

# Physics 225

## Homework Assignment 8

Due 25 March

### 1 Viscous losses

Consider the clarinet. It is a cylindrical tube, open on one end and closed on the other. “Something” at the closed end generates sound which resonates in the cylinder. Typical clarinet dimensions are 0.60 meters (60cm) in length and 0.0075 meters in radius (15 mm diameter). (The end of the instrument is slightly flared, but ignore that in what follows. Also do not worry about end corrections to the effective length of the instrument.)

Compute the lowest three resonant frequencies of the clarinet. (assume all tone holes are closed.) [Be careful—it is an open-closed instrument.]

Estimate the radiation efficiency and resonant  $Q$  due to radiation from the instrument’s open end, at each of the 3 frequencies you found.

Find the thickness of the (viscous) boundary layer at each of the 3 frequencies you found. How does it compare with the radius of the bore of the instrument?

Estimate the quality factor  $Q$  for each of the three resonant frequencies you found, IF the sole loss mechanism is viscous damping.

Estimate the quality factor  $Q$  considering all three loss mechanisms (radiation, viscous damping, thermal conductivity), at each resonant frequency. Which resonance is the highest “quality”? For each resonance, what fraction of the sound energy is radiated rather than being dissipated by some other mechanism?