

Assignment 12 Solutions

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4. A room has dimensions of 6 m (width) by 8 m (length) by 3 m (height). The walls and ceiling are plaster on lath; the floor is wood. The room has one archway (2 m by 2.5 m) and two windows (each window has dimensions of 1 m by 2 m). What is the total absorption of this room at 1000 Hz? We calculate the absorption of every surface. At 1000 Hz the absorption coefficients of plaster on lath, a wood floor, an open archway, and glass are 0.05, 0.07, 1.0, and 0.12 respectively. The area of the walls corrected for the open archway and two windows is given by $s_{walls} = 2 \times (6m \times 3m) + 2 \times (8m \times 3m) - (2m \times 2.5m) - 2 \times (1m \times 2m) = 75m^2$. The area of the ceiling and the floor are the same: $s_{floor} = s_{ceiling} = 6m \times 8m = 48m^2$. Similarly $s_{arch} = 2m \times 2.5m = 5m^2$ and $s_{windows} = 2 \times (1m \times 2m) = 4m^2$. Multiplying by the appropriate absorption coefficients, we have $A_{total} = s_{walls}\alpha_{walls} + s_{ceiling}\alpha_{ceiling} + s_{floor}\alpha_{floor} + s_{arch}\alpha_{arch} + s_{windows}\alpha_{windows}$. Substituting the correct numbers gives $A_{total} = 75m^2 \times 0.05 + 48m^2 \times 0.05 + 48m^2 \times 0.07 + 5m^2 \times 1.0 + 4m^2 \times 0.12 = 14.99sabins$.

6. for the room described in Question 4, determine the noise reduction that will result if the ceiling is covered with acoustical tile and a padded carpet is added to the floor. The absorption coefficients for acoustical tile and a padded carpet are 0.99 and 0.69, respectively at 1000 Hz. Thus, $s_{ceiling}\alpha_{ceiling} = 48m^2 \times 0.99 = 47.52sabins$ and $s_{floor}\alpha_{floor} = 48m^2 \times 0.69 = 33.22sabins$. Substituting these new values in the equation for total absorptivity we now have $A_{total} = 89.97sabins$. This in turn leads to a noise reduction given by $NR - 10\log \frac{89.97sabins}{14.99sabins} = 7.78db$.

8. A closet has dimensions of $2m \times 1.5m \times 3m$. What are the three lowest resonant frequencies of this enclosure? Here I assigned $l_x = 1.5m$, $l_y = 2m$, $l_z = 3m$ in the formula for the resonant frequencies, $f_{xyz} = \frac{v}{2} \sqrt{\left(\frac{n_x}{l_x}\right)^2 + \left(\frac{n_y}{l_y}\right)^2 + \left(\frac{n_z}{l_z}\right)^2}$. To get the lowest frequencies we need the square root to be as small as possible. Inspection suggests that f_{001} , f_{010} , f_{100} are likely candidates as well as f_{011} and f_{101} . We will use 345 m/s for the speed of sound. The results are as follows:

$$f_{001} = \frac{345m/s}{2} \frac{1}{3m} = 57.5 \text{ Hz.}$$

$$f_{010} = \frac{345m/s}{2} \frac{1}{2m} = 86.25 \text{ Hz.}$$

$$f_{100} = \frac{345m/s}{2} \frac{1}{1.5m} = 115 \text{ Hz.}$$

$$f_{011} = \frac{345m/s}{2} \sqrt{\left(\frac{1}{2m}\right)^2 + \left(\frac{1}{3m}\right)^2} = 102.7 \text{ Hz.}$$

$f_{101} = \frac{345m/s}{2} \sqrt{\left(\frac{1}{1.5m}\right)^2 + \left(\frac{1}{3m}\right)^2} = 128.6 \text{ Hz.}$ Thus, it is clear that the three lowest frequencies are given by f_{001} , f_{010} , and f_{011} .

11. Again consider the room described in Question 4 above. Calculate the reverberation time for this room. Ignore air absorption. The formula for calculating the reverberation time is $t_R = \frac{0.16V}{A} = \frac{0.16 \times (6m \times 3m \times 8m)}{14.99} = 1.54s$.

12. Some additions were made to the room described in Question 4. These additions are described in Question 6. Calculate the reverberation time for the room with the additions. Again,

ignore air absorption. $t_R = \frac{0.16V}{A} = \frac{0.16 \times (6m \times 3m \times 8m)}{89.97} = 0.26s$.

14. A lecture hall has a height of 5 m. Assuming that the first reflected sound is that which is reflected from the ceiling, estimate the initial time-delay gap for a student seated 5 m from the instructor. I assumed that the direct sound goes 5 m and travels 1m above the floor. The reflected sound is reflected from a point halfway between the instructor and the student. The path of the reflected sound travels a distance given by $2 \times \sqrt{(2.5m)^2 + (4m)^2} = 9.43m$. The direct sound travels a distance of 5 m. $t_D = \frac{5m}{345m/s} = 0.0145s$. $t_{reflected} = \frac{9.43m}{345m/s} = 0.0273s$. Therefore, $t_I = t_{reflected} - t_D = 0.013s$.