

# Resonance Frequency of a Helmholtz Resonator

R. Hill<sup>1</sup>, M. Mendieta<sup>1</sup>, P. Bruce<sup>1</sup>, E. Stokes<sup>1</sup>

<sup>1</sup>Electrical and Computer Engineering Department, University of North Carolina - Charlotte, Charlotte, NC, USA

## Abstract

Acoustic metamaterials commonly use Helmholtz resonators to attenuate an acoustic signal at the resonator's resonance frequency. The resonance frequency is only dependent on the geometry, which is shown by representing the Helmholtz resonator as a mass spring system using the lumped element model and solving for the frequency. The spring is represented by the air in the cavity expanding and contracting due to the movement of air into and out of the resonator. The restoring force of the spring requires the air to leave the neck for a small distance as though it was still inside the neck, which is represented by adding an end correction factor, but it still introduces error. However, using COMSOL Multiphysics®, it was shown that a Helmholtz resonator with a cylindrically or spherically shaped cavity and cylindrically shaped neck has nearly the same simulated and calculated resonance frequency, for reasonable neck and cavity dimensions. According to Panton and Miller, the classical resonance equation for a Helmholtz resonator with a cylindrically shaped cavity starts to lose accuracy when the cavity length is larger than a sixteenth of the wavelength or the ratio of the neck to cavity diameter is less than 0.1 or more than 0.8.

In COMSOL Multiphysics®, a Helmholtz resonator with a cylindrical cavity was used to model a physical chemical flask with a tapered neck as well as a spherical cavity with a flat bottom. This method was used to eliminate the time required to create the exact physical geometry of the chemical flask. Based on the previous simulation, it was expected that the experimental and simulated resonance frequency would have a difference of +/- 5% or less. The cavity volume of the physical flask was changed by adding water to the flask, which reduced the air in the cavity.

The COMSOL Multiphysics® model uses a modified version of the "Helmholtz Resonator with Flow" application model, which makes use of the Acoustics module.