AET Physics 2010 "Practice" Test 3, Answers

1. (6 points) Sound at "normal" incidence is scattered with nearly perfect 180° diffusion from a single monocylindrical diffusor. So why doesn't everybody just make an entire wall to be one giant monocylinder? (Answer in terms of the diffusion properties, not so much the construction or aesthetic aspects…)
Answer: Poor diffusion for non-normal incidence (e.g. 45 degrees).

2. (6 points) In an example in the book, the absorption due to a Coca Cola bottle acting as a Helmholtz absorber was measured. It was found to have an absorption of 5.9 Sabins --- equivalent to a whole adult person --- at resonant frequency was 185 Hz, and its Q value was 276. Why was the coke bottle judged to not have a significant effect on the acoustics of the room?
Because the bandwidth was so narrow. $\Delta f = f_0 / Q = 185/276 = 0.67$ **Hz.**

3. (10 points) What assumptions are implied when we speak of a "reverberation time" for a room?
Answer: High modal density, which implies uniformity of distribution of sound energy and randomization of direction of propagation.

4. (6 points) What are two reasons why it is easier to measure reverb times at high frequencies than at low frequencies?
Answer: Mode decay variations are less prominent at high freqs due to higher modal density.
Low frequency sounds can be difficult to generate, and thus it is more difficult to obtain good signal-to-noise at low frequencies.

5. (6 points) You're noticing a problem with flutter echo in your pimped-out Wii-playing basement room. Your dad won't let you splay the walls (…something about building codes…), and you're already maxed-out on absorption from the shag carpet and your mom's Beanie Babie™ collection on the shelves. What else can you add to the room, in order to control the flutter without degrading the acoustical quality of the room?
Answer: Diffusion.

6. (8 points) "Hey, Intern! Build me a bass trap to attenuate this 67-Hz room mode! Then get me some coffee!" Explain how you would do this, including dimensions, materials used, and their placement.
Answer: Build it out of fairly dense wood, and make it a quarter-wavelength deep, which at 67 Hz is 1140/67/4 = 4.25 ft. Have it coming out from the wall, and put porous absorber like glass fiber across the face, and have some panels of the absorber arranged inside the trap as well.

7. (12 points) Your best bud says, "Hey hombre, we can use some of this egg-crate-foam stuff to make absorbers and outfit our studio!" Describe two different ways you could measure the absorption coefficient of the egg-crate-foam stuff.
Answer: Any two of:
    a. **The "Reverberation Chamber Method": measure the RT60 of a (reverberant) room with & without the sample. Use the Sabine equation and the known area of the sample to solve for the absorption coefficient.**

b. **The "Tone Burst Method": Bounce sound off the sample, and use the ratio of the reflected sound intensity to the direct sound intensity (for the same distance from the source) to get a measure of the absorption coefficient.**
c. **The "Impedance Tube Method": Apply standing waves in a tube, and extend a mic down into the tube. The locations of the pressure nodes, along with an equation in the text, can be used to get the absorption coefficient.**

8. (8 points) You've got some plywood with a surface density of 2 lb/ft^2, and you want to make a "piece-o-wood" panel absorber to absorb frequencies around 130 Hz. How deep should you make the airspace?
Answer: The resonant frequency for the wood diaphragm absorber is given by

$$f_0 = \frac{170}{\sqrt{md}}, \text{ so } md = \left(\frac{170}{f_0}\right)^2$$

$$d = \frac{1}{m}\left(\frac{170}{f_0}\right)^2 = \frac{1}{2}\left(\frac{170}{130}\right)^2 = 0.86 \text{ inches}$$

9. (8 points) Stephen Doster has some pegboard with 5% perforation and thickness of 1" (from stacking 8 sheets of 1/8" pegboard). The hole diameter is 0.25". He wants to mount it near a wall to make a Helmholtz absorber with a resonant frequency of 96 Hz.. How deep should he make the air gap?
Answer:

$$f_0 = 200\sqrt{\frac{p}{dt}},$$

$$\text{where } t = (\text{thickness}) + 0.8(\text{hole diameter}) = 1" + 0.8(0.25) = 1.2"$$

$$d = \frac{p}{t}\left(\frac{200}{f_0}\right)^2 = \frac{5}{1.2}\left(\frac{200}{96}\right)^2 = (4.17)(4.34) = 18.1"$$

10. (8 points) Name 4 characteristics of a "perfectly diffuse sound field."
Answer: These are listed as bullet points in the beginning of the Everest chapter on Diffusion.

11. (6 points) You mount some porous absorber away from the wall with an air gap of 4". Name the three lowest frequencies at which absorption will be boosted the most due to this air gap.
Answer:

$$\boldsymbol{f = v/\lambda}$$

$$\mathbf{4" = 0.333\ ft = \lambda_1/4, so\ \lambda_1 = 1.333\ ft. Thus\ } \boldsymbol{f_1} \mathbf{= (1140\ ft/s)/(1.333\ ft) = 855\ Hz.}$$

$$\mathbf{0.333\ ft = 3\lambda_3/4, so\ } \boldsymbol{f_3 = 3 f_1} \mathbf{= 2565\ Hz.}$$

$$\mathbf{0.333\ ft = 5\lambda_5/4, so\ } \boldsymbol{f_5 = 5 f_1} \mathbf{= 4275\ Hz.}$$

12. (8 points) Sound is recorded in one room, and then played back in a room with a longer reverberation time. How does the reverberation time of the reproduced (i.e. "played-back") sound in the new room compare with the reverb times of the two rooms?

Answer: This is described in the Everest book in the section regarding Electro-Acoustically Coupled Spaces. The reverb time will be longer than the T_R of either room, but closer to that of the room with the larger T_R .

13. (8 points) Write a paragraph describing how would you measure the reverb time in Neely Dining Hall.
    Answer:

14. Extra Credit: (6 points) Write out the numerical sequence of well depths (i.e. their proportionality factors) for a quadratic residue diffusor based on the prime p=11.
    Answer:

n	n^2 mod 11
0	0
1	1
2	4
3	9
4	5
5	3
6	3
7	5
8	9
9	4
10	1
11	0