Chapter 28: The Sun-Earth-Moon System

Section 1: Tools of Astronomy

Objectives:

1. Describe electromagnetic radiation.
2. Explain how telescopes work.
3. Describe space exploration.

A. Electromagnetic Radiation

- Includes visible light (vis), infrared (IR) and ultraviolet (UV) radiation, radio waves, microwaves, X-rays, and gamma rays
- _____
- Is classified by
  - _____ (λ): the distance between two crests *or* two troughs
  - _____ (*f*): number of waves per second
  - _____

B. Telescopes

- When exploring space, telescopes
  (1) Can focus more light, allowing for the observation of faint objects
  (2) Allow for specialized equipment, such as photometers, which measure the intensity of vis, and detectors, which can detect all λs, to be used
  (3) Can be used to make time exposures to detect faint objects with the aid of imaging devices

1. Reflecting and Refracting Telescopes

- Reflecting telescopes (AKA reflectors): use _____ to bring vis to a focus; make up the majority of telescopes in use today
- Refracting telescopes (AKA refractors): use _____ to bring vis to a focus

Note: Most major observatories are located in remote, high elevation locations in order to minimize light and atmospheric interference.

2. Interferometry

- Is the process of linking separate telescopes together so that they act as one telescope
- Image detail improves with increased distance between telescopes
- Commonly used with radio telescopes but now being applied to other telescopes, as well

C. Space-based Astronomy

- Instruments must be sent into space to collect information because:
  (1) _____
  (2) When Earth's atmosphere does allow certain λs to pass through, the images are blurred.
  (3) It is the only way to make close-up observations of and obtain samples from nearby objects in the solar system.

1. **Space-based Telescopes**
   - *Hubble Space Telescope (HST):* makes observations in vis, IR, and UV λs
   - *Far Ultraviolet Spectroscopic Explorer*
   - *Chandra X-Ray Observatory*
   - *Spitzer Space Telescope*

2. **Spacecraft**
   - Space-based exploration can be achieved by sending spacecraft directly to the bodies being observed (example: lunar rocket).
   - Robotic probes make close-up observations and sometimes land to collect information directly (example: twin Mars rovers, *Spirit* and *Opportunity*).

3. **Human Spaceflight**
   - October 4, 1957: USSR launched the first satellite, _____
   - April 12, 1961: Soviet cosmonaut _____ became the first human in space
   - 1959-1963: _____
     - _____
     - Goal was to put a human in orbit around Earth
     - _____

       _____
   - 1965-1966: _____
     - Goal was to develop techniques for advanced space travel
     - June 3, 1965: Gemini 4 astronaut Edward "Ed" White became the first American to "walk" in space
   - 1961-1975: _____
     - Goal was to conduct manned moon-landing missions
     - January 27, 1967: Apollo 1 astronauts Virgil "Gus" Grissom, Ed White, and Roger Chafee were killed in a cabin fire during a launch pad test
     - _____

       _____
     - Only _____ missions (a total of twenty-four astronauts) made it to the moon... Of those, only six missions landed and only _____ astronauts walked on the moon
   - 1972-2011: Space shuttle program
     - _____
     - Original fleet composed of 4 shuttles: *Columbia*, *Challenger*, *Discovery*, and *Atlantis*
     - April 12, 1981: first shuttle launched (*Columbia*)

- January 28, 1986: *Challenger* exploded shortly after take-off , killing all seven astronauts on board (space shuttle *Endeavor* added after loss of *Challenger*)
- February 1, 2003: *Columbia* exploded during re-entry, killing all seven astronauts on board

- 1993-present: _____
  - Goal was to study the long-term effects of space on life
  - 2000-present: full-time habitation and research began

4. Spinoffs

- Are technologies originally developed for use in space programs that have become commonly used
- Include >1400 different NASA technologies have been incorporated into products such as artificial hearts and cordless tools

Section 2: The Moon

Objectives:

1. Describe the development of exploration of the Moon.
2. Identify features on the Moon.
3. Explain the theories about how the Moon formed.

A. The Moon

1. Properties

- Is the only large natural satellite among the inner four planets and is the fifth largest natural satellite in the solar system
- Is one of the largest natural satellites in the solar system when compared to the size of the planet it orbits: _____
- Is relatively farther from Earth than most natural satellites are from the planets they orbit
- _____
- Is the second densest natural satellite in the solar system

2. Surface

- Has an average albedo ≈ 0.07 (7%) vs. Earth's average of 0.31 (31%)
- _____
  _____
- Has no flowing water, either, so does not experience erosion, except for surface creep and wear caused by recent impacts
- Craters on the Moon are preserved until one impact covers another.
- Features:
  - Terrae (*singular*, terra): AKA _____; light-colored, mountainous regions that are covered with craters
  - Maria (*singular*, mare): dark, smooth plains-like regions, whose elevations are 3 km lower (on average) than the highlands

- Impact craters: scars produced by the impact of space debris, such as meteoroids, comets, etc., which are preserved on the surface until another impact occurs; produce ejecta, which may occur in the form of rays
- Lunar regolith: soil created by impact
- Rilles: German for "groove;" the long, narrow valleys on the lunar surface

