PART I: Multiple choice questions

Only one of the choices given is the correct answer. No explanation for your choice is required. Each multiple choice problem is worth 5 points.

1. The radio station KPIG announces their broadcast frequency as “107 oink 5” (that is, 107.5 on your FM dial). What is the corresponding wavelength of the waves they use to broadcast their signal?

(a) 140 nm

(b) 4.2 cm

(c) 2.8 m

(d) 42 m

(e) 2.8 km

2. One end of a heavy rope is tied to the wall and the other end is tied to a light rope. If you jerk the light rope with your arm creating a pulse, what will happen to the pulse when it reaches the heavy rope?

(a) The pulse will speed up when it reaches the heavy rope, but nothing else will happen.

(b) The pulse will slow down when it reaches the heavy rope, but nothing else will happen.

(c) The pulse will split into a transmitted and a reflected pulse. The reflected pulse will be inverted, and the transmitted pulse will speed up.

(d) The pulse will split into a transmitted and a reflected pulse. The reflected pulse will be inverted, and the transmitted pulse will slow down.

(e) The pulse will split into a transmitted and a reflected pulse. Neither will be inverted, but the transmitted pulse will slow down.

(f) The pulse will split into a transmitted and a reflected pulse. Neither will be inverted, but the transmitted pulse will speed up.

3. You stand a certain distance away from a speaker and you hear sound from the speaker at 50 dB. If you double your distance from the speaker, what would be the decibel level of the sound at the new distance?

(a) 12.5 dB

(b) 25 dB

(c) 44 dB

(d) 47 dB

(e) 50 dB

4. Consider a rectangular prism made out of glass, with a refractive index of $n = 1.58$ for violet light and $n = 1.54$ for red light. A ray of sunlight enters one of the prism faces at an angle of 30° from the perpendicular, and after it exits the other side hits a wall which is parallel to the opposite face of the prism. If the prism is 2 cm thick, what is the distance between the red and violet lines seen on the wall?

(a) exactly 0 mm (light is not split by a rectangular prism because all rays bend back to the same angle after emerging from the glass)

(b) about 0.2 mm

(c) about 1 mm

(d) about 2 mm

(e) about 4 mm

(f) It depends on the distance to the wall.

5. You are lying on your back at the bottom of a pool. As you look up you can see the whole sky and the rest of the world above the pool through a circle of radius R at the surface of the water. When you look outside that circle, you see only the reflection from the bottom and sides of the pool. If the water in the pool is 2 m deep, what is the value of R? Assume that the pool is wider than any of the choices (a)–(c) given below. (Note: the index of refraction of water is 1.33).

(a) 2.3 m

(b) 2.7 m

(c) 3.0 m

(d) You would still see sky all the way out to the edge of the pool.

6. A person breathes in gas that is denser than air, and then speaks in their normal voice to a friend. What would be different about the sound waves carrying the voice to the friend's ear (compared to the sound waves carrying the normal voice on a day when a strange gas has not been inhaled)?

(a) The frequency of the waves would be higher, but the wavelength would be the same.

(b) The frequency of the waves would be lower, but the wavelength would be the same.

(c) The frequency of the waves would be the same, but the wavelength would be longer.

(d) The frequency of the waves would be the same, but the wavelength would be shorter.

(e) The frequency of the waves would be lower, and the wavelength would be longer.

(f) The frequency of the waves would be higher, and the wavelength would be shorter.

PART II: Short problems

To earn full credit on the following problems, you must exhibit the steps that lead to your final result (and will depend on the clarity of your method of solution as well as on your final answer). Problems 7 and 8 are worth 20 points each and problem 9 is worth 30 points.

7. Two loudspeakers are placed 3.00 m apart. They emit 494 Hz sounds, in phase. A microphone is placed 3.20 m away from the point midway between the two speakers (in the direction perpendicular to the line between the two speakers– hence it is equidistant from both). An intensity maximum is recorded at this location for the microphone.

(a) How far must the microphone be moved parallel to the line between the speakers to find the first intensity minimum?

(b) Suppose the speakers are reconnected so that the 494-Hz sounds they emit are exactly out of phase. At what positions are the intensity maximum and minimum now?

8. A prescription for a corrective lens calls for +3.50 diopters. The lensmaker grinds the lens from a "blank" with $n = 1.56$ and convex front surface of radius of curvature of 30.0 cm.

(a) What must the radius of curvature of the back surface of the lens be in order to satisfy the prescription?

(b) From the perspective of others, by what percent would a person's eye be magnified through the lens if the lens is worn 1 cm from the eye?

9. Two helicopters are flying through the Grand Canyon. Both are flying in the same direction, but helicopter 1 is flying at speed v_1 and slightly ahead, while helicopter 2 is flying slower at speed $v_2 < v_1$ and is lagging behind. Probably both of the helicopters' blades will be too noisy for the pilots to hear anything outside but their own blades, but suppose for the sake of argument that these pilots have super-discriminating ears and can also discern the sound coming from the other helicopter and determine their frequencies.

(a) If the sound from the blades of helicopter 1 bounces off of a canyon wall which both are flying directly towards, how will the pitch of the sound be perceived by the other helicopter pilot? Find a formula for the frequency heard by pilot 2 in terms of the frequency f which is emitted from helicopter 1 (f is also the frequency as heard by pilot 1), v_1, v_2, and the speed of sound v_s.

(b) How does the frequency obtained in part (a) compare with the frequency of the sound that travels directly from helicopter 1 to helicopter 2, as heard by pilot 2? Will the sound that bounces off the canyon wall seem higher or lower pitched to pilot 2 than the sound coming directly from helicopter 1?

(c) What would the frequency be if the wall were behind both of the helicopters instead of in front of them?

(d) Arrange these four frequencies in order from lowest to highest: (1) the frequency pilot 1 hears from his own blades, (2) the frequency pilot 2 hears coming directly from helicopter 1, (3) the frequency pilot 2 hears after the sound from helicopter 1 bounces off of the wall in front of them, and (4) the frequency pilot 2 hears after the sound from helicopter 1 bounces off of the wall behind of them.