Mark schemes

1.

(a) smooth line drawn within half grid square of points ✓

minimum between 32.6 and 32.8 cm ✓

2

(b) value of their minimum (cm) ✓

Within a half grid square

1

(c) doubles 0.2 **OR** calculates percentage uncertainty for 0.2 (half range) ✓

Correct answer earns both marks

0.8 (%) ✓

CAO

2

(d) recognises that node-to-node spacing = $\lambda/2$ ✓

recognises the need to divide by 8 ✓

2.36×10^9 (Hz) ✓

Condone use of 7 or 9

3 sf required

For example:

$\lambda = \frac{0.509 \times 2}{8}$ *or 0.127(25) m seen; top line earns* $_1$✓ *and bottom line earns* $_2$✓

$f\left(=\frac{3\times10^8\times8}{0.509\times2}\right)$ *= 2.36 × 10⁹ (Hz) earns all 3 marks*

$f\left(=\frac{3\times10^8\times7}{0.509\times2}\right)$ *= 2.06 × 10⁹ earns 2 marks*

$f\left(=\frac{3\times10^8\times9}{0.509\times2}\right)$ *= 2.65 × 10⁹ earns 2 marks*

Allow 2 marks for 4.72 × 10⁹ (must be 3 sf)

3

(e) (microwaves are) <u>polarised</u> ✓

1

[9]

2.

B

*above **MN** by 0.20 m*

[1]

3.

B

third

[1]

4.

(a) Rotate aerial in vertical plane ✓

When aerial vertical signal is a maximum

When aerial horizontal signal is a minimum ✓

Max occurs when aerial aligned with plane of polarisation of microwave ✓

The first mark is for what needs to be done

The second mark is for what is measured

The third mark is for the link to polarisation

3

(b) Received signal goes through series of max and min✓

Reflected and direct microwaves interfere ✓

Path length of reflected wave/path difference increases as plate moved✓

Phase difference between reflected and direct waves changes (so signal strength changes.) ✓

First mark is for what is observed

Accept 'both' for 'reflected and direct'

If no other mark given, 1 mark can be awarded for mention of interference/ superposition/ out of phase

4

(c) Equation only valid if slit-screen distance is a lot greater than slit separation✓

Allow arguments in terms of angles

Allow 0.45 m for slit-screen distance

Allow use of standard symbols

1

(d) Maximum path length for first slit
$= \sqrt{(0.45^2 + (0.25 - 0.06)^2)}$
$= 0.49$ m✓$_1$

MP1 is for one path length correct

MP2 is for both path lengths correct

Max path length for second slit
$= \sqrt{(0.45^2 + (0.25 + 0.06)^2)}$
$= 0.55$ m✓$_2$

MP3 is for determination of path difference and conclusion.

Path difference = 0.55 – 0.49 = 0.06 m
Which is greater than half a wavelength – so yes✓$_3$

Alternative for MAX2

Young equation used to determine fringe separation. ✓$_{12}$

Idea that fringe separation < 0.25 m so wavelength can be determined. ✓$_3$

3

[11]

5. D

The frequency is 0.17 Hz.

[1]

6. A

P** is in antiphase with **R ***P** has the same amplitude as **Q***

[1]

7. (a) **Max 2**

Antiphase / completely out of phase / π radian out of phase ✓

Allow ½ cycle or 180° out of phase

Condone:

'Move in opposite directions'

'Displaced in opposite directions'

'when P is at its peak then Q is at its trough'

for loose descriptions of antiphase

'Opposite amplitudes' too vague (treat as neutral)

'When P is positive Q is negative' too vague

Similar amplitudes (of vibration) **or** similar (magnitudes of) displacement (at any instant in time) ✓

Same period **or** same frequency ✓

Move with the same speed ✓

Allow same amplitude / same (magnitude of) displacement

2

(b) Use of $v = f\lambda$ or determines the wavelength = 0.275 m ✓

Condone use of wavelength = 0.55 m or

0.1375 m in substitution for 1st MP

Condone Power of ten errors on wavelength for 1st MP

Two errors forfeit 1st mark:

