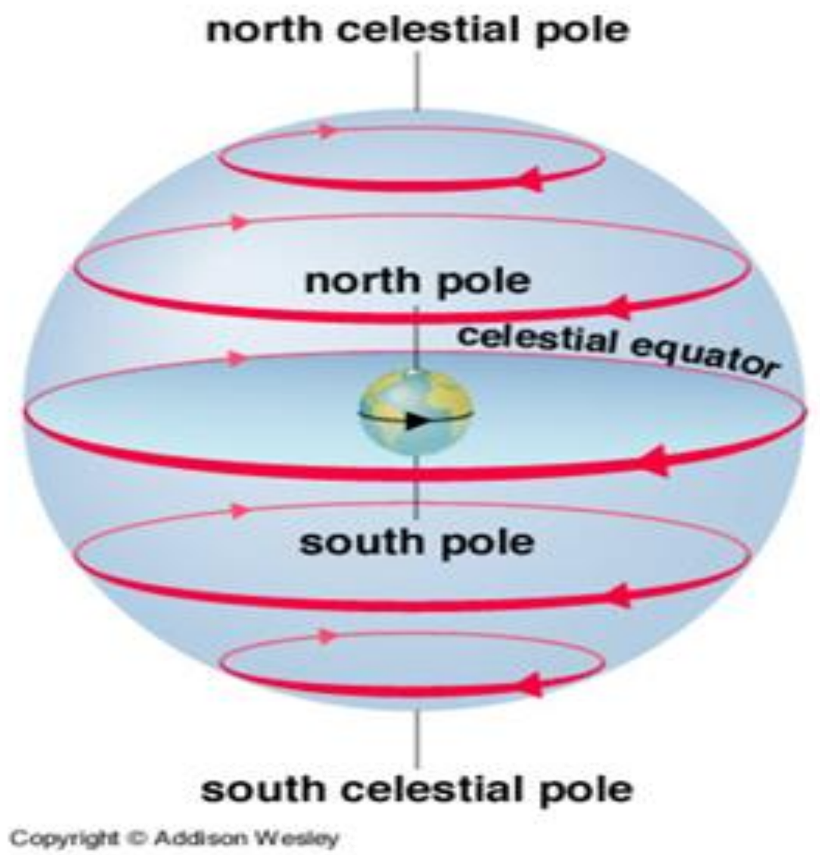
EQUINOXES AND SOLSTICES

- **Equinoxes** occur when the Sun's path on ecliptic crosses the celestial equator
- **Solstices** occur when Sun is at highest and lowest points above & below celestial equator



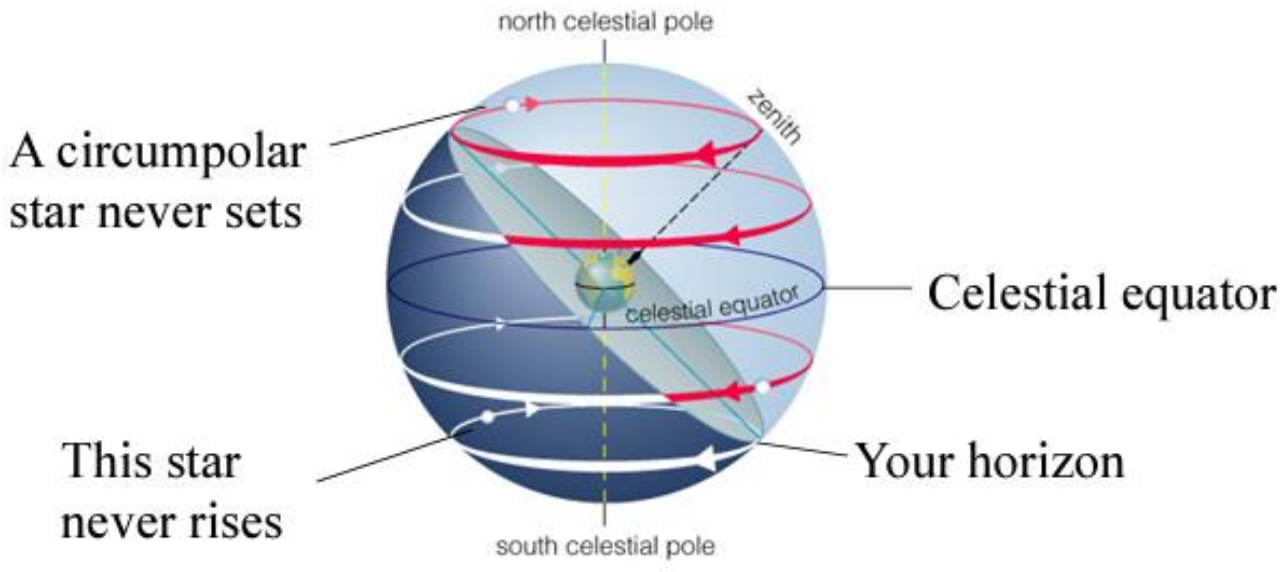
Why do stars rise and set?

- Earth rotates from west to east so stars appear to circle from east to west around the celestial poles – diurnal motion.



