

Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A string is stretched between two fixed points and set into oscillation.

The frequency of the vibrating string is **not** dependent on

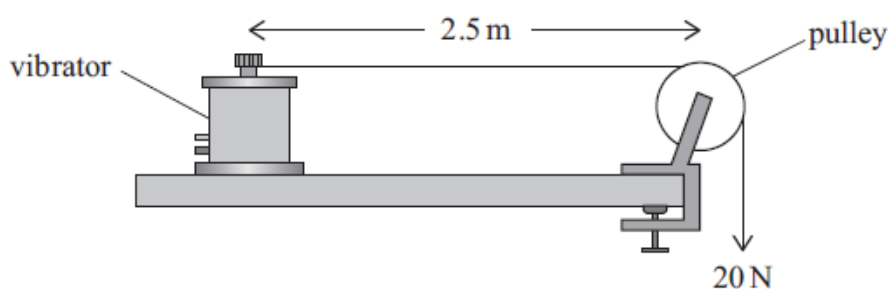
- ☒ **A** the amplitude of the string's vibration.
- ☐ **B** the length of the string.
- ☐ **C** the mass per unit length of the string.
- ☐ **D** the tension in the string.

(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

A student investigated stationary waves on a string, using the apparatus shown.



The vibrating length of the string has a mass of 0.005 kg and a length of 2.5 m.

Which of the following gives the speed of a transverse wave on this string in m s^{-1} ?

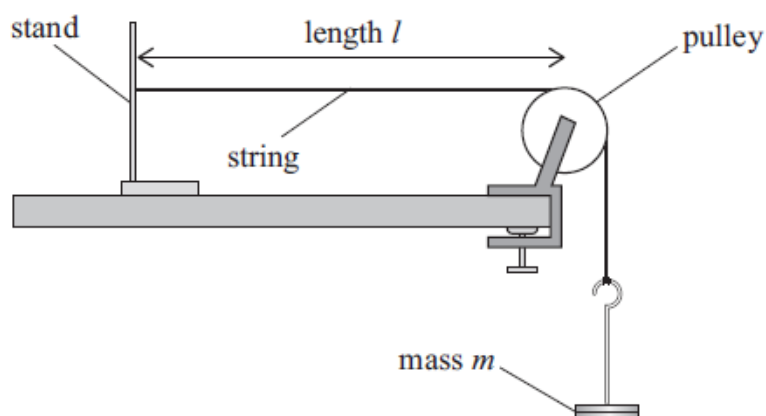
- ☐ A $\sqrt{\frac{20}{2.5}}$
- ☐ B $\sqrt{\frac{20 \times 2.5}{0.005}}$
- ☐ C $\sqrt{\frac{20 \times 0.005}{2.5}}$
- ☐ D $\sqrt{\frac{20}{0.005}}$

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A student sets up the apparatus shown.



When the string is plucked, it vibrates with a frequency f .

Which of the following single changes would increase f ?

- ☐ A decreasing the length l
- ☐ B decreasing the mass m
- ☐ C increasing the cross-sectional area of the string
- ☐ D increasing the mass per unit length of the string

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A string is placed under tension T . A wave travels along the string.

A second string has the same mass but twice the length. A wave travels along this string with the same velocity as the wave in the first string.

Which of the following is the tension in the second string?

☐ **A** $4T$

☐ **B** $2T$

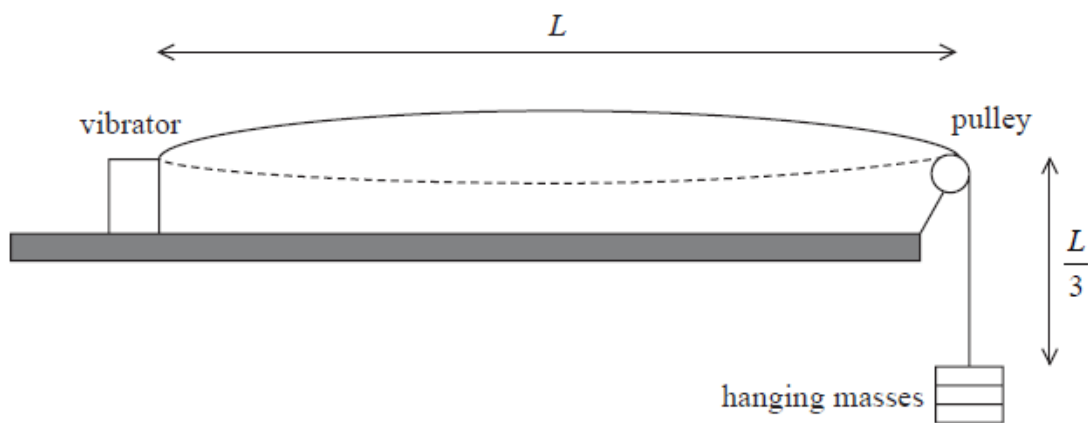
☐ **C** $\frac{T}{2}$

☐ **D** $\frac{T}{4}$

(Total for question = 1 mark)

Q5.