Allow wavelength in range 0.27 to 0.28 m

(v =) 69 m s^{-1} ✓

Allow answers in range 67.5 to 70.0 m s^{-1}

2

(c) Same speed ✓

Moving in opposite directions ✓

same wavelength / same frequency/ similar amplitudes ✓

The following are insufficient:

Progressive / transverse / transfer energy

Allow same amplitudes

3

(d) Horizontal line drawn from **P** to **Q** ✓

1

(e) Marks an A at each end of the string ✓

Condone other incorrect antinodes or nodes drawn (1st MP)

Marks all 5 As (evenly spaced by eye) on a horizontal line ✓
cao

Penalise incorrect number A or poorly positioned A (2nd MP)

2

(f) Third harmonic / third harmonic drawn in **Figure 6** ✓

Frequency for first harmonic has reduced to 1/3 of previous or

$f = \frac{1}{3} \times \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

or

speed reduces to 1/3 of previous ✓

String being driven at three times this frequency ✓

*Must be a clear statement that this is 3rd harmonic / accept 3 symmetrical loops drawn in **Figure 6***

*Where no other mark has been scored allow **1 mark** for:*

- *Speed decreases*
- *Fundamental frequency is lower/ frequency of 1st harmonic is lower*
- *use of*

$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

where 9μ has been substituted correctly (accept in any correct rearrangement)

3

[13]

8. **D**

[1]

9. **A**

[1]

10. (a) Refers to relative direction of oscillations to that of the direction of propagation / transfer of energy ✓

For transverse waves oscillations are at right angles to direction of propagation while in longitudinal waves they are in the same direction ✓

allow direction the wave is travelling in

2

(b) Correct value for μ = (1 ×) $\frac{\pi d^2}{4}$ ρ = 7.5 × 10^{-4} (kg $m^{-1)}$✓

$\left(\text{uses } f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}\right)$ ✓

Tension = 126 N (allow 9.7 × 10^5 × their value for μ) ✓

2

(c) Max tension permissible before breaking = $3.0 \times 10^9 \times$

$\frac{\pi \times (3.5 \times 10^{-4})^2}{4}$ = 288 (289)(290) N ✓

This is greater than required tension so wire is suitable. ✓

OR

stress in operation = $\frac{126 \times 4}{\pi \times (3.5 \times 10^{-4})^2}$ = 1.3×10^9 (N m^{-2})✓

which is less than breaking stress ∴ safe to use✓

Allow ecf for incorrect area in 2.2

2

(d) Shows second harmonic $\lambda = \frac{1}{f}\sqrt{\frac{T}{\mu}}$ ✓

Identify f and T are constant so λ is proportional to $\frac{1}{\sqrt{\mu}}$ ✓

λ increases from A to B ✓

mass per unit length decreases from A to B so A has a greater diameter✓

4

[10]

11. **A**

[1]

12. **C**

[1]

13. **A**

[1]

14. (a) 1.5 (ms) ✓

1

(b) A = 4.2 (mm) read from graph ✓

T = 2.0 (ms) read from graph ✓

($a_{max} = 4.2 \times 10^{-3} \times (2 \times \pi / (2 \times 10^{-3}))^2$

4.1(5) × 10^4 (m s^{-2}) ✓ (Do not allow 4.2)

Condone power of ten error in A and/or T but not in final answer.

Evidence for T might be seen in equation, as 500 (f).

Only allowed ecf for max 2 is use of 4.1 mm for A, giving 4.0 × 10^4 (m s^{-2})

3

(c) longitudinal

(they) oscillate along direction of energy transfer ✓

Both required for 1 mark

Condone "vibrate" for oscillate.

