Access Tuition

A-Level Physics

Interference

Mark Scheme

Time available: 73 minutes
Marks available: 58 marks

Mark schemes

1. (a) Understanding that for coherence sources must have same frequency/wavelength AND constant phase difference. ✓

And that this achieved by both speakers being connected to same signal (generator). ✓

2

(b) The sound waves from the two speakers superpose (at a point) ✓

*Do **not** accept 'interfere' or 'superimpose' for 'superpose'*

Accept for MP1 waves adding together/combine at a point (e.g. point A) for 'superpose'.

Do not accept diagram.

At A (and B) the two waves are in phase/ have zero phase difference (and a maximum is produced) ✓

Moving away from A introduces a path difference/phase difference/waves are out of phase (and amplitude decreases) ✓

(Moving on towards B the waves move back in phase)

Award MP3 for formation of minimum/destructive interference due to (odd number of) half wavelength path difference/π/ 180^o phase difference/ antiphase.

3

(c) Clear evidence of use of Pythagoras ✓

Correct calculation of either length PB or QB ✓

PB = $(2.25^2 + (0.95 – 0.3/2)^2)^{½}$ = 2.39 m

QB = $(2.25^2 + (0.95 + 0.3/2)^2)^{½}$ = 2.50 m

(Path difference =) QB – PB either numerically or algebraically ✓

(= 0.11 (0.12) m)

If ws/D used to give 0.13 (m) reward with 1 mark

3

(d) (Path difference = one wavelength)

Use of speed = frequency × wavelength to give

Speed = 2960 × 0.12 = 360 m s^{-1} ✓

Working or equation must be seen.

Condone use of 0.10 m or 0.11 m or 0.127m or 0.13 m

0.10 gives 300 (296) m s^{-1}

0.11 gives 330 (325.6) m s^{-1}

0.127 gives 376 m s^{-1}

0.13 gives 380 (385) m s^{-1}

1

(e) Wavelength (gradually) increases. ✓

So that path difference at C gets closer to one wavelength ✓

Alternative for MP2:

Separation of maxima (along line AB) increases ✓

(Amplitude of) sound will get larger/louder as waves move in phase (then smaller/quieter). ✓

Alternatives for MP3:

Maximum moves (from B) towards C so amplitude of sound gets larger/louder (then quieter).

OR

Maximum moves further along path/beyond C so amplitude of sound gets quieter ✓

3

[12]

2. (a) TWO FROM:

central white fringe ✓

(fringes either side) showing range of colours/spectrum ✓

with red furthest and blue/violet closest to centre ✓

Allow rainbow for spectrum

Reject different colour fringes

If colours mentioned for last mark must be in right order i.e. red last

1

1

(MAX 2)

(b) FOUR FROM:

central fringe is a mixture of red and green light/two wavelengths ✓

EITHER (1 marks)

(separate) red and green fringes are seen (on either side) ✓

OR (for 2 marks)

spacing of green fringes is less than spacing of red fringe / green fringes closer to middle than red ✓ ✓

OR (for 3 marks)

spacing of red fringes is 20% (or 1.2 times)greater than green fringes ✓ ✓ ✓

6^{th} green fringe overlaps with 5^{th} red fringe ✓

Allow orange/yellow for central fringe

If w used must be identified as fringe spacing for third alternative

1
1
1
1
(MAX 4)

(c) **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	QoWC
6	Explains how (%) uncertainties combine to determine uncertainty in wavelength OR identify % uncertainty *s* as being the largest	The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible.
5	Explain how wavelength is determined using $\lambda = \frac{ws}{D}$	
4	Explains how second change affects fringe spacing AND Comments on how change in fringe spacing affects (%)uncertainty / change in *s* OR *D* affects (%)uncertainty	The student presents relevant information and in a way which assists communication of meaning. The text is legible. Sp&g are sufficiently accurate not to obscure meaning.
3	Explains how second change affects fringe spacing OR Comments on how change in fringe spacing affects (%)uncertainty / change in *s* OR *D* affects (%)uncertainty	
2	States how one of the changes affects fringe separation (decrease *s* increases fringe separation / decrease *D* decrease fringe separation	The student presents some relevant information in a simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.
1	States that one of the changes alters fringe separation	
0	No correct change identified	The student's presentation, spelling and grammar seriously obstruct understanding.

