Light and Optics Problem Set

1. Which of the following types of electromagnetic radiation has the longest wavelength?

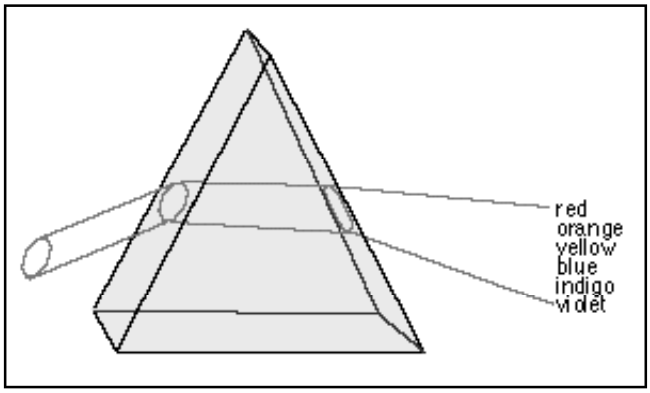
   a. visible light
   b. gamma rays
   c. radio waves
   d. X-rays

   The following passage pertains to questions 2 - 6.

   When light passes at an angle of incidence from one medium into another, refraction will occur because the speed of light is different within the two media. The ratio of the speed of light in a vacuum to the speed of light in a particular medium is called the index of refraction for that medium. The relationship between the angle of incidence, the angle of refraction, and the indices of refraction for the two media is given by Snell's law:

   $$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

   The index of refraction of a certain media is not constant for the entire electromagnetic spectrum, however, but depends somewhat upon the frequency. Most substances show increasing refractive index with increasing frequency of light. Such phenomena as dispersion of visible light into its spectral components by a prism, illustrated at right, can be understood in terms of the variation of refractive index with frequency.



2. If the index of refraction of glass for a certain wavelength of light is given as 1.5. What, approximately, will the angle of refraction be if the angle of incidence for light travelling from air is 45° (assume $n_{air} = 1$)?

   a. 45°
   b. 30°
   c. 60°
   d. 15°

3. Which of the statements below follows from the relationship posited above between the index of refraction for the glass of a prism and the wavelength of incident light?

   a. High frequency light is refracted with a smaller angle of refraction than low frequency light.
   b. Orange light has shorter wavelength than indigo.
   c. A high energy photon travels more quickly through quartz than a low energy photon.
   d. none of the above

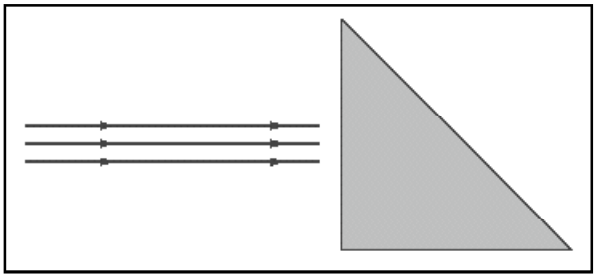
4. Assuming the index of refraction for red light in glass to be exactly 1.5, which of the following describes the speed of blue light in glass?

   a. slightly greater than 4.5×10^8 m/s
   b. slightly greater than 2.0×10^8 m/s
   c. slightly less than 2.0×10^8 m/s
   d. exactly 3.0×10^8 m/s

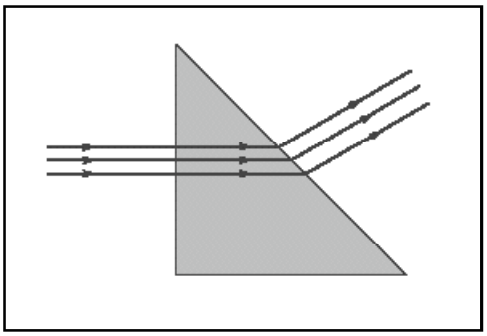
5. Orange light has a wavelength a vacuum of 600 nm. What is its frequency?

