ASTRONOMY

I. Stars and Galaxies

A. _____: A hot gaseous sphere that radiates energy from its surface into space.

1. Distances to Stars

a. _____:
   (1) Distance measured to the _____, the closest star to Earth.
   (2) Equal to the average distance between the Sun and Earth (150,000,000 km or 93,000,000 mi.)
   (3) Used for distances within our Solar System.

b. _____:
   (1) The distance that a ray of light travels in one year
   (2) At the speed of light (300,000 km/sec or 186,000 km/sec) light travels about 9.4 trillion kilometers (5.8 trillion miles) in one year
      (a) Double stars of Alpha Centuri are about 4.3 LY from Earth.
      (b) The red giant star Betelgeuse is nearly 490 LY from Earth.

c. _____: A larger unit of distance that is equal to 3.26 light years.

2. Physical Properties of Stars

a. *Sizes vary over a great range*.
   (1) Smallest stars may be smaller than _____.
   (2) Largest stars can be more than 2000 times the diameter of the _____.

b. *Density*:
   (1) _____: Betelgeuse (a red giant) is one ten millionth (_____) of the Sun's density.
   (2) _____: Companion star to Sirius is so dense that one teaspoon would weigh more than **one ton** on Earth.

c. *Mass*
   (1) Variation in mass is less than variation in density.
   (2) Most stars have masses _____ of the Sun's to _____times that of the Sun.

d. *Composition*:
   (1) One or two percent of a star's mass may be *heavier elements* such as oxygen (___), carbon (___), calcium (___), and sodium (___).

   (2) Main elements in the Sun are
      (a) _____
      (b) _____

e. *Brightness of Stars*

(1) _____

(a) How bright the star _____ to an observer on Earth.
(b) Brightest stars are first magnitude.
(c) Faintest stars are sixth magnitude
(d) Each magnitude represents a change by a factor of 2.5 magnitudes.
i) A first magnitude star is 2.5 times brighter than a second magnitude star.
ii) A first magnitude star is 100 times brighter than a sixth magnitude star.
(e) Objects brighter than first magnitude objects are _____.
(f) Apparent Magnitudes of Familiar Objects

OBJECT	MAGNITUDE	OBJECT	MAGNITUDE
Sun	-26.5	Aldebaran	+0.0
Full Moon	-12.5	Polaris	+0.9
Venus at Brightest	-4.4	Naked Eye Limit	+2.0
Jupiter	-2.5	Binocular limit	+9.0
Sirius	-1.4	5-meter telescope (visual)	+20.0

(2) Factors Affecting Apparent Magnitude

(a) _____: The farther a star is from the observer, the dimmer it appears *if all other factors are equal*.

(b) _____: Larger stars will appear brighter than smaller stars *if all other factors are equal.*

(c) _____: Hotter stars will appear brighter than cooler stars *if all other factors are equal*.

(3) _____

(a) Called _____
(b) This is the _____ brightness of a star.
(c) Depends on two factors
i) _____: Hotter stars emit greater intensity light than cooler stars
ii) _____: Larger stars are brighter than smaller stars
(d) Compares the brightness of stars on an _____ basis. Astronomers determine the *luminosity* by mentally moving all stars to a distance of 32.6 light years (10 parsecs) and then determining their magnitudes as seen from that distance.

3. <u>The Hertzsprung-Russell (H-R) Diagram</u>

a. Early in the 20th century two astronomers (Ejner Hertzsprung of Denmark and Henry N. Russell of the United States) working independently established the relationship between the surface temperature of a star and its luminosity. As a result, the graphic result of their work was named in their honor as the *H-R Diagram.*

b. Stars of a known distance have been plotted according to their spectral class)as determined by the _____ and _____) and their absolute magnitude.

c. The "Luminosity and Temperature of Stars" chart on page 15 of the *Earth Science Reference Tables* is a simplified H-R Diagram.

