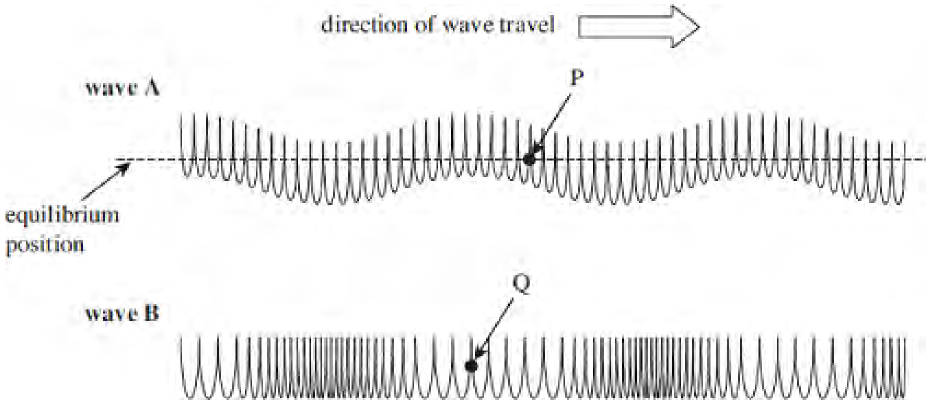
Q1. The figure below shows two ways in which a wave can travel along a slinky spring.



(a) State and explain which wave is longitudinal.

....

....

(2)

(b) On the figure above,

(i) clearly indicate and label the wavelength of **wave B**

(1)

(ii) use arrows to show the direction in which the points **P** and **Q** are about to move as each wave moves to the right.

(2)

(c) Electromagnetic waves are similar in nature to **wave A**.

Explain why it is important to correctly align the aerial of a TV in order to receive the strongest signal.

....

....

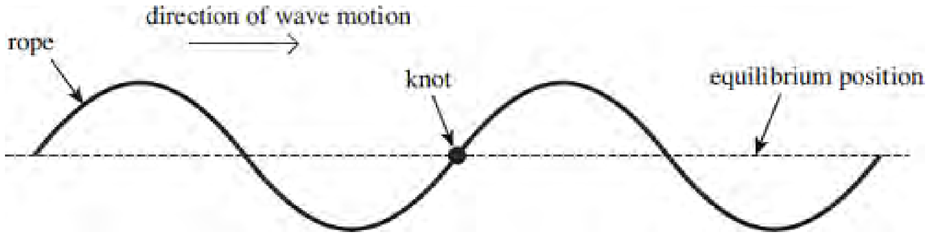
....

....

(2)

(Total 7 marks)

Q2. The figure below shows a continuous progressive wave on a rope. There is a knot in the rope.



(a) Define the amplitude of a wave.

....

....

(2)

(b) The wave travels to the right.
Describe how the **vertical** displacement of the knot varies over the next complete cycle.

....

....

....

....

....

(3)

(c) A continuous wave of the same amplitude and frequency moves along the rope from the right and passes through the first wave. The knot becomes motionless.
Explain how this could happen.

....

....

....

....

....

....

(3)
(Total 8 marks)

Q3. (a) State the characteristic features of

(i) longitudinal waves,

....

(ii) transverse waves.

....

....

(3)

(b) Daylight passes horizontally through a fixed polarising filter **P**. An observer views the light emerging through a second polarising filter **Q**, which may be rotated in a vertical plane about point **X** as shown in **Figure 1**.

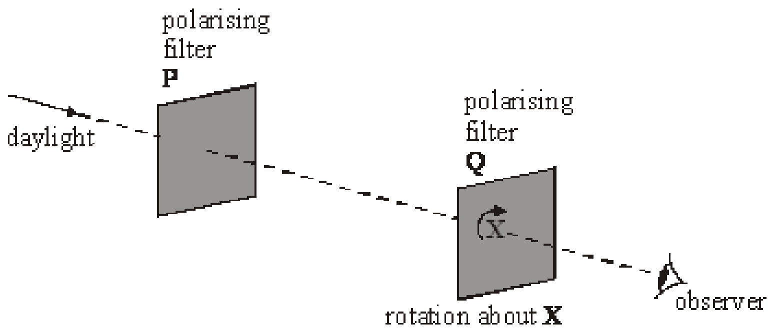


Figure 1

Describe what the observer would see as **Q** is rotated slowly through 360°.

