ECE 473
Homework Assignment #11
Due: Wednesday, December 12, 2018

1. Consider an infinitely long rigid-walled pipe of rectangular cross section of dimensions L_x = 0.5 m and L_y = 0.7 m and filled with water at 20°C. Find the cutoff frequencies for the lowest five modes.
2. A pipe is 0.02 m in radius and 2 m long. (a) Determine the three lowest resonance frequencies if the pipe is filled with air at 20˚C and has a rigid cap at its end. (b) Determine the three lowest resonance frequencies if the pipe is filled with water at 20˚C and has a rigid cap at its end. (c) Determine the three lowest resonance frequencies if the pipe is filled with air at 20˚C and has a flanged opening at its end.
3. An acoustical tile is placed at the end of a pipe with radius small compared to the wavelength. At the beginning of the pipe a piston is used to generate a 200 Hz acoustic plane wave. A very small microphone is inserted into the pipe via a small slot in the bottom so that it can be moved and used to measure the pressure amplitude as a function of distance from the end (x = L), without affecting the acoustic field. Using the microphone a standing wave ratio of 12 is measured and the first pressure minimum is found to be 0.4 m from the end (x = L). (a) What are the magnitude and polar angle for the complex reflection coefficient, $\tilde{B}/\tilde{A}$? (b) What is the normal specific acoustic impedance of the acoustic tile?
4. For an open ended unflanged pipe, show that the half-power points (frequencies) are given by $\omega_{u,1} = \omega_n \pm \frac{1}{4}(k_n a)^2 \frac{c}{L}$ and that $Q_n = \frac{\omega_n}{\omega_u - \omega_1} = \frac{2}{n\pi}\frac{L}{a}\frac{L+0.6a}{a}$.
5. A section of pipe of cross-sectional area 0.4 m^2 and length 0.3 m is in a pipe of cross-sectional area 0.2 m^2. (a) Over what frequency range will the larger cross-section of pipe act as a low pass filter? (b) What is the maximum attenuation it provides, in decibels?

Note to graduate students writing the paper: For the additional credit, you are required to write a paper (typically about 10 pages, double spaced) that discusses in some detail any topic on acoustics for which the fundamentals of engineering acoustics are explicitly described. The paper is typically a summary of some acoustic topic and based on 4-5 peer-reviewed publications. The paper will be due **Dec 12, 2018**.