Topic 4 – Motions of Earth, Sun and Moon

Vocabulary

Aphelion – The point in a planet's orbit when it is furthest from the sun; gravity and velocity are low.

Apogee – The point in a satellite's (moon) orbit when it is furthest from a planet; gravity and velocity are low

Axis – An imaginary line that through the North and South Pole that a planet, star or moon rotates.

Constellation – a group of stars that form a pattern in the night sky such as the big dipper

Coriolis effect – The deflection of moving particles to the right in the Northern hemisphere and to the left in the Southern hemisphere due to Earth's rotation.

Equinox – the time of year when the sun is directly overhead at the equator and every point on earth revives 12 hours of light and 12 hours of darkness.

Foucault pendulum – a freely swinging pendulum whose path appears to change in a predictable direction due to the Earth's rotation. Used to predict Earth's rotation.

Geocentric model – a model of the solar system that places Earth at the center and objects orbit the earth, no longer accepted

Heliocentric model – a models of the solar system that places the Sun at the of the solar system and object orbit the sun, accepted model

Lunar eclipse – the darkening of the moon by earth's shadow

Perihelion – When the Earth is at its closest to the sun in its orbit, gravity and velocity are the greatest in the obit

Perigee – When the moon or satellites are at their closest to the sun in their orbit, gravity and velocity are the greatest in the obit

Phase of the moon – the changing portion of the lit part of the moon visible from earth, a predictable pattern

Solar eclipse – the moon blocks the sun's light and creates a shadow on earth, earth is in the moons shadow

Solstice – the two times during the year when the sun is directly overhead at 23.5^{o} N or23.5^{o} S of the equator.

Summer solstice – on June 21 when the sun is directly overhead at 23.5^{o} N latitude and the northern hemisphere experiences the longest amount of daylight

Tides – the cyclic change of the levels of the oceans due to the gravitational attraction between the earth and moon.

Time zones – generally 15^{o} of longitude wide and represents 1 hour of time change travelling east or west from the prime meridian. In the contiguous United States there 4 times zone; eastern, central, mountain and pacific.

Winter solstice - on December 21 when the sun is directly overhead at 23.5^{o} S latitude and the southern hemisphere experiences the longest amount of daylight