You may be awarded marks for the quality of written communication provided in your an wer

....

....

....

....

....

....

(2)
(Total 5 marks)

Q4. (a) Define the amplitude of a wave.

....

....

(1)

(b) (i) Other than electromagnetic radiation, give **one** example of a wave that is transverse.

....

(1)

(ii) State **one** difference between a transverse wave and a longitudinal wave.

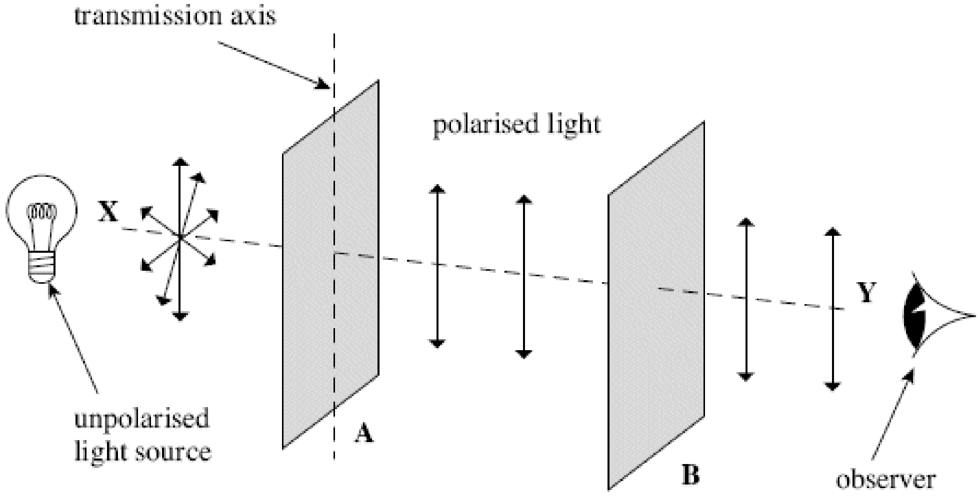
....

....

(1)

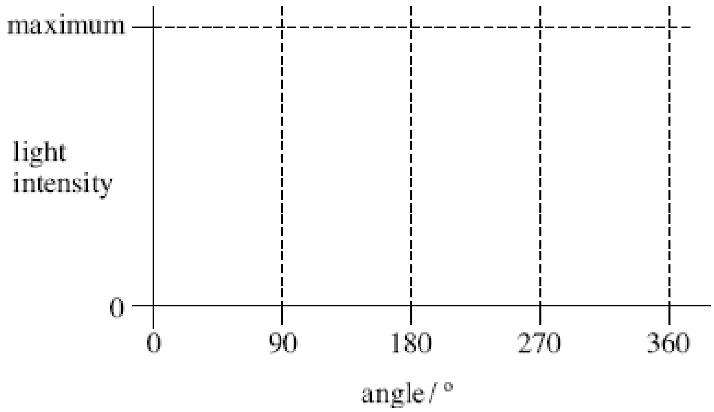
(c) The figure below shows two identical polarising filters, **A** and **B**, and an unpolarised light source. The arrows indicate the plane in which the electric field of the wave oscillates.

(i) If polarised light is reaching the observer, draw the direction of the transmission axis on filter **B** in the figure below.



(1)

(ii) The polarising filter **B** is rotated clockwise through 360º about line **XY** from the position shown in the figure above. On the axes below, sketch how the light intensity reaching the observer varies as this is done.



(2)

(d) State **one** application, other than in education, of a polarising filter and give a reason for its use.

....

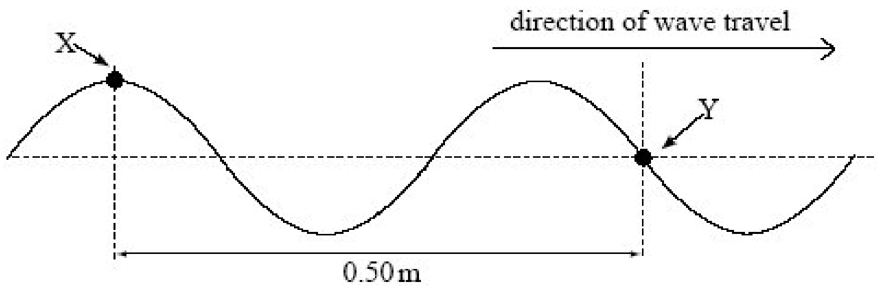
....

