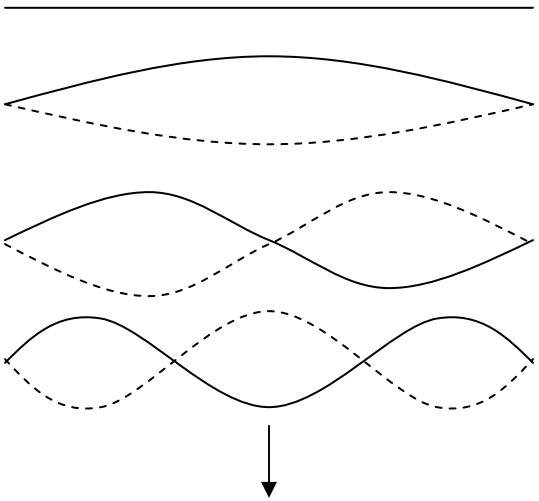
Standing Waves

Standing Wave – an observed wave pattern that does not appear to move



Rest (equilibrium position)

Fundamental frequency (f_1)
(1^{st} Harmonic)

2^{nd} Harmonic frequency (f_2)
(1^{st} Overtone)

3^{rd} Harmonic frequency (f_3)
(2^{nd} Overtone)

Resonance – the production of standing waves in an object by an applied force
The applied force causes the object to vibrate at its natural frequencies

Natural Frequencies of a long Spring or String:

$$f_n = \frac{nv}{2L}$$

$n = 1$: *fundamental* $\left[f_1 = \frac{v}{2L}\right] = f_1$

$n = 2$: *2^{nd} harmonic* $\left[f_2 = \frac{v}{L}\right] = 2f_1$

$n = 3$: *3^{rd} harmonic* $\left[f_3 = \frac{3v}{2L}\right] = 3f_1$

…

harmonic series - any set of natural frequencies that can be produced by an integer (*whole number*) multiple of the fundamental frequency

harmonic - a specific frequency in a harmonic series

➔ $f_n = n f_1$ *Harmonic series* (f_n = *n^{th} harmonic frequency*)

Harmonics of OPEN and CLOSE PIPES

The harmonic series (*natural frequencies*) for an ***Open*** pipe are generated by:

$$f_n = \frac{nv}{2L} \qquad n = 1, 2, 3\ldots \;\rightarrow\; \text{harmonics: } f_n = n f_1 \quad \left[f_1 = \frac{v}{2L}\right]$$

The harmonic series (*natural frequencies*) for a ***Closed*** pipe are generated by:

$$f_n = \frac{nv}{4L} \qquad n = 1, 3, 5\ldots \;\rightarrow\; \text{harmonics: } f_n = n f_1 \quad \left[f_1 = \frac{v}{4L}\right]$$