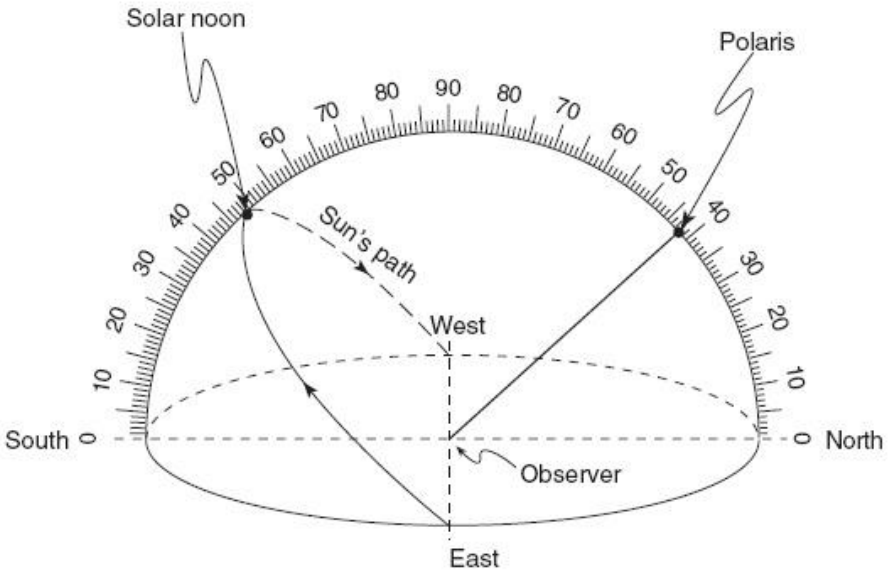
Overview of Topic

I. Celestial Sphere

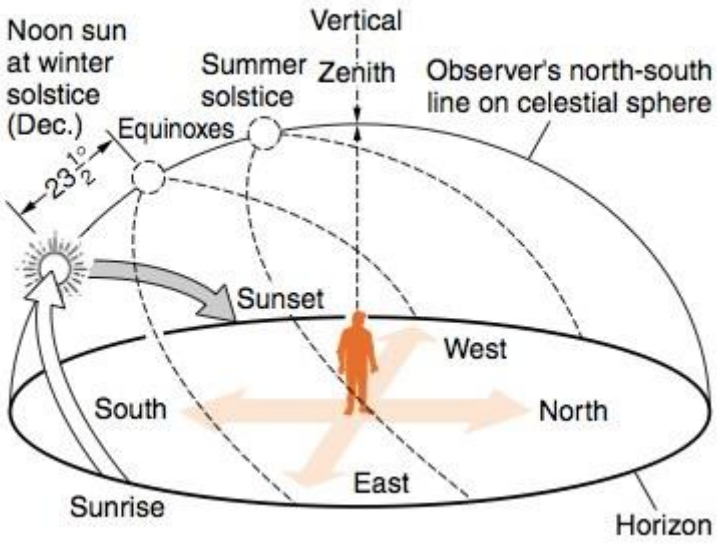
a. An imaginary sphere surrounding the Earth on which celestial objects appear to be located.

b. Shows altitude of sun and Polaris on Regents examination

- Directions are indicated.
- Sun rises in the earth part of the sky, sets in the western part of the sky,
- At our latitude in New York State (41°N to 45°N) sun's paths in southern part of sky.
- Shadows point opposite of sun's path in sky.



Shows positions of sun and moon for a given date. Polaris' altitude equals latitude in northern hemisphere. This indicates Polaris is 42° in altitude, therefore, observer is at 42°N latitude.

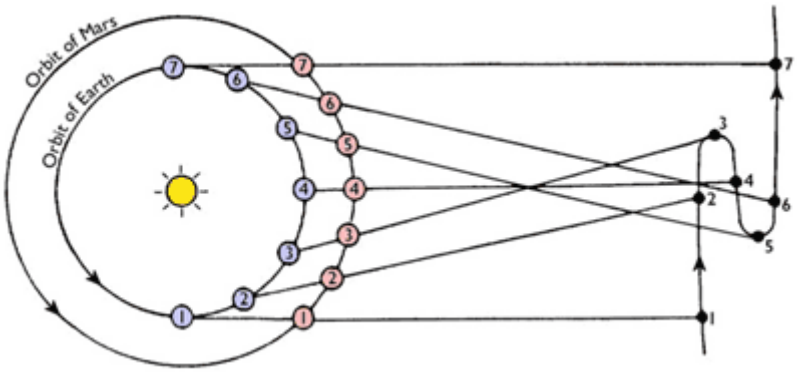


The path of the sun on the Solstices and Equinoxes. Notice where the sun rises and sets for these dates.

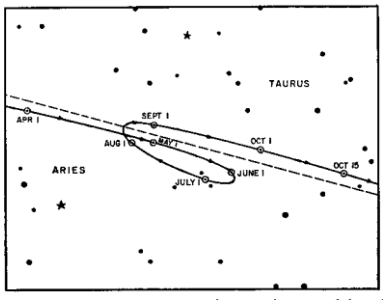
II. Apparent Motions of Celestial Objects

a. Motion of the Stars
- Rise in east, set in west
- Appear to make a circle around Polaris in Northern sky
- Caused by Earth's daily rotation in its axis

b. Apparent Motion of Planets
- Similar to stars, but they orbit sun too.
  - Appear to change direction in night sky over several months.



Model of Earth and Mars orbit with positons seen in night sky.



Example of Mars' path in the night sky over several months.

- Cause due to differences in orbital distance from sun. Earth's orbit smaller, Mars' orbit larger.