The speed of waves on a vibrating string is investigated using the apparatus shown.



length of string between vibrator and pulley = L

length of string between pulley and hanging masses = $\frac{L}{3}$

mass of whole string = m

mass of hanging masses = M

Which of the following expressions represents the speed of the waves on the string?

☐ A $\sqrt{\left(\frac{4MgL}{3m}\right)}$

☐ B $\sqrt{\left(\frac{2MgL}{3m}\right)}$

☐ C $\sqrt{\left(\frac{MgL}{m}\right)}$

☐ D $\sqrt{\left(\frac{MgL}{3m}\right)}$

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

A student investigates how different variables affect the speed of waves on a vibrating string.

Which of the following would increase the speed of waves along the string?

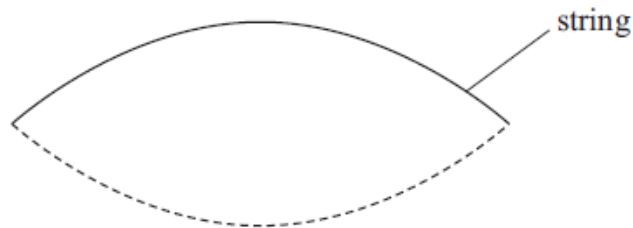
- ☐ **A** increasing the frequency
- ☐ **B** increasing the length of the string
- ☐ **C** increasing the mass per unit length of the string
- ☐ **D** increasing the tension in the string

(Total for question = 1 mark)

Q7.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

A string vibrates between two fixed points. The diagram shows the stationary wave formed on the string when the string vibrates with frequency f .



The tension in the string is doubled. The frequency of vibration is adjusted until the same shape of standing wave forms on the string.

Which of the following expressions gives the frequency f of the new standing wave?

- ☐ **A** $\frac{f}{\sqrt{2}}$
- ☐ **B** $\sqrt{2} \times f$
- ☐ **C** $\frac{f}{2}$
- ☐ **D** $2 \times f$

(Total for question = 1 mark)

Q8.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

There is tension T in a string of length l . When the string is displaced and then released, waves move on the string with speed v .

A string of length $2l$ has the same diameter and is made from the same material. The tension in this string is $2T$.

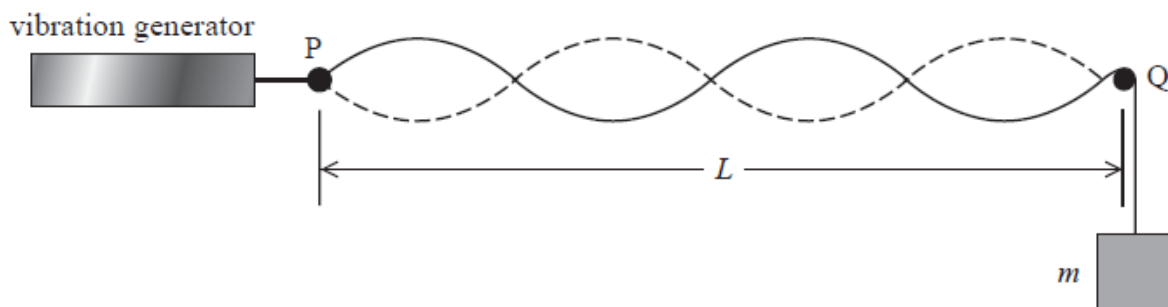
Which of the following expressions gives the speed of waves on the string of length $2l$?

- ☐ A $\frac{v}{\sqrt{2}}$
- ☐ B $\frac{v}{2}$
- ☐ C $\sqrt{2}v$
- ☐ D $2v$

(Total for question = 1 mark)

Q9.

An experiment is carried out to investigate the speed of transverse waves on a stretched string of length L . A vibration generator causes the string to oscillate so that a stationary wave is produced. The frequency of the vibration generator is adjusted until the wave pattern shown in the diagram is produced.



Sourced from: https://people.highline.edu/iglozman/classes/physnotes/media/waves_9.jpg

(a) Determine the wavelength of the waves on the string when vibrating as shown.

length $L = 1.70 \text{ m}$

(2)

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Wavelength =

(b) Calculate the speed of waves on the string.