(1) Horizontal Axis: Instead of using the stellar spectrum classes (e.g., O5, B3, A1, A3, F0, etc.) temperature using the Celsius scale instead of the absolute scale (Kelvins) and color are used.
(2) Vertical Axis: Instead of using the actual luminosities, absolute brightness is shown in terms of the Sun's brightness.

4. Our Sun
   a. *Properties of the Sun*
      (1) Size: _____ times Earth's diameter (1.38×10^6 km)
      (2) Volume: Could hold more than _____ Earth's.
      (3) Temperature:
         (a) _____ temperature is about 5,550° Celsius (~10,000° Fahrenheit).
         (b) _____ temperature may be as high as 15,000,000° Celsius

      (4) Mass: 745 times greater than the combine mass of all the planets in the Solar System.

   b. *The Source of the Sun's Energy*
      (1) _____ of light elements into heavier elements.
      (2) _____ converts to _____
         (a) Four _____ (H) nuclei (each with a mass of about 4.030 mas units) join to form a _____ (He) nucleus with a mass of only about 4.003 energy units.
         (b) The mass that seems to have been lost is converted into _____, which is radiated into space.
         (c) Estimates indicate that about 4 million metric tons of matter are converted into energy every second but because the Sun is so massive, this process can continue for another five billion years!

   c. *The Sun's Atmosphere*

      (1) _____
         (a) Bright yellow surface
         (b) 400 km thick
         (c) Made of millions of *granules* (individual cells). Granules are wide (about 1500 km across), have a bright center, dark edges, and are the tops of columns of gases that are rising in the center and sinking at the edges. Granules last 8 minutes.
         (d) This is the lower denser part of the Sun's atmosphere.

      (2) _____
         (a) Only seen during solar eclipses
         (b) _____
            i) Lower part of the atmosphere
            ii) Colored red by glowing hydrogen
            iii) Extends thousands of kilometers about the photosphere

(c) _____
   i) Has so little gas that on Earth it would be considered a vacuum.
   ii) Surrounds the Sun to a height of more than one million kilometers.
   iii) During a solar eclipse it is seen as a faint, pearly light.

(3) _____
   (a) Huge, red, flame-like arches of material that occur in the corona.
   (b) Appear like flames but the light is caused by changes in the cooler, denser parts of the corona.
   (c) Prominences may last for hours and can extend millions of kilometers about the photosphere.

(4) _____
   (a) Dark spots on the _____.
   (b) Size may be greater than Earth's diameter.
   (c) Lifetime varies from a few hours to a few months.
   (d) Have a dark center.
   (e) Occur in pairs. One is a north magnetic pole and the other is a south pole.
   (f) Because of the concentration of magnetic forces, gases in a sunspot may be as much as 1,500° C cooler than the surrounding photosphere.
   (g) Due to the Sun's rotation (25 days at the equator and 27 days near the poles) sunspots move from left to right across it's surface.
   (h) _____: The number of sunspots varies over an ____-year cycle.

5. Stellar Spectra
   a. *The Electromagnetic Spectrum*

      (1) _____:
         (a) Travels out in all directions from its source.
         (b) Does not need a medium through which to travel.

      (2) Electromagnetic energy travels through space at the _____.
      (3) Electromagnetic energy is defined by _____ which affects it's frequency.

      (4) The entire range of wavelengths, from radio waves to gamma rays, makes up the *electromagnetic spectrum* (page 14 in the *Earth Science Reference Tables*).

   b. *Spectral Analysis*

      (1) Separates light into different wavelengths.
      (2) _____: Replaces the eyepiece of a telescope with a photographic plate.

(3) Types of Observable Visible Spectra

(a) _____ Spectrum

i) Unbroken band of colors
ii) Indicates that the source is emitting light of all visible wavelengths.
iii) Three kids of materials emit visible spectra.
a) Glowing _____
b) Glowing _____
c) Hot compressed _____ (as in a star)

(b) _____ Spectrum

i) Called an *emission spectrum*
ii) Light of only _____ wavelengths is present.
iii) Originate from chemical elements when in a glowing gas or vapor state.
iv) Each _____ has its own unique bright line spectrum.