....

....

(2)
(Total 8 marks)

Q5. (a) The diagram below represents a progressive wave travelling from left to right on a stretched string.



(i) Calculate the wavelength of the wave.

answer .... m

(1)

(ii) The frequency of the wave is 22 Hz. Calculate the speed of the wave.

answer............................m s^{-1}

(2)

(iii) State the phase difference between points X and Y on the string, giving an appropriate unit.

answer ....

(2)

(b) Describe how the displacement of point Y on the string varies in the next half-period.

....

....

....

....

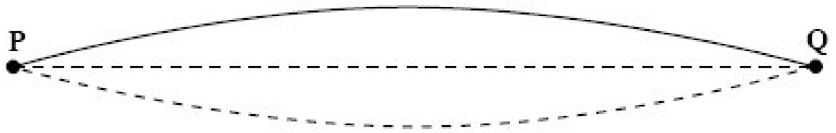
....

....

(2)
(Total 7 marks)

Q6. **Figure 1** represents a stationary wave formed on a steel string fixed at P and Q when it is plucked at its centre.

Figure 1



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

....

....

....

....

....

(3)

(b) (i) The stationary wave in **Figure 1** has a frequency of 150 Hz. The string **PQ** has a length of 1.2 m.
Calculate the wave speed of the waves forming the stationary wave.

Answer .... m s^{-1}

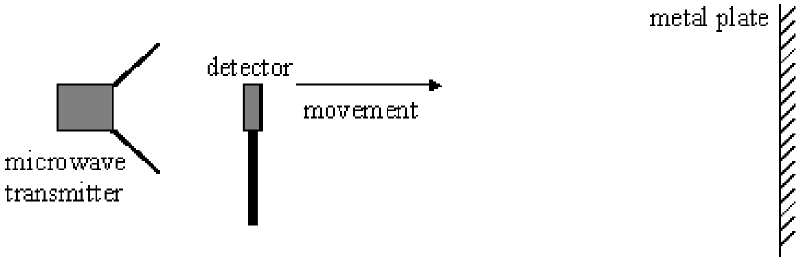
(2)

(ii) On **Figure 2**, draw the stationary wave that would be formed on the string at the same tension if it was made to vibrate at a frequency of 450 Hz.

Figure 2

(2)
(Total 7 marks)

Q7.



A microwave transmitter directs waves towards a metal plate. When a microwave detector is moved along a line normal to the transmitter and the plate, it passes through a sequence of equally spaced maxima and minima of intensity.

(a) Explain how these maxima and minima are formed.

You may be awarded marks for the quality of written communication in your answer.

....

....

....

....

....

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....

....

....

(4)

(b) The detector is placed at a position where the intensity is a minimum. When it is moved a distance of 144 mm it passes through nine maxima and reaches the ninth minimum from the starting point.

Calculate

(i) the wavelength of the microwaves,

....

....

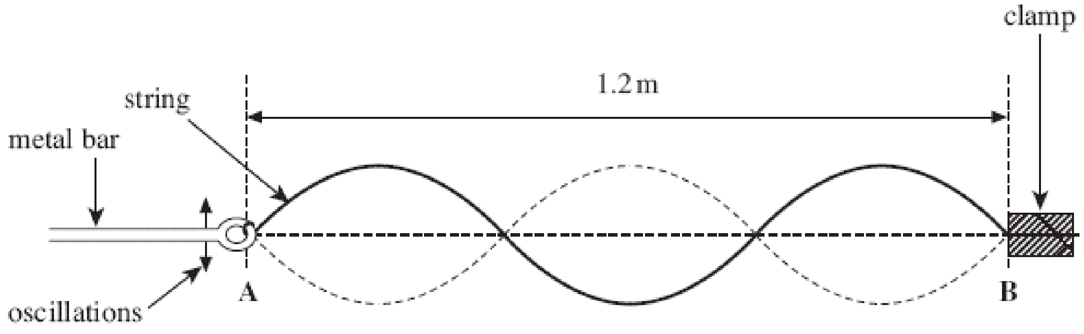
(ii) the frequency of the microwave transmitter.

....

....

(3)
(Total 7 marks)

Q8. The figure below shows a stationary wave on a string. The string is tied onto a thin metal bar at **A** and fixed at **B**. A vibration generator causes the bar to oscillate at a chosen frequency.