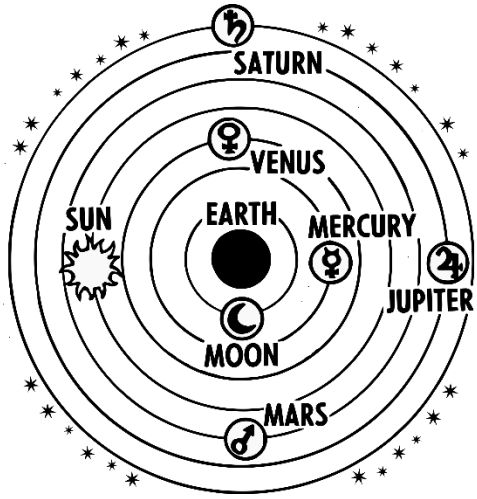
c. Apparent motion of the Moon
   - East to west pattern
   - Rises 50 minutes later each day.
     - Moon orbits Earth.

d. Apparent Motion of Sun in the Northern Hemisphere.
   - Changes in Altitude of the Noon Sun
   - Sun is directly overhead at:
     - Tropic of Cancer (23.5^{o}) June 21st
     - Equator (0^{o}) Sept 22nd and Mar 21st
     - Tropic of Capricorn (23.5^{o}) Dec 21st
     - Sun is never directly overhead anywhere in the continental United States.
   - Sun rises
     - Northeast June 21st
     - East Sept 22nd and Mar 21st
     - Southeast Dec 21st
   - Sun sets
     - Northwest June 21st
     - West Sept 22nd and Mar 21st
     - Southwest Dec 21st

III. Models to Explain Apparent Motion in Solar System

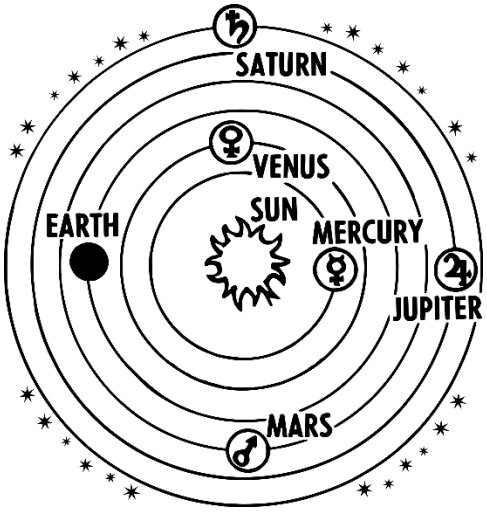
a. Geocentric model (wrong)

- Object in solar system orbit Earth.
  - No longer accepted



b. Heliocentric model (correct)

- Objects orbit the sun, moons orbit planets.
  - Current model



IV. Actual Earth Motions

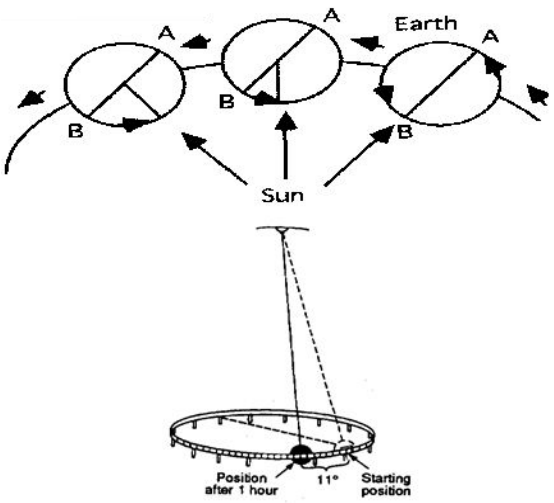
a. Rotation of Earth

- Spins on its axis

- Axis tilted 23 ½ ° from perpendicular.