(c) _____ Spectrum

i) Called an _____ spectrum
ii) Continuous spectrum with dark lines created by selective absorption of light.
iii) Lines coincide with _____ lines of the element's bright line spectrum.
iv) Produced when _____ gases lie between the source and the spectrograph. The cooler gas absorbs the same wavelength it would emit when heated.
a) Atmospheres of stars are much cooler than their interiors.
b) Most stars have absorption spectra.
c) The Sun's absorption spectrum has 67 elements.
v) Determination of the Atmosphere of a Planet can be made using absorption spectrum
a) Planets shine due to _____ light from the Sun.
b) Dark lines present in the spectrum of the planet that are not present in the spectrum of the Sun must have originated in the planet's atmosphere.

6. <u>The Life Cycle of a Star</u>

a. _____: Huge clouds of gas and dust
(1) About 99% of the cloud is gas, mostly hydrogen.
(2) The remaining 1% is dust (1/10,000 cm in diameter) consisting of silicon, carbide, graphite, diamond, and minor amounts of nitrogen and other elements.
(3) Average nebula is 25 light years in diameter.
(4) An outside force (e.g., shockwave from a supernova) triggers the force of gravity between atoms of gas and dust and they move towards each other.
(5) Cloud becomes denser.
(6) Temperature increases.
(7) Parts start to glow when the temperature is high enough. It is now a _____.

b. Continued contraction increases the density of the protostar.

c. Fusion begins and the star is born.

d. When the release of energy counterbalances the force of gravity the star stops contracting and is said to be in a _____.
   (1) Massive blue stars may reach a stable state in a few hundred thousand years.
   (2) Less massive yellow stars may take millions of years to reach a stable state.

e. Eventually the light nuclei in the core (helium in the case of the Sun) become depleted.
   (1) Energy of fusion no longer balances the force of gravity and the core contracts again.
   (2) The core heats up and the star's outer layers expand causing the star to radiate more light and become brighter.
   (3) Fusion starts again in the outer layers but the core is now composed of only helium.
   (4) The result is the continued expansion of the star and the formation of a red giant or a supergiant.

f. _____
   (1) Final stage of a star's life
   (2) Most of the fuel for fusion is depleted.
   (3) Temperature and pressure of the core can no longer support the weight of the outer layers.
   (4) Collapse of the giant squeezes the nuclei of its atoms together and the star becomes a white dwarf that is most likely no larger than Earth.

g. _____
   (1) White dwarf flares increasing in brightness a hundred to a million times.
   (2) Might be caused by collision with a companion star.

h. _____
   (1) Very massive stars
   (2) When the star cools a central iron core collapses.
   (3) Increased temperature and pressure fuses iron with heavy elements result in a violet explosion that blows away half it's mass as a great cloud.
      (a) After a supernova the mass that remains is called a *neutron star* because astronomers believe during the explosion all atom's electrons are crushed in the nucleus and combine with protons to form neutrons.
      (b) If the star is very massive the star collapses into a very small volume with gravitational forces so strong that even light cannot escape. These invisible objects are called *black holes.*

i. The Life Cycle of a Star and the H-R Diagram.
   (1) As stars go through their life cycle they change characteristics and thus will be plotted at different locations on the H-R Diagram.
   (2) Most stars are grouped in a diagonal band called the *Main-Sequence.* This grouping is where a star spends the majority of it's life-time.

