The Particle Wave

Purpose: To explore the nature and the properties of a wave.

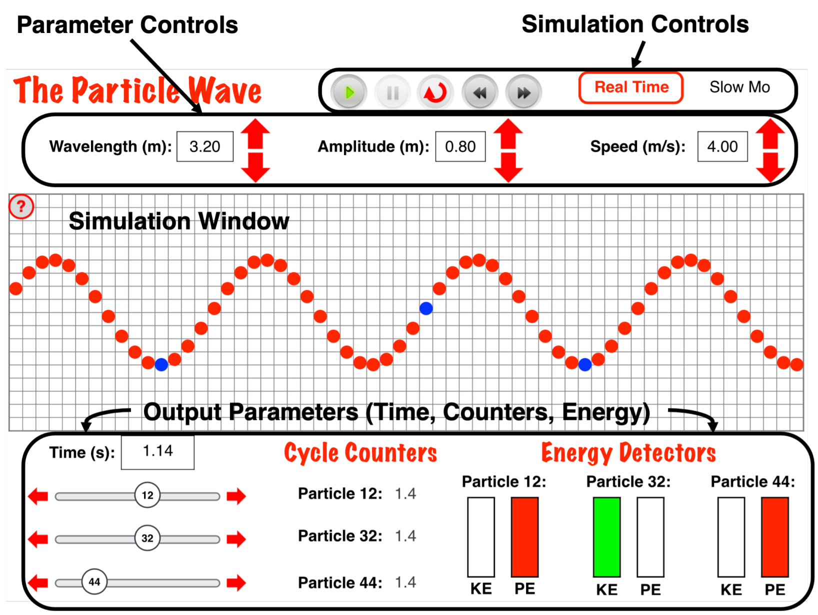
Getting Ready: Navigate to **The Particle Wave Simulation** found in the **Physics Interactives** section at **The Physics Classroom**.

https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/ParticleWave

Navigation:
www.physicsclassroom.com => Physics Interactives => Waves and Sound => The Particle Wave

Background:
This interactive model a wave in terms of the vibrational motion of 60 particles lying along the medium. You can think of the medium as a Slinky and the up-and-down motion of each coil is represented by a particle (a red dot). The type of wave you will be observing is known as a **transverse wave**. As you study the vibrations of the particles and the movement of the transverse wave through the medium, you will also learn about wave properties such as wavelength, amplitude, speed, period, and energy.

Getting Acquainted/Play:
Begin by becoming acquainted with the simulation environment. Observe the **simulation controls** that allow you to control the simulation (Play I Pause I Forward I Back I Reset). Also observe the wavelength, amplitude, and speed controls that affect what you will observe in the **simulation window**. Changes become immediately observable. Finally observe the **output parameters** found at the bottom of the simulation. Experiment with the controls until you become acquainted with how to interact with the simulation. Once you learn the program, you can then learn about waves.



Part 1: Particle Motion vs. Wave Motion

1. As a transverse wave moves through a medium, the medium assumes a shape or pattern characterized by a series of alternating **crests** (high points) and **troughs** (low points). In which direction are the crests of the wave moving? ________________ In which direction are the troughs of the wave moving? ________________ In which direction is the entire wave pattern moving? ________________

2. As the transverse wave moves through the medium, the particles that make up the medium vibrate about a fixed position. Focus on one or more of the blue particles. In which direction do the particles of the medium move? ____________________

3. Question 1 pertains to what we call **wave motion**. Question 2 pertains to what we call **particle motion**. Use your observations to complete this sentence:

   For transverse waves, the direction of wave motion is ________ to the direction of particle motion.
   a. opposite b. parallel c. perpendicular d. equal

Part 2: Wavelength, Amplitude, Speed and Frequency

4. Tap the green **Play** button to run the simulation. Then alter the **wavelength** and observe how the wave pattern changes. Describe how the wave pattern changes as the wavelength is increased. Use the words **crests** or **troughs** in your description.

5. As the simulation runs, alter the **amplitude** and observe how the wave pattern changes. Describe how the wave pattern changes as the amplitude is increased.

6. As the simulation runs, alter the **speed**. As you make changes, observe a crest of the wave pattern moving from the left to the right. Observe how its motion is affected by changes in speed; use values as low as 1.0 m/s and as high as 6.0 m/s until you get a feel for what speed affects. In terms of the movement of a crest, describe how is a high-speed wave different than a low-speed wave.

7. Each particle (red dot) is vibrating about a fixed position. The **frequency** describes how many up and down cycles occur per unit of time. Focus on a particle along the medium while changing the wavelength between a very low value (2.0 m) to a very high value (6.0 m) to answer the question:

   As the wavelength of the wave is increased, the frequency of vibration of the particles is __________.
   a. increased b. decreased c. unaffected

Part 3: Wavelength, Frequency, Speed – Quest for a Relationship

Now you will conduct a quantitative study of the relationship between wavelength, frequency, and speed. Use a range of wavelengths. Your study will give best results if you use values that have obvious relationships to one another (for example 1.5 times larger, 2.0 times larger, 2.5 times larger, etc.). For each trial, use the Cycle Counter to determine the number of cycles during an approximately 5-second trial. Calculate the frequency as the # of cycles divided by the time. Finally, keep the speed constant for all five trials and record its value.

Trial	Wavelength (m)	Time (s)	# of Cycles	Frequency (cycles/s)	Speed (m/s)
1					
2					
3					
4					
5					

8. For a constant speed, an ↑ in wavelength causes the frequency to ______ (↑ or ↓).

9. For a constant speed, an ↑ in wavelength by a factor of 2.0 causes the frequency to _______ (↑ or ↓) by a factor of _______.

   Support your claim by identifying two trials that serve as evidence and explain the reasoning behind your claim.

10. Play with some of your numbers to come up with an equation for speed (**v**) as a function of wavelength and frequency. You're looking for an equation of the form **v = …** . Make a claim (equation) and then justify it with evidence (reference to data and trials) and reasoning (logic that shows how the presented evidence supports the claim).

    Claim: ________________________________

    Evidence and Reasoning:

Part 4: Waves - an Energy Transfer Phenomenon
Part 4 is best done in Slow Mo mode. You will give attention to the energy bar charts at the bottom of the simulation. The goal is to make meaning of the phrase *A* wave is *an energy-transport phenomenon that transports energy without transporting matter*. Run the simulation in Slow Mo. Pause and use the Step Forward/Step Backward buttons as needed. Focus on the blue particles.

11. The diagram at the right represents seven positions along the up-and-down cycle of a particle's vibration. Use an arrow and the words High KE and Zero KE to mark the locations of greatest kinetic energy and zero kinetic energy.

    Repeat for the potential energy using an arrow and the words High PE and Zero PE to mark the locations of greatest kinetic energy and zero potential energy.

12. Complete the statement: As the kinetic energy of a particle increases, the potential energy of the particle ______________________.

13. Is there anything physical or material that you can see moving from the left to the right side of the medium?

14. Suppose you are a *wave announcer* (like a sports announcer) and you are doing the *play-by-play*. Describe your observations in a manner that a radio audience can acquire a visual picture of what is happening when a wave moves through a medium. Make use of the word energy in your description.