PHYSICS 534

ANSWERS

EX SE-46 **Inrtro to Optics Part-2 /2**

STERN

Otto Stern was awarded the Nobel prize for physics in 1943 for his development of molecular-beam studies.

In studying optics, it is convenient to classify objects into those that emit light (luminous) and those that reflect light (non-luminous):

LUMINOUS (originate light)
- Incandescent
- Neon
- Fluorescent

NON-LUMINOUS or **ILLUMINATED** (do not originate light)
- Opaque (light cannot pass through)
- Transparent (light and images pass through)
- Translucent (light passes through, images do not)

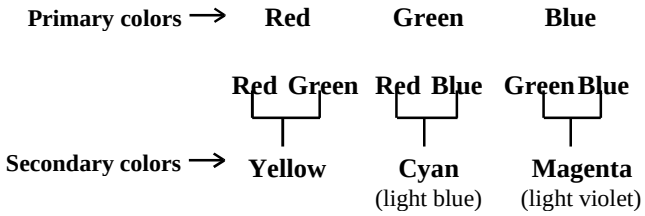
- **BEAM OF LIGHT**: A beam of light is a "bunch" of light rays.
- **CONVERGENCE**: When rays of light come together to meet at a point, they are said to **converge**.
- **DIVERGENCE**: When rays of light go away from a point, they are said to **diverge**.
- **MEDIUM:** A medium is the material through which light travels. Optical mediums are classified according to density. The more "optically dense" a material is, the slower light travels in that medium.

- **THE PRIMARY COLORS**

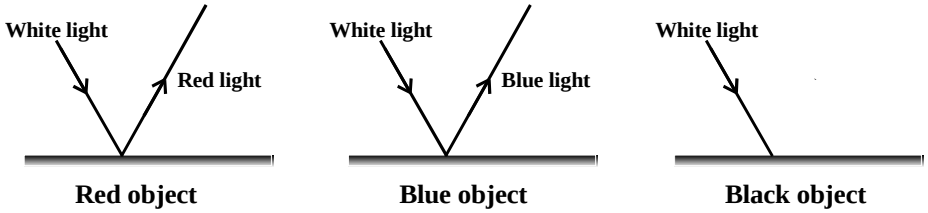
Monochromatic light is light of one color. ***Polychromatic*** light is light of many colors.

In everyday language we use names to represent monochromatic light such as red, orange, yellow, green, blue and violet. Furthermore, each of these colors has a variety of different shades. Collectively, the colors form the "light band" which is part of the "electromagnetic spectrum".

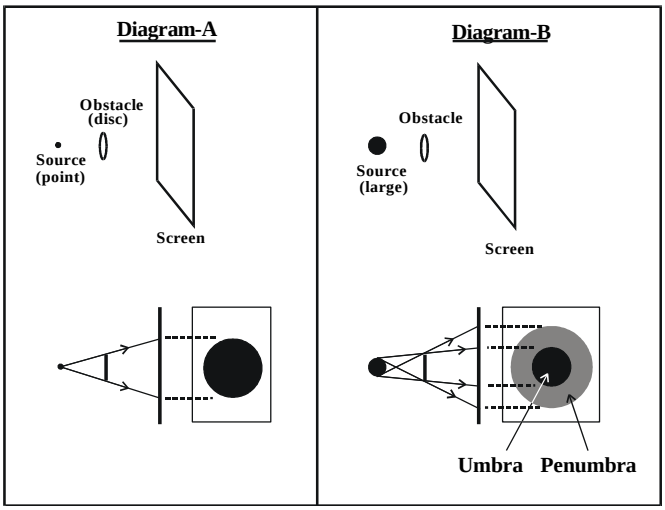
Red, green and blue light (RGB) are called the ***primary colors***. Adding these three primary colors together forms "white" light. Adding pairs of the primary colors form the ***secondary colors***.



The color of an object is determined by the color (or colors) it reflects. Suppose white light shines on a red object. The object will absorb all the colors except red. Thus, it is red. Study the illustration below.



