a.) **Both Ends Closed:**

$$v = f_n \lambda_n$$

$$f_n = n f_1 = n \frac{v}{2L}$$

$$\lambda_n = \frac{\lambda_1}{n} = \frac{2L}{n}$$

$$n = 1, 2, 3, 4 \ldots$$

$$f_1 = \frac{c}{2L}, \qquad (8)$$

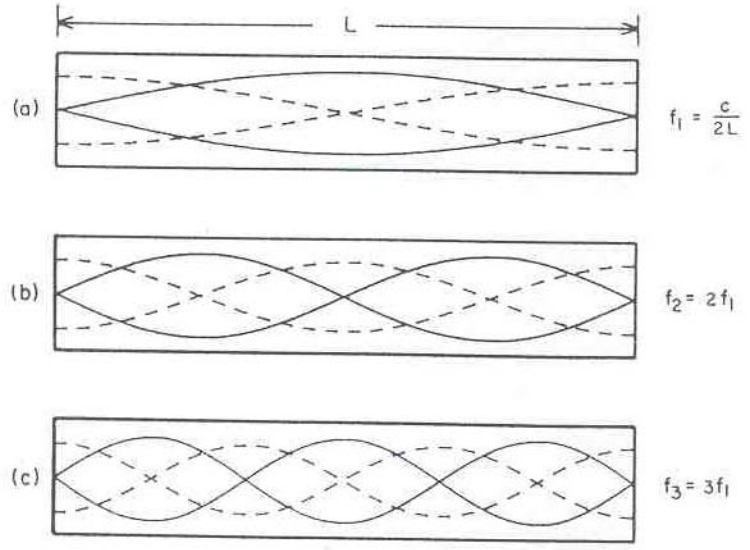

FIG. 7. First three vibration modes of an air column closed at both ends. Solid lines give displacement amplitudes; dashed lines, pressure amplitudes.

Closed Ends: ⇒ **Pressure *anti-nodes*** and **displacement *nodes*** at $x = 0$ and $x = L$.