A tube, open at both ends, has a length of 6.0-m.

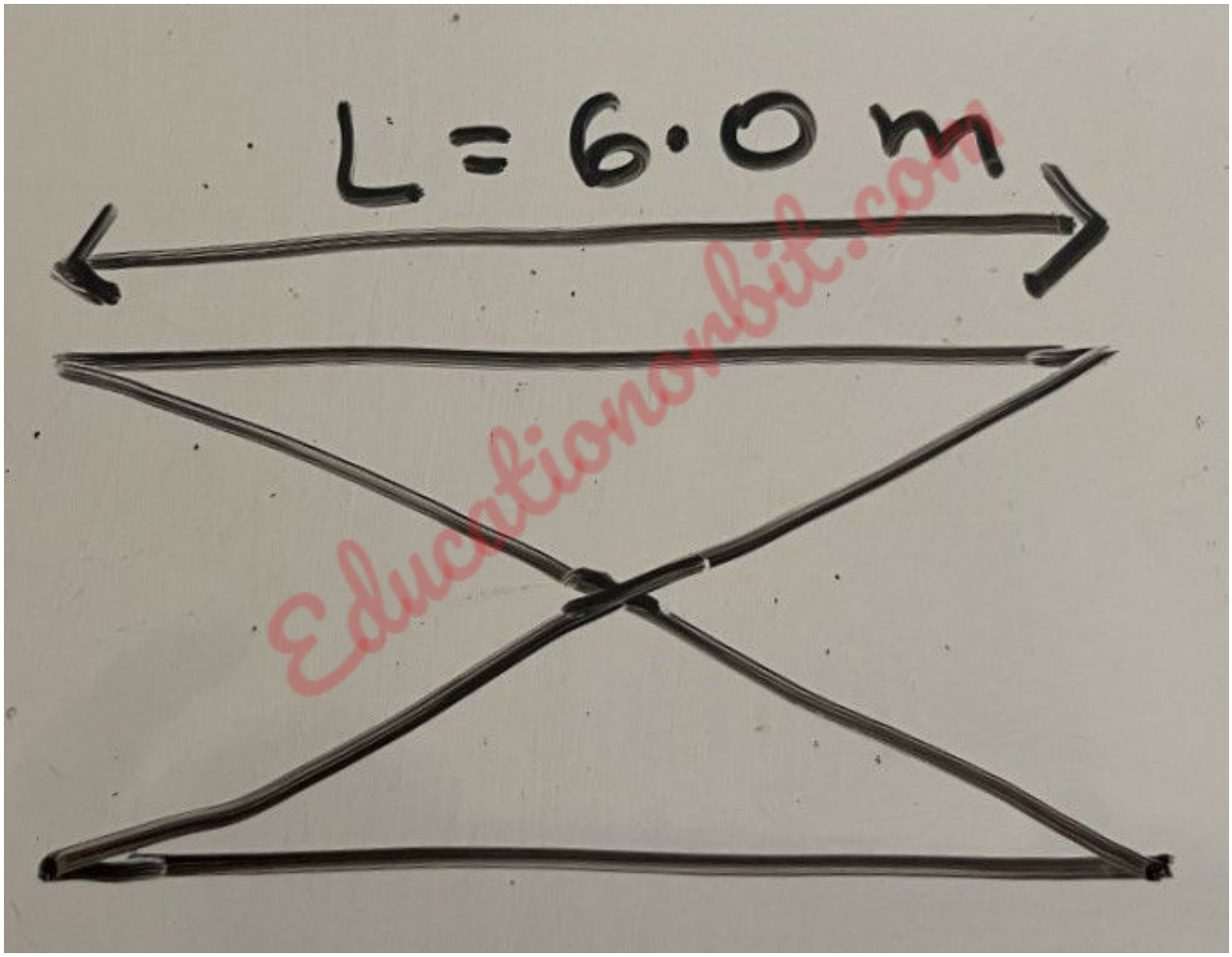
a) What is the frequency of the first harmonic of vibration of air in the tube?
b) What are the frequencies of second and third harmonics of vibration?

Given:

Length of tube: L = 6.0 m

Determine:

a) frequency of the first harmonic of vibration: f_1



The open end of the air column is an antinode of displacement. The length of the tube is occupied by half a wavelength for the first harmonic of vibration.

$$L = \lambda / 2 \text{ ----------(1)}$$

Substituting for L in (1):

$$\lambda = 2 \times 6.0 = 12 \text{ m}$$

Then, fundamental frequency of vibration is:

$$f_1 = v / \lambda \text{ ----------(2)}$$

"v" is the speed of sound in air is 343 m / s at 20° C.

Substituting for v and λ in (2):

$$\boldsymbol{f_1 = 343 / 12 = 29 \text{ Hz}}$$

b) frequencies of second and third harmonics of vibration: f_2 and f_3

Use formula:

$$f_n = nf_1 \text{ ----------(3)}$$

"n" is the harmonic and is 2 and 3 in this problem.

Substituting for n and f_1 in (3):

$$\boldsymbol{f_2 = 2 \times 29 = 58 \text{ Hz}}$$

$$\boldsymbol{f_3 = 3 \times 29 = 87 \text{ Hz}}$$