Unit 8 · Waves in Pipes and Strings

WORKSHEET

Full marks 32.5

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 32.5

1 Key words [4]

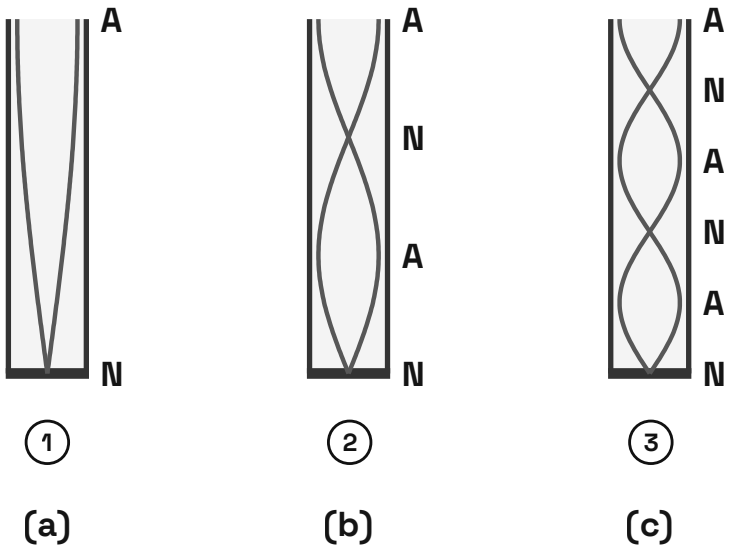
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

amplitude	**beat**	**closed organ pipe**	**end correction**	**fundamental frequency**	**harmonics**	
linear mass density	**node**	**overtones**	**sonometer**			

The lowest frequency at which a string or an air column naturally vibrates is its _____. Whole-number multiples of it are its _____; the frequencies above it that it actually produces are its _____. A pipe with one end closed is a _____, and it has a _____ at its closed end. The antinode at an open end forms a little outside the pipe; the distance it lies beyond the end is the _____. The mass per unit length of a string is its _____. The laws of a stretched string are tested with a _____.

2 Label the diagram [1.5]

The diagram shows the first three modes of a pipe closed at the bottom. Write the label that belongs in place of 1 to 3. Each carries 0.5 mark.



1. _____ 2. _____

3. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. An open pipe 0.68 m long sounds its fundamental. If sound travels at 340 m/s, its frequency is (ignore the end correction): [1]

a. 125 Hz **b.** 250 Hz
c. 500 Hz **d.** 1000 Hz

ii. A pipe closed at one end can produce: [1]

a. all harmonics **b.** only the odd harmonics
c. only the even harmonics **d.** only its fundamental

iii. Waves travel at 240 m/s along a sitar string 0.60 m long between its fixed ends. Its fundamental frequency is: [1]

a. 100 Hz **b.** 200 Hz
c. 400 Hz **d.** 144 Hz

iv. The second overtone of an open pipe is its: [1]

a. second harmonic **b.** third harmonic
c. fifth harmonic **d.** fourth harmonic

v. Two closed pipes have the same length, but one is much wider. The wider pipe sounds: [1]

a. a slightly lower note **b.** a slightly higher note
c. the same note **d.** an octave lower

4 Short answers [7]

Write short answers to the following questions.

a. Why does an open pipe sound richer than a closed pipe of the same fundamental? [2]

b. State the law of length and the law of tension for the transverse vibrations of a stretched string. [2]

c. A closed pipe 25.0 cm long has an internal diameter of 3.0 cm. Taking the end correction as 0.3d and the speed of sound as 336 m/s, find its fundamental frequency. What would you get if you ignored the end correction? [3]

5 Long answer [4]

Write a long answer to the following question.

For an air column of length l in a pipe closed at one end, find the frequencies of the first three modes of vibration (ignore the end correction), and show that only odd harmonics are produced.

6 Numerical problems [8]

Solve the following problems. Show your working.

a. A sonometer wire has a mass per unit length of 2.5×10^{-3} kg/m and a vibrating length of 0.80 m, and is stretched by a tension of 49 N. Find i. its fundamental frequency, ii. the length that would give a fundamental of 175 Hz at the same tension, and iii. the tension that would give 175 Hz with the length kept at 0.80 m. [4]

Answer:

b. In a resonance tube experiment with a 480 Hz tuning fork, the first resonance is heard with an air column 17.0 cm long and the second with 52.4 cm. Find i. the wavelength, ii. the speed of sound, iii. the end correction, and iv. the tube's internal diameter (e = 0.3d). [4]

Answer:

7 Think [3]

A sitar player finds that one string sounds 10% lower than it should. Keeping the same length, by what percentage must she raise its tension? Why is the change in tension larger than the change in frequency?

8 Activity: A bottle organ (not marked)

Line up four or five glass bottles of the same size. Put a different amount of water in each, and blow across the top of each one. Measure the height of the air above the water.

Bottle	Air column (cm)	Note: higher or lower?
A		
B		
C		
D		

Which bottle gives the highest note? Why?