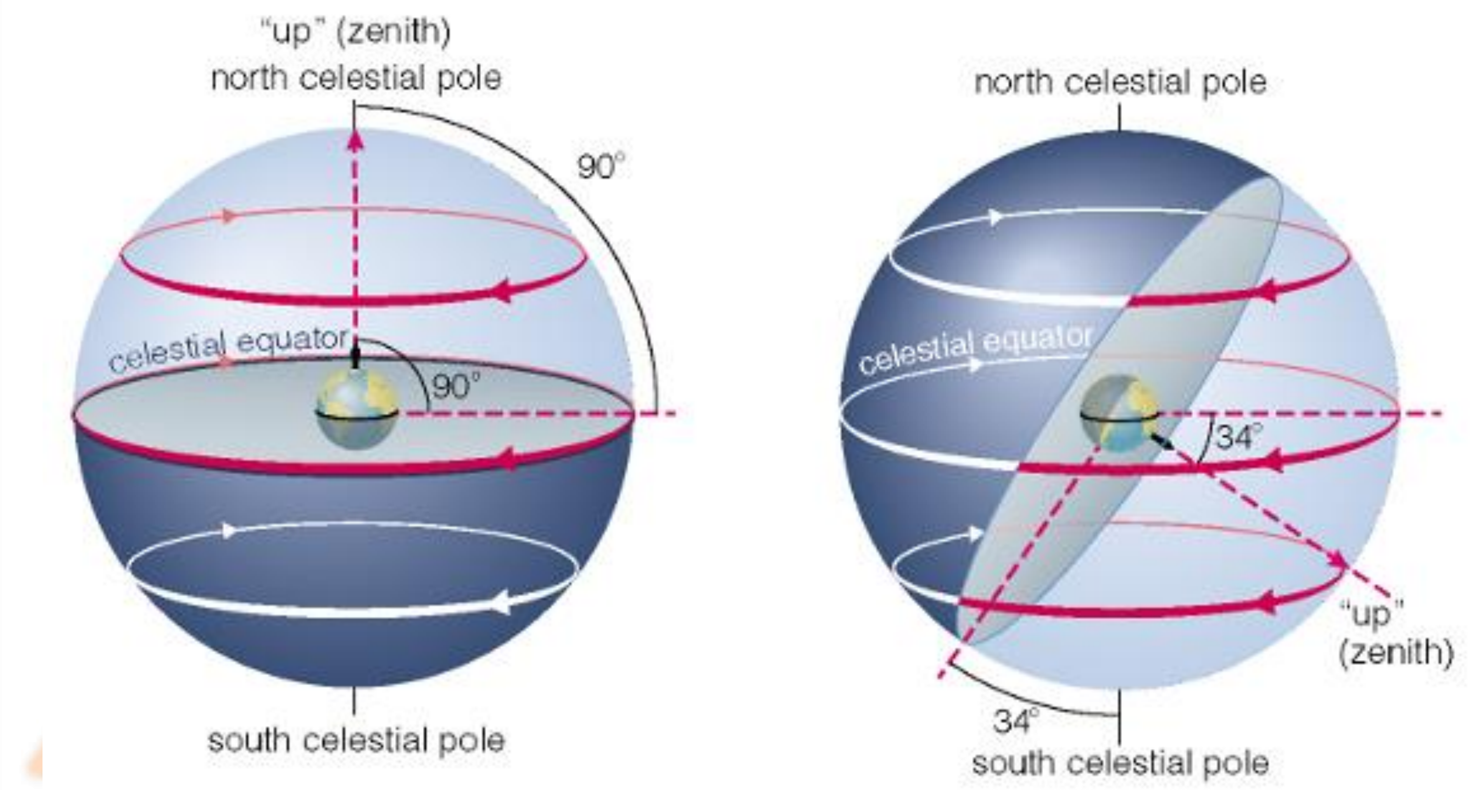
View From Northern Hemisphere

- Stars near the north celestial pole are circumpolar and never set.
- We cannot see stars near the south celestial pole.
- All other stars (and Sun, Moon, planets) rise in east and set in west.



View From Northern Hemisphere

- The appearance of the sky varies with your latitude but not longitude.