3. Composition

- Is made up of minerals (mostly silicates) similar to those of Earth
  - Terrae: predominately _____
  - Maria: predominately anhydrous (i.e., contains no water) _____
  - _____: rock formed by the impact-induced fusing together of smaller pieces of rock

B. History of the Moon

- 3.8-4.6 heavy bombardment period results in the formation of terrae and regolith
- 3.1-3.8 bya: lava upwells from inside the Moon and fills in the larger impact basins, which results in the formation of the maria

1. Tectonics on the Moon?

- _____
  _____
- Although the Moon does experience moderate *moonquakes* (~1/yr), scientists theorize that it is ***not*** tectonically active because it has

  (1) _____

  (2) _____

2. Formation Theories

(1) Capture Theory: states that as the solar system was forming, a large object came too close to the forming Earth, became trapped in its gravitational pull, and formed into what is now the Moon

(2) Simultaneous Formation Theory: states that the Moon and Earth formed at the same time and in the same general area, and thus the materials from which they formed are essentially the same

(3) Impact Theory
- States that the Moon formed as the result of a gigantic collision between Earth and a Mars-sized object about 4.5 billion years ago, when the solar system was still forming
- Is the most commonly accepted theory of lunar formation

Section 3: The Sun-Earth-Moon System

Objectives:

1. Identify the relative positions and motions of Earth, the Sun, and the Moon.
2. Describe the phases of the Moon.
3. Explain eclipses of the Sun and Moon.

A. The Sun-Earth-Moon System

- The Sun provides light, warmth, and energy.
- The Moon raises tides and illuminates our night sky.
- Every society throughout history has based its calendar and timekeeping system on the apparent motions of the Sun and Moon.

B. Daily Motions

- _____
- As a result of Earth's rotation, the Sun rises in the E and sets in the W, as do the Moon, planets, and stars.
- Two ways to demonstrate that Earth is rotating:
  (1) _____
  (2) _____: the diversion of flowing air and water from a N-S direction to an E-W direction
- Our timekeeping system is based on the solar day, or _____, which is the time period from one sunrise or sunset to the next, or 24 hours. However, this is a little longer than the 23 hours, 56 minutes, and 4 seconds it takes Earth to rotate once on its axis, which is known as a rotational day, or _____.

C. Annual Motions

- The annual changes in day length and temperature are the result of Earth's orbital motion about the Sun.
- Earth orbits the Sun in a plane called the _____.
- _____
- As Earth orbits the Sun, the orientation of Earth's axis remains fixed.
- _____ is measured in degrees from the observer's horizon to the object. There are 90^{o} from the horizon to the point directly overhead, called the _____ of the observer.

1. Solstices

(1) Summer (Aestival)
- _____
- Corresponds to the Sun's maximum altitude in the sky in the N hemisphere

(2) Winter (Hibernal)
- _____
- Corresponds to the Sun's lowest altitude in the sky in the N hemisphere

2. Equinoxes

(1) _____: occurs around September 21, halfway between the summer and the winter solstices when the Sun is directly over the equator

(2) _____: occurs around March 21, halfway between the winter and the summer solstices when the Sun is directly over the equator

D. Phases of the Moon

- _____: the sunlit portion of the Moon is increasing
- _____: the sunlit portion of the Moon is decreasing
- _____: when the Moon is between Earth and the Sun and the sunlit side is facing away from Earth
- _____: the entire sunlit side of the Moon
- _____
  _____
  _____

E. Motions of the Moon

- Lunar month: the length of time it takes for the Moon to go through a complete cycle of phases = 29.5 days
- _____
  _____
  _____
- The Moon also rises and sets 50 minutes later each day because the Moon moves 13° in its orbit over a 24-hour period, and Earth has to turn an additional 13° for the Moon to rise.
- Tides
  - The Moon's gravity pulls on Earth along an imaginary line, creating bulges of ocean water on both the near and far sides of Earth. As Earth rotates, these bulges remain aligned with the Moon.
    (1) _____: higher-than-normal tides; due to the Sun and Moon aligned along the same direction
    (2) _____: lower-than-normal tides; due to the Moon being at a right angle to the Sun-Earth line

F. The Effects of Orbits

- The Moon's distance from Earth increases and decreases as it moves in its elliptical orbit around Earth.
  - _____: closest point in the Moon's orbit to Earth
  - _____: farthest " "
- The Moon's orbit is tilted 5° relative to the ecliptic… A solar eclipse can occur only when the intersection of the Moon and the ecliptic is in a line with the Sun and Earth.

G. Solar Eclipses

- _____
  _____
- Total solar eclipse
  - Occurs when the Moon perfectly blocks the Sun's disk and only the dim, outer gaseous layers of the Sun is visible
  - Seen by those in the umbra, or the inner portion of the shadow that does not receive direct sunlight
- _____: occurs when the Moon is near apogee and does not completely block the disk of the Sun
- Partial solar eclipse
  - Occurs when the Moon blocks only a portion of the Sun's disk
  - Seen by those in the _____, or the outer portion of the shadow that receives partial sunlight

H. Lunar Eclipses

- _____
- Can happen only during a full moon, when the Moon is in the opposite direction from the Sun
- Total lunar eclipse: occurs when the entire Moon is within Earth's umbra
- Occur *slightly* more than solar eclipses