**PHY2010 HW9 - Modes - Answers.**

1. (1 point) Describe the *gist* of the "small room problem."

**Small rooms tend to have the "B" frequency region (see question #2) well into the range of (low) audible frequencies. The modal density at these frequencies is thus very low, and the response of the room is characterized by modes which "stick out." See Everest p.325, end of 2nd to last paragraph.**

2. (2 points) Name and describe the four frequency regions associated with modes in a room.

**A- The frequency too low for modes. $f < F_1 = v_s / L$.**
**B- Wave approach is valid, modes have low density and tend to "stick out."**
**freq range from $F_1$ up to $F_2 \approx 11{,}250/\text{sqrt}(RT60/V)$**
**C- "Transition region": wavelengths too short for "wave" approach and too long for "ray" approach**
**D- High modal density, statistical approaches valid, ray approach valid $f > 4F_2$**

3. (2 points) What is meant by these three terms: axial, tangential, oblique? Which of these three types of modes tends to be the loudest?

<u>axial</u> **- involves reflections along one axis, between two walls.**
<u>tangential</u> **- involves reflections in two dimensions, between two pairs of walls.**
<u>oblique</u> **- involves reflections in three dimensions, between three pairs of walls.**

**Axial modes tend to be the loudest.**

4. (1 point) Two modes of a room exist at 500 Hz and 1000 Hz. If the Q value for the lower mode is 4, and for the higher mode is 3, find the bandwidth of each mode.

**$Q = f_0 / \Delta f$. Thus $\Delta f = f_0 / Q$.**

**$\Delta f_1 = 500 / 4 = 125$ Hz. $\Delta f_2 = 1000 / 3 = 333$ Hz.**

5. (2 points) Find the reverb times associated with the two modes in the previous problem.

**$RT60 = 2.2 / \Delta f$. (eq 15-3, p.337).**

**$RT60_1 = 2.2 / 125 = 17.6$ ms $RT60_2 = 2.2 / 333 = 6.6$ ms**

6. (2 points) A room has dimensions 8m x 15m x 5m. Hint: *That was in meters*. Find the five lowest modes in the room and their associated mode numbers (e.g. 1,1,0).

**Using a speed of sound of $v_s = 345$ m/s, we find the following frequencies for the lowest modes:**

| nx | ny | nz | Freq. (Hz) |
|---|---|---|---|
| 0 | 0 | 1 | 34.5 |
| 0 | 1 | 0 | 11.5 |
| 1 | 0 | 0 | 21.6 |
| 0 | 2 | 0 | 23.0 |
| 1 | 1 | 0 | 24.4 |