Speed of a Pulse on a Taut Wire

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ABSTRACT

In high school and undergraduate general physics classes the speed of a wave on a string is taught with an accompanying lab experiment using standing waves. However, it is possible to economically demonstrate the speed of a single pulse on a guitar string with high precision using basic lab equipment and open-source oscilloscope software which uses the computer's sound card. This software is available at: (http://www.zeitnitz.de/Christian/scope_en)

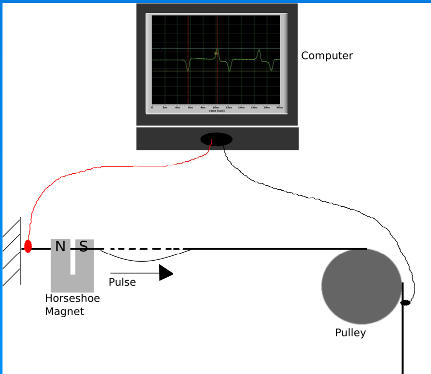


Figure 1.
Experimental setup

SETUP

The general setup includes a guitar string anchored at one end by a clamp and held taut by suspended mass over a pulley. The string passes through the middle of a common horseshoe magnet and both sides have alligator clips leading to a computer's microphone-in plug.

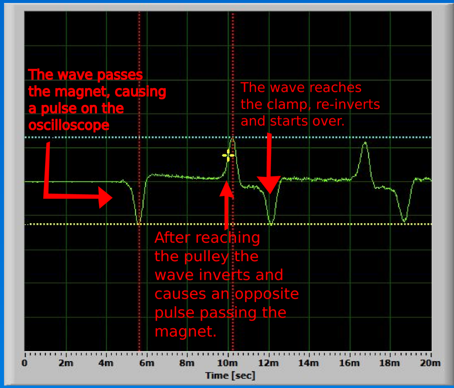


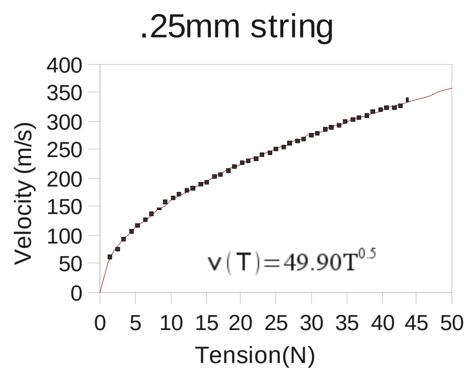
Figure 2. Screenshot from the Soundcard Oscilloscope

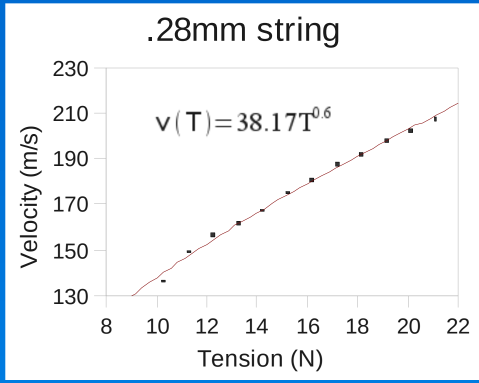
THEORY

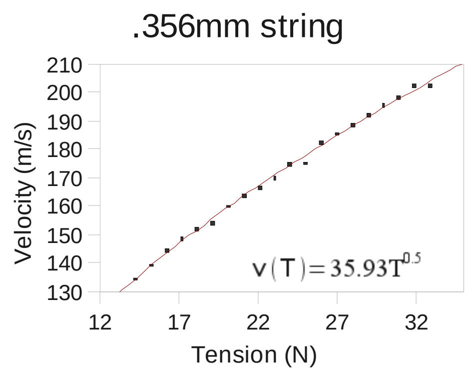
The laboratory is based around the velocity equation of a wave on a string

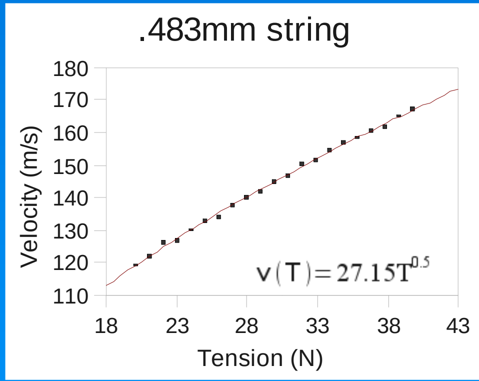
$$v = (T/\mu)^{0.5}$$

The time and position of the string are measured by the magnet. That is, when the steel string moves in the magnetic field of the horseshoe a potential difference is created that is passed to the computer oscilloscope via the alligator clips. This interaction is recorded as a pulse and a dip when the wave travels back down the string in the opposite direction. The oscilloscope software includes movable cursors so as to record time. The distance traveled by the wave is simply double the distance between the magnet and the pulley. With a time and a distance the velocity is calculated. Tension is controlled by varying the masses suspended on one end of the string. The results are then plotted to yield the familiar power curve of the velocity versus tension graph.









String Thickness (mm)	Direct Measurement (g/m)	Pulse Measurement (g/m)	Std. Dev.	Number of Deviations from direct measurement
0.25	0.393	0.402	0.00291	1.58591
0.28	0.485	0.494	0.03866	1.94502
0.36	0.711	0.774	0.06704	0.27693
0.43	1.11	1.05	0.02234	-0.58527
0.48	1.31	1.19	0.06662	0.20582

Table: The linear-mass density measured by wave velocity was compared to the density measured by meter stick and triple-beam balance. The standard deviations of each data set are shown along with the number of deviations from the direct measurement. An average of 20 measurements were taken for each wire. These results were achieved with quickness and ease thus showing the experiment's usefulness in the high school/undergraduate teaching lab.