B. _____
1. A galaxy is a system containing _____ or _____ of stars.
2. Space contains several _____ galaxies.
3. Galaxies glow from the combined light of billions of stars.
4. Classification of galaxies is according to _____: There are three main types
   a. _____
      (1) Central lens-shape, bright nucleus surrounded by a flat disk.
      (2) Spiral arms (usually two) come out from opposite sides and trail behind as the galaxy rotates.

b. _____:
(1) Range from nearly spherical to lens-shaped.
(2) No arms are present.

c. _____:
(1) These are smaller, fainter, and less common than other types of galaxies.
(2) Stars are spread unevenly.
(3) The two Magellanic Clouds are irregular galaxies.

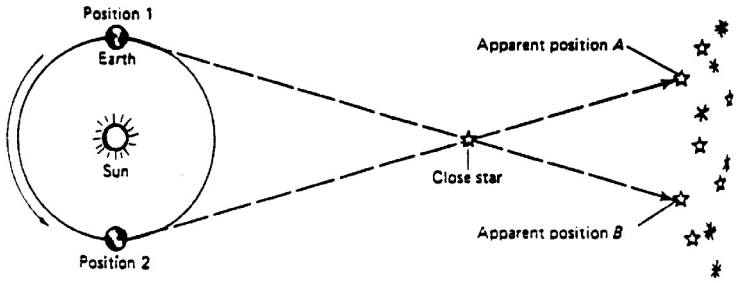
5. _____
a. The home galaxy to which the Sun belongs.
b. Spiral Galaxy.
c. Diameter: 140,000 light years
d. Greatest thickness: 20,000 light years.
e. Sun: About 23,000 light years from the galaxy's center. (See Rev. Book *Figure 9-1*, p. 425)
f. Approximately 100 billion stars.
g. Belongs to a small cluster of 17 galaxies know as the _____.

C. Finding Distance in the Universe

1. *Spectroscopic Distance* (Apparent vs. Absolute Magnitude)
a. Knowing the spectral class allows its _____ magnitude to be determined.
b. Difference between apparent magnitude and absolute magnitude is a result of the distance of the star from Earth.
c. Distance is mathematically determined.

2. Stellar _____

a. Because Earth revolves around the Sun in its orbit, a star that is relatively nearby appears to change position against the background (faraway) stars.
b. The angular separation at two dates (6 months apart) can be measured. This is angle "p" in the diagram shown below.
c. Using the known distance from Earth to the Sun, the distance to the nearby star can be determined geometrically using a right triangle.



3. _____
a. A radar pulse is reflected off a solid object such as the moon.
b. The time of the round-trip is measured with high accuracy.
c. Using rate (speed of light) and time the distance can be mathematically determined.

4. _____: Same method as radar.

II. **Theories on the Origin of the Universe and Solar System**

A. The _____

1. The entire universe was a very hot dot, smaller than the diameter of an atom
2. 15 billion years ago (More recent research indicates that the universe is 13.7 billion years old with only a 1% margin error.)

    a. Expanded faster than the speed of light
    b. Mechanism that initiated the event is still being researched.
3. As expansion occurred:
    a. It cooled and matter and antimatter, such as quarks and leptons (along with their antimatter twins, antiquarks and antileptons) smashed into each other an annihilate one another.
    b. This left behind a small residue of matter and a great deal of energy.
4. Cooling eventually became cool enough to form atoms of hydrogen, helium, deuterium, and lithium
5. Gravity gathered gases and dust into massive globs that eventually collapsed in on themselves until fusion reactions were ignited and the first stars were born (200 million years after the Big Bang).
6. Peak of galaxy formation occurred when the universe was about three billion years old.

B. <u>Evidence for the Expanding Universe</u>

1. The _____ Effect

    a. There is a change in _____ of light or sound waves as a source moves towards or away from the observer.
        (1) Approaching: Frequency increases _____
        (2) Receding: Frequency decreases _____

    b. _____:

        (1) Black lines of a star's spectrum are shifted to the red end of the spectrum
        (2) Indicates that distance between the star and Earth is _____.
        (3) The greater the shift, the greater the velocity of the source.

