2023 MCAS Sample Student Work and Scoring Guide

High School Introductory Physics
Question 16: Constructed-Response

Reporting Category: Waves
Practice Category: Mathematics and Data
Standard: HS.PHY.4.1 - Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.
Item Description: Calculate the velocity of a wave, interpret a model to compare the wavelengths of the wave in different situations, and explain how the velocity of the wave is changed as a result of the wavelength changing.

View item in MCAS Digital Item Library

Scoring Guide

Select a score point in the table below to view the sample student response.

Score*	Description
3A	The response demonstrates a thorough understanding of the relationships among the frequency, wavelength, and speed of a wave. The response correctly calculates the velocity of the resulting wave. The response correctly compares the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water. The response also correctly compares the velocity of the waves in the deep water with the velocity of the waves in the shallow water and clearly explains the reasoning.
3B	
2	The response demonstrates a partial understanding of the relationships among the frequency, wavelength, and speed of a wave.
1	The response demonstrates a minimal understanding of the relationships among the frequency, wavelength, and speed of a wave.
0	The response is incorrect or contains some correct work that is irrelevant to the skill or concept being measured.

*Letters are used to distinguish between sample student responses that earned the same score (e.g., 3A and 3B).

Score Point 3A

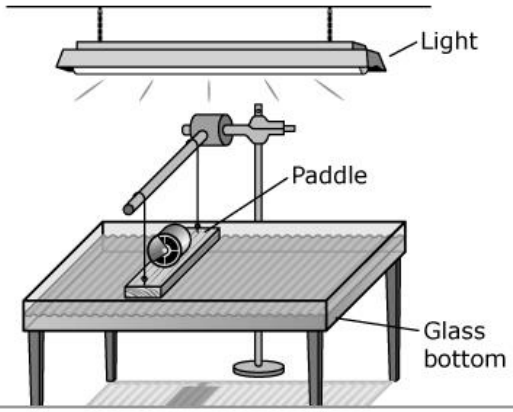
This question is part of a module with an introduction. The full introduction is available via the link to the Digital Item Library on the first page of this document. The first part of the introduction is shown.

Students in a physics class studied wave behaviors by observing different types of waves in two demonstrations.

Demonstration 1

For demonstration 1, the students observed waves in a ripple tank, which is a container with a glass bottom. The ripple tank was filled with a couple inches of water. The waves were generated by a paddle that moved up and down in the water. The students could adjust the frequency of the paddle's movement.

A light above the tank created shadows of the waves on the floor. Each wave crest made a dark shadow, while each wave trough made a light shadow. The setup for demonstration 1 is shown.



This question has three parts.

In demonstration 1, the students set the frequency of the paddle motion in the ripple tank to 8 Hz. The wavelength of the resulting wave was 0.11 m.

Part A

Calculate the velocity of the resulting wave. Show your calculations and include units in your answer.

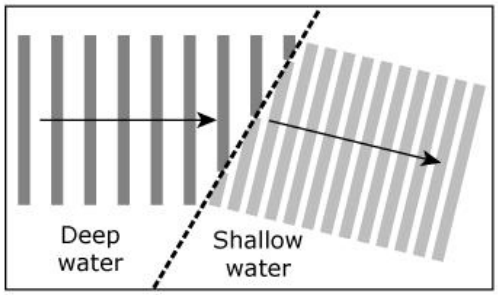
Velocity = $frequency \times wavelength$

$V = 8Hz \times 0.11m$

$V = 0.88 \cdot \frac{m}{s}$

Part B

The ripple tank used in demonstration 1 was replaced with a ripple tank that had a deep water section and a shallow water section. The diagram shown below represents the wave pattern produced when the new ripple tank was used.



Based on the diagram, compare the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water.

The wavelength in the shallow water had a shorter wavelength than the wavelength in the deep water. In the visual, the lines of the deep water are farther apart than the lines of the shallow water.

Part C

The frequency of the waves stayed the same as the waves moved from the deep water to the shallow water in the new ripple tank.

Compare the velocity of the waves that traveled in the deep water with the velocity of the waves that traveled in the shallow water. Explain your reasoning.

The velocity of the waves in the deep water would be larger than the velocity of the waves in the shallow water. The equation for velocity of a wave is V= frequency * wavelength. The frequency is the same for both, so the wavelength is what changes the velocity. The shallow water has a smaller wavelength, and therefore a smaller velocity.

Back to Scoring Guide

Score Point 3B

This question is part of a module with an introduction. The introduction can be seen via the link to the Digital Item Library on the first page of this document.

This question has three parts.

In demonstration 1, the students set the frequency of the paddle motion in the ripple tank to 8 Hz. The wavelength of the resulting wave was 0.11 m.

Part A

Calculate the velocity of the resulting wave. Show your calculations and include units in your answer.

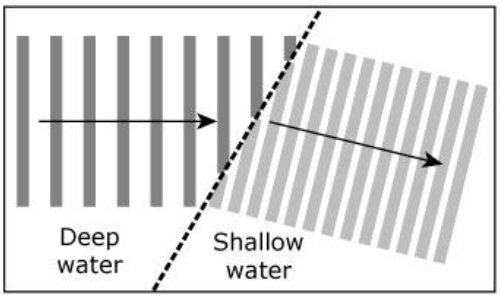
velocity = (wavelength)(frequency)

$v = (.11)\ (8)$

$v = .88$ meters per second

Part B

The ripple tank used in demonstration 1 was replaced with a ripple tank that had a deep water section and a shallow water section. The diagram shown below represents the wave pattern produced when the new ripple tank was used.