Explain how a stationary wave is formed. Then describe the key features of the stationary wave shown in the figure above.

The quality of your written answer will be assessed in this question.

....

....

....

....

....

....

....

....

....

....

....

....

....

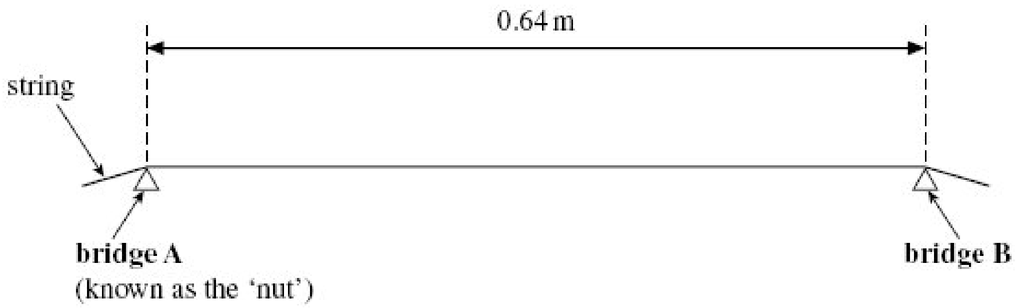
....

(Total 6 marks)

Q9. **Figure 1** shows a side view of a string on a guitar. The string cannot move at either of the two bridges when it is vibrating. When vibrating in its fundamental mode the frequency of the sound produced is 108 Hz.

(a) (i) On **Figure 1**, sketch the stationary wave produced when the string is vibrating in its fundamental mode.

Figure 1



(1)

(ii) Calculate the wavelength of the fundamental mode of vibration.

answer = ... m

(2)

(iii) Calculate the speed of a progressive wave on this string.

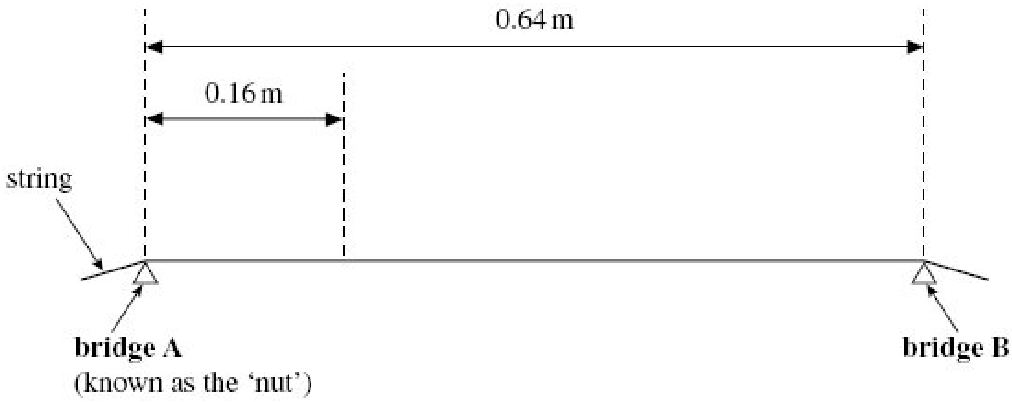
answer = ... m s^{-1}

(2)

(b) While tuning the guitar, the guitari t produce an overtone that ha a node 0 16 m from **bridge A**.

(i) On **Figure 2**, sketch the stationary wave produced and label all nodes that are present.

Figure 2



(2)

(ii) Calculate the frequency of the overtone.

answer = ... Hz

(1)

(c) The guitarist needs to raise the fundamental frequency of vibration of this string. State **one** way in which this can be achieved.

....

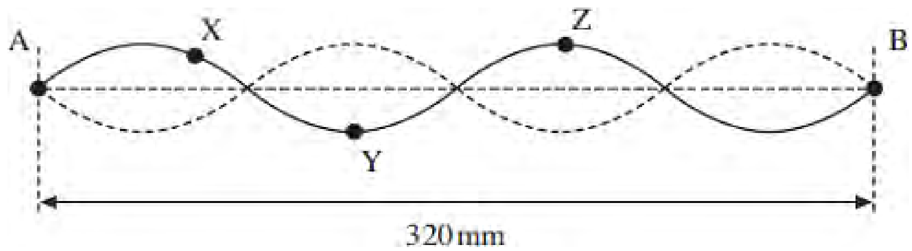
....

