4.5 Standing Waves

Question Paper

Course	DP IB Physics
Section	4. Waves
Topic	4.5 Standing Waves
Difficulty	Medium

Time allowed: 60

Score: /49

Percentage: /100

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Question 1a

A standing wave is created in an open pipe that is open at both ends and placed within a chamber filled with an unknown gas. The pipe has a length of 45 cm and the fundamental frequency in this pipe is 381 Hz.

(a)
Calculate the speed of this standing wave.

[2 marks]

Question 1b

(b)
Calculate the wavelength of the fourth harmonic for this pipe.

[2 marks]

Question 1c

(c)
Calculate the frequency of the sixth harmonic.

[2 marks]

Question 1d

The pipe is now submerged and filled with water.

(d)
If the speed of sound in the water is 1500 m s^{-1}, deduce the period of the fundamental frequency in this pipe.

[3 marks]

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Question 2a

A speaker is set-up directly above the top of a vertical pipe which is partially filled with water.

Initially, there is a strong sound heard from the pipe when the distance between the loudspeaker and the water is 83 cm. This is the longest length for which a strong sound is heard.

As the pipe is filled with more water, a second strong sound is heard from the pipe when the distance between the loudspeaker and the water is 67 cm.

(a)
Outline how a standing wave is created between the speaker and the surface of the water.

[2 marks]

Question 2b

(b)
Predict the distance between the speaker and the water at which the next strong sound will be produced as the pipe is filled water.

[2 marks]

Question 2c

The air within the pipe and the water at the bottom of the pipe are both heated to 70 . The speed of sound in this warmer air is 371 m s^{-1} and the speaker now plays a sound at a constant frequency of 600 Hz.

(c)
The speaker is brought down to the surface of the water and slowly raised until a strong sound is produced. The distance between the surface of the water and the speaker is 15.5 cm when this occurs. State what is causing the strong sound and estimate the wavelength of this sound.

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[2 marks]

Question 2d

(d)
If the water volume is kept constant, predict the distance that the speaker must be raised for the next strong sound to be produced and outline what causes this strong sound.

[2 marks]

Question 3a

(a)
Explain clearly how the following vary in a stationary wave:

- Amplitude
- Phase
- Energy transfer

[3 marks]

Question 3b

A stationary wave in the third harmonic is formed on a stretched string.

(b)
Discuss the formation of this wave and its properties. Your answer must include:

- An explanation of how the stationary wave is formed
- A description of the features of this particular harmonic of the stationary wave

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[4 marks]

Question 3c

(c)
On the diagram shown, draw the stationary wave that would be formed on the string in part (b) with two more nodes and two more antinodes. State the harmonic of this new stationary wave.

[2 marks]

Question 3d

(d)
Calculate the length of the string in part (c) if it oscillates at 500 cycles per second and the speed of waves travelling within it is 140 m s^{-1}

[2 marks]

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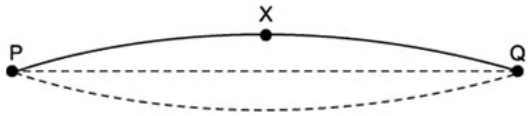
Question 4a

The diagram represents a stationary wave formed on a violin string fixed at **P** and **Q** when it is plucked at its centre. **X** is a point on the string at maximum displacement.



(a)
Explain why a stationary wave is formed on the string.

[3 marks]

Question 4b

The stationary wave formed represents the "A" string of a violin which has a frequency of 440 Hz.

(b)
Calculate the time taken for the string at point **X** to move from maximum displacement to its next maximum displacement.

[3 marks]

Question 4c

The progressive waves on the "A" string travel at a speed of 280 m s^{-1}.

(c)
Calculate the length of the "A" string.

[3 marks]

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Question 4d

This diagram shows the string between **P** and **Q**.

A violinist presses on the string at **C** to shorten it and create the higher "B" note. The distance between **C** and **Q** is 0.252 m.

The speed of the progressive wave remains at 280 m s^{-1} and the tension remains constant.

(d)
Calculate the frequency of the note "B".

[3 marks]

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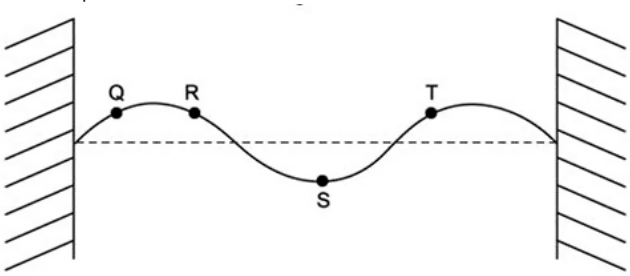
Question 5a

The diagram shows the appearance of a stationary wave on a stretched string at one instant in time. In the position shown each part of the string is at a maximum displacement.



(a)
Mark clearly on the diagram the direction in which points **Q**, **R**, **S** and **T** are about to move.

[2 marks]

Question 5b

In the diagram from part (a), the frequency of vibration is 240 Hz.

(b)
Calculate the frequency of the second harmonic for this string.

[2 marks]

Question 5c

The speed of the transverse waves along the string is 55 m s^{-1}.

(c)
Calculate the length of the string.

[3 marks]

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Question 5d

(d)

Compare the amplitude and phase of points **R** and **S** on the string in the diagram used in part (a).

[2 marks]

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