2. <u>Cosmic Microwave Background Radiation</u>

    a. Energy output from expansion as a result of the Big Bang should appear cooled and should exhibit itself as background radiation equivalent to a cold blackbody (Theoretically, blackbody is a perfect radiator. It absorbs and reemits all radiation which falls on it.)

    b. New data (published in February 2003) shows images of the Big Bang's "afterglow", known as *cosmic microwave background.*

    c. This is evidence supporting the Big Bang theory.

C. Origin of the Solar System (_____ Theory)

1. Planets formed at the _____ as the Sun and from the same nebular material.
2. The Solar System is believed to be _____ years old.
3. Huge gas and dust cloud became unstable.
   a. Due to gravitational attraction a condensation formed at one point becoming the _____.
   b. The cloud rotated faster as it contracted.
   c. Some gas and dust was left in a flattened disk surrounding the protosun.
   d. Condensation occurred within the disk forming _____ which continued to move in the same direction as the disk.
4. As material in the disk became more concentrated in the protoplanets:
   a. Space between the new Sun and the protoplanets cleared;
   b. Light and heat was able to reach them driving off lighter elements and even most of its atmosphere leaving a more dense core of heavier elements.
5. _____ Planets
   a. Closer to the Sun and most lighter elements driven off.
   b. Small, rocky, and dense
   c. Mercury, Venus, Earth, Mars
   d. No atmosphere.
   e. Numerous impacts from objects from space (meteors, comets)
   f. _____: Atmosphere evolved from the release of water from volcanoes.
   g. _____: Some meteorites contain water which likely was released into the impact when the vaporized upon impact with Earth's surface.
   h. Origin of Earth's Oceans: Release of water from precipitation over millions of years early in Earth history.
   i. Planets beyond Mars are made of lighter elements and are the _____.

III. Motions of the Planets

A. Two Views of Planetary Motion in the Solar System

1. _____ (See Rev. Book *Figure 9-12*, page 450)
   a. Based on celestial observations from Earth, it was thought by early civilizations (and up through the Renaissance) that
      (1) Earth was located at the _____ of the solar system and is motionless
      (2) Stars were located on a transparent sphere that rotated each day from _____.
      (3) The Sun, moon, and each planet were carried by separate spheres.
      (4) Each planet is located on an _____ that rotates at a fixed rate. This was to explain the phenomenon of _____ motion.
   b. This is the model advanced by the Greek astronomy Ptolemy (Claudius Ptolemaeus) in the second century.
   c. Difficulties with the Geocentric Model.
      (1) Through the centuries, as more and more data accumulated, the astronomers kept adjusting the model to make it work better.
      (2) By 1500 the model had become very complicated and it still didn't work well.
      (3) And, it's not correct!

2. _____

   a. The planets revolve around the _____.
   b. Polish astronomer Nicolas Copernicus proposed this model in 1543.
   c. It would be many years until the modern model of the solar system was refined. Copernicus had the Sun in the exact center of the solar system and the planets revolving in perfect circles. This was later shown to be incorrect by Kepler.
   d. Accounts for _____ motion of planets. (See Rev. Book *Figure 9-13*, page 451)

B. Kepler's Laws of Planetary Motion:

Johannes Kepler (1571-1630) used the accumulated data of Danish nobleman Tycho Brahe to develop *three laws of planetary motion*. Tycho's careful measurements of the positions of stars and planets were made without the use of a telescope over a period of 20 years and were the first long-term observations of the sky.

1. *Kepler's First Law of Planetary Motion*

   a. The orbit of each planet around the Sun is an _____.
   b. The Sun is located at a _____ within the elliptical orbit and is *not at the exact center of the orbit.*

2. *Kepler's Second Law of Planetary Motion* (See Rev. Book *Figures 9-15* and *9-16*, page 454)

   a. Each planet moves around the Sun so that an imaginary line (_____) joining the planet and the Sun will sweep over _____.

   b. This means that because the orbits are elliptical, the planet's travel at different speeds at different positions in the orbit.
      (1) _____
         (a) The planet's position in it's orbit where it is _____ to the Sun.
         (b) The speed is _____ at perihelion.

