AET Physics 2010 Practice Test 2

Show all work
100 points
Turn off all cell phones.
Use 1140 ft/s for the speed of sound in air.

<u>Part 1: Multiple Choice.</u> Select the answer you deem most correct. No need to show work.

1. (5 points) At 10m from a source the SIL is 120dB. What is the intensity of the sound at 10,000 m from the source?

a) 10^{-12} W/m^2 b) 10^{-6} W/m^2
c) 10^{-4} W/m^2 d) 0.001 W/m^2 e) None of the above

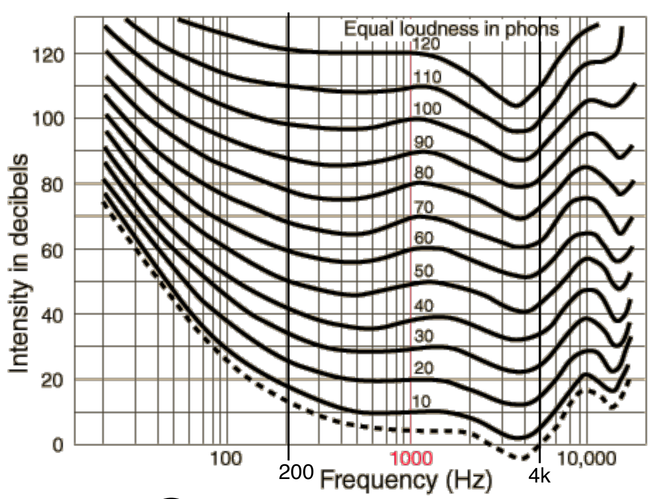
2. (5 points) Your home studio has dimensions 13' x 17' x 15'. What is the frequency of the 0,0,1 mode?

a) 33.5 Hz b) 50.7 Hz
c) 43.8 Hz d) 38.0 Hz e) None of the above

3. (5 points) For the same room as the previous question, what is the frequency of the 1,1,0 mode?

a) 55.2 Hz b) 50.7 Hz
c) 79.5 Hz d) 91.2 Hz e) None of the above

4. (5 points) Refer to the equal loudness curve below. What is the intensity in dB of a 4kHz tone that sounds as loud as a 200Hz tone which is playing at 110dB?



a) 90 dB b) 100 dB
c) 110 dB d) 120 dB e) None of the above

5. (5 points) A difference in SPL of 40 dB corresponds to a factor of _____ in pressure fluctuation.

a) 10 b) 100
c) 1,000 d) 10,000 e) None of the above

6. (5 points) A sawtooth wave and a square wave of the same pitch differ in

a) spectrum and timbre. b) fundamental frequency and spectrum
c) fundamental frequency and timbre. d) all of the above.

7. (5 points) You are sitting comfortably at your seat at a movie theater. When the movie starts, a couple guys come in and sit *right behind you*, at a distance of 0.5 m, and they start talking really loud. Ever-prepared, you whip out your SPL meter and measure them to be talking at 80 dB. You notice that most of the seats in the rows directly in front of you are free. Then, performing a quick calculation, you figure out at what distance you'd need to be in order for the sound of the rowdy guys to diminish to 48 dB. What distance would that be? (Assume a free sound field.)

a) 6.29 m b) 12.0 m
c) 19.9 m d) 88.6 m e) None of the above

8. (5 points) The SPL meter contour which most closely approximates the human auditory response at low to medium intensities is the _____ contour

a) A b) B
c) C d) Max Hold e) Fast

9. (5 points) The claim that the human auditory system is insensitive to the relative phases of harmonics is known as

a) Huygens' Principle b) Fourier's Theorem
c) Helmholtz's Resonator d) Mersenne's Law of Hearing e) None of the above

10. (5 points) In general, greater fullness implies

a) less warmth. b) the first reflected sound reaches the listener in under 20ms.
c) more clarity. d) a longer reverberation time.

<u>Part II: Short Answer.</u> Show any applicable work.

11. (5 points) If two sounds are identical then they have the same frequency spectra. If two sounds have the same frequency spectra are they identical sounds? Why or why not? Give an example to support your reasoning.

Not necessarily. The frequency spectrum graph does not contain phase information. Thus identical spectra such as those shown in the text in section 4.2, correspond to different waveforms from section 4.1.

