In the following questions, unless otherwise stated, you may assume the speed of sound in air is 343 m/sec.

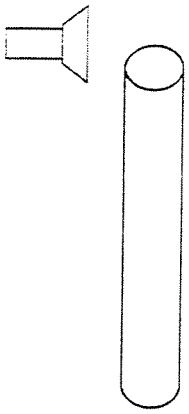
1. For a particular tube there are six harmonic frequencies below 1000Hz. Four of these are 300Hz, 600Hz, 750Hz and 900Hz. You can see that one end of the tube is open, but you can not see the other end. Is it open or closed? Explain your answer?

2. In the tube described above, what two frequencies are missing?

3. When a musical note is played on a large church pipe organ, the sound originates from blowing puffs of air into a tube of a fixed length. Does this puff of air have to have only the particular frequency of the final note? If so, how do you think the organ creates the puff with this frequency? If it does not, why do you think you only hear a single frequency?

4. The audible frequency range for normal hearing is from about 20 HZ to 20 kHz. What are the wavelengths of sound waves at these frequencies?

5. A small loudspeaker driven by an audio oscillator and amplifier, adjustable in frequency. Nearby is a tube of cylindrical sheet-metal pipe 45.7 cm long, with a diameter of 2.3cm and which is open at both ends. If the room temperature is $20^{\circ}C$, at what frequencies will resonance occur in the pipe when the frequency emitted by the speaker is varied from 1000 to 2000 Hz?



6.

a) What is the fundamental frequency of the tube in the previous problem?

b) What would be the fundamental frequency if we doubled the diameter of the to 4.6cm?

c) What would be the fundamental frequency if we doubled the length of the tube to 91.4cm?

d) What would be the fundamental frequency if we decreased the velocity of sound in air to 320 m/sec?