Condone 'travel' for transfer

1

[5]

15. **D**

[1]

16. **B**

[1]

17. **C**

[1]

18. (a) f (from $\frac{1}{T}$) in range 61 ± 1 Hz $_1$✓ $_2$✓

OR

61 ± 3 Hz $_{12}$✓

maximum 1 mark for POT error OR incorrect rounding

no credit for 1 sf; treat 60 as 2 sf unless clearly rounded to 6×10^1

*for $_1$✓ $_2$✓ **require ≥ 2 sf** that rounds to not less than 60 and not more than 62*

*for $_{12}$✓ **require ≥ 2 sf** that rounds to not less than 58 but less than 60*

OR

*for $_{12}$✓ **require ≥ 2 sf** that rounds to more than 62 but not more than 64*

if incorrect rounding leads to 60 treat this as 1 sf and give no credit

use of $\frac{1}{T}$ does not have to be seen; marks are for final answer seen

2

(b) (figures) 804 and 226 seen in working $_1$✓

λ = difference between their readings × 2;

given to nearest mm; expect 1.156 (m)

OR

to nearest cm; expect 1.16 (m) $_2$✓

for $_1$✓ 578 is not enough

for $_2$✓ range is based on x = (804 – 226 =) 578 ± 2mm;

give no credit for POT errors eg 115.6 / 116 etc

accept 1156 mm etc if unit on answer line is amended

2

(c) c correctly evaluated to ≥ 2 sf from their f × their λ ✓

substituted data may be from 03.1/2 final answers or unrounded (intermediate) data from working

expected answer = 61 × 0.578 × 2 = 70.5 m s–1

1

(d) μ correct to 2 sf based on their f and their λ earns both marks $_1$✓ $_2$✓

for incorrect / missing μ

EITHER

use of $c = \sqrt{\frac{T}{\mu}}$

OR

use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

for $_1$✓ their value of μ can be given to ≥ 2 sf but must agree with $\frac{0.5 \times g}{(\text{their } f \times \lambda)^2}$ OR $\frac{0.5 \times g}{(\text{their } c)^2}$ ***when rounded to 2 sf****; use of g = 9.81 or 9.8 only; no ecf for mixed units*

expected answer $\mu = 9.9 \times 10^{-4}$ (kg m^{-1}): be wary of which approach has been taken by the candidate

for $_{12}$✓ 'use of' means allow ***either***

rearranges so that μ is the subject eg $\mu = \frac{T}{c^2}$

(accept $\mu = \frac{mg}{c^2}, \frac{T}{c^2} = \mu$ *etc)* ***or***

substitution of all relevant data including their c into a correct expression with μ as the only unknown

for T allow 4.9 / 4.91 / 4.905 (accept 0.5 × 9.81 or 0.5 × 9.8); allow mixed units; allow 0.5g

OR 'use of' means allow ***either***

rearranges to $\mu = \frac{T}{(2 \times l \times f)^2}$ OR $\frac{T}{4 \times l^2 \times f^2}$ ***or***

substitution of all relevant data including their l and f leaving μ as the unknown; allow sub of λ for $2l$

watch for possible error $\lambda = L$

2

(e) 0.71 (mm) ✓

only answer that gets mark

1

(f) ANY TWO FROM

repeat readings at different points along the rod and calculate an average / mean $_1$✓

repeat readings in different directions (perpendicular to the rod) and calculate an average / mean $_2$✓

reject / discard anomalous readings before calculating an average / mean $_3$✓

award $_{123}$✓= 1 MAX for checking at different points / in different directions to confirm that the rod is uniform / that there are no anomalies

allow 'cylinder' / 'wire' etc for rod

for $_1$✓ $_2$✓ and $_3$✓ averaging idea only needs to be seen once;

if averaging idea missing then allow 'repeat at different points and in different directions, then remove anomalies' $_{123}$✓= 1 MAX

if 'calculate' is not seen allow 'work out' / /'determine' / 'compute'; anything that sounds like a mathematical process is ok;

'find' / 'obtain' / 'take' / 'do an average' are just ok;

'get' is not ok

for $_1$✓ allow repeat at 'different positions' / 'down / along the rod'

for $_2$✓ allow (repeat in different directions) 'around the rod' / 'different orientations' / 'angles' / 'planes' / 'sides'

for $_3$✓ allow 'ignore anomalies'; 'outlier' = 'anomaly'

reject 'calculate an average to eliminate effect of anomalies'

treat as neutral: 'turn the wheel to close the callipers' / suggestions about calibration

treat as neutral: 'zero callipers before use' this is a procedure to eliminate a source of systematic error

2

(g) (for use of expected 0.71)

ρ = 8.9(41) × 10^3 (kg m^{-3})

OR

(for use of 0.53)