      (2) _____
         (a) The planet's position in it's orbit where it is _____ from the Sun.
         (b) The speed is _____ at aphelion.
         (c)

3. *Kepler's Third Law of Planetary Motion* (Called the **Harmonic Law**)

   a. The time it takes the planet to revolve around the sun (it's _____) is equal to the cube it its distance from the Sun. The period (P) must be in Earth years and the distance (D) must be in astronomical units. The equation can be stated: $\mathbf{P^2 = D.^3}$

   b. This further states that _____

      _____

C. Celestial Mechanics Affecting Planetary Motions

1. *The Three Laws of Sir Isaac Newton* (1642-1727)

   a. Newton's First Law
      (1) Every body continues in it's state of rest, or of uniform motion unless _____

      (2) An object _____ at rest or _____ to move in direction and velocity.

      (3) Law of _____.

   b. Newton's Second Law: _____

   c. Newton's Third Law: Every action has an _____.

2. *Newton's Universal Law of Gravitation*

   a. Referred to as the _____.

   b. The force of attraction between two bodies is directly proportional to the product of their masses *and* inversely proportional to the square of the distance between their centers.

   c. Expressed mathematically as $F \propto \frac{m_1 \bullet m_2}{d^2}$

   (Where F is the force between the objects, m_1 is the mass of the first object, m_2 is the mass of the second object, and G is the gravitational constant which is equal to 6.67×10^{11} N • meter^2/kg^2 . A newton (now called a Joule is the force necessary to accelerate a 1 kilogram mass one meter per second squared. This can be expressed as 1kg •m/sec^2)

   d. Examples:

IV. Earth Motions: Rotation vs. Revolution

A. _____:

1. Earth spins on it's _____, the imaginary straight line through Earth between the North Pole and the South Pole

2. The axis of rotation is _____ 23 ½ degrees from a perpendicular to the plane of Earth's orbit.

3. The north axis always stays aimed towards the North Star (_____).

4. The Rate of Earth's Rotation

   a. Earth makes one complete turn from _____ to _____ every _____.
   b. Angular Rate of Rotation: One complete rotation is equal to _____ degrees in 24 hours or _____.
   c. Linear Rate of Rotation: (See Rev. Book *Figure 9-17* on page 459)
      (1) Speed changes with _____ north or south of the equator.
      (2) The greater the latitude, the _____ the speed.
      (3) At the equator the speed is 1,000 miles/hour or 1,670 km/hour.

5. *Evidence of Earth's Rotation*

   a. The Foucault Pendulum (pronounced foo-koe) See Rev. Book *Figure 9-18*, page 460

      (1) Once set in motion, a free-swinging pendulum will continue to swing along the same path unless acted upon by an outside force due to _____.
      (2) In 1851Jean Bernard Leon Foucault performed his third demonstration using the principal of a pendulum to prove that Earth rotates.
      (3) A steel wire 220 feet long heavy weight (bob) of lead in copper at its end was suspended from the Pantheon in Paris.
         (a) After a period of time it *appeared* that the direction of the pendulum's path had changed but no outside force had affected it.
         (b) He concluded _____
         _____

   b. Apparent Motion of Celestial Objects

      (1) Circumpolar Motion of Stars in the North Sky (See Rev. Book *Figures 9-8* & *9-9*, p. 446)

      _____

      (2) In the southern sky, the sun, the moon, stars, and planets appear to _____
      _____

      (3) _____: When photographs of stars are taken in the night sky using long-term exposures they appear as streaks of light rather than points of light.