(1)
(Total 9 marks)

Q10. When a note is played on a violin, the sound it produces consists of the fundamental and many overtones.

Figure 1 shows the shape of the string for a stationary wave that corresponds to one of these overtones. The positions of maximum and zero displacement for one overtone are shown. Points **A** and **B** are fixed. Points **X**, **Y** and **Z** are points on the string.

Figure 1



(a) (i) Describe the motion of point **X**.

....

....

....

....

(2)

(ii) State the phase relationship between

X and **Y** ....

X and **Z** ....

(2)

(b) The frequency of this overtone is 780 Hz.

(i) Show that the speed of a progressive wave on this string is about 125 ms^{-1}.

(2)

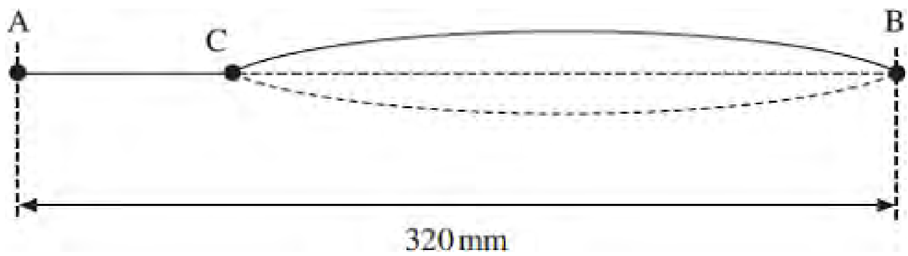
(ii) Calculate the time taken for the string at point **Z** to move from maximum displacement back to zero displacement.

answer = ... s

(3)

(c) The violinist presses on the string at **C** to shorten the part of the string that vibrates. **Figure 2** shows the string between **C** and **B** vibrating in its fundamental mode. The length of the whole string is 320 mm and the distance between **C** and **B** is 240 mm.

Figure 2



(i) State the name given to the point on the wave midway between **C** and **B**.

....

(1)

(ii) Calculate the wavelength of this stationary wave.

answer = ... m

(2)

(iii) Calculate the frequency of this fundamental mode. The speed of the progressive wave remains at 125 ms^{-1}.

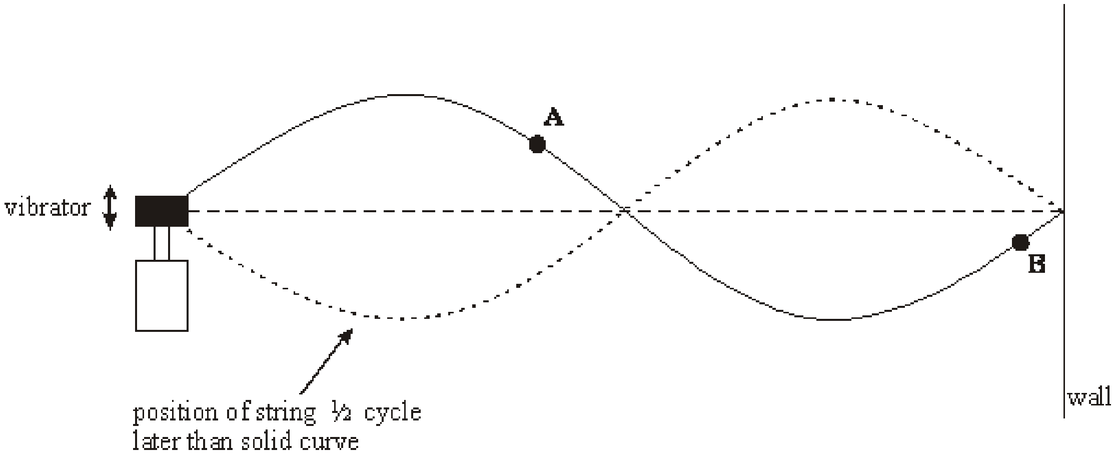
answer = ...Hz

(1)

(Total 13 marks)

Q11. **Figure 1** shows a stretched string driven by a vibrator. The right-hand end of a string is fixed to a wall. A stationary wave is produced on the string; the string vibrates in two loops.

Figure 1



(a) State the physical conditions that are necessary for a stationary wave to form on the string.

....

....

....

....

(3)

(b) State how you know that the wave on the string is transverse.

....

(1)

(c) Compare the *amplitude* and *phase* of the oscillations of points **A** and **B** on the string.