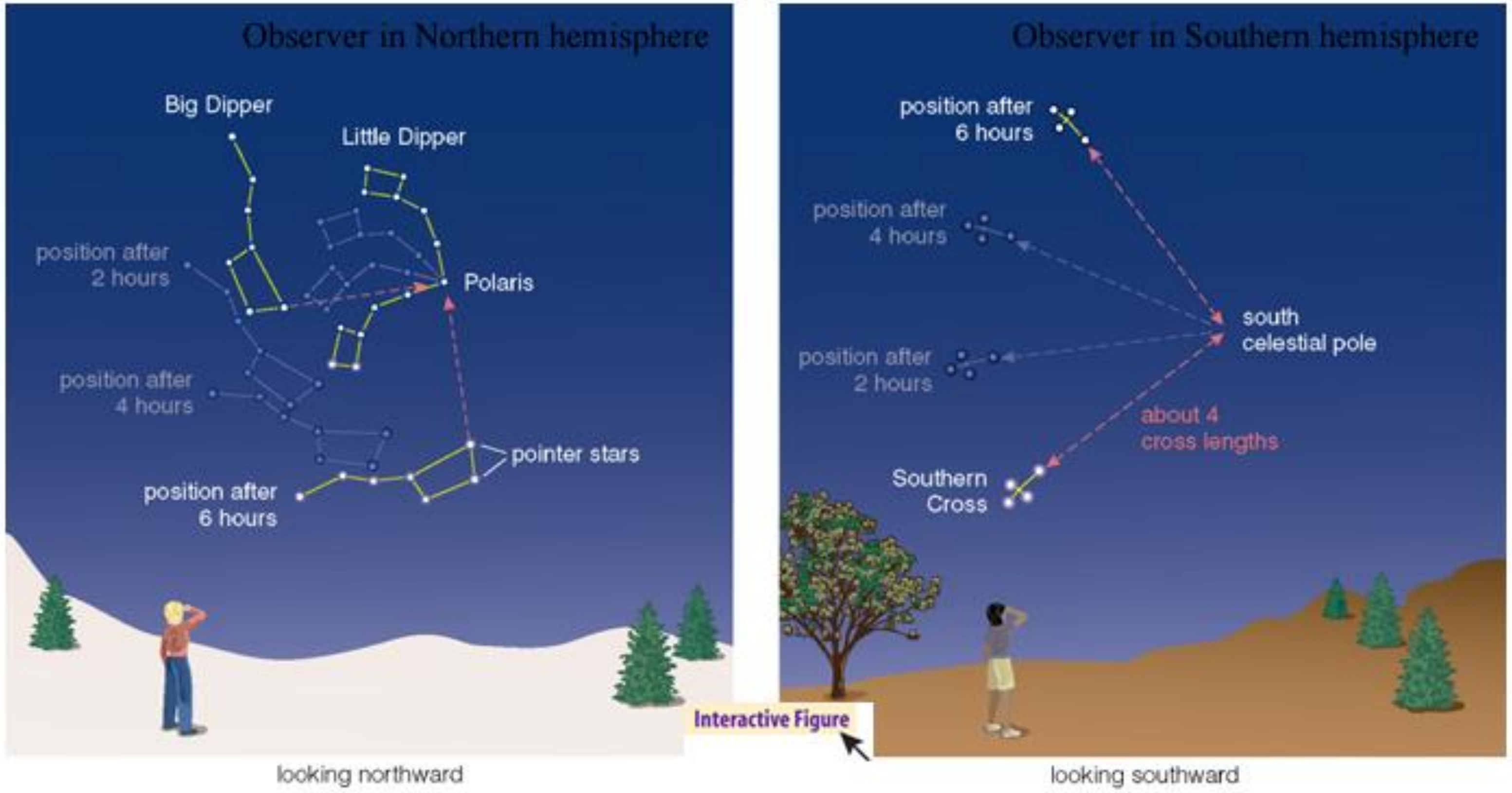


Observer in Northern hemisphere

Observer in Southern hemisphere

Altitude Of The Celestial Pole

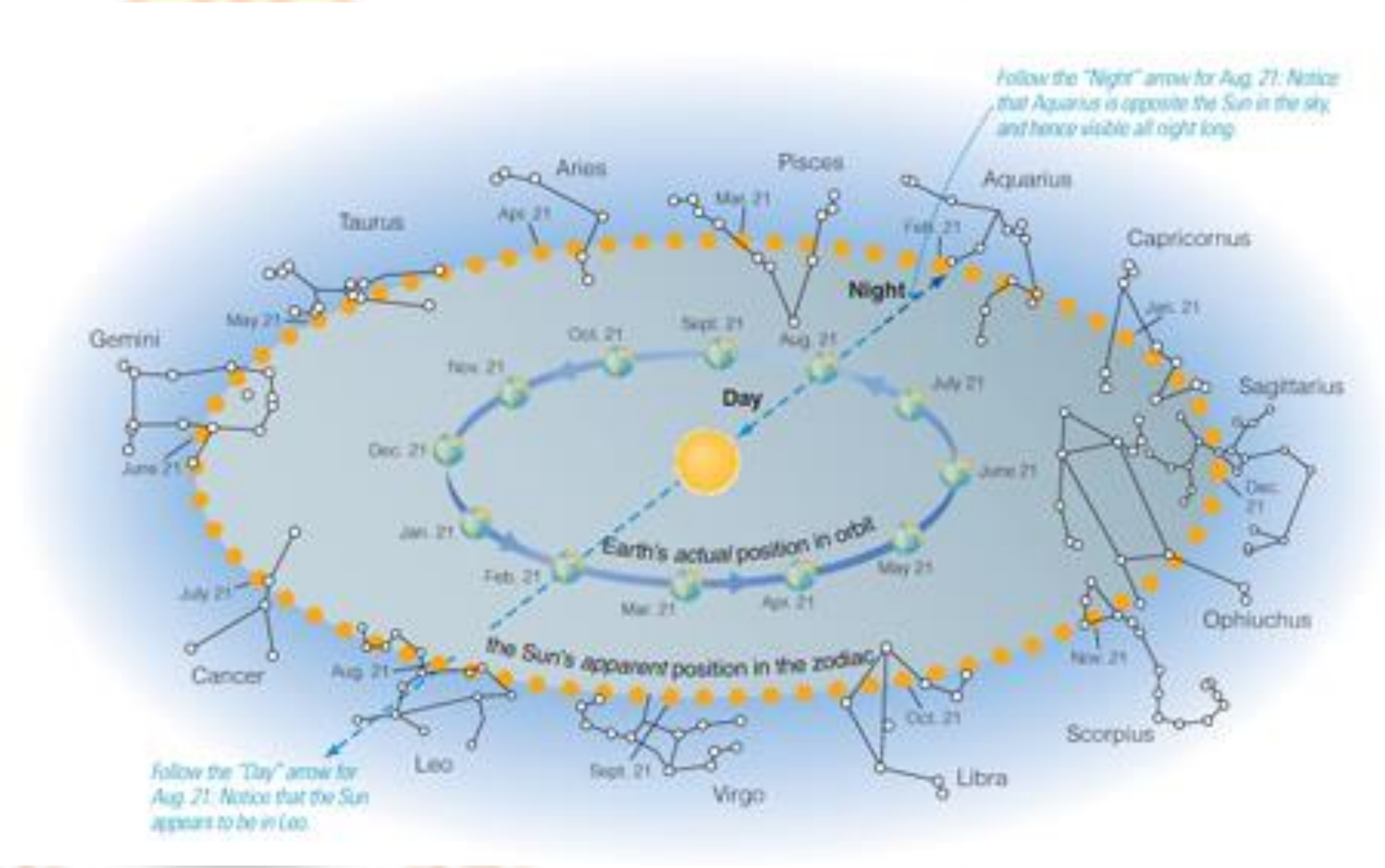
- Altitude of the celestial pole = your latitude.



