PHYS 229 - Ryan Kaufmann/Experiment 1/Acoustics - Prelab

SIGNED by Ryan Kaufmann Feb 08, 2018 @12:43 PM PST

Ryan Kaufmann Jan 25, 2018 @04:11 PM PST

Acoustics 1: Prelab

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In order to analytically calculate the resonant frequencies of a one-dimensional resonator, we must have the speed of propagation of the relevant waves and the length of the resonator. We calculated the height of our resonator (i.e. the insulated box) to be approximately 1.04m. Furthermore, by looking online, we can find that the speed of sound, our wave, is approximately 343 m/s. Then using the equation given to us, we can calculate the resonant frequencies:

0.437m

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$$f_n = \frac{n * v_s}{2X}$$

$$f_n = \frac{n * 343m/s}{2 * 1.04m}$$

$$f_n = \frac{343n}{2.08} Hz$$

$$f_n = n164.90Hz$$

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Then the first five resonant frequencies are approximately:

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$$f_1 = 164.90Hz$$

$$f_2 = 329.81Hz$$

$$f_3 = 494.71Hz$$

$$f_4 = 659.62Hz$$

$$f_5 = 824.52Hz$$

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However, this assumes that the lengths in any direction besides the height is negligible. If we consider the x-direction and y-direction, we must consider that the wave propagates in three dimensions instead of one. We can then try to find the resonant frequencies when we consider three dimensions. We measured the dimensions of our insulated box. We found that in addition to the 1.04m height, the box had a width and length of roughly 0.437m. Then we can apply a formula we had found online:

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$$f_{mnq} = c_s\left[(m/2a)^2 + (n/2b)^2 + (q/2d)^2\right]^{0.5} \ [\mathrm{Hz}] \ \text{(resonant frequencies)} \quad (13.2.33)$$

ResonanceEquation.JPG(19.3 KB)

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Where m, n, and q are integers; a, b, and d are the dimensions of the box; and Cs is the velocity of propagation (i.e. the speed of sound). This formula was retrieved from a MIT electrical engineering textbook (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-013-electromagnetics-and-applications-spring-2009/readings/MIT6_013S09_chap13.pdf). Then we can find resonant frequencies by plugging in our dimensions and the speed of sound into our equation. Thus the equation becomes:

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$$f_{mnq} = c_s((\frac{m}{2a})^2 + (\frac{n}{2b})^2 + (\frac{q}{2d})^2)^{0.5}$$

$$f_{mnq} = 343m/s * (\frac{m^2}{4 * 0.437^2} + \frac{n^2}{4 * 0.437^2} + \frac{q^2}{4 * 1.04^2})^{0.5}(1/m)$$

$$f_{mnq} = 343 * (\frac{m^2 + n^2}{0.763876} + \frac{q^2}{4.3264})^{0.5} Hz$$

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We can then plug in various values for m, n, and q to find some small values of resonance frequencies.

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$$f_{100} = f_{010} = 392.45Hz$$

$$f_{001} = 164.90Hz$$

$$f_{110} = 555.01Hz$$

$$f_{101} = f_{011} = 425.69Hz$$

$$f_{111} = 578.97Hz$$