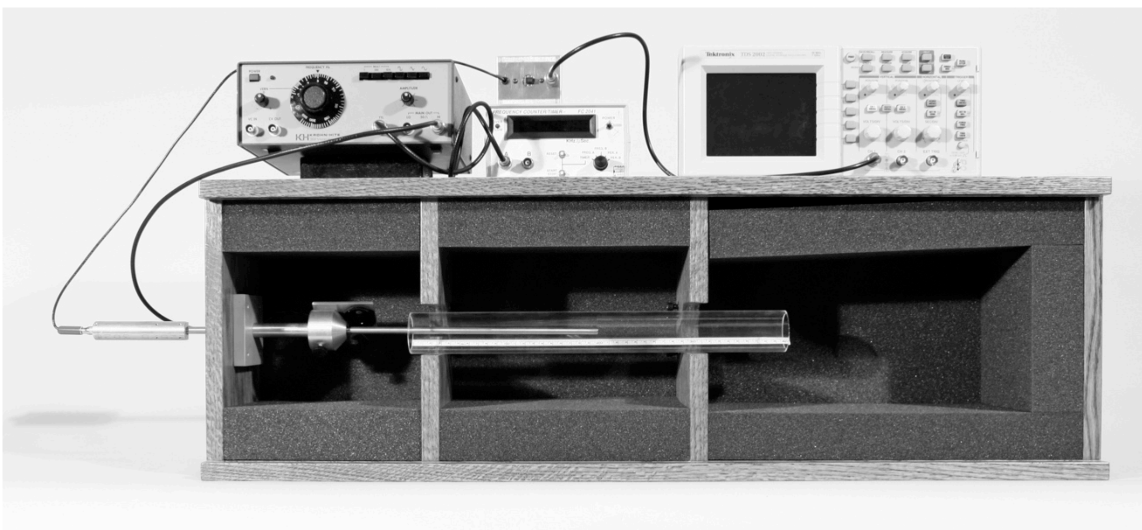
Lab 9
Modes of open and closed pipes

Equipment:
Our laboratory setup has a number of advantages over commercially available equipment. These include placing the equipment in a sound-insulated box to avoid the distracting noise in the lab when many setups are used at the same time. In addition, the arrangement allows insertion of a miniature microphone into closed (or even conical) pipes without interference with the loudspeaker used to excite the pipe oscillations. The pipes are transparent in order to observe the microphone position, and thus the location and nodes and anti-nodes.

The figure below shows the equipment. For the purpose of this picture (but not in actual use in the lab) the sound insulating box was turned on its side and the electronics (oscillator, frequency counter, oscilloscope) was placed on top of the box.



Excitation of pipe oscillations is by a small loudspeaker (3.6 cm diameter, 3 mm thickness, 0.3 W). The speaker can be driven by any common audio generator available in the student laboratory. For certain experiments we use as a driver an inexpensive frequency synthesizer. The speaker is mounted offset to one side, (with speaker axis perpendicular to pipe axis) as shown in the above figure. This allows access for the microphone stem from the same side and thus permits studies of closed pipes or even conical pipes. The students move the microphone along the pipe to find the location of nodes and antinodes. The largest amplitude of excitation is obtained with the end of the pipe a few cm from the speaker. More details about the equipment and examples of measurements are described in a paper by W. Haeberli, entitled "*Laboratory Exercises on Oscillation Modes of Pipes*" in the American Journal of Physics, volume 77, issue 3, pp. 204-208 (2009).

Experiments:

1. Modes of open pipes with different pipe lengths (40 cm and 60 cm) and different diameters (13 mm and 26 mm). Find the mode frequencies for the first five modes.
2. Record results in a table. Locate nodes and antinodes by moving the mike along the pipe.
3. Compare results to the pipe formula. Calculate the acoustic length and compare to the physical length. In what respect are pipes similar and different from strings? (Compare effect of pipe diameter to string thickness, compare the effect of pipe length to string length, does string tension have an analog for pipes?).
4. Find mode frequencies of a closed pipe.
5. Pipes with tone holes (finger holes): find the first five mode frequencies for a 60-cm long open pipe with one large tone hole. Mark the frequencies on a number line – are they still equally spaced? Find the acoustic length of the pipe – and compare to the length from pipe end to tone hole.
6. Rise and decay of pipe oscillation: the oscillations do not start or stop suddenly but build up and decay over some short time. Use the speaker switch to cut off the speaker and measure the decay time by freezing the scope display at the right moment. Hint: use slow sweep time and try several times until you hit the right moment – then freeze and expand the display.