The north star (Polaris) can be found using the Big Dipper's pointer stars

Why Do The Constellations We See Depend On Time Of Year?

- As the Earth orbits the Sun, the Sun appears to move along ecliptic.
- At midnight, the stars on our meridian are opposite the Sun in sky.
- We see over 2,000 stars and the Milky Way with naked eye; each star is part of a constellation.
- Time of year determines the location of the Sun in the sky.

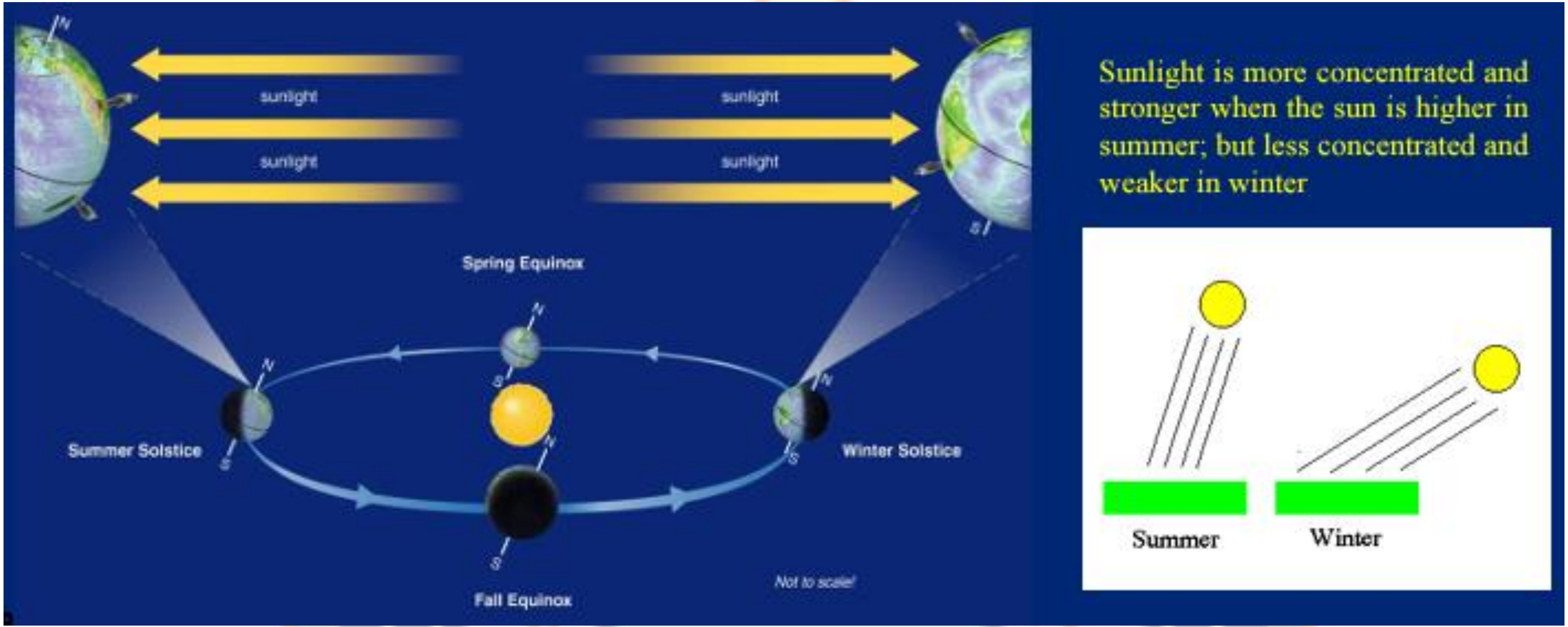


WHAT CAUSES THE SEASONS?