   a. 5.0×10^{16} Hz
   b. 1.8×10^{2} Hz
   c. 5.0×10^{14} Hz
   d. 5.0×10^{11} Hz

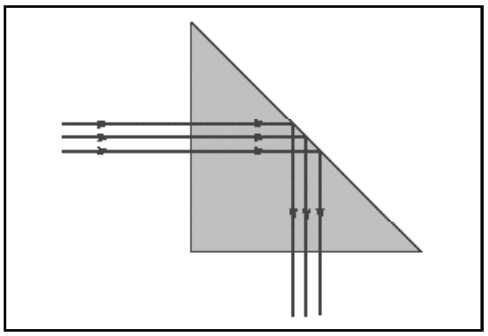
6. Suppose that blue light were beamed normal to the side of an isosceles right-triangular prism as shown at right. If the index of refraction for blue light in the prism is 1.6, which of the diagrams below correctly illustrates the result? (assume $n_{\text{air}} = 1$)



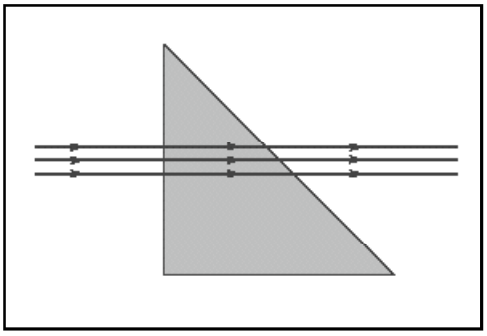
a.



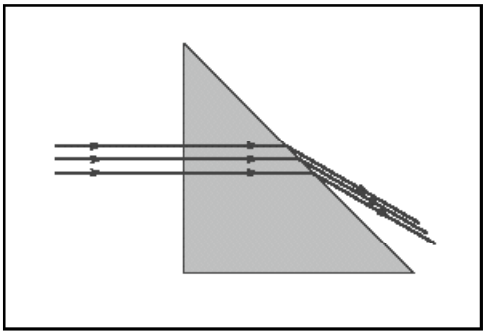
b.



c.



d.



7. The theory that light propagates through space in the form of photons is useful in explaining which of the following phenomena?

   I. Polarization
   II. Interference
   III. The photoelectric effect

   a. only I
   b. only III
   c. both I. and II
   d. I, II, and III

8. Which of the following distinguishes electromagnetic waves from sound waves?

    I. Electromagnetic waves carry momentum as well as energy.
    II. Electromagnetic waves are transverse.
    III. Electromagnetic waves can be polarized.

    a. only I
    b. only II
    c. both I. and II
    d. I, II, and III

9. A concave mirror has a focal length of 2 m. What type of image will be formed corresponding to an object 8 m away from the mirror?

    a. virtual, erect, diminished
    b. real, erect, enlarged
    c. real, inverted, diminished
    d. virtual, inverted, enlarged

10. A boy is examining a fall leaf with a magnifying glass when he discovers the capacity of the instrument to focus the rays of the sun and start a fire. Which of the following is the most plausible scenario to describe the discovery?

    a. To examine the leaf, the boy was holding the lens a distance from the leaf equal to its focal length. He moved the lens back so that the distance was twice the focal length. The sun was shining over his shoulder and the leaf began to burn.
    b. To examine the leaf, the boy was holding the lens a distance from the leaf less than its focal length. He moved the lens to a distance a small amount greater than its focal length. The sun was shining over his shoulder and the leaf began to burn.
    c. To examine the leaf, the boy was holding the lens a distance from the leaf equal to twice its focal length. He moved the lens to a distance less than its focal length. The sun was shining over his shoulder and the leaf began to burn.
    d. To examine the leaf, the boy was holding the lens a distance from the leaf more than twice its focal length. He moved the lens to a distance less than its focal length. The sun was shining over his shoulder and the leaf began to burn.