Math Connections

Name: ______________________________ Date: __________

Waves have unique properties including a specific wavelength, frequency, period, and amplitude. We use variables, equations, and graphical models to understand wave properties, how they relate to each other, and how they may change in various materials (or mediums).

Wave Properties

Wave cycle: one complete wave cycle begins and ends at the same point on the wave model. In the diagrams below, one complete wave cycle would be crest-to-crest or trough-to-trough.
Amplitude (A): the amount that a cycle moves away from equilibrium. The amplitude of a wave is related to the amount of energy it carries. The greater the amplitude, the more energy it carries.
Wavelength (λ): the distance (in meters) of one complete wave cycle (e.g., crest-to-crest).
Period (T): the time (in seconds) required for one complete wave cycle (e.g., crest-to-crest).
Frequency (f): the number of wave cycles in one second; this unit (1/s) is known as a **Hertz** (Hz).

The relationship between these wave properties can be represented in equations using variables.

The **period** and **frequency** of a wave are related to each other in the following equation:

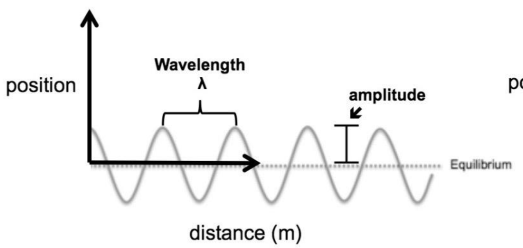
$$T = \frac{1}{f}$$

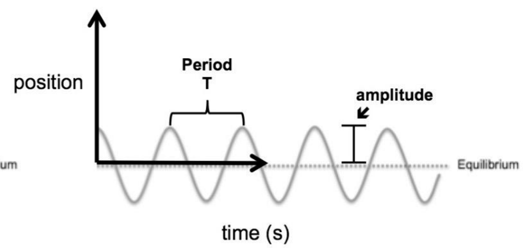
If you know its **wavelength** and **period** or **frequency**, a wave's **speed** can be calculated using the following equation:

$$v = \frac{\lambda}{T}$$

When we graph waves, we are using a mathematical model to represent their properties.

- Representing a wave's position as a function of distance helps us find its **wavelength**.
- Representing a wave's position as a function of time can help us find its **period** and from there its **frequency**.





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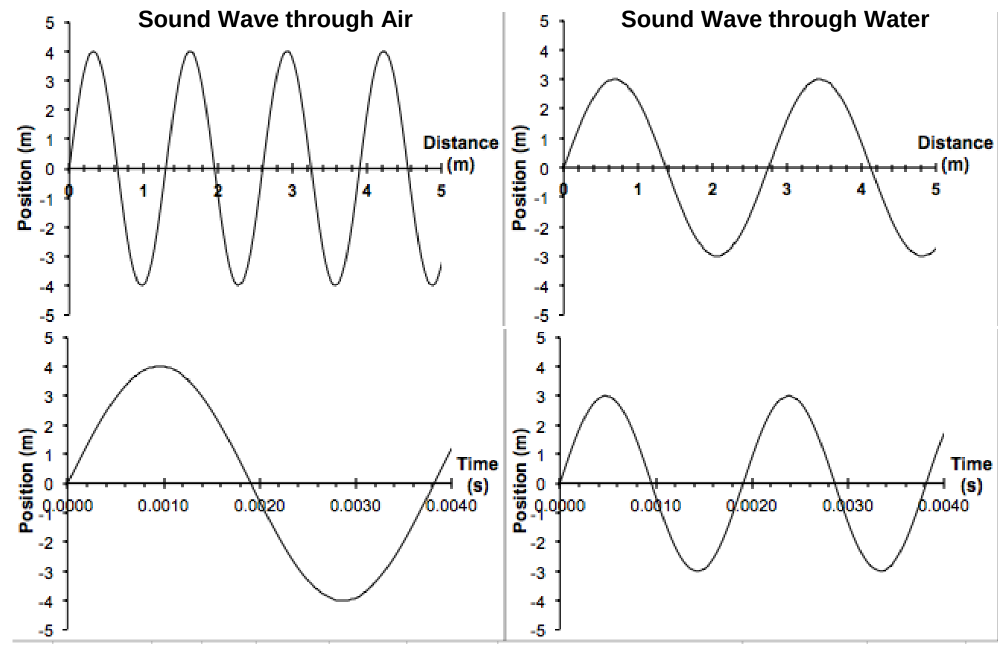
Part I: Sound Waves

Below are models of sound waves moving through different mediums. One wave is moving through air (left), while the other is moving through water (right). **Using this information and your knowledge of variables and equations, fill in the table below and answer questions 1–3.**



Wave	A (m)	λ (m)	T (s)	f (Hz)	v (m/s)
Air					
Water					

1. Which wave properties were you able to find the values by reading the graphs?

2. Which wave properties did you calculate? Write the equation(s) you used.

3. Which sound wave was traveling faster: the one moving through water or air?

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Part II: Speed of Sound Waves

The speed of a sound wave changes depending on the medium it is moving through. It can be estimated if you know how elastic the material is (K) and the material's density (ρ). The equation below represents the relationship between these properties of a medium and the speed of a sound wave. **Use this equation and the table of properties to answer questions 4–5. Show your work and units.**

$$v = \sqrt{\frac{K}{\rho}}$$

Table of Properties

Medium	Elastic Parameter, K (kg/(m•s^2))	Density, ρ (kg/m^3)
Water	2,000,000,000 = 2.0×10^9	1,000 = 1.00×10^3
Steel	140,000,000,000 = 1.4×10^{11}	7,800 = 7.80×10^3

4. What is the speed of a sound wave moving through water?

5. What is the speed of a sound wave moving through steel?

Part III: Effect of Air Temperature on Speed of Sound

The speed of a sound wave in air can even change if the temperature of the air changes. The relationship between air temperature and a sound wave's speed is represented by:

$$\mathbf{v = 331 + 0.6 \cdot T}$$

where T is the temperature of the air in °C. The constant, 331, is a sound wave's speed at 0°C. **Use this equation and your knowledge of variables, equations, and wave properties to answer questions 6–8.**

6. What is the speed of a sound wave if it is 100°C out?

7. Does a sound wave get faster or slower if the temperature of air increases?

8. Look back to table you filled in for Part I. What was the speed of the sound wave traveling through air? Using that information and rearranging the equation above, what temperature was the air?