- Seasons are opposite in the North and South hemispheres, so distance cannot be the reason.
- The real reason for seasons involves Earth's axis tilt.
- Variation of Earth–Sun distance is small—about 3%; this is overwhelmed by the effects of axis tilt.
- Seasons depend on tilt of Earth's axis affecting directness & strength of sunlight, NOT distance from the Sun.
- Direct sunlight is stronger, causing summer; indirect sunlight is weaker, causing winter.
- Length of the day also plays a role – longer in summer, shorter in winter, etc.
- **Seasons are defined as follows: -**

a. Summer solstice (June)
b. Winter solstice (December)
c. Spring (vernal) equinox (March)
d. Fall (autumnal) equinox (September)

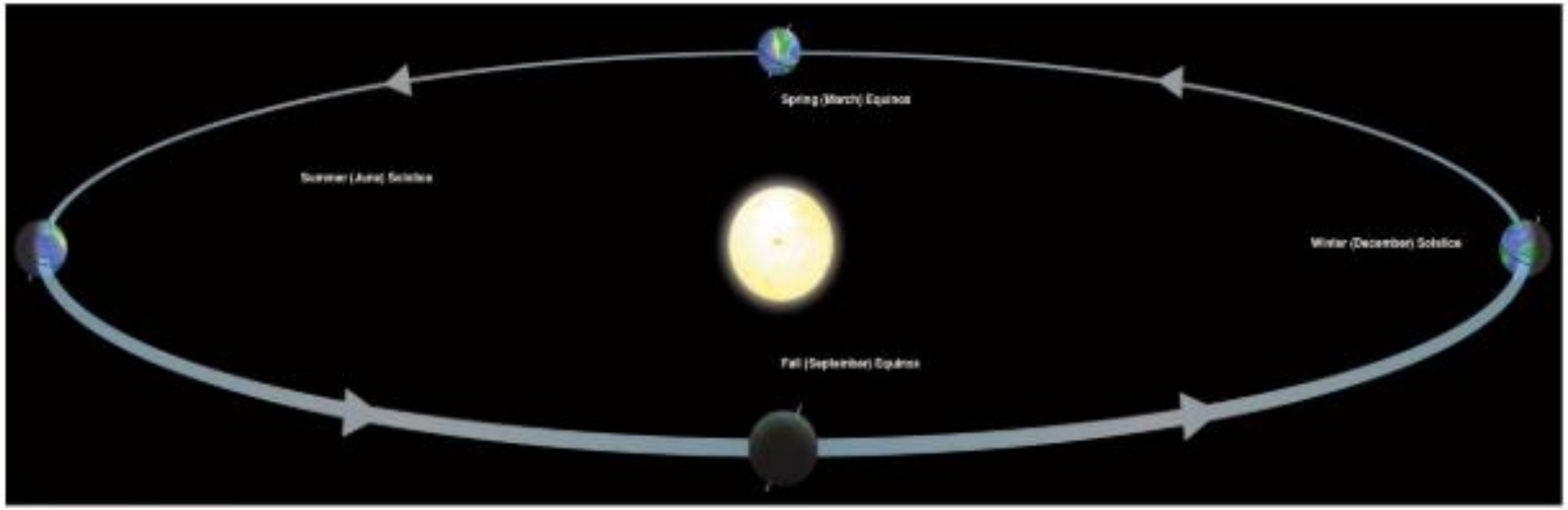
What Causes The Seasons?



Earth's axis tilt causes the seasons!

WHAT CAUSES THE SEASONS?

- Earth's axis always points towards North Celestial Pole so its orientation relative to the Sun changes as Earth orbits the Sun.
- Summer occurs in your hemisphere when sunlight hits more directly; winter occurs when sunlight is less direct.
- The TILT of Earth's AXIS is the key to the seasons; without it, no seasons.
- Variation of Earth–Sun distance is small (about 3%)