Amplitude ....

Phase ....

(2)

(d) The length of the string is 1.2 m and the speed of the transverse wave on the string is 6.2 m s^{-1}. Calculate the vibration frequency of the vibrator.

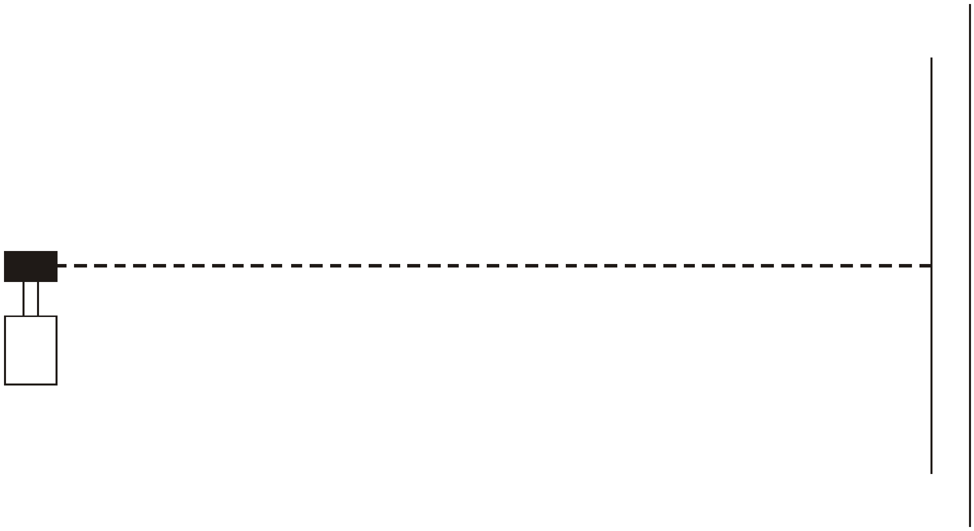
Vibration frequency ....

(4)

(e) The frequency of the vibrator is tripled.

(i) Sketch the new shape of the stationary wave on **Figure 2**.

Figure 2



(ii) Show on your diagram three points, P, Q and R that oscillate in phase.

(2)
(Total 12 marks)

M1. (a) (wave) **B** ✓

(the parts of the) spring oscillate / move back and forth <u>**in direction of / parallel to**</u> wave travel
OR
mention of <u>compressions and rarefactions</u> ✓

Second mark can only be scored if first mark is scored

2

(b) (i) (double ended arrow / line / brackets) from between two points in phase ✓

1

(ii) wave A: arrow vertically upwards ✓

wave B: arrow horizontally to the left ✓

2

(c) (transmitted radio waves are often) polarised ✓

aerial (rods) must be aligned in the same <u>plane</u> (of polarisation / electric field) of the wave ✓

2

[7]

M2. (a) the **maximum displacement** (of the wave or medium) ✓

from the equilibrium position ✓

accept ‘rest position’, ‘undisturbed position’, ‘mean position’

2

(b) (vertically) **down**wards (¼ cycle to maximum negative displacement) ✓

then **upwards** (¼ cycle to equilibrium position and ¼ cycle to maximum po itive di placement) ✓

down (¼ cycle) to **equilibrium position/zero** displacement **and** correct reference to either **maximum** positive **or** negative displacement or correct reference to fractions of the cycle ✓

candidate who correctly describes the motion of a knot 180 degrees out of phase with the one shown can gain maximum two marks
(ie knot initially moving upwards)

3

(c) **max 3 from**

stationary wave formed ✓

by **superposition or interference** (of two progressive waves) ✓

knot is at a **node** ✓

waves (always) cancel **where the knot is** ✓

allow 'standing wave'

3

[8]

M3. (a) (i) particle vibration (or disturbance or oscillation) **(1)**
same as (or parallel to) direction of propagation
(or energy transfer) **(1)**

(ii) (particle vibration)
perpendicular to direction of propagation (or energy transfer) **(1)**

3

(b) variation in intensity between max and min (or light and dark) **(1)**
two maxima (or two minima) in 360° rotation **(1)**

2
QWC 1

[5]

M4. (a) **maximum displacement** from equilibrium/mean position/mid-point/etc **(1)**

