Physics 2020 Discussion Examples for the week of Mar 18, 2013

1. In a mixture of argon (atomic mass = 39.9 u) and neon (atomic mass = 20.2 u), the speed of sound is 363 m/s at 3.00 x 10^2 K. Assume that both monatomic gases behave as ideal gases. Find the percentage of the atoms that are argon and the percentage that are neon.

57% argon, 43% neon

2. A person wears a hearing aid that uniformly increases the intensity level if all audible frequencies by 30 db. The hearing aid picks up sound having a frequency of 250 Hz at an intensity of 3.0x10^-11 W/m².

(a) What is the intensity delivered to the ear

3.0x10^-8 W/m²

(b) How many decibels is that?

58.0 db

3. Suppose that when a certain sound intensity level (in dB) triples, the sound intensity (in W/m²) also triples. Determine this sound intensity level.

2.39 dB

4. A convertible moves toward you and then passes you; all the while, its loudspeakers are producing a sound. The speed of the car is a constant 9.00 m/s, and the speed of sound is 343 m/s. What is the ratio of the frequency you hear while the car is approaching to the frequency you hear while the car is moving away?

1.054

5. A car is accelerating while its horn is sounding. Just after the car passes a stationary person, the person hears a frequency of 966.0 Hz. Fourteen seconds later, the frequency heard by the person has decreased to 912.0 Hz. When the car is stationary, its horn emits a sound whose frequency is 1.00 x 10^3 Hz. The speed of sound is 343 m/s. What is the acceleration of the car?

1.5 m/s²
6. Two loudspeakers are vibrating in phase. They are set up as in the figure, and point C is located as shown there. The speed of sound is 343 m/s. The speakers play the same tone. What is the smallest frequency that will produce destructive interference at point C?

107 Hz

7. Speakers A and B are vibrating in phase. They are directly facing each other, are 7.80 m apart, and are each playing a 73.0-Hz tone. The speed of sound is 343 m/s. On the line between the speakers there are three points where constructive interference occurs. What are the distances of these three points from speaker A?

3.90 m, 1.55 m, 6.25 m

8. The entrance to a large lecture room consists of two side-by-side doors, one hinged on the left and the other hinged on the right. Each door is 0.700 m wide. Sound of frequency 607 Hz is coming through the entrance from within the room. The speed of sound is 343 m/s. What is the diffraction angle θ of the sound after it passes through the doorway when (a) one door is open and (b) both doors are open?

(a) 53.8°  (b) 23.8°

9. A 3.00-kHz tone is being produced by a speaker with a diameter of 0.175 m. The air temperature changes from 0 to 29 °C. Assuming air to be an ideal gas, find the change in the diffraction angle θ.

3.7°
10. (exam review) A conducting rod is free to slide along a pair of conducting rails, in a region where a uniform and constant (in time) magnetic field is directed into the plane of the paper, as the drawing illustrates. Initially the rod is at rest. There is no friction between the rails and the rod. The rod has a finite mass and resistance.

What happens to the rod after the switch is closed? If any induced emf develops, be sure to account for its effect.

Answer: The rod accelerates to the right and eventually reaches a constant velocity at which it continues to move.

Note: This is another version of the Navy’s new Rail gun (the voltage would actually be supplied by a very large capacitor)

11. (Exam Review) Continuing from the previous problem: The voltage of the battery is 3.0 V. The magnitude of the magnetic field (directed perpendicularly into the plane of the paper) is 0.60 T. The rails are very long and have negligible resistance. The rod has mass $m = 2.5$ kg, resistance $R = 0.015$ Ω, and length between the rails of 0.20 m.

(a) Find the initial acceleration of the rod, right after the switch is closed.

(b) Find the maximum speed attained by the rod long after the switch is closed.

(a) 9.6 m/s²  (b) 25 m/s

12. (Exam Review) A flat circular coil with 105 turns, a radius of $4.00 \times 10^{-2}$ m, and a resistance of 0.480 Ω is exposed to an external magnetic field that is directed perpendicular to the plane of the coil. The magnitude of the external magnetic field is changing at a rate of $\Delta B/\Delta t = 0.783$ T/s, thereby inducing a current in the coil. Find the magnitude of the magnetic field at the center of the coil that is produced by the induced current.

$1.42 \times 10^{-3}$ T
13. (Exam Review) The maximum strength of the earth’s magnetic field is about $6.9 \times 10^{-5}$ T near the south magnetic pole. In principle, this field could be used with a rotating coil to generate 60.0-Hz ac electricity. What is the minimum number of turns (area per turn = 0.022 m$^2$) that the coil must have to produce an rms voltage of 120 V?

$3.0 \times 10^5$

14. (Exam Review) A step-down transformer (turns ratio = 1:8) is used with an electric train to reduce the voltage from the wall receptacle to a value needed to operate the train. When the train is running, the current in the secondary coil is 1.6 A. What is the current in the primary coil?

0.20 A