ρ = 1.6(05) × 10^4 (kg m^{-3})

OR

$$\rho = \frac{4.51\times10^{-3}}{(\text{their } d \text{ from (e)})^2}$$

OR

attempts to use μ OR 3.5(4) × 10^{-3} divided by their (recognisable) cross-sectional area $_1$✓

AND/OR

evidence showing cross-sectional area = $\frac{\pi d^2}{4}$ using their d from (e) (allow πr^2 using their d) $_2$✓

correct answer scores $_{123}$✓✓✓

for $_{123}$✓✓✓ allow an answer that rounds to the correct 2 sf value

sample results for expected d

d/mm	A/m^2	ρ/kg m^{-3}
0.71	3.96×10^{-7}	$8.9(41) \times 10^3$
0.53	2.21×10^{-7}	$1.6(05) \times 10^4$

for $_1$✓ accept use of symbols, eg

$$\rho = \frac{\mu}{A} \; / = \frac{3.54 \times 10^{-3}}{A(\times 1)} \; / = \frac{4 \times \mu}{\pi \times d^2} \; / = \frac{4 \times 3.54 \times 10^{-3}}{\pi \times d^2 (\times 1)}$$

$$= \frac{3.54 \times 10^{-3}}{\pi \times r^2 (\times 1)}$$

for $_2$✓ expect correct value of A seen or correct values of A or d in working, eg

$$\rho = \frac{3.54 \times 10^{-3}}{3.96 \times 10^{-7} (\times 1)} \; / = \frac{4 \times 3.54 \times 10^{-3}}{\pi \times (0.71 \times 10^{-3})^2 \times (1)}$$

accept values ≥ 2 sf for A; allow ecf d and don't penalise POT error in A or d (eg missing 10^{-7}, 10^{-3})

1
2

[13]

19. **D**

[1]

20. **A**

[1]

21. (a) Waves travel to the boundaries and are reflected ✓

Not bounce off ...

1

two waves travelling in opposite directions interfere/superpose ✓

Not superimpose or interferes with itself

1

Fixed boundaries (cannot move so) are nodes ✓

creates nodes and antinodes bland = 0

In some positions the waves always cancel /interfere destructively to give zero amplitude/no vibration/nodes)
OR
interfere constructively to produce positions of maximum amplitude/maximum vibration/antinodes ✓

1
Max 3

(b) Use of $f=\frac{1}{2l}\sqrt{\frac{T}{\mu}}$ ✓

Either rearranges for μ without substitution or substitutes correctly in the formula

1

4.2 (4.19) × 10^{-4} (kg) ✓

1

(c) 240 (244) (m s^{-1})

1

(d) 1 rotation of the peg = 22 mm ✓

Or Reads increase in tension produced by the extra extension (about 10 N) from graph and adds to 25

1

extra extension = 22 × 75/360 = 4.6 mm

(ecf for incorrect circumference) ✓

πd × 75/360 not evaluated =1

1

Total extension = 11 + 4.6 (15.6 mm) so tension 35 - 36N ✓

Inspect their length and their tension in the substitution

1

Calculates frequency **for their tension**

T must be greater than the original 25N

Condone adding or subtracting extra extension to 0.33 m

If 4.0 × 10^{-4} kg used then answer will be in range 448 Hz to 455 Hz

If 4.19 × 10^{-4} used 438 to 444 Hz

1

[10]

22. (a) Period = 0.2 × 10^{-14} (s) read off

OR

Recognisable T substituted into $T = 1 / f$ ✓

An acceptable subject (period, time for one cycle, one cycle, T, etc.)

Allow non-standard symbol with unit seen on time.

Allow this subtraction of two times seen in $f = 1/T$

Use of $T = 1 / f$ and $c = f\lambda$ ✓

OR

Use of $\lambda = cT$

Use of here is:

Subject must be seen with substitutions or rearranged equations with $f = 1/T$ and $\lambda = c/f$

Condone power 10 error here

Condone lack of subject in vertical working where rearranged equation with appropriate subject seen at heading of column

6(.0) × 10^{-7} (m) ✓

Number must be expressed as 6 × 10^{-7} or 600 × 10^{-9}

or equivalent not enough to see only nano prefix.

