Closed book. No work needs to be shown for multiple-choice questions.

1.   If $n_{water} = 1.33$ and $n_{glass} = 1.50$, then total internal reflection at an interface between this glass and water:

       a. occurs whenever the light goes from glass to water.
       b. occurs whenever the light goes from water to glass.
       c. may occur when light goes from glass to water.
       d. may occur when light goes from water to glass.
       e. can never occur at this interface.

2. Light traveling in water, $n_{water} = 1.33$, strikes a plastic block at an angle of incidence of 51.4°; part of the beam is reflected and part is refracted. If the reflected and refracted portions make an angle of 90.0° with each other, which one of the following choices best corresponds to the index of refraction of the plastic?
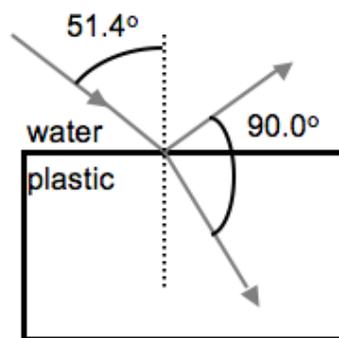
       a. 1.50.
       b. 1.67.
       c. 1.06.
       d. 2.13.
       e. 1.25.

3.   A light ray initially in Medium X travels into Medium Y as shown in the figure to the right. When light travels from Medium X to Medium Y:
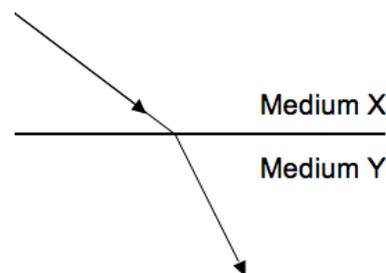
       a. both the speed and the frequency decrease.
       b. both the speed and frequency increase.
       c. both the speed and the wavelength decrease
       d. both the speed and the wavelength increase.
       e. both the wavelength and the frequency are unchanged.

4. A ray of light in air is incident on the mid-point of a Lucite prism surface at an angle of 20° with the normal. For the Lucite, $n = 1.60$, and the prism apex angle is 35°. What angle does the ray make with respect to the normal as it exits the Lucite prism on the right (assume the prism is surrounded by air)?
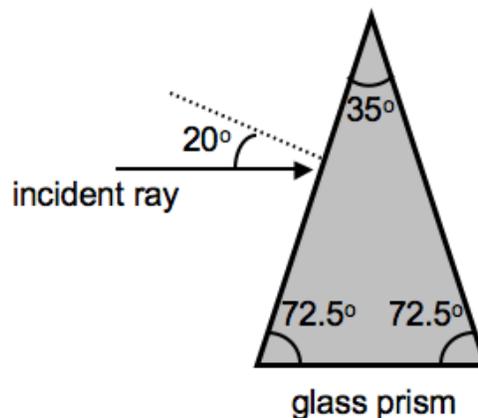
       a.   38.0°.
       b.   67.3°.
       c.   22.7°.
       d.   12.3°.
       e.   20.0°.

5. Rank the following electromagnetic waves in terms of increasing frequency (*i.e.* from least to greatest).

    a. Visible light, radio waves, ultraviolet light, X-rays.
    b. Infrared light, visible light, ultraviolet light, gamma rays.
    c. Visible light, gamma rays, ultraviolet light, X-rays.
    d. Infrared light, X-rays, visible light, gamma rays.
    e. All of the electromagnetic waves listed above have the same frequency.

6. The electric field, $\vec{E}$, in an electromagnetic wave is oriented in what direction with respect to its associated magnetic field, $\vec{B}$?

    a. $\vec{E}$ will be parallel to $\vec{B}$.
    b. $\vec{E}$ will be anti-parallel to $\vec{B}$.
    c. $\vec{E}$ will be perpendicular to $\vec{B}$.
    d. $\vec{E}$ will be at a 45° angle to $\vec{B}$.
    e. $\vec{E}$ will be at a 30° angle to $\vec{B}$.

7. What is the lowest frequency that will create a standing wave in an organ pipe 2.00 m in length and filled with air, closed at one end and open at the other? Assume the speed of sound in air is 340 m/s.

    a. 42.5 Hz.
    b. 85.0 Hz.
    c. 170 Hz.
    d. 510 Hz.
    e. 680 Hz.

8. You are lying at the bottom of a swimming pool filled with 9ft deep of water (n=1.33). What is the diameter of the "hole" at the water surface through which you can see out of the pool?

    a. 5ft.
    b. 10ft.
    c. 15ft.
    d. 20ft.
    e. 25ft.

9. A string, 2.0 meters in length, is fixed at both ends and tightened until the wave speed is 78 m/s. What is the frequency of the standing waves shown in the figure below?

    a. 470 Hz.
    b. 230 Hz.
    c. 350 Hz.
    d. 120 Hz.
    e. 39 Hz.

10. Polarized light passes through a sequence of two polarizers whose axes of polarization form a 60 degree angle. The second polarizer has the same polarization as the incoming light before it hits the first polarizer. What fraction of the incident intensity emerges from the set of polarizers?

   a. 0.5
   b. 0.25
   c. 1/8
   d. 1/16
   e. none