Lecture Outlines
PowerPoint

Chapter 21

Earth Science 11e

Tarbuck/Lutgens

Earth Science, 11e

Origin of Modern Astronomy
Chapter 21

Early history of astronomy

- Ancient Greeks
  - Used philosophical arguments to explain natural phenomena
  - Also used some observational data
  - Most ancient Greeks held a geocentric (Earth-centered) view of the universe
    - "Earth-centered" view
      - Earth was a motionless sphere at the center of the universe

Early history of astronomy

- Ancient Greeks
  - Most ancient Greeks held a geocentric (Earth-centered) view of the universe
    - "Earth-centered" view
      - Stars were on the celestial sphere
        - Transparent, hollow sphere
        - Celestial sphere turns daily around Earth

Early history of astronomy

- Ancient Greeks
  - Most ancient Greeks held a geocentric (Earth-centered) view of the universe
    - Seven heavenly bodies (planetai)
      - Changed position in sky
      - The seven wanderers included the
        - Sun
        - Moon
        - Mercury through Saturn (excluding Earth)

Early history of astronomy

- Ancient Greeks
  - Aristarchus (312-230 B.C.) was the first Greek to profess a Sun-centered, or heliocentric, universe
  - Planets exhibit an apparent westward drift
    - Called retrograde motion
    - Occurs as Earth, with its faster orbital speed, overtakes another planet

Early history of astronomy

- Ancient Greeks
  - Ptolemaic system
    - A.D. 141
    - Geocentric model
    - To explain retrograde motion, Ptolemy used two motions for the planets
      - Large orbital circles, called deferents, and
      - Small circles, called epicycles

The universe according to Ptolemy, second century A.D.

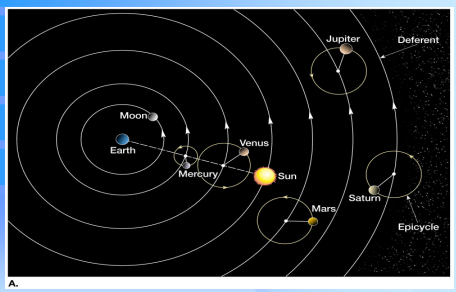

Figure 21.4 A

Retrograde motion as explained by Ptolemy

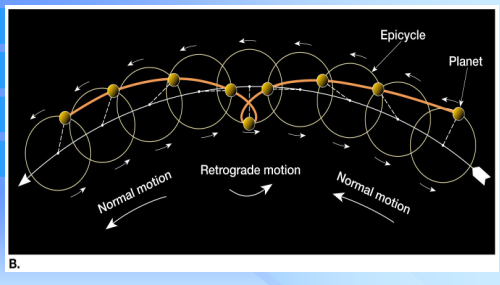

Figure 21.4 B

Early history of astronomy

- Birth of modern astronomy
  - 1500s and 1600s
  - Five noted scientists
    - Nicolaus Copernicus (1473-1543)
      - Concluded Earth was a planet
      - Constructed a model of the solar system that put the Sun at the center, but he used circular orbits for the planets
      - Ushered out old astronomy

Early history of astronomy

- Birth of modern astronomy
  - Five noted scientists
    - Tycho Brahe (1546-1601)
      - Precise observer
      - Tried to find stellar parallax – the apparent shift in a star's position due to the revolution of Earth
      - Did not believe in the Copernican system because he was unable to observe stellar parallax

Early history of astronomy

- Birth of modern astronomy
  - Five noted scientists
    - Johannes Kepler (1571-1630)
      - Ushered in new astronomy
      - Planets revolve around the Sun
      - Three laws of planetary motion
        - Orbits of the planets are elliptical
        - Planets revolve around the Sun at varying speed

Kepler's law of equal areas

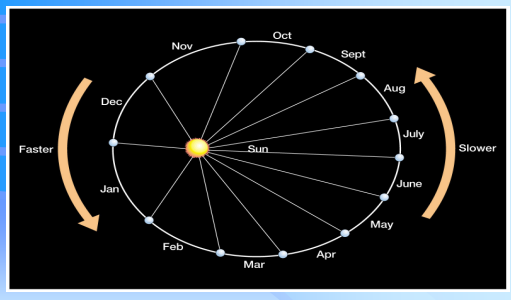

Figure 21.10

Early history of astronomy

- ❖Birth of modern astronomy
  - Five noted scientists
    - Johannes Kepler (1571-1630)
      - Three laws of planetary motion
        - There is a proportional relation between a planet's orbital period and its distance to the Sun (measured in astronomical units (AU's) – one AU averages about 150 million kilometers, or 93 million miles)