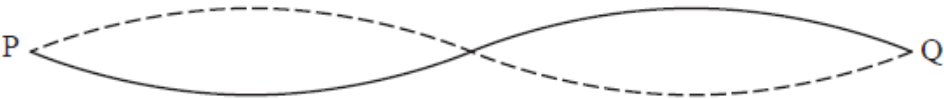
mass $m = 0.20\text{ kg}$
mass per unit length of string $= 4.5 \times 10^{-3}\text{ kg m}^{-1}$

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Speed =

(c) The frequency of the vibration generator is reduced until the wave pattern shown below is produced.



Explain the effect that this would have on the speed of the waves on the string.

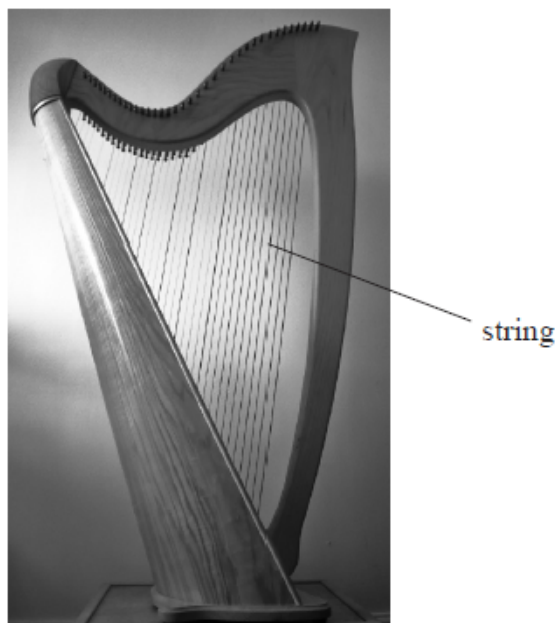
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(Total for question = 7 marks)

Q10.

The photograph shows a musical instrument called a harp.



When a harp string is plucked, transverse waves travel along the string forming a standing wave.

(a) State what is meant by a transverse wave.

(1)

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(b) The diagram represents one string of the harp.



The string is fixed at both ends.

The string is made to vibrate at its lowest frequency.

Add to the diagram to show the stationary wave on the string. You should label any nodes and antinodes.

(2)

(c) One string produces sound with a frequency of 196 Hz. The wavelength of the wave on the string is 0.72 m. The tension in the string is 41 N.

This string breaks and needs replacing with a new string.

The table shows the mass of four new strings, A, B, C and D.
Each new string has a length of 1.5 m.

String	Mass of string / g
A	1.5
B	3.1
C	4.4
D	6.3

The new string is cut to the same length as the broken string, and is placed under the same tension.

Deduce which new string, A, B, C or D, should be used to replace the broken string.

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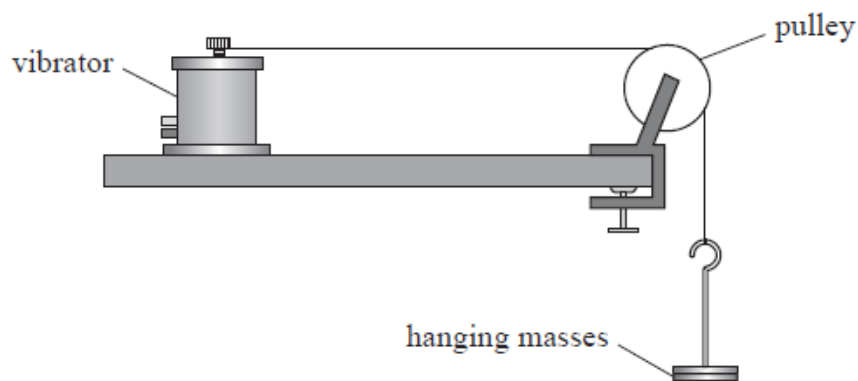
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(Total for question = 7 marks)

Q11.

A student investigated stationary waves on a string, using the apparatus shown.