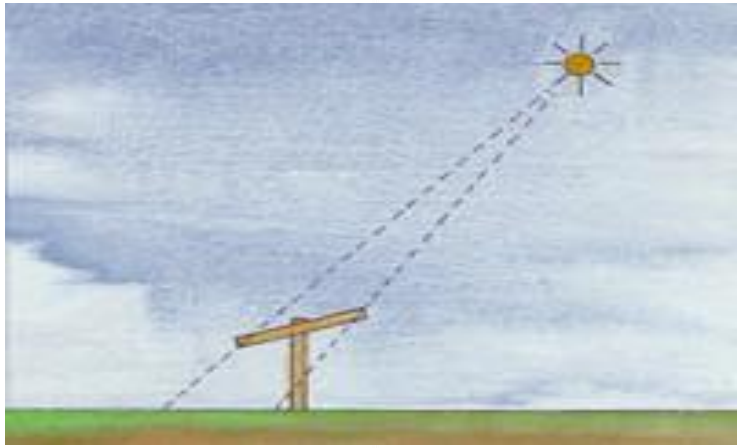
Determination of Latitude and Longitude

MEASURING LATITUDE

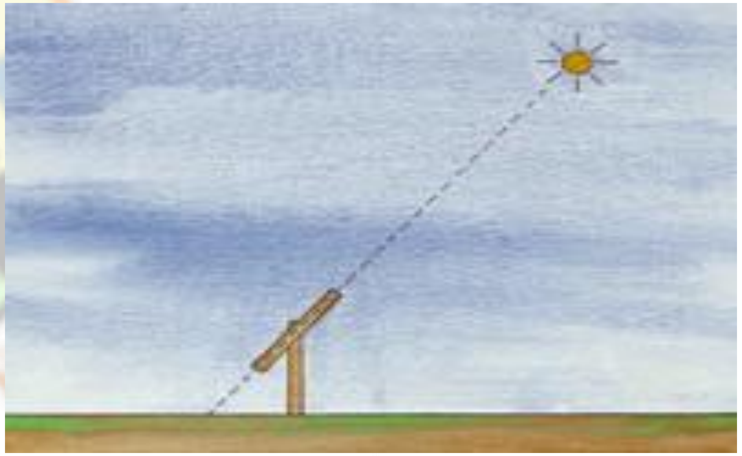
- It's possible to measure latitude by comparing your position on Earth with the position of either the sun or the North Star (Polaris).
- Measurements using the sun are possible on a clear day in the northern or southern hemispheres, when the sun is easy to find.
- However, measurement of latitude isn't as straightforward as you might think. Accurate readings can only be taken at noon, when the sun is at its highest in the sky.
- To complicate matters further, the sun rises higher in summer than in winter, and this must be allowed for in any calculation.
- Being so far away and only one of a myriad stars visible to the naked eye, the North Star isn't as easy to find as the sun.
- Furthermore, you can only see it at night, which isn't always convenient. Its major limitation, however, is that it isn't visible from the southern hemisphere.
- For our purposes, we shall therefore assume that we're in the northern hemisphere.
- You can use a simple quadrant to measure latitude using either the sun or the North Star. Both methods are described below.

Measuring Latitude Using The Sun

- Measuring latitude using the sun can only be done at noon, when the sun is at its highest point in the sky.
- To determine when it's noon (without a watch or radio) place a stick at the southernmost end of your north-south line.
- Use a plumb line to make sure that the stick is vertical. When the shadow cast by the stick crosses the north-south line, it's noon.
- As soon as it's noon, align the sighting nails on the quadrant's aiming beam with the sun. DO NOT USE THE SIGHT LINE TO LOOK DIRECTLY AT THE SUN.



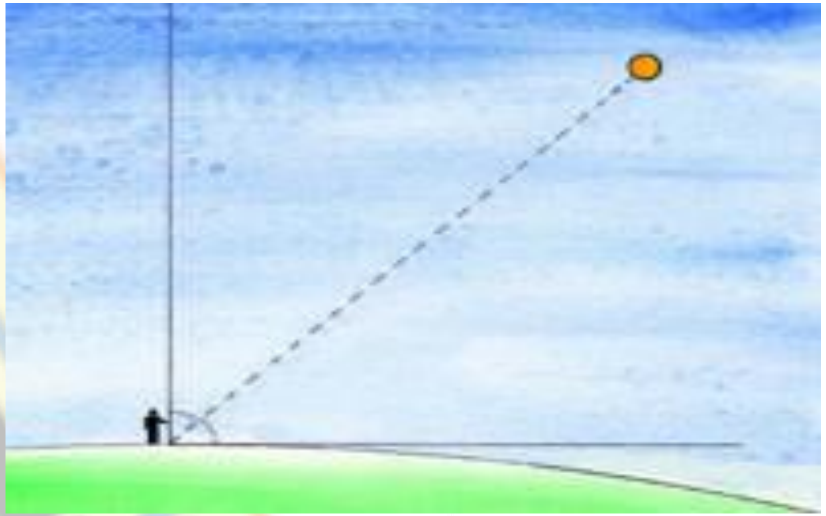
Two shadows on the ground - beam aimed incorrectly