Based on the diagram, compare the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water.

The wavelengths of the waves in deep water are longer than the wavelengths in the shallow water.

Part C

The frequency of the waves stayed the same as the waves moved from the deep water to the shallow water in the new ripple tank.

Compare the velocity of the waves that traveled in the deep water with the velocity of the waves that traveled in the shallow water. Explain your reasoning.

The velocity of the waves in the shallow water is less than the velocity of the waves in deep water. The velocity of the waves in shallow water is less because the wavelength is shorter. The wavelength directly affects the velocity.

Back to Scoring Guide

Score Point 2

This question is part of a module with an introduction. The introduction can be seen via the link to the Digital Item Library on the first page of this document.

This question has three parts.

In demonstration 1, the students set the frequency of the paddle motion in the ripple tank to 8 Hz. The wavelength of the resulting wave was 0.11 m.

Part A

Calculate the velocity of the resulting wave. Show your calculations and include units in your answer.

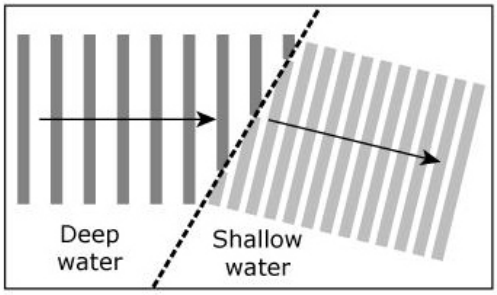
$V = \lambda f$

$= 8Hz \times 0.11 \text{ m}$

$= 0.88 \ \frac{m}{s}$

Part B

The ripple tank used in demonstration 1 was replaced with a ripple tank that had a deep water section and a shallow water section. The diagram shown below represents the wave pattern produced when the new ripple tank was used.



Based on the diagram, compare the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water.

In the deep water the wavelengths were much longer, while in the shallow water the wavelengths are shorted.

Part C

The frequency of the waves stayed the same as the waves moved from the deep water to the shallow water in the new ripple tank.

Compare the velocity of the waves that traveled in the deep water with the velocity of the waves that traveled in the shallow water. Explain your reasoning.

The velocity of the waves in the deep water were much less than the velocity of the waves in the shallow water.

Back to Scoring Guide

Score Point 1

This question is part of a module with an introduction. The introduction can be seen via the link to the Digital Item Library on the first page of this document.

This question has three parts.

In demonstration 1, the students set the frequency of the paddle motion in the ripple tank to 8 Hz. The wavelength of the resulting wave was 0.11 m.

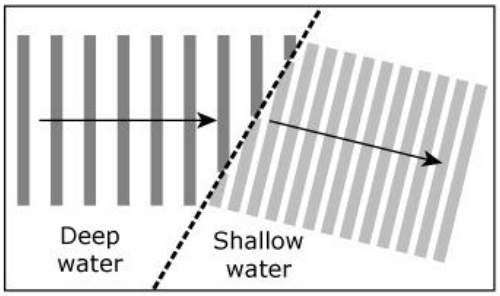
Part A

Calculate the velocity of the resulting wave. Show your calculations and include units in your answer.

the velocity of the wave is 40 juuls. I did this by multiplying 4 by 10.

Part B

The ripple tank used in demonstration 1 was replaced with a ripple tank that had a deep water section and a shallow water section. The diagram shown below represents the wave pattern produced when the new ripple tank was used.



Based on the diagram, compare the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water.

The wavelength in the shallow water is very short, while the wavelength in the deep water is longer.

Part C

The frequency of the waves stayed the same as the waves moved from the deep water to the shallow water in the new ripple tank.

Compare the velocity of the waves that traveled in the deep water with the velocity of the waves that traveled in the shallow water. Explain your reasoning.

The velocity will change, because as the waves get deeper so does the velocity.

Back to Scoring Guide

Score Point 0

This question is part of a module with an introduction. The introduction can be seen via the link to the Digital Item Library on the first page of this document.

This question has three parts.

In demonstration 1, the students set the frequency of the paddle motion in the ripple tank to 8 Hz. The wavelength of the resulting wave was 0.11 m.

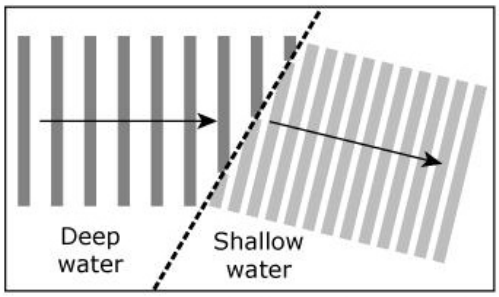
Part A

Calculate the velocity of the resulting wave. Show your calculations and include units in your answer.

$8 \div 0.11 = 72.72727273$

Part B

The ripple tank used in demonstration 1 was replaced with a ripple tank that had a deep water section and a shallow water section. The diagram shown below represents the wave pattern produced when the new ripple tank was used.



Based on the diagram, compare the wavelength of the waves in the shallow water with the wavelength of the waves in the deep water.

they are very similar to each ther

Part C

The frequency of the waves stayed the same as the waves moved from the deep water to the shallow water in the new ripple tank.

Compare the velocity of the waves that traveled in the deep water with the velocity of the waves that traveled in the shallow water. Explain your reasoning.

they are about the same velocity

Back to Scoring Guide