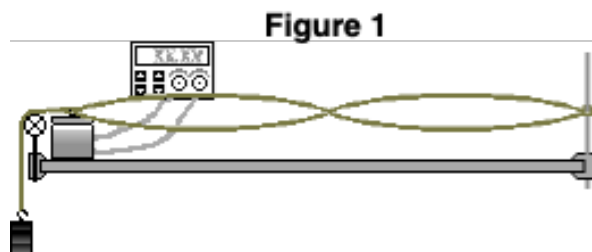


Standing Waves in a Rope

A group of students are conducting experiments to determine the effect of various factors on the speed of a wave. The apparatus, shown in **Figure 1**, includes a rope extending from a metal pole on one end to a pulley on the other. The rope wraps around the pulley and is pulled tight by a hanging mass. A *mechanical oscillator* vibrates the rope. The frequency of vibrations can be controlled by the students. Frequencies are chosen that cause the rope to vibrate as a **standing wave** with fixed points of no vibration called **nodes**.



Experiment 1

In Experiment 1, students hang a 1.0 kilogram mass on the end of the rope. They vary the frequency to create standing wave patterns with varying number of nodes. They measure the wavelength and calculate the speed of the wave. See **Table 1**.

Table 1

Trial	# of Nodes	Frequency (Hz)	Wavelength (m)	Speed (m/s)
1	2	62.2	2.25	141
2	3	93.3	1.50	139
3	4	124.4	1.13	140
4	5	155.6	0.90	141

Experiment 2

In Experiment 2, students vary the amount of mass that hangs on the end of the rope. Increasing the mass causes the tightness (tension) of the rope to increase. In each case, they chose frequencies that vibrate the rope with the same standing wave pattern. The measured frequencies and wavelengths and the calculated speeds are shown in **Table 2**.

Table 2

Trial	Mass (kg)	Frequency (Hz)	Wavelength (m)	Speed (m/s)
5	0.5	65.9	1.50	99
6	1.0	93.6	1.50	140
7	1.5	114.4	1.50	172
8	2.0	131.9	1.50	198

Experiment 3

In Experiment 3, students vary the rope that is being vibrated. They keep the tension the same from trial to trial and vibrate the rope with the same standing wave pattern. For each rope, they measure the *linear density* (the mass per unit length of the rope). The measured frequencies and wavelengths and the calculated speeds are shown in **Table 3**.

Table 3

Trial	Lin. Dens. (kg/m)	Frequency (Hz)	Wavelength (m)	Speed (m/s)
9	0.000345	112	1.50	168
10	0.000492	94.3	1.50	142
11	0.000695	79.1	1.50	119