One shadow - beam aimed correctly

MEASURING LATITUDE USING THE SUN

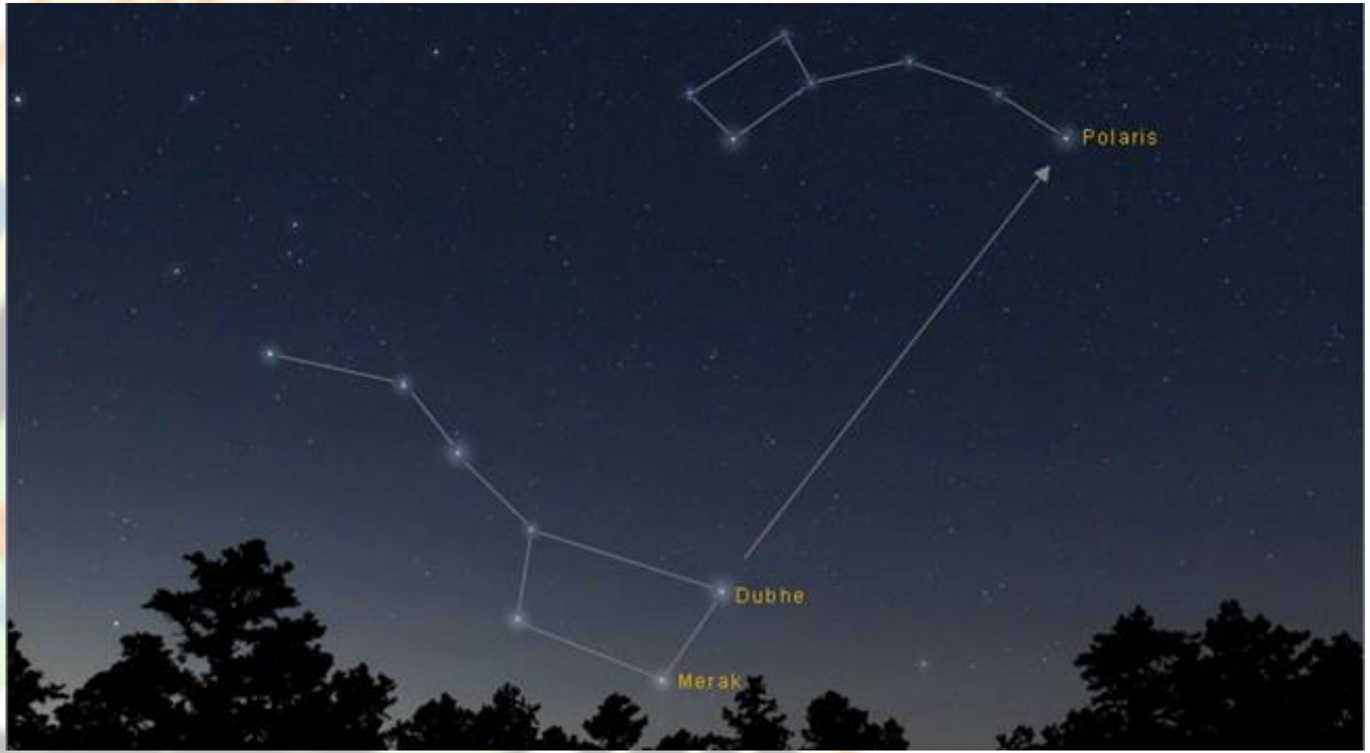
- Instead, watch the shadows formed by the nails on the ground as you tilt the aiming beam up and down. At first, the nails will cast two separate shadows, so move the end of the beam up or down so that these two shadows move closer together.
- When the shadows coincide, the beam is aimed exactly at the sun. Using the protractor, measure the smaller angle between the beam and the plumb line.
- If the sun is directly over the Equator, this is your latitude reading.



The angle to measure when using the sun or North Star. Note that the horizon is always 90° to the plumb line.

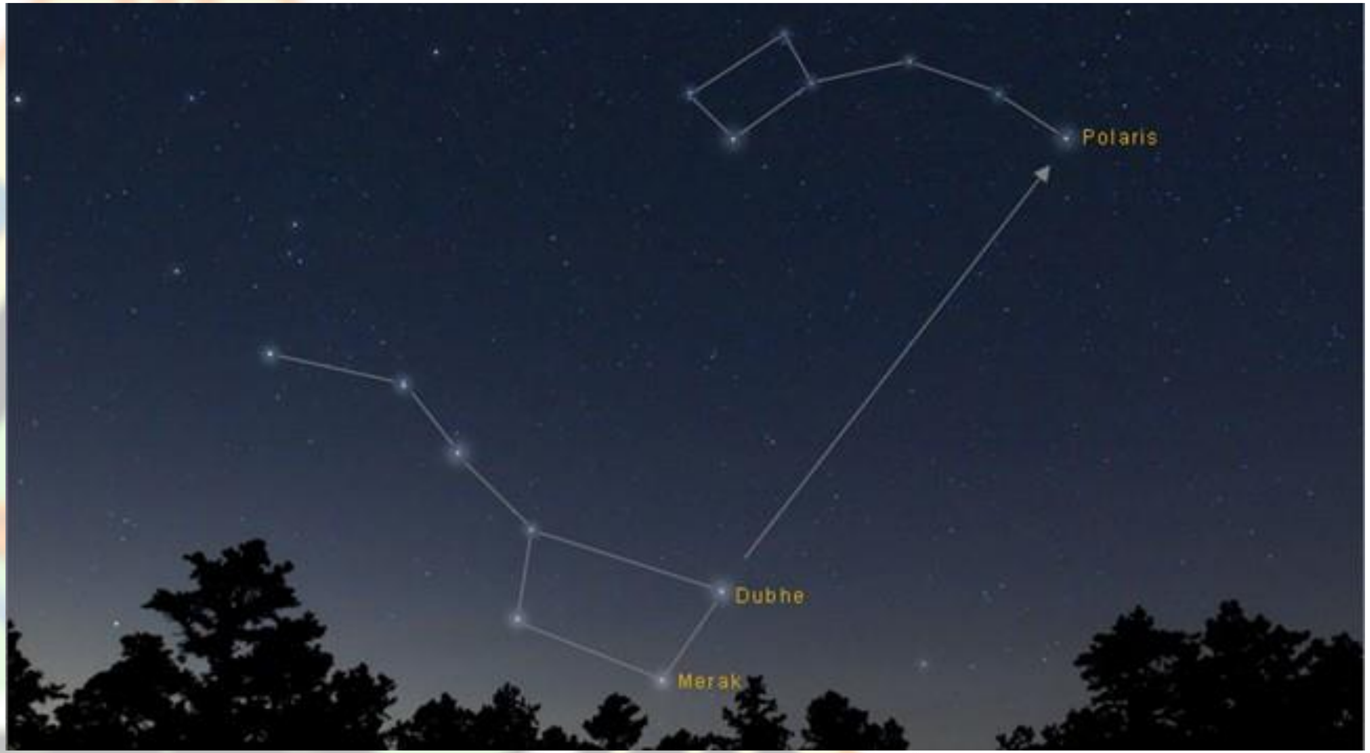
Latitude and Longitude using Stars

- The stars in the sky can aid you in finding your latitude and longitude.
- The North Star (Polaris) can help you find your latitude (but only in the Northern hemisphere…why?)
- The Sun can help you determine your longitude.



