Activity #12: Speed versus Tension & Density of Medium (Teacher notes)

The Purpose: of this laboratory activity is to determine the relationship among speed of a wave through a rope or spring, tension in the rope, and mass per length "density" of the rope or spring using the physlet illustration found at this address…
http://cwx.prenhall.com/bookbind/pubbooks/walker2/chapter14/custom1/deluxe-content.html

Procedure:

1. Practice using the physlet found about halfway down the website. Press start to begin. Use the pause button to stop the pulse. Restart the pulse using the play button. The space on the grid is one meter.
2. Determine the speed by timing the pulse as it moves a given distance. Be consistent about the part of the wave you measure. Record the time, distance, mass/length, tension and calculate the speed. Keep the mass/length constant. (Change and record all mass/length values in kg/m.)
3. Repeat the step above as you change the tension to five different values. Record each time, distance, mass/length, tension and calculate the speed.
4. Graph Speed versus Tension.
5. Re-graph as needed to create a straight line.
6. Now keep the tension constant. Determine the speed by timing the pulse as it moves a given distance. Be consistent about the part of the wave you measure. Record the time, distance, mass/length, tension and calculate the speed.
7. Repeat the step above as you change the mass/length to five different values. Record each time, distance, mass/length, tension and calculate the speed.
8. Graph Speed versus Mass/length.
9. Re-graph as needed to create a straight line.

Analysis:

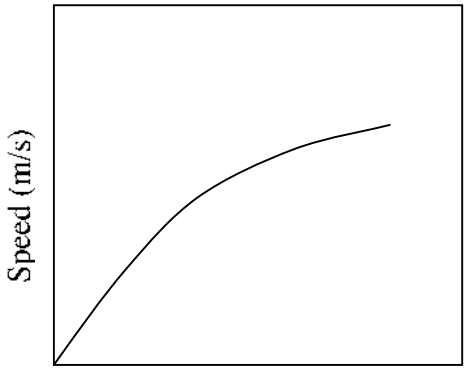
1. On each of the two straight line graphs write the general equation of a straight line graph, the equation written with the actual variables replacing the x and y in the straight line equation, the equation with the actual slope and y-intercept values replacing m and b in the straight line graph (with units), and finally the general physics equation for the speed of a wave in a rope or spring.
2. What does the slope represent in the first graph you drew? *Inverse of the Square Root of mass/length*
3. What does the slope represent in the second graph you drew? *Square root of Tension*
4. How is speed related to the tension in the rope or spring? *Speed ∝ Square root of Tension*
5. How is speed related to the mass/length in the rope or spring? *Speed ∝ Inverse of the Square Root of mass/length*
6. Write one equation showing both relationships. *$v = 1/\sqrt{(m/l)} * \sqrt{T}$ or $v = [T/(m/l)]^{1/2}$*
7. If a spring with a mass of 0.80 kg is 5.0 m long is under 6.0 N of tension, how long with it take a pulse to move 3.0 m down the spring? Show your work below.

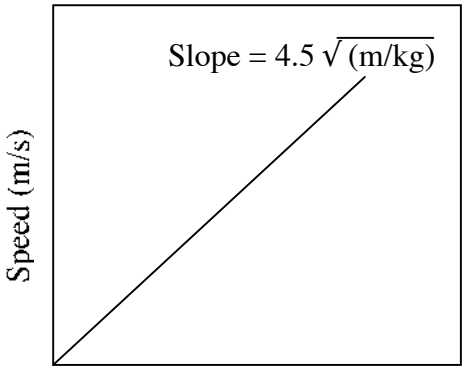
$v = [T/(m/l)]^{1/2}$ $v = [6.0\ N/(0.80\ kg/5.0\ m)]^{1/2}$
$v = 6.1\ m/s$ $t = d/v$ $t = 3.0\ m / 6.1\ m/s$ ***$t = 0.49\ s$***

Conclusion: *The speed of a wave in a spring or rope is directly proportional to the square root of the tension and inversely proportional to the square root of the mass per length of the spring or rope.*

Calculation { Data } Calculation

Sq Rt of Tension (√N)	*Tension (N)*	*Mass/length (kg/m)*	*Distance (m)*	*Time (s)*	*Speed (m/s) = distance /time*
2.24	*5*	*0.050*	*10.0*	*1.0*	*10.*
3.87	*15*	*0.050*	*17.5*	*1.0*	*17*
5.00	*25*	*0.050*	*11.2*	*0.5*	*22*
7.07	*50*	*0.050*	*15.8*	*0.5*	*32*
8.94	*80*	*0.050*	*20.0*	*0.5*	*40*



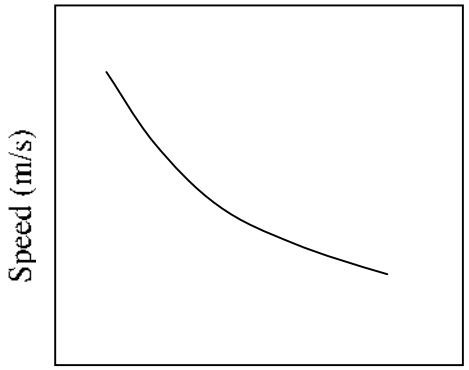


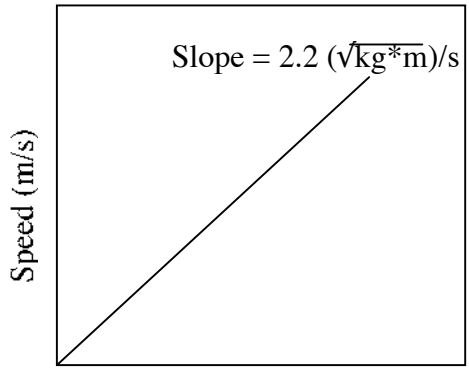
$Y = mX + b$ $v = m^* \sqrt{T} + b$ $v = 4.5 \sqrt{(m/kg)} * \sqrt{T} + 0$

$v = 1/\sqrt{(m/l)} * \sqrt{T}$ or $v = [T/(m/l)]^{1/2}$

Calculation { Data } Calculation

Inverse of Sq Rt of Mass/length 1/(√kg/m)	*Mass/length (kg/m)*	*Tension (N)*	*Distance (m)*	*Time (s)*	*Speed (m/s) = distance /time*
4.47	*0.050*	*5.0*	*10.0*	*1.0*	*10.*
8.17	*0.015*	*5.0*	*18.0*	*1.0*	*18*
5.77	*0.030*	*5.0*	*12.9*	*1.0*	*13*
4.08	*0.060*	*5.0*	*9.1*	*1.0*	*9.0*
3.43	*0.085*	*5.0*	*7.8*	*1.0*	*7.8*





$Y = mX + b$ $v = m* 1/[\sqrt{(m/l)}] + b$ $v = 2.2\ (\sqrt{kg*m})/s * 1/[\sqrt{(m/l)}] + 0$

$v = \sqrt{T} * 1/\sqrt{(m/l)}$ or $v = [T/(m/l)]^{1/2}$