Relation v = λf: surface waves

FizziQ activity · High school · 25 min

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With the Waves on a Lake simulation in the online FizziQ Web, high school students vary the frequency, measure the wavelength of circular ripples and verify $v = \lambda \times f$.

Learning objectives

- Observe the propagation of mechanical waves on a water surface
- Measure the wavelength from the simulation
- Experimentally verify the relationship $v = \lambda \times f$
- Understand that propagation speed depends on the medium, not on frequency
- Establish that wavelength and frequency are inversely proportional at constant speed

Instruments and sensors

FizziQ Web Waves on a Lake simulation

Materials

- Computer, tablet, or smartphone with FizziQ Web
- Note: the protocol remains adaptable to any comparable simulation or data-plotting tool.

Protocol

1. Open the Waves on a Lake simulation in FizziQ Web (Experiment → Simulations → Waves on a Lake).
2. Fix the propagation speed to a given value (for example 2 m/s) and the amplitude to 0.5 m. These parameters will not change during the experiment.
3. Set the frequency to 0.5 Hz. Start the simulation (START). Observe the circular waves propagating on the surface.
4. Observe the distance between two successive crests: this is the wavelength λ. Measure it or note it from the data display.
5. Stop the simulation. Change the frequency to 1.0 Hz, then restart. Has the distance between crests changed? In which direction?
6. Repeat for frequencies 1.5 Hz, 2.0 Hz, 2.5 Hz, and 3.0 Hz. For each frequency, note the wavelength λ in a table.
7. Create a table with three columns: Frequency f (Hz), Wavelength λ (m), and Product $\lambda \times f$ (m/s).
8. Calculate the product $\lambda \times f$ for each row. What do you notice? Is this product constant?
9. Plot the graph of λ versus 1/f. If the relationship $v = \lambda \times f$ holds, you should get a straight line through the origin with slope v.
10. Verify that the slope matches the propagation speed you set at the beginning. Conclusion: $v = \lambda \times f$.

Expected results

For v = 2 m/s: λ = 4.0 m (f = 0.5 Hz), λ = 2.0 m (f = 1.0 Hz), λ = 1.33 m (f = 1.5 Hz), λ = 1.0 m (f = 2.0 Hz), λ = 0.8 m (f = 2.5 Hz), λ = 0.67 m (f = 3.0 Hz). The product $\lambda \times f$ is constant and equals 2 m/s (the propagation speed). The graph λ(1/f) is a straight line through the origin with slope 2 m/s.

Questions

- If you double the frequency, what happens to the wavelength? And to the speed?

- Does the wave amplitude affect the propagation speed or the wavelength?
- Why do waves on deep water travel faster than waves on shallow water?
- Could you determine the propagation speed using only a float and a stopwatch?
- What is the difference between the speed of a wave and the speed of a float?
- Does the $v = \lambda f$ relationship also apply to electromagnetic waves like light?

Going further

- Fix the frequency and vary the propagation speed to verify that λ changes proportionally to v
- Observe the float motion and verify that their oscillation period matches $1/f$
- Measure the time delay between two floats at different distances to determine the propagation speed independently
- Compare the wave pattern at high frequency (many close crests) with that at low frequency (few distant crests)
- Investigate whether the amplitude affects the propagation speed