3

(b) (Determines a fraction of cycle)

$\frac{0.04}{0.2}$ or $\frac{2}{10}$ or $\frac{1}{5}$ or 0.2 or $\frac{1.2(\times 10^{-7})}{6(\times 10^{-7})}$ or 0.2λ seen ✓

Condone their fraction × 2π or their decimal × 2π

For 1st mark

2π/5 OR 0.4 π

OR

1.26 or 1.3 ✓

Allow 8π/5 OR 1.6 π

OR

5.03 or 5.0

2

(c) (Distance =) $3 \times 10^{-7} \times 2.37 \times 10^{5}$ seen

OR

(Distance =) 0.07(11) (m) seen ✓

Subs into $s = \frac{1}{2}at^2$ ✓

Condone error in sub for s where formula has been otherwise correctly manipulated with a (or g) as subject

<u>9.88</u> (3 sf only) ✓

Alternative:

1st mark *average speed* = $\frac{3 \times 10 - 7 \times 2.37 \times 105}{0.12}$

2nd mark $a = \frac{2 \times \text{their average speed}}{0.12}$

3rd mark *9.88*

3

(d) Draws a tangent to the curve at approximately

t = 120 ms <u>and</u> attempts a gradient calculation ✓

Tangent must be a straight line that touches curve and divergent from curve before 90 ms and after 150 ms

(Gradient =) 1.2 (range 1.1 to 1.3) ✓

Allow 1.2 × 10^{-3} (range 1.1 × 10^{-3} to 1.3 × 10^{-3}) ✓

Ignore units on answer line

2nd mark is dependent on 1st mark

Max 1 mark for correct answer in range where tangent satisfies above conditions but doesn't quite touch curve (half-square tolerance)

First alternative:

1st mark

Use of v = u +at with sub for a = 9.88 or 9.875 ***and*** *t=0.12*

2nd mark

1.2 or 1.19 or 1.185 ***only***

Second alternative:

1st mark

Use of s = 1/2at^2 and ds/dt = at with sub for a = 9.88 or 9.875 ***and*** *t = 0.12*

2nd mark

1.2 or 1.19 or 1.185 ***only***

4

(e) (instantaneous) Velocity (of the mirror) or (instantaneous) speed (of the mirror) ✓

Ignore any units quoted

Do not allow:

Average speed / constant speed

4

[8]

23. **D**

[1]

24. **A**

[1]

25. **B**

[1]

26. (a) 180 degrees

accept ° for degrees

OR

π radians ✓

condone ^{c} or 'rad' for radian

reject 'half a cycle'

treat 'π radians in phase' as talk out

1

(b) (idea that) sets of combining waves do not have the same amplitude ✓

condone 'waves do not have same intensity' or 'same energy' or 'some energy is absorbed on reflection' or 'same power' or 'same strength' or idea that non point source or non point receiver would lead to imperfect cancellation

condone the idea that the waves may not be monochromatic

ignore 'some waves travel further' or 'waves do not perfectly cancel out'

reject 'waves may not be 180° out of phase'

1

(c) valid use of a set square or protractor against TR (to ensure perpendicular) $_1$ ✓

measure *x* at two <u>different</u> points [at each end of M] **<u>and</u>** adjust until [make sure] both <u>distances are the same</u> $_2$ ✓

OR

use of set square to align M with the perpendicular line earns $_2$ ✓

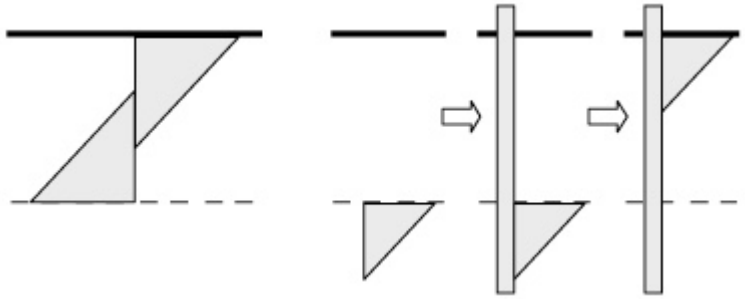
if method used does not allow <u>continuous</u> variation in *x* then award maximum 1 mark