1

(b) (i) any **one** from:

surface of water/water waves/in ripple tank **(1)**

rope **(1)**

slinky clearly qualified as transverse **(1)**

secondary ('s') waves **(1)**

max 1

(ii) transverse wave: oscillation (of medium) is perpendicular to wave travel

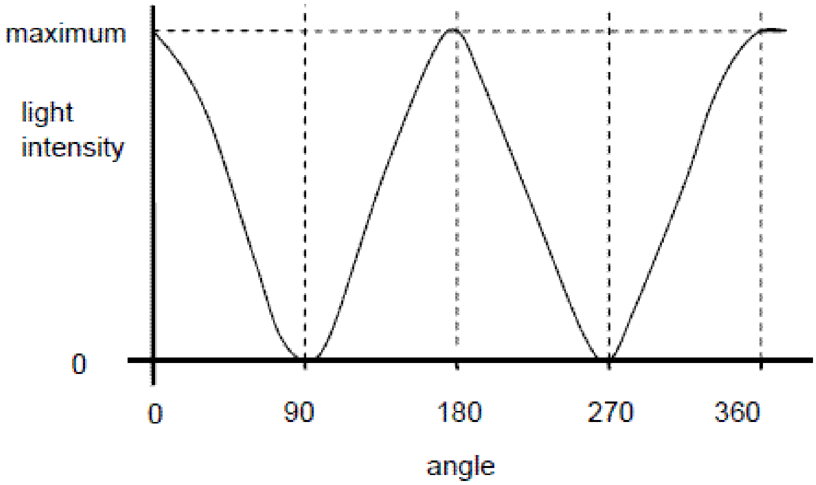
or transverse can be polarised

or **all** longitudinal require a medium **(1)**

1

(c) (i) vertical line on B ± 5° **(1)** 1

(ii)



max 0, 180, 360 + min 90, 270 **(1)**

and line reaches same minimum and maximum every time and reasonable shape **(1)** 2

(d) appropriate use **(1)**

reason for Polaroid filter being used **(1)**

eg

Polaroid gla e / **un**gla e /	to reduce glare windscreens
camera	reduce glare/enhance image
(in a) microscope	to identify minerals/rocks
polarimeter	to analyse chemicals/concentration or type of sugar
stress analysis	reveals areas of high/low stress/ other relevant detail
LCD displays	very low power/other relevant detail
3D glasses	enhance viewing experience, etc

2

[8]

M5. (a) (i) 0.4(0) m **(1)**

(ii) speed (= frequency × wavelength) = 22 × 0.4(0) ecf **(1)**
= 8.8 (m s^{-1}) **(1)**

(ii) 90 or 450 (1) ° or **degrees (1)**
or 0.5π or 2.5π or 5π/2 **(1) rad**(ians)
or **r** or ʳ **(1)** no R, Rad, etc

5

(b) displacement of Y will be a **positive (or 'up') maximum** at 1/4 of a period (or cycle) (0.0114 s) **(1)**

returns to original position (at 0.5 of a period or cycle) (owtte) **(1)**

2

[7]

M6. (a) (progressive waves travel from centre) to ends and reflect **(1)**

two (progressive) waves travel in opposite directions along the string **(1)**

waves have the same frequency (or wavelength) **(1)**

wave have the ame (or imilar) **amplitude (1)**

superposition (accept 'interference') **(1)**

max 3

(b) (i) wavelength (= 2 × PQ = 2 × 1.20 m) = 2.4 m **(1)**

speed (= wavelength × frequency = 2.4 × 150) = 360 m s^{-1} **(1)**

(answer only gets both marks)

(ii) diagram to how three 'loop ' **(1) and** of equal length and good shape **(1)** (or loop of one third length **(1)**)

4

[7]

M7. (a) interference or superposition **(1)**
reflection from metal plate **(1)**
two waves of the same frequency/wavelength **(1)**
travelling in opposite directions (or forward/reflected waves) **(1)**
maxima where waves are in phase or interfere constructively **(1)**
minima where waves are out of phase/antiphase or interfere destructively **(1)**
nodes and antinodes or stationary waves identified **(1)**

max 4
QWC 2

(b) (i) (distance between minima = $\frac{\lambda}{2}$)

$\left(\frac{\lambda}{2} = \frac{144}{9} \text{ gives}\right)$ λ = 32.0 mm **(1)**

(ii) $c = f\lambda$ and $c = 3 \times 10^8$ (m s^{-1}) **(1)**

$f = \frac{3 \times 10^8}{32 \times 10^{-3}} = 9.38 \times 10^9$ Hz **(1)**

(allow C.E. for value of λ from (i))

3

[7]

M8. **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria.