Latitude using Stars

- If you know the altitude of the North Star or Polaris, you can find your latitude THE ALTITUDE OF POLARIS IS EQUAL TO THE LATITUDE OF THE OBSERVER!!!
- Altitude = Latitude



Longitude Determination

- Based on Earth's rotation.
- The Earth rotates 15^o per hour.
- $\frac{360^o}{15^o} = 24$ hours.
- Observers on the same line of longitude have the same local time.
- To find longitude, you should know: -

a. Your local time and the time at the prime meridian.

b. Direction from prime meridian (east or west).

c. Time difference

d. Multiply the difference by 15^o.

Longitude Determination – Example

- Time at the prime meridian GW is 12:00 pm.
- Local time is 4 pm.
- Therefore, time difference is 8 hours.
- Now multiply the difference in hours by 15° If GMT is earlier than local time, your longitude is W.
- If GMT is later than local time, your longitude is E.

Online Resources

Online Resources

1. Nautical Almanac and Astronomical Almanac (http://stormy.ca/almanac/index.html)
2. The Nautical Almanac (https://thenauticalalmanac.com/Everything_You_Need_For_2024.html)
3. Calculate Altitude and Azimuth of a Star (https://kaukor.fi/star_altitude.html)
4. Astronavigation: Latitude and Longitude from two stars (https://kaukor.fi/astronavigation.html)
5. Astronavigation: Latitude and Longitude from one Star (https://kaukor.fi/positioning_from_azimuth_altitude.html)
6. LONG-TERM ALMANAC FOR SUN, MOON, AND POLARIS V1.12 (https://celnav.de/longterm.htm)

Now
It Comes to an End!

Course Assessment

CONTENT (W.R.T FENG BYLAW)

Geodesy 1B (SUR223)

- Introduction
- Figure of the earth
- Datums
- Geoid and its significance
- Coordinate systems in geodesy
- Gravimetric effect
- Triangulation, Trilateration, Hybrid Networks
- Two- and three-dimensional computations
- Geodesic line, LOS, and great circles.
- Direct and inverse problems.
- Intersection and resection
- Precise and trigonometric leveling
- GPS leveling
- Height systems

Geodesy 2 (GED209)

- Introduction, Celestial sphere, astronomic and geodetic coordinate systems
- Latitude, longitude, and azimuth determination
- Zenith determination
- Spherical triangles – Napier's rule
- Time – Methods to change time and its determination.
- History of the Egyptian Geodetic network
- Coordinate systems used in Geodesy
- Establishing of local and world best fitting ellipsoid
- Gravimetric effect on observations
- Coordinate transformations and datum shift
- Two and three-dimensional Geodesy
- Adjustment of three-dimensional geodetic networks.

Intended Lecture Series (A reasonable Merge of Content)

1) LOS Engineering (This lecture)
2) Overview of Celestial sphere, latitude, longitude, zenith, and azimuth determination
3) Datums, Geoid and its significance
4) Coordinate Systems in Geodesy
5) Gravimetric effect on observations
6) Establishing of local and world best fitting ellipsoid
7) Coordinate transformations and datum shift
8) Height systems
9) Intersection and resection
10) Two and three-dimensional Geodesy
11) Adjustment of three-dimensional geodetic networks.
12) History of the Egyptian Geodetic network.

Lecture Series (15 Weeks)

1. LOS Engineering
2. Intersection and Resection
3. Coordinate Systems in Geodesy
4. Datums and Geoid
5. Datum Transformation
6. Reduction to Ellipsoid
7. History of Egyptian Geodetic Networks
8. Lecture 8 - Midterm Exam
9. Lecture 9 – Public Holiday
10. Height Systems
11. Establishing of Best Fitting Ellipsoid
12. Two and Three-Dimensional Geodetic Computations
13. Geodetic Astronomy I
14. Geodetic Astronomy II (This Lecture)
15. Oral Exam

Tutorial Series (15 Weeks)

- One Practical (2 weeks)
- Six Assignments
- Two Take-Home Assignments

Assessment Criteria

Geodesy 1B - SUR223		
Final Exam	**90**	10 Jan. 2024
Midterm	20	Done
Attendance Lectures	10	Done
Attendance Sections	5	Done
Quiz (avg. of 3)	10	2
Assignments (Avg. of 6)	5	Done
Practical	10	Done
Total	**150**	

Geodesy1 - GED209		
Final Exam	**90**	17 Jan. 2024
Midterm	30	Done
Attendance Lectures	10	Done
Attendance Sections	5	Done
Quiz (avg. of 3)	15	Done
Assignments (Avg. of 6)	10	Done
Take-Home assignments	10	Done
Practical	10	Done
Total	**180**	

What Have We Learnt In Geodesy So Far?

Now, you should be able to answer the question:
How could this course benefit a geomatics engineer?

End Of Presentation

Thank You For Attention!