OR

align <u>graph paper</u> with TR $_1$ ✓

align M with grid lines on graph paper $_2$ ✓

both marks can be earned for suitable sketch showing a viable procedure involving one or more recognisable set squares or protractors; the sketch may also show a recognisable ruler, eg



allow use of scale on set square to measure the perpendicular distances don't penalise incorrect reference to the set square, eg as 'triangular ruler', as long as the sketch shows a recognisable set square

2

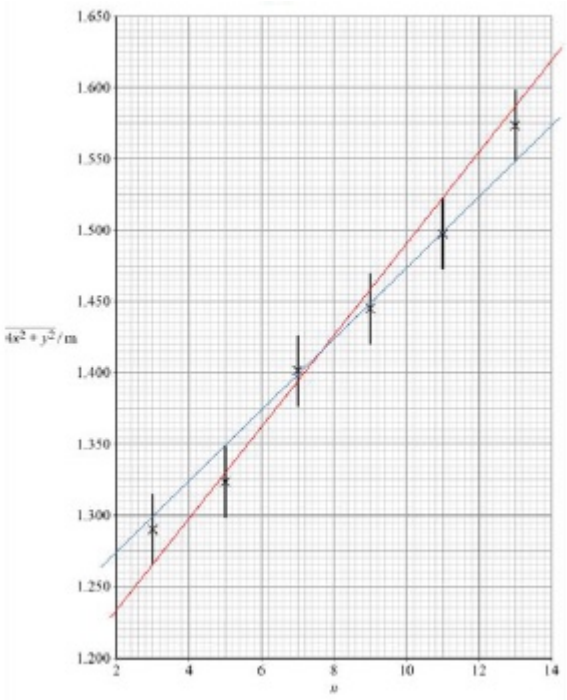
(d) G_{max} line ruled through bottom of n = 3 error bar and through top of n = 11 error bar 1✓

G_{min} line ruled through top of n = 5 error bar and through bottom of n = 13 error bar $_2$ ✓

G_{max} and G_{min} calculated from valid y step divided by valid x step; both n steps ≥ 6 $_3$ ✓

allow 1 mm tolerance when judging intersection of gradient lines with error bars

ignore any unit given with G_{max} or G_{min}; penalise power of ten error in 01.5



12 ✓*= 1 MAX if (either) line is thicker than half a grid square or of variable width or not continuous;*

expect G_{max} = 3.2(1) × 10^{-2} and G_{min} = 2.5 (2.49) × 10^{-2}

3

(e) $\lambda (\text{from} \frac{G_{max} + G_{min}}{2})$

AND

result in range 2.8(0) to 2.9(0) × 10^{-2} (m) $_1$ ✓ $_2$ ✓

OR

award one mark for

2.7(0) to 3.0(0) × 10^{-2} (m) $_{12}$ ✓

penalise 1 mark for a power of ten error

reject 1 sf 3 × 10^{-2} (m)

if a best fit line is drawn between the G_{max} and G_{min} lines and the gradient of this is calculated award 1 mark for λ in range 2.8(0) to 3.0(0) × 10^{-2}(m)

2

(f) uncertainty in λ = $G_{max} - \lambda$

OR

$\lambda - G_{min}$

OR

$\left(\frac{G_{max} - G_{min}}{2}\right)_1$ ✓

percentage uncertainty = (uncertainty/λ)×100 $_2$ ✓

result in range 11(.0) % to 14(.0) % $_3$ ✓

$_1$✓ can be earned by showing a valid uncertainty then dividing by λ

ecf their λ, G_{max} and G_{min} for $_1$ ✓ and $_2$ ✓

allow λ found from best fit line

accept $\left(\frac{G_{max} - \lambda}{\lambda}\right) \times 100$ or $\left(\frac{G_{max} - G_{min}}{G_{max} + G_{min}}\right) \times 100$ etc for $_{12}$ ✓

allow $\left(\frac{\Delta\lambda}{\lambda}\right)$ × 100 where $\Delta\lambda$ is any plausible uncertainty for $_2$ ✓

numerical answer without valid working can only earn $_3$ ✓

3

(g) (states) calculate the (vertical) intercept $_1$ ✓

OR

outlines a valid calculation method to calculate y $_1$ ✓

determine the intercept for <u>both lines</u> and calculate average value $_2$ ✓

OR

determine the (vertical) intercept of the line of best fit (between G_{max} and G_{min}) $_2$ ✓

draw the line of best fit (between G_{max} and G_{min}); perform calculation to find intercept earns $_{12}$ ✓

