**Waves on a String: Speed of a Wave Lab**

**Student Prior Knowledge:**

* [Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.](http://standards.nsta.org/DisciplinaryCoreIdeas.aspx?id=11&detailid=110)
* [Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).](http://standards.nsta.org/DisciplinaryCoreIdeas.aspx?id=11&detailid=110)
* [A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.](http://standards.nsta.org/DisciplinaryCoreIdeas.aspx?id=11&detailid=110)

**Part A: Method for determining speed of a wave**

**Learning Objective:** *Develop an experimental method to determine the speed of a wave on a string.*

1. **Initial Ideas (Warm-Up): Assessing students’ background knowledge of waves**

* Students define term “wave”, list types of waves, and describe the function of a wave.
* Students review meaning of “speed”.
* Class Discussion:
  + What is a wave?
  + Review: What is speed?
  + What is “speed of a wave”?

1. **Explore Sim (5 min Free-Play)**

* <http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html>
* Show students how to set “Dampening” to zero, select “no end”
* Challenge students to:
  + Explore controls / variables that they can control
  + Determine difference between “manual”, “pulse” and “oscillate”
  + Develop a strategy for determining the speed of a wave.
* Share-Out:
  + Discuss the meaning of the different controls
    - Amplitude
    - Frequency
    - Tension
    - “manual” vs. “pulse” vs. “oscillate”
    - Tools for measuring (time, distance)
  + Strategies for determining speed of a wave

**Part** B**: Variables Affecting Speed of a Wave**

**Learning Objective:**

**I. Mini-Lesson: Anatomy of a Wave & Key Vocabulary**

* Sketch a wave and have students help label and define key components
  + Amplitude
  + Wavelength
* Define other key terms based on student observations from sim
  + Frequency
  + Period
  + Tension

**II. PhET Investigation 1: How can you increase the speed of a wave?**

1. Students brainstorm variables that might affect the speed of a wave (eg, amplitude) then select one variable to test. Students then write a hypothesis in the form of “If…then…because…” regarding the effect of their variable on the speed of a wave, then test their hypothesis recording their observations in a cause-effect table. After testing variable, students evaluate their hypothesis and make a claim about whether they were correct or incorrect based on their data.

*Note 1: Remind students to only change one variable at a time, but to look for effects on multiple variables.*

*Note 2: For more quantitative results, students can instead record actual values of their independent and dependent variables, then graph these to determine if there is a relationship between the two variables.*

**III. PhET Investigation 2: How are other wave variables related?**

1. After testing the effect of a single variable on the wave speed, challenge students to search for other relationships between variables.

*Note 3: Students should observe an inverse relationship between wavelength and frequency.*

**Part C: New Equation for the Speed of a Wave**

**Learning Objective:** *Develop an equation that demonstrates the relationships between wavelength, frequency and speed of a wave*

* Students will identify wave variables that represent length and time measurements, then use these to assemble a new equation for speed of a wave.

*Note: Although students will quickly identify wavelength as the measurement for length, they might try to substitute frequency directly into the equation for time. Students may need a quick reminder of the relationship between frequency and period (f=1/T; T=1/f), and some scaffolding with substituting in these values into the speed equation. The student handout includes a table with two rows for the wave speed equation—one that includes period and one that includes frequency.*

* The assignment wraps up with two conceptual questions regarding their findings, including the relationship between frequency and wavelength.
* Future activities might incorporate practice problems solving for wave speed, frequency or wavelength. Alternatively, the teacher might look at the application of this relationship to electromagnetic or sound waves (constant speed for all forms), the effect of medium on wave speed, or the relationship between frequency and energy.