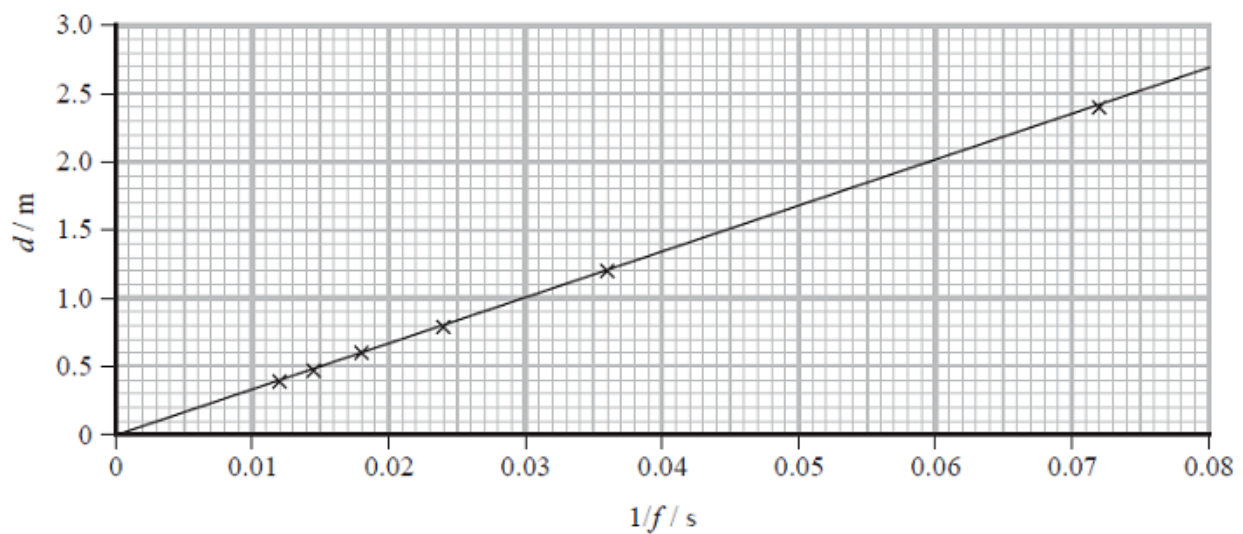
The frequency f of the vibrator was adjusted until a stationary wave was formed with a node at each end. This was repeated for various stationary waves on the string. A metre rule was used to measure the distance d between adjacent nodes on the string.

(a) The resolution of the metre rule was 1 mm, but the measurements were recorded to the nearest 0.5 cm.

Suggest why.

(1)

(b) The student plotted a graph of d against $1/f$ as shown.



(i) Determine the total mass of the hanging masses used in the investigation.

mass per unit length of string = $4.5 \times 10^{-4} \text{ kg m}^{-1}$

(5)

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Total mass of hanging masses =

(ii) The string was replaced with one that had twice the mass per unit length.

The length of the string and the mass of the hanging masses did not change.

Add a line to the graph to show how d varied with $1/f$ for the new string.

(2)

(Total for question = 8 marks)

Q12.

An Aeolian harp is a stringed musical instrument that is 'played' by the wind. An Aeolian harp is shown in the photograph.



(Source: www.youtube.com)

As air passes the strings, it forces them to vibrate, creating stationary waves on the strings.

(a) Explain how stationary waves are formed on the strings.

(2)

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(b) When the strings of an Aeolian harp vibrate, the frequency f of the string vibrations is given by the equation

$$f = \frac{Ku}{d}$$

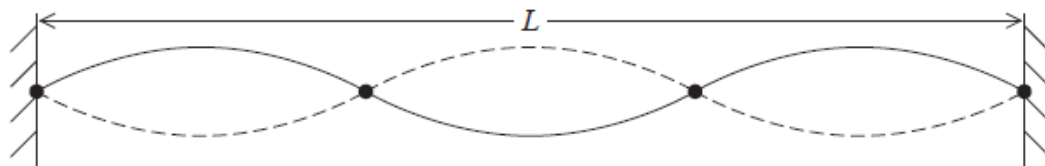
where u is the speed of the moving air, d is the diameter of the string and K is a constant.

(i) Show that the constant K has no units.

(2)

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(ii) A stationary wave is produced on a string of length L as shown.



(Source: hep.physics.indiana.edu)

Calculate the speed of the air required to produce this stationary wave.

length of string = 0.33 m

diameter of string = 0.15 mm

tension in string = 63 N

mass per unit length of string = $0.58 \times 10^{-3} \text{ kg m}^{-1}$

$K = 0.20$

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Speed of the air =

(Total for question = 9 marks)

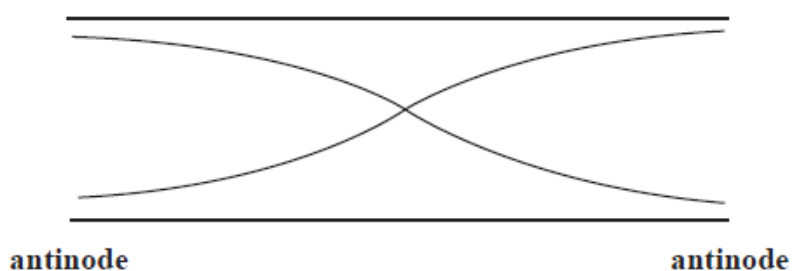
Q13.

A recorder is a musical instrument with a mouthpiece at one end, as shown.



(a) When a musician blows into the mouthpiece, a stationary wave is produced in the air column inside the recorder.

(i) The stationary wave has antinodes at both ends of the air column as shown.