2

(h)

result	reduced	not affected	increased
G_{max}		✓	
G_{min}	✓		
λ	✓		
y			✓

general marker question

allow any distinguishing mark as long as only one per row

for ✓ and X in same row ignore X

for ✓ and ✓ in same row give no mark

ignore any crossed-out response

4

alternative approach: single best fit line drawn on **Figure 4**

(d) *G* calculated from *y* step divided by *x* step;

n step ≥ 6 $_3$ ✓

MAX 1

(e) λ in range 2.8(0) to 2.9(0) × 10$_{-2}$ ✓

MAX 1

(f) percentage uncertainty in $\lambda = \left(\frac{\Delta\lambda}{\lambda}\right) \times 100$

AND

result in range 11(.0) % to 14(.0) % ✓

MAX 1

(g) calculate intercept

OR

outlines a valid calculation method to find *y* ✓

MAX 1

(h) as main scheme

no ecf possible

4

alternative approach: non-crossing lines for G_{max} and G_{min} on **Figure 4**: includes lines that meet but do not cross

(d) G_{max} and G_{min} calculated from *y* step divided by *x* step; both *n* steps ≥ 6 $_3$ ✓

MAX 1

(e) to (h) as main scheme

1

[18]

27. (a) waves are reflected (from the oven wall) ✓

1

and superpose/interfere with wave travelling in opposite direction/incident waves/transmitted wave ✓

NOT superimpose

1

(b) energy/amplitude is maximum ✓

1

(chocolate melts at) antinode ✓

if refer to node can still be awarded first mark

1

(c) clear evidence that used first and third antinode ✓

can be from diagram

1

distance from first to third antinodes = 0.118 ± 0.001 (m) OR
distance between two adjacent antinodes = 0.059 ± 0.001(m) ✓

mark for either value

carry their value forward for subsequent marks even if outside tolerance

1

wavelength = 0.118 (m) ✓

mark for using their wavelength (range 0.112 to 0.124)

1

frequency = 3.0×10^8 /0.118 ✓

mark for use of $v = f\lambda$ allow this mark if use 0.059

1

frequency = 2.5×10^9 (Hz) ✓

***must** be in range $2.40 \times 10^9 - 2.60 \times 10^9$*

if use 330 for speed lose last 2 marks

1

(d) position of antinode/maximum energy/maximum amplitude/nodes (in food) continually changes ✓

must be clear antinode maximum energy/maximum amplitude changes location

1

[10]

28. C

[1]

29. A

[1]

30. (a) A wave transfers energy <u>from one point to another</u> ✓
without transferring material / (causing permanent displacement of the medium) ✓ owtte

2

(b) (i) 0.6 (mm) or 0.60 (mm) ✓

1

(ii) 0.080 (m) ✓

Allow 1 sig fig

1

(iii) $f = 1/T = 1/0.044 = 23$ (Hz) ✓ (22.7 Hz)

1

(iv) $v = f\lambda = 22.7 \times 0.080 = 1.8$ (m s^{-1}) ✓ (1.82 m s^{-1})

allow CE v = (biii) × (bii) but working must be shown

1 sig fig not acceptable

1

(c)

sound waves are transverse	sound waves are longitudinal	sound waves can interfere	sound waves can be polarised
	√	√	

1

(d) the wavelength would be smaller
smaller spread in main peak or more peaks (between A and B)
the central peak is higher (owtte)
as the energy is concentrated over a smaller area (owtte)
reference to (sin $\theta_{min} = \lambda/d$)
✓ ✓ ✓ any 3 lines max 3

Note that the marks here are for use of knowledge rather than performing calculations.

No bod if writing does not make increase or decrease clearly distinct.

Marking should be lenient.

3

[10]