Access Tuition

A-Level Physics

Longitudinal and Transverse Waves

Mark Scheme

Time available: 65 minutes
Marks available: 48 marks

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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* $_2$✓

$f \left(= \frac{3 \times 10^8 \times 8}{0.509 \times 2} \right)$ *= 2.36 × 10*^{9} *(Hz) earns all 3 marks*

$f \left(= \frac{3 \times 10^8 \times 7}{0.509 \times 2} \right)$ *= 2.06 × 10*^{9} *earns 2 marks*

$f \left(= \frac{3 \times 10^8 \times 9}{0.509 \times 2} \right)$ *= 2.65 × 10*^{9} *earns 2 marks*

Allow 2 marks for 4.72 × 10^9 *(must be 3 sf)*

3

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

1

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2. (a) Max 2 from: ✓ ✓

(Because) the refractive index of water is greater than air

(and) the angle of incidence is greater than the critical angle

<u>total internal reflection</u> (of laser beam) occurs

Allow optical density for refractive index.

Allow answer given as a diagram.

2

(b) Use of $n = \frac{c}{c_s}$ eg $c_s = \frac{3.00 \times 10^8}{1.33}$ ✓

2.26×10^8 (m s^{-1}) ✓

3 sf answer from some relevant working ✓

3

(c) 49 (°) ✓

Do not allow 1 sf answer.

1

(d) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question**

Mark	Criteria
6	Both functions and dispersion problems discussed. No significant error or inconsistency.
5	Both functions and dispersion problems discussed. There may be some significant error or inconsistency.
4	Functions or dispersion problems described. No significant error or inconsistency.
3	Functions or dispersion problems described. There may be some significant error or inconsistency.
2	Both X and Y named and a function of one given; or A function of X and Y given, but only one named
1	X and Y identified by name or function
0	No relevant analysis

Level 2 max if dispersion modes confused in descriptions.

The following statements are likely to be present.

<u>Names</u>

X *is Core*

Y *is Cladding*

<u>Functions</u>

X*:*

Propagates/Guides the wave/light

By TIR

(with) low attenuation/absorption

Refractive index of core > cladding

Y*:*

Protects core from damage

Prevents cross talk between touching fibres

Provides 'clean' boundary for TIR

<u>Dispersion problems</u>

Both*: Cause pulse broadening/limited bandwidth*

Material*: different wavelengths have different speeds due to different refractive indices within the core – use monochromatic beam*

Modal*: different paths have different lengths so effective time along fibre differs – use single-mode fibre (narrow core/small Δn between core and cladding)*

6

(e) Max 2 from: ✓ ✓

Allow responses shown on diagram.

Light may encounter impurities at different positions/angles

Light may encounter different number of impurities

Allow "different impurities".

Light may encounter different sizes of impurities

Angle of incidence may become less than critical angle

Don't accept "critical angle changes"

Bending may cause cracks in the core/cladding

Light may be refracted (more/differently)

2

(f) Transverse – displacement/oscillations/vibrations at right angles/(perpendicular) to direction of energy transfer ✓

Condone "direction of wave" once.

1 mark for correct reference to difference in polarisation.

Longitudinal – displacement/oscillations/vibrations along/(parallel to) direction of energy transfer ✓

Treat references to P and S wave as neutral.

2

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3. (a) 1.5 (ms) ✓

1

(b) A = 4.2 (mm) read from graph ✓

T = 2.0 (ms) read from graph ✓

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

$4.1(5) \times 10^4$ (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]

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
= √(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
= √(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

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5. (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]