(4) _____ Effect

(a) Objects moving over Earth's surface appears to be deflected from a straight path and curve.
(b) This is due to the fact that Earth rotates at different speeds at different latitudes.
(c) North Hemisphere deflection: _____
(d) Southern Hemisphere deflection: _____
(e) The Coriolis Effect is responsible for the curved path of:
_____

(f) Observations from Space

B. Revolution (See Rev. Book *Figure 9-20*, page 467)

1. Revolution is the motion of Earth traveling around the _____ in it's _____ .

2. _____ of Earth's axis: The position of Earth's axis is parallel to every other position of the axis.

   a. This is the cause of _____ on Earth.

   b. _____: When the hemisphere "leans" _____ the sun.

      (1) The apparent path of the sun is the _____.

      (2) The sun reaches it's _____ altitude for the year.

      (3) _____ period of daylight.

   c. _____: When the hemisphere "leans" _____ from the sun.

      (1) The apparent path of the sun is the _____.

      (2) The sun reaches it's _____ altitude for the year.

      (3) _____ period of daylight.

3. *Seasonal Change in Constellations*

   a. _____ are groups of stars appearing to form _____.

   b. If Earth didn't revolve we would see the same constellations in the sky throughout the year.

   c. As Earth revolves, the night side faces a _____ part of the celestial sphere. As a result, there is a seasonal change in constellations observed.

V. **The Moon's Motions and Phases**

A. The Moon's Orbit

1. The moon _____ around Earth from _____ to _____.
2. The moon's orbit is an _____.
3. The plane of the moon's orbit is inclined to Earth's at about 5 degrees.
4. The moon takes _____ days to make one complete revolution around Earth.

B. Moonrise and Moonset

1. Like the sun, the moon rises in the _____ and sets in the _____.
2. The moon rises at a _____ time each night.
   a. Every 24 hours the moon travels about 13° in its orbit.
   b. When Earth has rotated 360° the moon can't be seen because it has moved in its orbit. As a result, Earth must rotate an addition 13° to see the moon.
   c. Moonrise and Moonset occur about _____minutes later each night.
   d. Moonrise will appear in the sky to east of its Moonrise position the previous night.

C. Phases of the Moon (Refer to Rev. Book *Figure* 9.27, page 478)

1. _____ (____%) of the moon is always in sunlight.

2. As the moon revolves around Earth we don't always see all of the illuminated portion of the moon because we see it from different angles.

3. As a result, the moon appears to _____ during the month. These changes in shape are called _____.

   a. For the first approximately 14 days, the moon appears to _____ in size.
   b. The lighted portion of the moon is on the _____ side.
   c. The moon is said to be _____.
   d. From the full moon to the new moon the moon appears to get _____.
   e. The lighted portion of the moon is on the _____ side.
   f. The moon is said to be _____.
   g. The complete cycle of phases, from new moon to new moon takes _____ days and is referred to as the _____month.

4. _____: Within a few days of the new moon the faint outline of the entire circular disc of the moon, along with the bright crescent can be seen. This is due to sunlight reflecting off Earth and illuminating the dark side of the moon.

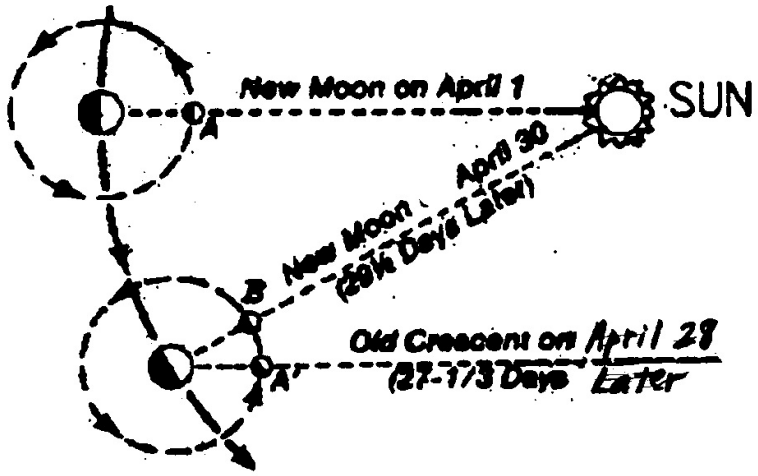
D. The Lunar Month vs. the Sidereal Month