Early history of astronomy

- ❖Birth of modern astronomy
  - Five noted scientists
    - Galileo Galilei (1564-1642)
      - Supported Copernican theory
      - Used experimental data
      - Constructed an astronomical telescope in 1609
        - Four large moons of Jupiter
        - Planets appeared as disks
        - Phases of Venus
        - Features on the Moon
        - Sunspots

Early history of astronomy

- ❖Birth of modern astronomy
  - Five noted scientists
    - Sir Isaac Newton (1643-1727)
      - Law of universal gravitation
      - Proved that the force of gravity, combined with the tendency of a planet to remain in straight-line motion, results in the elliptical orbits discovered by Kepler

Constellations

- ❖Configuration of stars named in honor of mythological characters or great heroes
- ❖Today 88 constellations are recognized
- ❖Constellations divide the sky into units, like state boundaries in the United States
- ❖The brightest stars in a constellation are identified in order of their brightness by the letters of the Greek alphabet – alpha, beta, and so on

Positions in the sky

- ❖Stars appear to be fixed on a spherical shell (the celestial sphere) that surrounds Earth
- ❖Equatorial system of location
  - A coordinate system that divides the celestial sphere
  - Similar to the latitude-longitude system that is used on Earth's surface
  - Two locational components
    - Declination – the angular distance north or south of the celestial equator

Positions in the sky

- Equatorial system of location
  - Two locational components
    - Right ascension – the angular distance measured eastward along the celestial equator from the position of the vernal equinox

Astronomical coordinate system on the celestial sphere

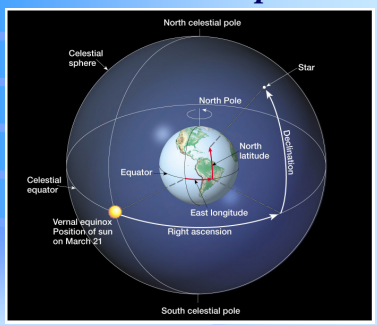

Figure 21.16

Earth motions

- Two primary motions
  - Rotation
    - Turning, or spinning, of a body on its axis
    - Two measurements for rotation
      - Mean solar day – the time interval from one noon to the next, about 24 hours
      - Sidereal day – the time it takes for Earth to make one complete rotation (360°) with respect to a star other than the Sun – 23 hours, 56 minutes, 4 seconds

The difference between a solar day and a sidereal day

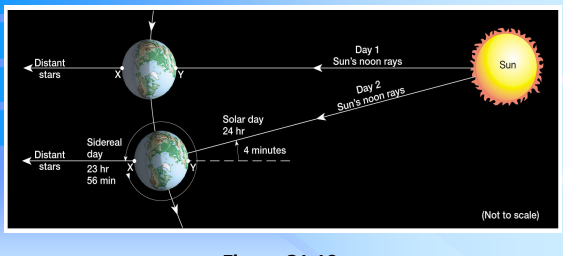

Figure 21.19

Earth motions

- Two primary motions
  - Revolution
    - The motion of a body, such as a planet or moon, along a path around some point in space
    - Earth's orbit is elliptical
      - Earth is closest to the Sun (perihelion) in January
      - Earth is farthest from the Sun (aphelion) in July
    - The plane of the ecliptic is an imaginary plane that connects Earth's orbit with the celestial sphere

Earth motions

- Other Earth motions
  - Precession
    - Very slow Earth movement
    - Direction in which Earth's axis points continually changes
  - Movement with the solar system in the direction of the star Vega
  - Revolution with the Sun around the galaxy
  - Movement with the galaxy within the universe