12. (9 points) Describe three criteria (other than “fullness”) in acoustical design, i.e. three “vocabulary words”: how they relate to the qualitative aspects of sound in the room, and how they relate to something technically measurable in the room.

13. (6 points)

a. What is a Helmholtz resonator?

A cavity with a hole and a neck, in which the cross sectional area of the cavity is significantly larger than that of the neck. It is an acoustical simple harmonic oscillator.

b. What is unique about the resonance curve for a Helmholtz resonator?

The resonance curve has only one peak.

c. What was its original use?

Arrays of such resonators tuned to different frequencies were used by Helmholtz as a kind of "old-timey RTA", for measuring amplitudes of various frequencies in complex sounds.

d. Give examples of resonators that are similar to a Helmholtz resonator.

Blowing across the top of a coke bottle… The narrow neck compared to the wide cavity inside the bottle makes for a good approximation of a Helmholtz resonator.

14. (18 points) Assuming the absorption coefficient of stone is 0.1 at 500Hz, what would be the reverberation time inside a cathedral which is 200 feet long, 75 feet wide and 100 feet high…

a) …if you just calculate the "raw value", without any air absorption or absorbing objects present?

b) …if you cover the floor with carpet (a=0.5) and all walls with curtains (a=0.3)?

c) …if you also add in the absorption due to 500 adults, each with an absorption of 0.4 Sabines?

a)

Volume = 200 * 75 * 100 = 1,500,000 ft^3

Area = 2*[(200*75) + (200*100) + (75*100)] = 85000 ft^2

$$T_R = \frac{(0.050)(1.5 * 10^6)}{(0.1)(85000)} = 8.82\ s$$

b)

		Area / Number	Abs. Coeff	Sabins
Floor	Carpet	15000	0.5	7500
Ceiling	Stone	15000	0.1	1500
Wall - Back	Curtains	20000	0.3	6000
Wall - Front	Curtains	20000	0.3	6000
Wall - Left	Curtains	7500	0.3	2250
Wall - Right	Curtains	7500	0.3	2250
			Total Sabins	**25500**

$$T_R = \frac{(0.050)(1.5 * 10^6)}{(25500)} = 2.94\ s$$

c)

		Area / Number	Abs. Coeff	Sabins
	People	500	0.4	200
Floor	Carpet	15000	0.5	7500
Ceiling	Stone	15000	0.1	1500
Wall - Back	Curtains	20000	0.3	6000
Wall - Front	Curtains	20000	0.3	6000
Wall - Left	Curtains	7500	0.3	2250
Wall - Right	Curtains	7500	0.3	2250
			Total Sabins	**25700**

$$T_R = \frac{(0.050)(1.5 * 10^6)}{(25700)} = 2.92\ s$$

15. (12 points) Your boss's studio is 30ft (long) x 20ft (wide) x 13ft (high). He's complaining of a resonant mode at 34.3 Hz.
a) Which mode does this correspond to? i.e., give the mode numbers Nx, Ny, and Nz.
b) He wants you to install acoustic panels in the ceiling to kill this mode. Is this a good idea or not, and why or why not?

a) 1, 1, 0. How to find it: Caculate freq's for various mode numbers and find the one that works.

Nx	Ny	Nz	Freq (Hz)
1	**0**	**0**	**1140/2*(1/30) = 19**
0	**1**	**0**	**1140/2/20 = 28.5**
0	**0**	**1**	**570/13 = 43.8**
0	**1**	**1**	**570*sqrt(1/20^2 + 1/13^2) = 52.3**
1	**0**	**1**	**570*sqrt(1/30^2 + 1/13^2) = 47.8**
1	**1**	**0**	**570*sqrt(1/30^2 + 1/20^2) = 34.3**

b) No, because the mode is formed by reflections off the *walls*. The floor and ceiling are not involved.

Extra credit:
(5 points) The window well outside HSB102 resonates as air blows across its open end. If the fundamental frequency is 109Hz, find
a) the frequency of the next overtone.
b) the depth of the well.

a) Since one end is closed, the next overtone will be 3(109) = 327 Hz
b) f = Nv/(4L), so L = Nv/(4f) = 1140/4/109 = 2.6 ft = 0.8m