High Level (good to excellent) 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

Mentions **waves** travelling in **opposite directions** or waves of **same frequency** (and amplitude) **and** superpose **or** interfere **or** add together.

Intermediate Level (modest to adequate) 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

Mentions **waves** travelling in **opposite directions** (accept 'waves reflect/ rebound back or from clamp') **or superposition/addition/interference of waves or** waves of same frequency/wavelength.

Low Level (poor to limited) 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate.

One correct key feature **or** one relevant remark regarding formation given.

The explanation expected in a competent answer should include a coherent account of the following points concerning the physical principles involved and their consequences in this case.

- 4 nodes where there is no movement/zero amplitude
- 3 antinodes where amplitude is maximum
- wavelength 0.80 m
- end antinodes in phase/middle and ends in antiphase
- between node and antinode, amplitude of oscillation increases
- waves reflect off the clamp (and the rod)
- waves travelling in opposite directions superpose/add/interfere
- wave have same wavelength and frequency (similar amplitude)
- always cancellation at nodes/always constructive superposition at antinodes
- energy is not transferred along string

[6]

M9. (a) (i) one 'loop' (accept single line only, accept single dashed line)

+ nodes at each bridge (± length of arrowhead)

+ antinode at centre **(1)**

1

(ii) $\lambda_0 = 2L$ or $\lambda = 0.64 \times 2$ **(1)**

= 1.3 (m) **(1)** (1.28)

2

(iii) ($c = f\lambda$) = 108 × (a)(ii) **(1)**

= 138 to 140(.4) (m s^{-1}) **(1)** ecf from (a) (ii)

2

(b) (i) four antinodes **(1)** (single or double line)

first node on 0.16 m (within width of arrowhead)

+ middle node between the decimal point and the centre of the 'm' in '0.64 m'

+ middle 3 nodes labelled 'N', 'n' or 'node' **(1)**

2

(ii) (4 f_0 =) 430 (Hz) **(1)** (432)

or use of $f = \frac{v}{\lambda}$ gives 430 to 440 Hz correct answer only, no ecf

1

(c) decrease the length/increase tension/tighten string **(1)**

1

[9]

M10. (a) (i) oscillates / vibrates ✓

(allow goes up and down / side to side / etc, <u>repeatedly, continuously, etc</u>)

about <u>equilibrium</u> position / perpendicularly to central line ✓

2

(ii) X and Y: antiphase / 180 (degrees out of phase) / π (radians out of phase) ✓

X and Z: in phase / zero (degrees) / 2π (radians) ✓

2

(b) (i) $v = f\lambda$

= 780 x 0.32 / 2 or **780 x 0.16 OR 780 x 320 / 2** or **780 x 160** ✓

THIS IS AN INDEPENDENT MARK

= 124.8 ✓ (m s^{-1}) correct 4 sig fig answer must be seen

2

(ii) ¼ cycle ✓

T = 1 / 780 OR = 1.28×10^{-3} ✓

$0.25 \times 1.28 \times 10^{-3}$

= 3.2×10^{-4} (s) ✓

Allow correct alternative approach using distance of 0.04m ✓

travelled by progressive wave in ¼ cycle divided by speed.

0.04 /125 ✓ = 3.2×10^{-4} (s) ✓

(c) (i) antinode ✓

1

(ii) 2 x 0.240 ✓

= 0.48 m ✓ '480m' gets 1 mark out of 2

2

(iii) (*f* = *v/λ* = 124.8 or 125 / 0.48) = **260** (Hz) ecf from cii ✓

1

[13]

M11. (a) reflection (or 2 waves travelling in opposite directions) **(1)**

waves have similar amplitudes **(1)**

waves have similar frequency **(1)**

reflected wave loses only a little energy at the wall **(1)**

max 3

(b) displacement perpendicular to rest position of the string **(1)**

1

(c) **A** larger than **B** **(1)**

A 180° out of phase with **B** **(1)**

2

(d) λ = 1.2m **(1)**

$c = f\lambda$ **(1)**

f = 6.2/1.2 **(1)** 5.2Hz **(1)**

4

(e) (i) diagram correct: 6 loops **(1)**

(ii) Q and R correct **(1)**

2

[12]