Name: _____________________________________________________________

Directions: Select the best answer for each question. (1 point each)

1. Sound with an intensity of $10^{-6}$ W/m$^2$ is
   A) -60 dB.
   B) -6 dB.
   C) 6 dB.
   D) 60 dB.

2. A wave moves on a string with wavelength $\lambda$ and frequency $f$. A second wave on the same string has wavelength $2\lambda$ and travels with the same velocity. What is the frequency of the second wave?
   A) $0.5f$
   B) $f$
   C) $2f$
   D) It cannot be determined from the information given.

3. Consider a string of length $L$. What are the wavelengths of the three lowest harmonic tones produced by this string?
   A) $4L$, $2L$, $L$
   B) $2L$, $L$, $L/2$
   C) $2L$, $2L/3$
   D) $4L$, $4L/3$, $4L/5$

4. A sound source approaches a stationary observer. The frequency heard by the observer is
   A) higher than the source.
   B) lower than the source.
   C) the same as that of the source.
   D) equal to zero.

5. You shout at a cliff, and hear the echo in 4.00 s. The temperature is 0°C. How far away is the cliff?
   A) 662 m
   B) 680 m
   C) 1320 m
   D) 1760 m

6. Plane mirrors produce images which
   A) are always smaller than the actual object.
   B) are always larger than the actual object.
   C) are always the same size as the actual object.
   D) could be smaller, larger, or the same size as the actual object, depending on the placement of the object.

7. A light ray, traveling parallel to a concave mirror's axis, strikes the mirror's surface near its midpoint. After reflection, this ray
   A) again travels parallel to the mirror's axis.
   B) travels at right angles to the mirror's axis.
   C) passes through the mirror's center of curvature.
   D) passes through the mirror's focal point.

8. A beam of light with intensity $I_0$ passes through one polarizer. The light then passes through a second polarizer whose polarization axis is rotated $45^\circ$ with respect to the first polarizer. The intensity of light that emerges from the second polarizer is
   A) $1/6 I_0$
   B) $1/2 I_0$
   C) $1/4 I_0$
   D) $1/8 I_0$
9. The principle which allows a rainbow to form is 
   A) refraction. 
   B) polarization. 
   C) dispersion. 
   D) total internal reflection.

10. Light with wavelength slightly longer than 750 nm is called 
    A) ultraviolet light. 
    B) visible light. 
    C) infrared light. 
    D) violet light.

11. In a single slit diffraction experiment, if the width of the slit increases, what happens to the width of the central maximum on a screen? 
    A) It increases. 
    B) It decreases. 
    C) It remains the same. 
    D) There is not enough information to determine.

**Long Answer: Write out a solution for each problem. Be sure to show all your work.**

12. A parallel beam of light from a He-Ne laser, with a wavelength of 656 nm, falls on two slits 0.050 mm apart.
   A) How far apart are the fringes in the center of the pattern on a screen 4.0 m away? 
   B) What happens to the separation if the slits are moved further apart? 
   C) What happens to the separation if blue light is used?

13. A parallel beam of light containing two wavelengths, $\lambda_1 = 450$ nm and $\lambda_2 = 650$ nm, enters the equilateral prism as shown. At what angle does each beam leave the prism (give angle with normal to the face)? Assume the index of refraction is 1.52 at 650 nm and 1.55 at 450 nm.

14. An object with height of 2.0 cm is placed 8.0 cm from a converging lens. The lens has a focal length of 4.0 cm.
   A) Using ray tracing, find the position, height, and orientation of the image. 
   B) Confirm your findings mathematically. 
   C) Calculate the magnification of the image. 
   D) Is the image real or virtual? Explain briefly.