Precession of Earth

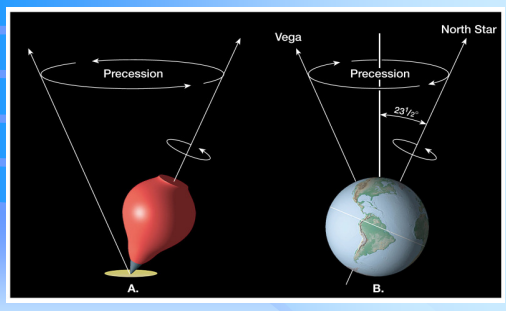

Figure 21.22

Motions of the Earth-Moon system

- Phases of the Moon
  - When viewed from above the North Pole, the Moon orbits Earth in a counterclockwise (eastward) direction
  - The relative positions of the Sun, Earth, and Moon constantly change
  - Lunar phases are a consequence of the motion of the Moon and the sunlight that is reflected from its surface

Phases of the Moon

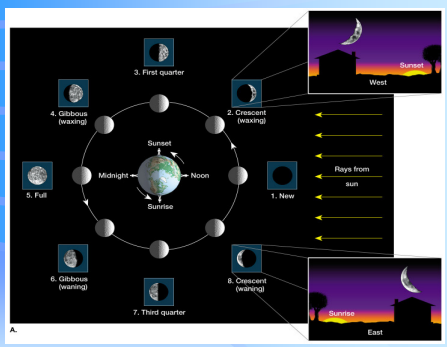

Figure 21.23

Motions of the Earth-Moon system

- Lunar motions
  - Earth-Moon
    - Synodic month
      - Cycle of the phases
      - Takes 29 1/2 days
    - Sidereal month
      - True period of the Moon's revolution around Earth
      - Takes 27 1/3 days

The difference between the sidereal month and the synodic month

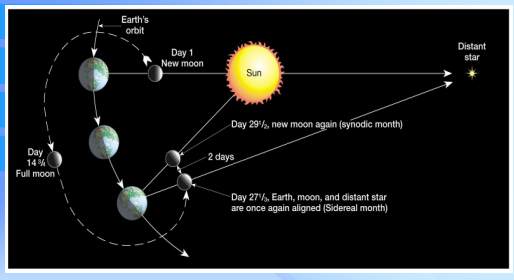

Figure 21.24

Motions of the Earth-Moon system

- Lunar motions
  - Earth-Moon
    - The difference of two days between the synodic and sidereal cycles is due to the Earth-Moon system also moving in an orbit around the Sun
  - Moon's period of rotation about its axis and its revolution around Earth are the same, 27 1/3 days
    - Causes the same lunar hemisphere to always face Earth

Motions of the Earth-Moon system

❖Eclipses

- Simply shadow effects that were first understood by the early Greeks
- Two types of eclipses
  - Solar eclipse
    - Moon moves in a line directly between Earth and the Sun
    - Can only occur during the new-Moon phase

Solar eclipse

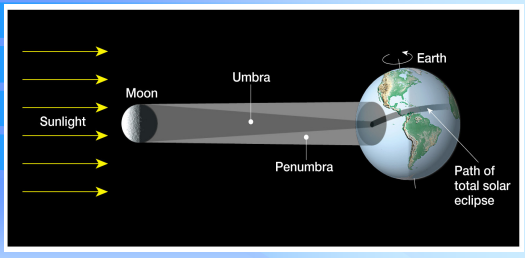

Figure 21.25

Motions of the Earth-Moon system

❖Eclipses

- Two types of eclipses
  - Lunar eclipse
    - Moon moves within the shadow of Earth
    - Only occurs during the full-Moon phase
    - For any eclipse to take place, the Moon must be in the plane of the ecliptic at the time of new- or full-Moon

Motions of the Earth-Moon system

❖Eclipses

- Two types of eclipses
  - Lunar eclipse
    - Because the Moon's orbit is inclined about 5 degrees to the plane of the ecliptic, during most of the times of new- and full-Moon the Moon is above or below the plane, and no eclipse can occur
    - The usual number of eclipses is four per year

Lunar eclipse

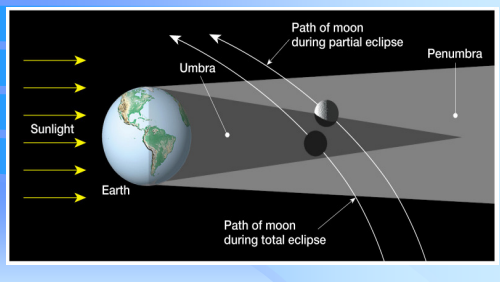

Figure 21.26

End of Chapter 21