Chapter 12 Study Guide

Physical Science— Light and Color

1. The Nature of Light
   1. Theories of light
      1. Particle theory of light—the idea that light is a stream of physical particles—proposed by Sir Isaac Newton in his book *Optiks*
      2. Wave theory of light—lights consists of electromagnetic waves not particles; two transverse oscillating at right angles to each other—demonstrated by James Clerk Maxwell
      3. Dual nature of light—called the quantum theory of light—that light is electromagnetic waves traveling as photons (tiny bundles or packets of energy); when interacting with matter, light acts like photons, when traveling through space, photons act like electromagnetic waves
   2. Light and color
      1. Visible light—the frequencies of electromagnetic spectrum that the eye can detect (this is a very small portion of all light)
         1. Color is a the perception of frequency: red, orange, yellow, green, blue, violet
         2. White—all the colors
         3. Black—absence of visible light
      2. Additive primary colors—red, green, blue
      3. Subtractive primary colors—magenta, cyan, yellow
2. The Behavior of Light
   1. Reflection of light
      1. Convex mirror—mirror is on the outside of a spherical surface
      2. Concave mirror—mirror is on the inside of a spherical surface (picture a headlight on a car)
   2. Refraction—bending of light as it passes through a different medium
      1. Applications: eyeglasses, contact lenses, cameras, binoculars, magnifying glass
      2. Lens—a piece of glass designed to bend light rays
      3. Natural occurrences of refraction: mirage, scintillation, rainbow
   3. Interference—constructive and destructive
   4. Diffraction—for example, the blurring at the edge of a shadow
3. Electromagnetic Radiation: radio waves, microwaves, infrared waves, visible light, ultraviolet waves, x-rays, gamma rays ( the higher the frequency, the more powerful the wave)
   1. Radio waves—used for many forms of communication: radio, television, cellular phones
   2. Microwaves—used in microwave ovens, satellite communications, GPS, radar (used to measure the distance and direction of faraway objects)
   3. Infrared waves—also known as heat rays, used by heat lamps, and infrared video cameras
   4. Visible light
   5. Ultraviolet radiation—
      1. UVA—not dangerous, given off by “black lights”
      2. UVB—somewhat dangerous; this is what causes sunburns
      3. UVC—quite dangerous, used to sterilize instruments
   6. X-rays—powerful rays that penetrate many materials, including flesh, which make it useful in medicine, dentistry, and security
   7. Gamma rays—very high energy and causes damage to the human body; can be used selectively to target tumors and to sterilize medical equipment and food
4. Lasers—a intense beam of monochromatic(containing only one frequency), coherent (all of the waves are in phase) light
   * 1. Fiber optics—transmitting light through narrow glass tubes in order to communicate
     2. Holograms—three-dimensional images produced by laser light
5. The Speed of Light
   1. The speed of light is constant, always constant, constant no matter what, constant everywhere, and constant from every perspective—**3.0 x 108 m/s**
   2. Special Theory of Relativity—time, length, and mass in relation to the speed of light
      1. Two basic principles
         1. All motion must be measured relative to some arbitrary reference point
         2. The speed of light is constant in relation to any observer
      2. Consequences of theory
         1. Time dilation—time slows down for objects moving at high speeds
         2. Length contraction—objects appear shorter in the direction of motion
         3. Mass increase—the mass of an object moving at high speed increases
         4. Nothing can travel faster than light
   3. General Theory of Relativity—time and length in relation to gravity
      1. Gravity happens when mass “stretches” or “distorts” space near itself
      2. Time slows down at areas of high gravity
      3. Length contracts in a high gravitational field

* Former student’s description of the special theory of relativity:

The theory states that light is the only constant in the universe. This means that no matter how fast you go, or which way you travel, light’s speed will always measure the same speed, 3 x 108 m/s. Since the speed stays the same, something else needs to give. The things that determine speed will need to change. These properties are time and length. Time gets longer, length gets shorter, and mass increases.

* And “Einstein in a Nutshell”:

Light is the constant

so something has to give

time, mass, and length do