SPEED OF A MECHANICAL WAVE

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| **OBJECTIVE:** | 1. To measure the speed of a wave in a medium.
2. To describe the relationship between the frequency and the wavelength of a wave travelling in a given medium.
3. To determine the relationship between the speed of a wave and the tension in the rope.
 |
| **MATERIALS** | Wave on a String PhET simulation |
| **ONLINE RESOURCES** | Wave on a String PhET simulation: <https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html>  |
| **PROCEDURE** |  |
| Speed of a “Rope Wave” | 1. Open the Wave on a String PhET simulation.
2. Set the following parameters:

|  |  |
| --- | --- |
| Simulation | PAUSED |
| Damping | None |
| Tension | High |
| Rope’s End | No End |
| Source | Oscillate |
| Ruler | Enabled |
| Amplitude | 0.5 cm |

 1. Set the frequency of oscillation to 1.5 Hz. Run the simulation by clicking on the Play/Pause button. Measure the wavelength of the wave, using the ruler and the Play/Pause button.
2. Using the parameters in (1), increase the frequency to 3 Hz. Determine the wavelength of the wave. Summarize your data in Data Table 1.

Data Table 1

|  |  |  |
| --- | --- | --- |
| Frequency | Wavelength | Speed |
| 1.5 Hz | 4 cm | 6 cm/s |
| 3.0 Hz | 2cm | 6 cm/s |

Guide Questions:* How did you measure the wavelength of the wave?

Measure the distance between two consecutive peaks.* What happened to the wavelength of the wave when the frequency increased from 1.5 Hz to 3.0 Hz? What happened to the speed?

Wavelength decreased.* For a rope of uniform density (and tension), what relationship exists between the frequency and the wavelength of the wave?

For a wave travelling in a given medium, the frequency is inversely proportional to the wavelength of the wave. |
| Speed and Tension | 1. Set the following parameters:

|  |  |
| --- | --- |
| Simulation | PAUSED |
| Damping | None |
| Rope’s End | No End |
| Source | Oscillate |
| Ruler | Enabled |
| Stopwatch | Enabled |
| Amplitude | 0.5 cm |
| Frequency | 1.5 Hz |

1. Set the Tension to “Low” (value = 1 unit). Run the simulation. Using the ruler determine the speed of the wave by measuring the time it takes for the wave to travel by 3 cm. (Hint: Use the “Pause/Play/Step button”)
2. Repeat (2) for “Medium” (value = 9 units) and “High” (value = 25 units) Tension. Summarize your calculations in Data Table 2

Data Table 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Tension | Distance Travelled, d (cm) | Time Elapsed, t (s) | Speed, v(cm/s) | v2 |
| Low | 1 unit | 3 | 2.4  | 1.25 | 1.56 |
| Medium | 9 units | 3 | 0.8 | 3.75 | 14.06 |
| High | 25 units | 3 | 0.48 | 6.25 | 39.06 |

1. Using a spreadsheet, plot the values of the Tension against the values of v2. Describe the graph formed.

The graph is a straight line.Guide Questions:* Describe what you did in determining the speed of the wave.
* What is the effect of increasing the tension in the rope on the speed of the wave?

Increasing the tension increases the speed of the wave.* Approximately how many times did the speed change when the tension is increased by a factor of 9 (e.g. Tmedium/Tlow = 9)? 9 times
* Approximately how many times did the speed change when the tension is increased by a factor of 25 (e.g. Tmedium/Tlow = 25)? 25 times
* What does the graph of T vs. v2 suggest about the relationship between the tension in the rope and the speed of the wave?
* The square of the speed is proportional to the tension in the rope.

$$v^{2} ∝T$$  |
| **CONCLUSION(S)** | Answers may vary |
| **GOING FURTHER** | What is the effect of the amplitude of oscillation on the speed of the wave? Use the Wave on a Rope simulation to write/develop a procedure to investigate the effect of the amplitude on the speed of the wave.Answers may vary |