NAME: Answers, Sect. #______

Physics 109 **Homework #5** due Monday Oct. 15, 2001

Formulae: in air v= 340m/s. Open: $f_1 = v/2L$; $f_n = nf_1$; Closed: $f_1 = v/4L$

Exercises on pipes:

1. **(a)** Find the fundamental frequency and the frequencies of the first two overtones of an open pipe of **60 cm** length.

$f_1 = \frac{v}{2L} = \frac{340}{1.2}$ Hz

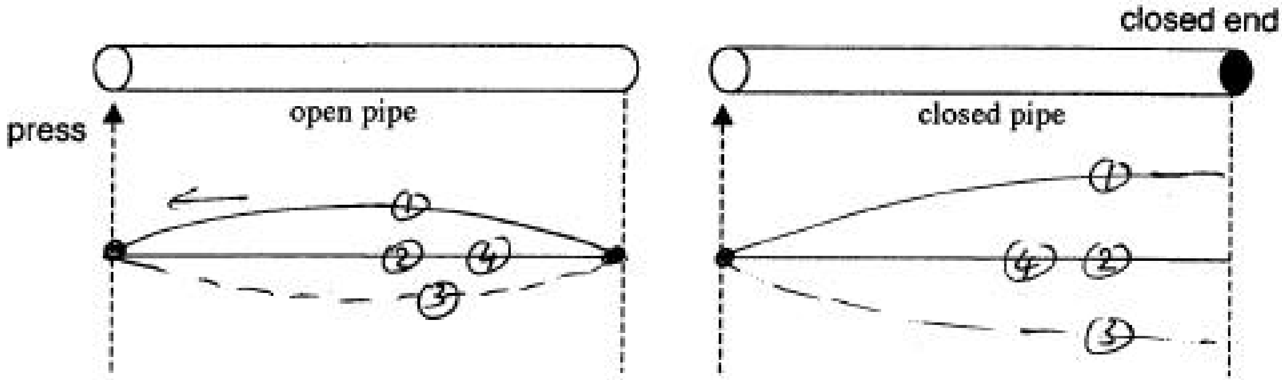
283 **Hz,** 567 **Hz,** 850 **Hz.**

(b) if the same pipe is closed at one end, what are the corresponding frequencies?