- **SHADOWS**



Shadows are formed when light is obstructed. The light may be totally obstructed thereby forming a dark shadow known as an ***umbra***, or it may be partially obstructed thereby forming a gray shadow known as a ***penumbra***.

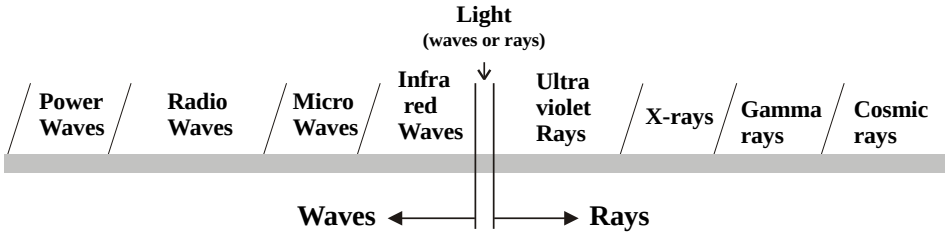
For example, in diagram-A of the illustration, a point source of light encounters an obstacle (a disc) causing an umbra (total darkness). In diagram-B, a large source of light causes both an umbra and a penumbra.

Note that when the source is a point (small), the shadow consists of an umbra (total darkness) with a well defined outline. From the side view, we have two rays (one to the top of the obstruction, one to the bottom of the obstruction) to define the shadow (the light source has no top and bottom portions).

However, when the light source is large (extended), from the side view, we have two sources of light (a top source and a bottom source). From both these two sources, we draw two rays, one ray striking the top of the obstruction and another striking the bottom of the obstruction. As a result, as illustrated above, both an umbra (total darkness) and a penumbra (partial darkness) are formed.

- **THE ELECTROMAGNETIC SPECTRUM**

Below is a sketch of the electromagnetic spectrum. The spectrum is displayed in increasing order of energy content (or ***frequency***). For convenience, as you can see, the energy quanta have been grouped into "families". Each family has a name and holds a specific location in the electromagnetic spectrum according to its frequency (or energy).



Note that light is just one member of a large family of energy collectively called the "Electromagnetic Spectrum". Each individual member in the spectrum family is called a "***quantum***" (a specific **quantity** of energy). Since the plural of quantum is "***quanta***", the electromagnetic spectrum consists of energy ***quanta***. Remember, each quantum of energy possesses both wave and particle properties and consists of a discrete (specific) amount of energy.

The "light family", or the "light band", is by far the ***smallest*** family. Yet, it is important because this is the range of quanta which our eyes can detect. Notice how those families below the light band are called "***waves***" while those above the light band are called "***rays***". This is simply because the "wave" families behave more like ***waves*** while the "rays" families behave more like ***particles***. Having a dual nature, light behaves both as a wave and as a particle. Thus, we can correctly refer to light as ***light waves*** or as ***light rays***. The quanta of light are called ***photons*** and it is these that our eyes can detect and which behave both as particles and as waves.

The reason that the lines dividing the families in the electromagnetic spectrum are slanted, is because those quanta in between families can be considered as being in either the previous family or the next family.

1. Define the following terms:

a) Beam of light — **A stream of photons emanating (coming from) a light source.**

b) Medium — **The material through which light travels.**

c) Opaque — **A material which blocks light (light rays cannot pass through).**

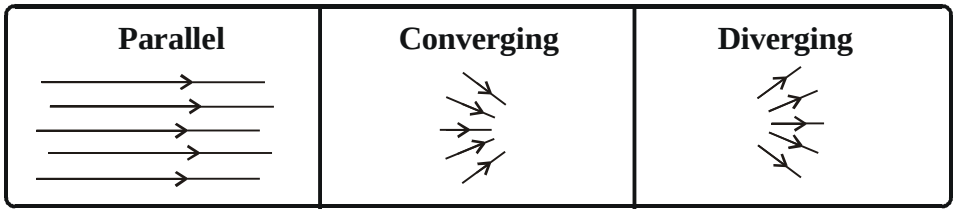
d) Transparent — **A material though which light and images can pass through.**

