Physics 225

Homework Assignment 3

Due 29 January 2008

1 A speaker and its images

Approximate an electric speaker as a sound source which emits sound from a point (roughly at the centre of the speaker).

A speaker is placed a distance d from a wall, "outside" where there are no other sound reflecting objects. (Assume the ground is perfectly absorbing but the wall is a perfect reflector.) You listen at a distance which is much larger than d. Normally, you would expect to measure a sound intensity which is twice as large as if there were no wall there. Why do you expect that? (Hint: think of "image" speakers.)

If the speaker is producing a long wavelength sound with $\lambda \gg d$ (wavelength much larger than the distance to the wall), the sound will actually be louder. How many more dB is the sound than it would be without the wall there?

Now suppose the speaker is exactly 1/4 wavelength from the wall, $d = \lambda/4$. Suppose you stand right in front of the speaker, so the line from you through the speaker is at right angles to the wall. How much is the sound intensity changed, compared to the case where there is no wall?

Now suppose that the floor (or ground) is also a perfect sound reflector. How many "images" of the speaker do you hear? How many times louder is the sound, in the case where the speaker is close to the wall and to the ground (much less than 1 wavelength from either)?

If you wanted to get a "bass boost" (an enhancement in sound production at low frequencies) from your loudspeaker at home, should you place it up on a wall, in the middle of the floor, on the floor against the wall, or on the floor in a corner? (Assume walls and floor are all good reflectors.)

What is the actual size of a speaker you have at home (or a roomate has, or some other speaker you have access to)? Based on this size, what is the frequency below which you would get a "boost" by placing the speaker as you determined?

2 Dipole radiation from a string

A string on a musical instrument is about 0.8 millimeters thick and about 65 centimeters long. When the instrument is played, it vibrates back and forth so the middle of the string moves 2 millimeters to each side, when playing at note at 150 Hertz. (If you think these numbers are unrealistic and you own a music instrument, measure them for your instrument.)

Calculate the peak velocity of the string, in the middle. [Recall that the peak distance the string moves is $v_0/(2\pi f)$.] To make life easier, approximate that the string has this velocity along its whole length. What is the intensity of the sound produced right at the surface of the string (given that the air has to move at the same speed as the string)?

Multiply this intensity by the area of the string (length times thickness) to determine a total power emitted by the string, **IF** this were the only source of sound.

Now the problem. The back side of the string also makes the air move. However, since it moves the air backwards when the front side moves the air forwards, it is producing a sound wave with the opposite sign for the pressure.

Explain why the string acts like a *dipole radiator*. Given the separation distance of the front and back of the string (set by the string's thickness), what is the total power of sound actually emitted by the string?

Argue that the sound from a string instrument cannot possibly be generated because of the string moving through the air. [If you don't believe this, listen to an electric guitar played when it is unplugged.] Where do you think the sound of a musical instrument is really coming from?