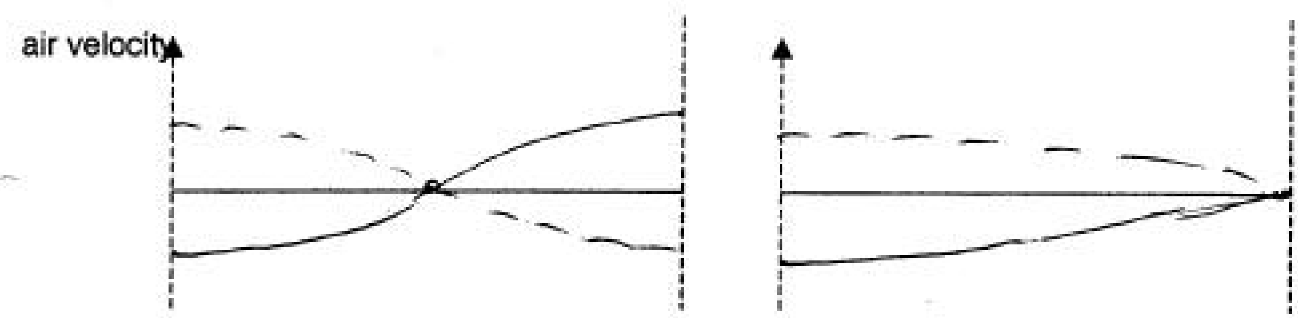
f_1 = octave below

odd harmonics only 142 **Hz,** 425 **Hz,** 708 **Hz.**

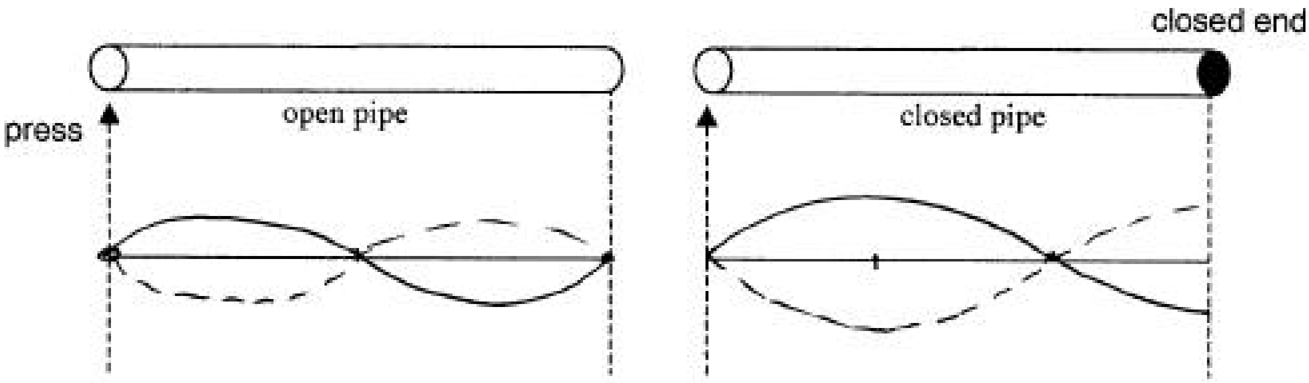
2. (a) Make a graph of the **pressure** at different instances in an open pipe (left) and in a closed pipe (right) oscillating in the fundamental mode.
(hint: first mark the pressure nodes by letter **N** - then draw the curves)



make a corresponding graph or the air **velocity** distribution in the pipe.
(remember slinky demo - where does it move most, where does it not move at all?)



(b) make corresponding **pressure** graphs for the **next higher mode**.



3. Between room temperature (20° C) and body temperature (37° C) the speed of sound increases by 10 m/s. A flute has a frequency of 260 Hz when it is cold. Find the frequency when the flute is warmed to body temperature by the flutist's breath (hint: use proportions to relate frequencies to speed of sound - what is the ratio of speed of sound at the two temperatures? What is the frequency ratio?)

f_2 = warm flute f_1 = cold flute
for fixed L, f is prop. v

$\frac{f_2}{f_1} = \frac{(340+10)}{340} = 1.029$

$f_2 = 260 Hz \times 1.029$

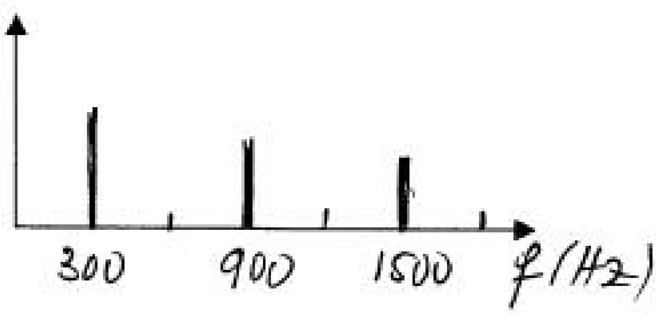
f = 267.6 Hz

comment: 6% change in a semitone, so here ½ semitone

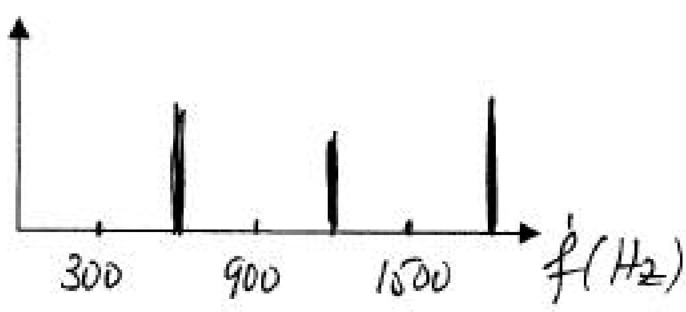
Exercises on Fourier Analysis

NOTE: we can usually not figure out the amplitudes of the overtones, but can only find out which are present and what their frequencies are. Thus when you are asked to draw a Fourier spectrum the position of the Fourier components should be in the right place, but the intensity is arbitrary.

4 a) What might the Fourier spectrum of a closed pipe with fundamental frequency 300 Hz look like?



(b) What is the spectrum when the same pipe is open at both ends?



5. What might the Fourier spectrum of a 500 Hz violin string look like when it is plucked 1/3 the length from one end?

#3, #6, #9 missing