1. The moon's period of revolution around Earth is _____ days.

2. The actual period of revolution is called the _____ month.

3. This is 2.2 _____ than the lunar month.

4. The difference between the lunar month and the sidereal month is described below and illustrated by the diagram.
   a. A new moon occurs when the moon is between Earth and the Sun.
   b. At position A in the diagram the moon is between Earth and the Sun, as viewed from Earth.
   c. At position A, an observer on Earth would see a new moon.
   d. When the moon revolves around Earth to position A', it is 27.3 days later.
   e. The entire Earth-moon system has travel in space along its curved orbit around the Sun.
   f. When the moon has reached position A' it has traveled one complete revolution around Earth.
   g. At position A' the moon is seen against the same background stars as it was at position A (sidereal month.
   h. At A' the moon is not between Earth and the Sun. The phase is not yet new.
   i. The moon requires an additional 2.2 days to swing around that extra angle to reach position B. Here it is between Earth and the Sun once more. A new moon would be seen from Earth.
   j. Total time = 27.3 days + 2.2 days + 29.5 days (Lunar Month.)



The lunar month, 29½ days, is the time span from one new moon to the next. The diagram shows why the lunar month is longer than the moon's period of revolution, 27⅓ days.

E. Eclipses (See Rev. Book *Figure 9.27* (page 478) and *Figures 9-28, 9-29, 9-30* (page 479)

1. Eclipses occur when Earth passes into the shadow of the moon or when the moon passes into Earth's shadow.

2. Because the Sun is a _____ and not a point of light, there are two parts of the shadows of Earth and the moon.

   a. _____: Inner section and total darkness.
      (1) Is a long narrow cone-shape.
      (2) The tip of Earth's umbra is nearly 1,400,000 km beyond Earth

   b. _____: Outer section and partial darkness.

3. _____ Eclipse.

   a. Occurs during a _____moon phase.
   b. Duration may last for up to _____ hours.
   c. The moon remains visible as a dusky red-orange or coppery color due to some sunlight being refracted through Earth's atmosphere into the umbra.

4. _____ Eclipse.

   a. Occurs only during a _____ moon.
   b. The moon's umbra is just long enough for its tip to touch Earth during perigee.
   c. With a width of just about 269 km, only locations within the umbra will experience a total eclipse.
   d. Duration: on up to _____ minutes.

F. Tides (See Rev. Book *Figures 9-24* and *9-25* on page 477)

1. Bulges of water that are actually movements of ocean water, caused by the gravitational attraction of Earth's water by the Moon and the Sun.

2. In the case of Earth, the gravitational force of attraction from the Moon is greater on the oceans than it is on the solid Earth. (Earth's crust rises only a few centimeters, while the oceans may rise several meters.)

3. Due to the Moon's gravitational attraction, a bulge of ocean water always faces the Moon, and water particles from nearby areas add to the bulge as they flow toward this place of greatest attraction.

4. On the side of Earth facing away from the Moon, a second tidal bulge occurs because the Moon attracts the nearby Earth with more force than it attracts the faraway ocean water.

5. Any given location has a high tide when it faces the Moon directly. As that location turns one-quarter of the way around Earth from the Moon (as Earth rotates once per day), a low tide occurs. Then that location reaches a point facing directly away from the Moon and a second, lesser high tide occurs. Another quarter turn, and that location experiences a low tide again. Finally, as it faces the Moon again, there is a high tide again. (***Semidiurnal*** tides.)

6. Tides are also affected by the shape of the shoreline and the Coriolis Effect.

7. The combined effects of the Moon's gravity and the Sun's gravity on Earth's oceans result in "spring tides" and "neap tides."