Calculate the frequency of the sound produced by this stationary wave.

speed of sound in air = 330 m s^{-1}

length of recorder = 23.6 cm

(3)

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Frequency =

(ii) The recorder is made from three separate sections that slide together as shown.



A musician plays the recorder and produces the same frequency sound as in (i).
The temperature of the air increases. As the temperature of the air increases, the speed of sound also increases.

Explain how the musician can adjust the recorder to produce the same frequency sound as in (i).

(3)

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(b) On a violin, a stationary wave is created when a string is plucked. A violin string has a fixed length but the tension can be adjusted.

When a string is plucked, it produces a sound with a frequency of 432 Hz. This string is adjusted to produce a sound of frequency 440 Hz.

Calculate the percentage increase in the tension in the string.

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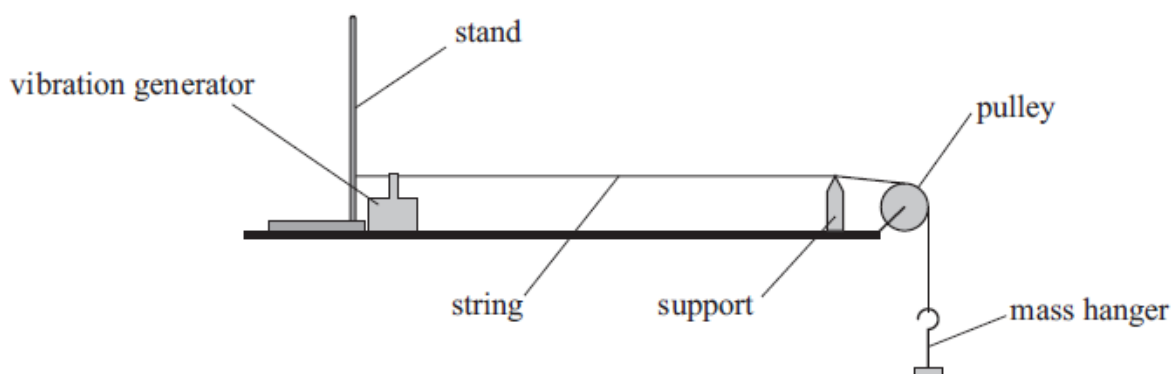
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Percentage increase =

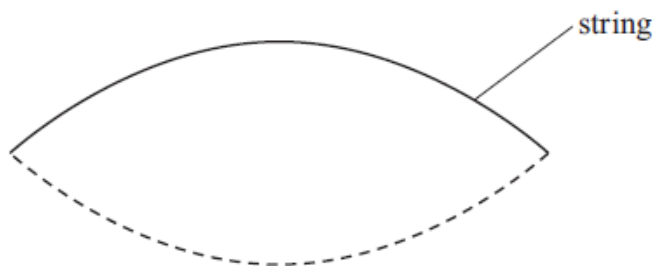
(Total for question = 9 marks)

Q14.

A student investigated stationary waves on a vibrating string using the apparatus shown.



The student adjusted the frequency of the vibration generator until a standing wave formed on the string, as shown below.



(a) Label each node on the standing wave with a letter N, and each antinode with a letter A.

(1)

(b) Explain how a standing wave forms on the string.

(3)

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(c) The student added masses to the hanger to vary the tension T in the string. He adjusted the frequency f of the vibration generator until the same shape of standing wave formed. He recorded T and the corresponding value of f .

The student repeated the procedure for different values of T . The length l of the string between the vibration generator and the support was kept constant.

The mass per unit length of the string is μ .

The student plotted a graph of f^2 on the y-axis against T on the x-axis.

(i) Explain why the graph is a straight line with a gradient of $\frac{1}{4l^2\mu}$

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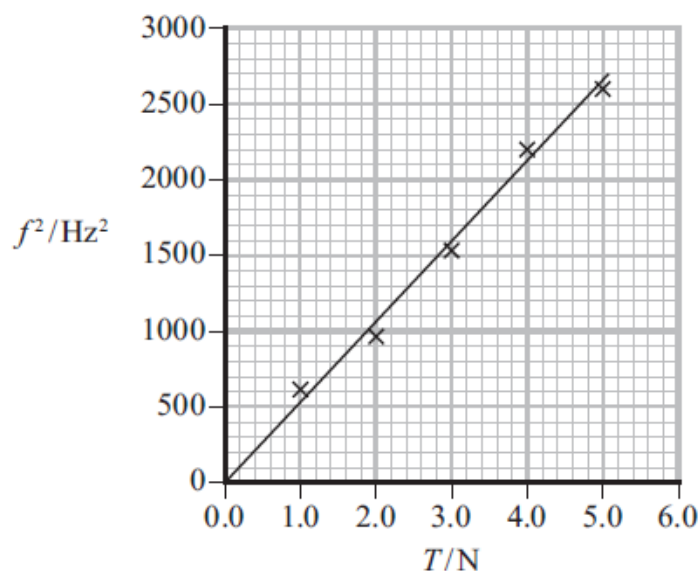
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(ii) The student's graph is shown below.