V. Evidence of Earth's Rotations

a. Foucault Pendulum



- Earth actually rotates under the pendulum. Pendulum appears to move.

b. Coriolis effect

- Earth's rotation causes object that are moving to deflect to the right in the northern hemisphere.
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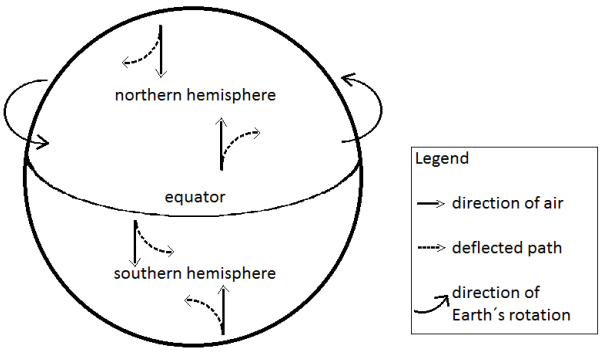
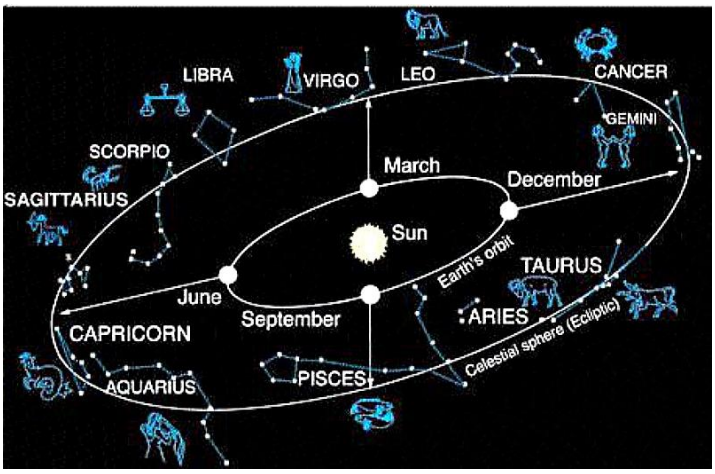


VI. Evidence of Earth's Revolution Around Sun

a. Constellations change position in the night sky during the year.



The dark side of the Earth faces away from the sun. As it moves through its orbit different constellation come in to view.

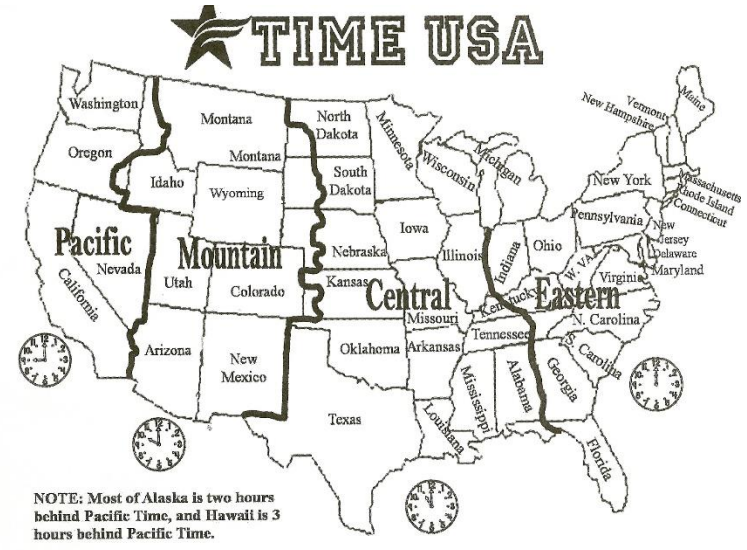
VII. Time based on Earth and Moon motions

a. Local Time
   - Time at your location on Earth

b. Local Solar Time
   - The point when the sun reaches its highest point in the sky.

c. Time Zones
   - Each time zone is 1 hour
   - Each time zone is 15^{o} of longitude
   - Earth rotates 360^{o} in 24 hour (360^{o}/24 hrs)
   - Earth Rotates 15^{o}/1 hr

d. Finding zones time in U.S.
   - U.S. has four time zones
     - Eastern
     - Central
     - Mountain
     - Pacific



- Travelling west you subtract 1 hour per 15°
- Travelling east you add 1 hour per 15°
- Generally true anywhere is the world.