e) Translucent — **A material through which light can pass but images cannot.**

2. Define the meaning of the terms ***monochromatic*** and ***polychromatic*** light.

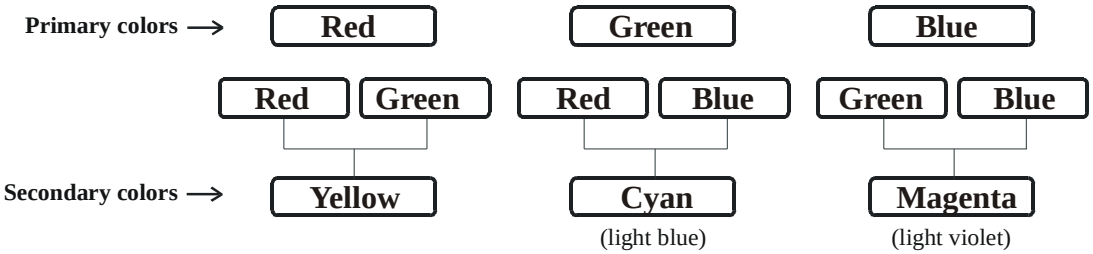
Monochromatic is light consisting of a single color.
Polychromatic is light consisting of many colors.

3. Draw 5 rays of light that are parallel, converging and diverging.



4. What does **RGB** stand for? [redacted]

5. Fill in the primary and secondary colors in the chart below:



6. Define an ***umbra*** and explain how it is formed.

The umbra consists of total darkness caused by obstruction to the light rays.

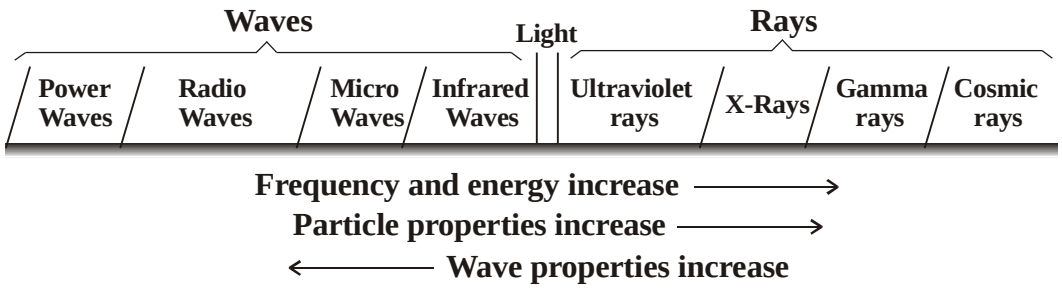
7. Define an ***penumbra*** and explain how it is formed.

The penumbra consists of partial darkness caused by obstruction to the light rays.

8. In your own words, define a ***light intensity***.

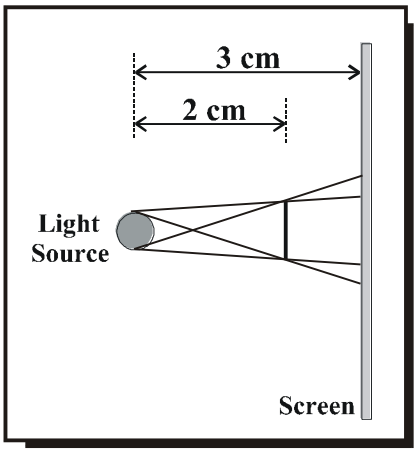
The light intensity (or brilliance) of a light source refers to the total number of photons emitted per second.

9. Briefly explain the similarities and differences among the families of the electromagnetic spectrum.



Note: Light is said to have a *dual nature* since it possesses both wave and particle properties.

10. In the given diagram, measure the length of the umbra and penumbra of the shadow formed by the obstruction (line).



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