Determine the mass per unit length μ of the string.

$l = 0.85 \text{ m}$

(3)

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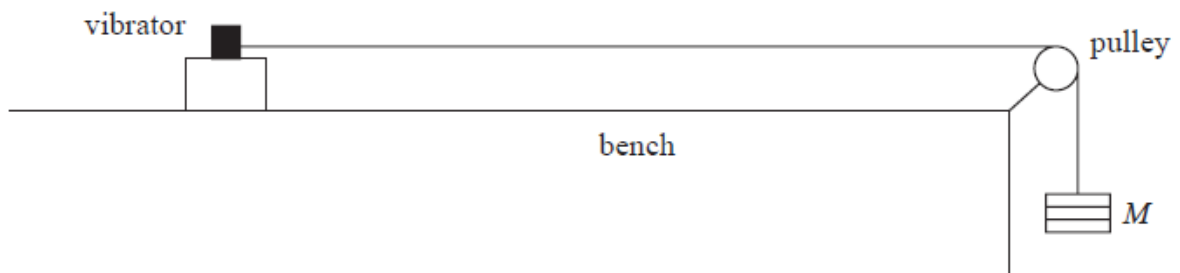
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$\mu = \dots\dots\dots$

(Total for question = 10 marks)

Q15.

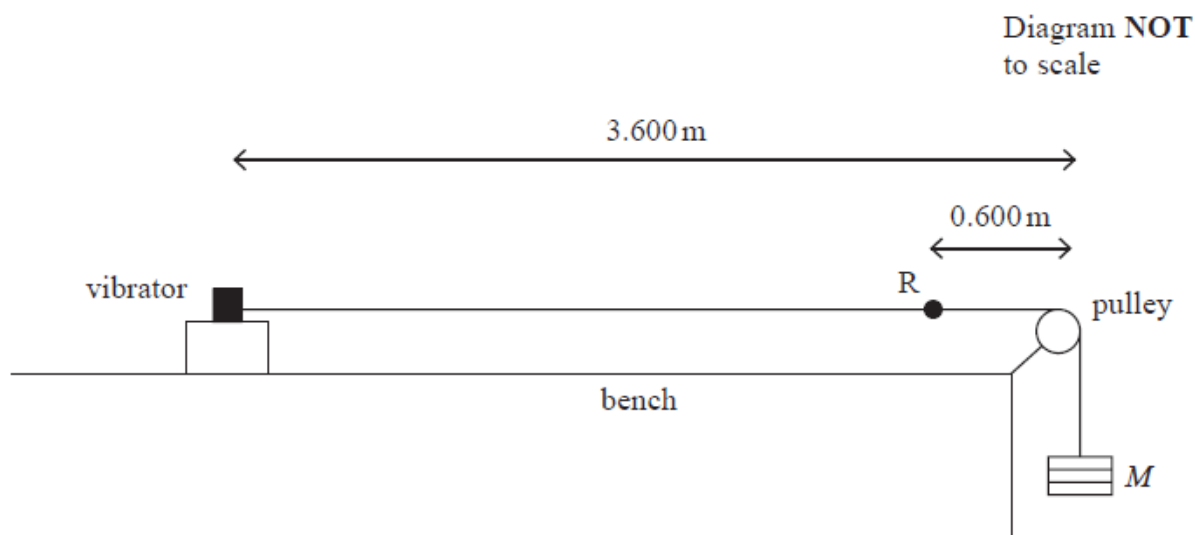
A student investigated stationary waves on a stretched string. The string was attached to a vibrator and a mass M , as shown.



(a) Explain how a stationary wave forms on the string.

(3)

(b) The frequency of the stationary wave was 30.0 Hz. The distance between the vibrator and the pulley was 3.600 m. Point R is 0.600 m from the pulley, as shown.