VIII. Actual Earth and Moon Motions

a. Moon Phases

- Difficult concept for student to grasp.
  - Light from sun hits Moon surface
  - Moon's revolution around Earth creates moon phases
  - It takes 29 ½ days to complete a phase change from new moon to new moon
  - Moon waxes from new moon to full moon
    - Right side of moon is lit in the night sky when waxing
  - Moon wanes from full moon to new moon
    - Left side of moon is lit in the night sky when waning

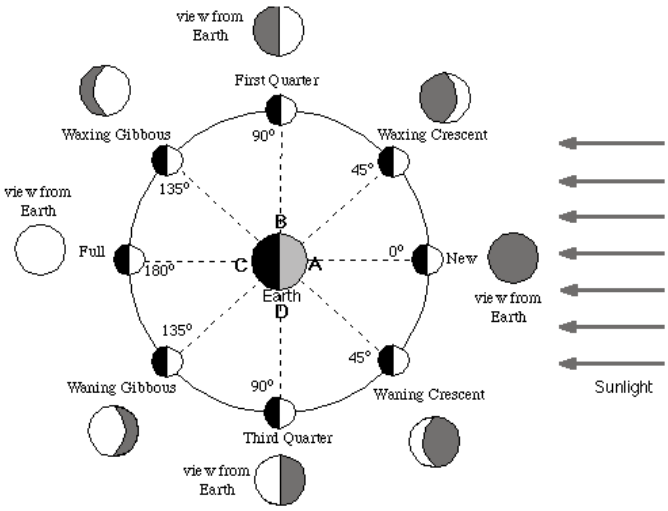


Diagram shows moon phases beginning with new moon.

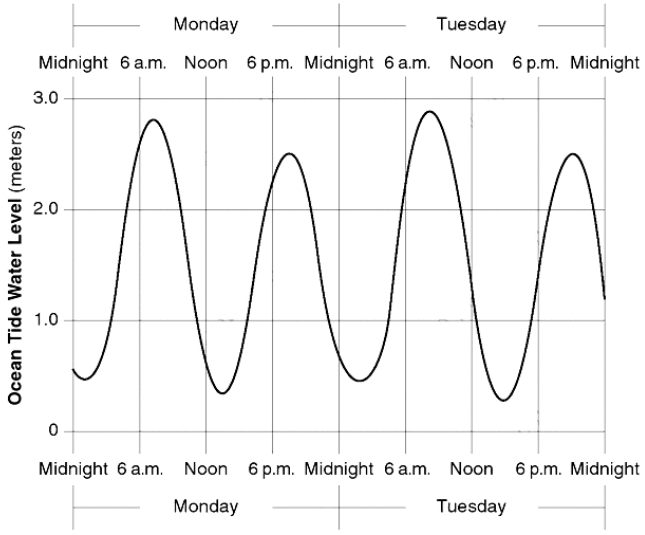
New → waxing → full →waning→ new

IX. Tides

a. Gravity between Moon, Earth and Sun pull water from Earth.

b. Cyclical

- Predicable
  - About 12 hours and 30 minutes from high tide to high tide.