Determine whether there was a node at point R.

$$M = 0.300 \text{ kg}$$

$$\text{mass per unit length of string} = 2.27 \times 10^{-3} \text{ kg m}^{-1}$$

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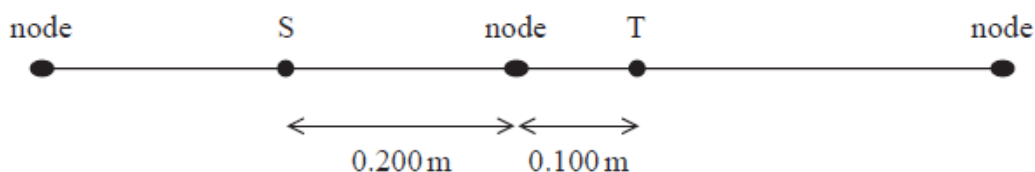
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(c) The mass M was changed and the frequency of the vibrator was adjusted, so that a different stationary wave formed on the string. Adjacent nodes were separated by 0.400 m. The diagram shows two points, S and T, on the string at an instant when the string was straight.



(i) Explain the phase relationship between points S and T.

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(ii) Explain how the amplitude of vibration of the string at point S compares with the amplitude of vibration of the string at point T.

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(Total for question = 12 marks)

Q16.

The human ear can only hear two sounds as separate frequencies when the difference in frequency between the sounds is greater than 0.3%.

Sounds with a difference in frequency less than 0.3% are heard as the same frequency.

(a) Two sounds with frequencies of 880 Hz and 882 Hz are produced.

(i) Show that the person hears these two sounds as the same frequency.

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*(ii) When listening to these two sounds at the same time, the loudness of the sound increases and decreases repeatedly.

Explain why. Your answer should refer to coherence and phase difference.

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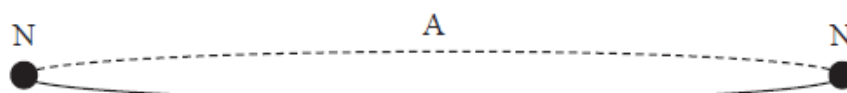
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(b) A wire is stretched between two fixed points. The wire is made to vibrate and a stationary wave is created. This produces a sound wave in the air.

The fixed ends of the wire act as nodes (N). There is an antinode (A) in the middle of the wire, as shown.



A wire of length 18.7 cm produces a sound with a frequency of 882 Hz.
The tension in the wire is adjusted until the frequency of the sound is 880 Hz.

Calculate the decrease in tension required to cause this change in frequency.

mass per unit length of wire = $5.08 \times 10^{-3} \text{ kg m}^{-1}$

(4)

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Decrease in tension =

(Total for question = 12 marks)

Q17.

The photograph shows a musical instrument called a violin.



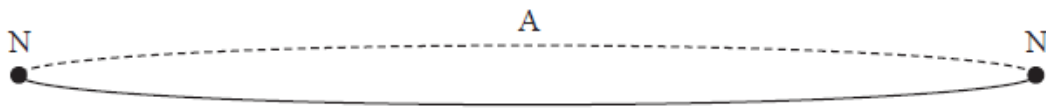
The violin has four strings. Each string is held in a fixed position by a peg and at the bridge.

When a string is plucked, a stationary wave forms on the string.

(a) Explain how a stationary wave forms on the string.

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(b) The simplest stationary wave that can be formed on the string has a node (N) at each end and an antinode (A) at the centre, as shown.



The frequency of this wave is called the fundamental frequency.

The strings on a violin have different fundamental frequencies, as shown in the table.

String	Fundamental frequency / Hz
1	196
2	294
3	440
4	659

The tension in one of the strings is 71.5 N. The length of the string is 32 cm and the mass per unit length of the string is $2.03 \times 10^{-3} \text{ kg m}^{-1}$.

Deduce whether this is string 1, 2, 3 or 4.

(4)

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(c) The stationary wave on the string causes sound waves to be transmitted through the air.

Describe the similarities and differences between the stationary wave on the string and the sound waves transmitted through the air.

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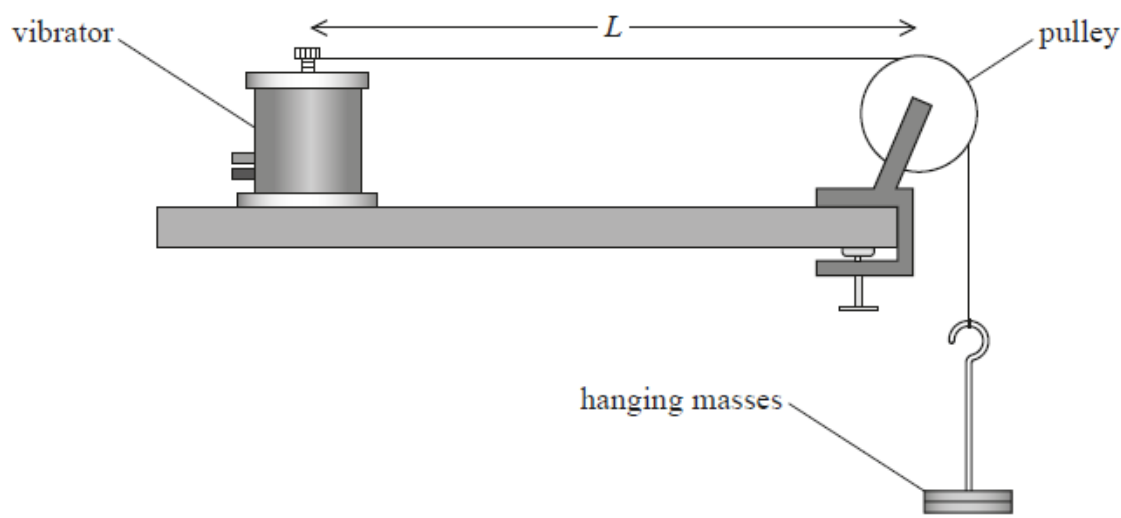
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(Total for question = 12 marks)

Q18.

A student investigated how the frequency of vibration of a string varies with the tension in the string. The student connected masses to one end of the string and attached the other end to a vibrator as shown.



(Source: http://www.schoolphysics.co.uk/age16-19/Sound/text/Vibrating_strings/index.html)

A signal generator was connected to the vibrator. The signal generator was adjusted until a stationary wave was produced on the string. The stationary wave had nodes at both ends of the vibrating length of the string, L , and an antinode in the middle.

(a) Explain how nodes and antinodes are created on a string.

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(b) The student changed the weight W applied to the string and adjusted the frequency f of the signal generator until the same stationary wave was set up on the string.

The student plotted a graph of f^2 against W .

Explain why the graph was a straight line through the origin.

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(c) Describe a method that can be used to confirm that the frequency value stated on the signal generator is correct.

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(d) When W is 80.0 N, f is 659 Hz.

Calculate the mass per unit length of the string.

length $L = 0.328$ m

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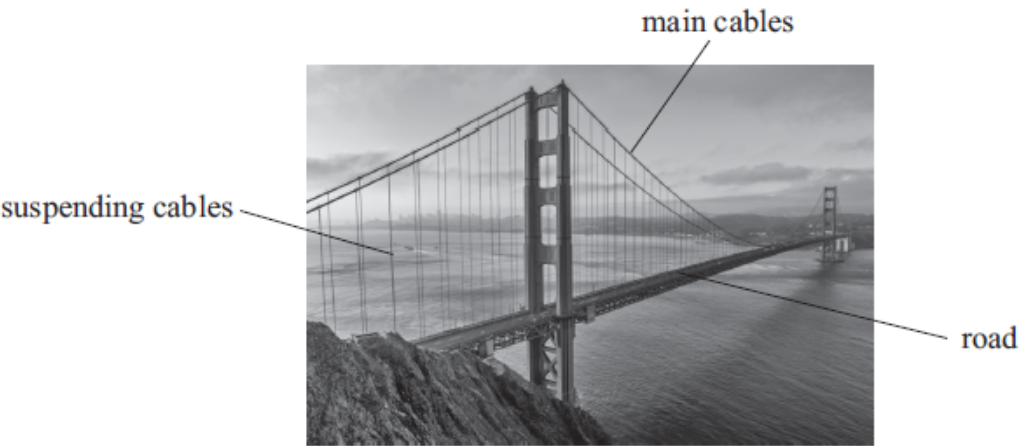
Mass per unit length =

(Total for question = 13 marks)

Q19.

The photograph shows the Golden Gate Bridge in San Francisco, USA.

The bridge has two main cables. Attached to these cables are smaller suspending cables, which support the road.



(Source: © Don White / Getty Images)

Wind causes each suspending cable to oscillate, so standing waves form on the suspending cables.

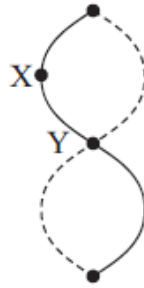
(a) Explain how a standing wave can form on a cable that is fixed at both ends.

(3)

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(b) The diagram shows a standing wave on a cable that is fixed at both ends. X and Y are two points on the cable.



(3)

(c) In strong winds, the Golden Gate Bridge emits a humming sound.

(i) One of the suspending cables on the bridge has a mass of 2.10×10^3 kg and a length of 87.0 m.

Show that the mass per unit length μ of the cable is about 24 kg m^{-1} .

(2)

(ii) The lowest frequency of the humming sound produced by the bridge is 280 Hz.

The total mass of the road on the bridge is 140×10^6 kg.

The weight of the road is supported equally by 500 suspending cables.

The range of lengths of the suspending cables is from 3.5 m to 160 m.

The value of μ for all of the suspending cables is 24 kg m^{-1} .

Deduce whether the lowest frequency standing waves on the suspending cables could be producing the humming sound.

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(Total for question = 14 marks)