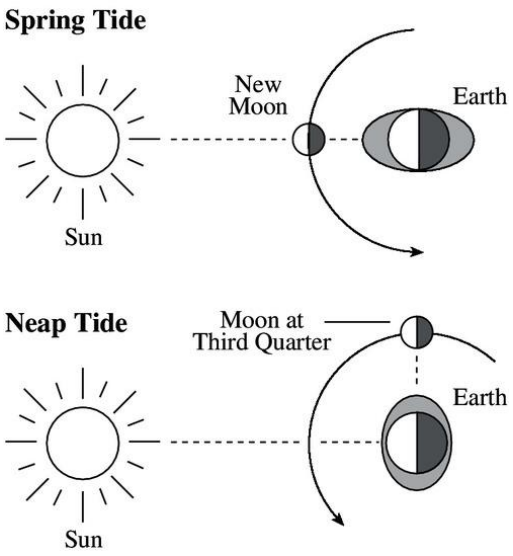


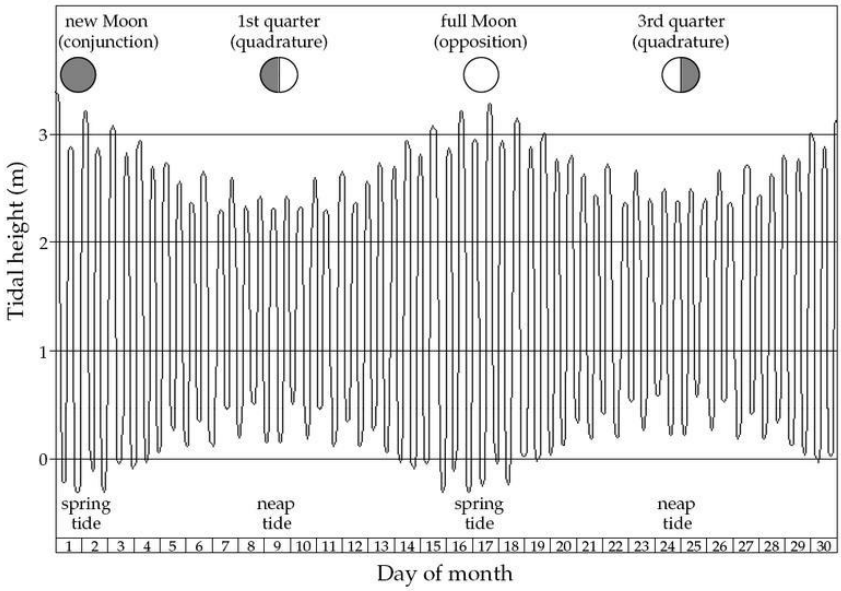
c. Neap tide

- Weak high tides

d. Spring tide

- Strong high tide

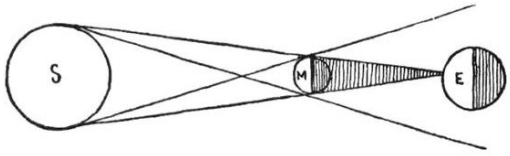




X. Eclipses

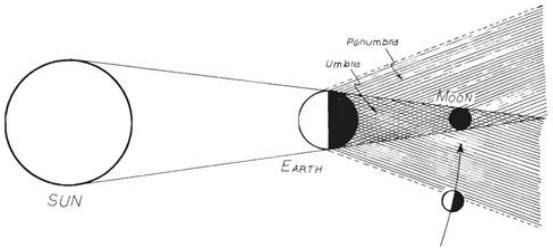
a. Solar

- https://www.youtube.com/watch?v=2iWA2tMgbio
- Shadow of Moon is cast on Earth



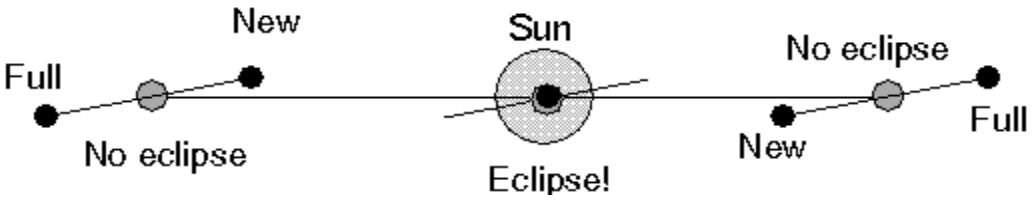
- Conditions are not exact every time for a solar eclipse

b. Lunar eclipse
   - https://www.youtube.com/watch?v=lNi5UFpales
   - Shadow of Earth falls on Moon.



   - conditions are not exact every time for a lunar eclipse

c. Proper conditions



   - The orbit of the Earth to Moon is tilted in comparison to the Earth- Sun orbit
   - Moon's orbit must fall into the Earth – Sun orbit
   - Predictable event

Earth Science Reference Table – (ESRT)

Pages used from the ESRT (page 15)

- Rotation
- Revolution

Students must be able to use diagrams and read charts to be able to solve many problems from this topic.

Sun's path is the most difficult topic followed by moon phases.