The following statements may be present for decreasing slit separation s:

Fringe separation increases
Uncertainty in measuring fringe separation will decrease
and as this is needed to measure wavelength, uncertainty in wavelength measurement will decrease

The following statements may be present for smaller D:

Uncertainty in measuring D would increase
Fringe separation would also decrease
so uncertainty in measuring fringe separation would increase
Both are required to find wavelength so uncertainty in finding wavelength would increase

FOR Middle Band ***one*** *of these considered:*

Decrease s
Larger fringe separation so smaller (%) uncertainty (in w)
Smaller s so higher (%) uncertainty in s
Decrease D
Smaller fringe separation so larger (%) uncertainty (in w)
Smaller D so higher (%) uncertainty in D

If explain reverse change correctly (s increase D increase) no penalty

6

[12]

3. (a) Clear indication of correct process

two correct values for λv from working plus conclusion

(7.35; 7.25; 7.35) ✓

three correct values plus conclusion ✓

Condone no or misuse of powers of 10

Allow use of value of h as the constant to show that v values in table are consistent with the λ values

1

....

ratio approach $v_1/v_2 = \lambda_2/\lambda_1$ shown for 2 sets of data ✓

shown for two other sets of data + conclusion ✓

May predict one of the values assuming inverse proportionality and compare with table value

(once for 1 mark; twice for 2 marks)

1

(b) $h = \lambda mv$ or substitution of correct data in any form ✓

May determine average value using mean constant from 2.1 or average 3 calculations in this part

1

$6.7(0) \times 10^{-34}$ from first and third data set; $6.6(0) \times 10^{-34}$ from second ✓

1

(c) Particle behaviour would only produce a patch/circle of light /small spot of light or Particles would scatter randomly ✓

Wave property shown by diffraction/ interference ✓

Graphite causes (electron)waves/beam to spread out /electrons to travel in particular directions ✓

Bright rings/maximum intensity occurs where waves

interfere constructively/ are in phase ✓

for a diffraction grating maxima when sinθ = $n\lambda/d$ ✓

Marks are essentially for

1. Explaining appearance of screen if particle

2. Identifying explicitly a wave property

3. Explaining what happens when diffraction occurs

4. Explaining cause of bright rings

5. Similar to diffraction grating formula (although not same)

NB Not expected: For graphite target maxima occur when sinθ =$\lambda/2d$ (d =spacing of atomic layers in crystal)

1
1
1

(d) Electrons must provide enough (kinetic) energy

'instantly' to cause the excitation

OR

the atom or energy transfer in 1 to 1 interaction

OR

electron can provide the energy in discrete amounts

OR

energy cannot be provided over time as it would be in a wave

Description of Photoelectric effect = 0

Not allowed: any idea that wave cannot pass on energy, e.g. waves pass through the screen

1

Any 2 from

Idea of light emission due to excitation and de-excitation of electrons/atoms ✓

Idea of collisions by incident electrons moving electrons in atoms between energy levels/shells/orbits ✓

Light/photon emitted when atoms de-excite or electrons move to lower energy levels ✓

1
1

[10]

4. (a) path difference for two waves ✓

Allow 'waves travel different distances'

Condone out of phase

gives rise to a phase difference ✓

if phase and path confused only give 1 for first 2 marks

Destructive interference occurs ✓

allow explanation of interference

3

(b) (Path difference =) 0.056 m ✓

Path difference = 2λ or wavelength = 0.028 m ✓e

Use of $f = c/\lambda$ so f = 11(10.7) × 10^9 Hz ✓

Allow 2 max for 5.4 × 10^9 Hz or 2.7 × 10^9 Hz

Allow ecf

3

(c) Intensity decreases with distance ✓

One wave travels further than the other ✓

Amplitudes/intensities of the waves at the minimum points are not equal ✓

Or "do not cancel out"

max 2

(d) The signal decreases/becomes zero ✓

The waves transmitted are polarised ✓

zero when detector at 90° to the transmitting aerial/direction of polarisation of wave ✓

max 3

[11]

5. (a) uniform width peaks ✓ (accurate to within ± one division)

peaks need to be rounded ie not triangular

the minima do not need to be exactly zero

a collection of peaks of constant amplitude or amplitude decreasing away from central peak ✓

pattern must look symmetrical by eye

condone errors towards the edge of the pattern

double width centre peak total mark = 0

2

(b) (i) constant / fixed / same phase relationship / difference (and same frequency / wavelength) ✓

in phase is not enough for the mark

1

(ii) single slit acts as a point / single source diffracting / spreading light to both slits ✓

OR

the path lengths between the single slit and the double slits are constant / the same / fixed ✓

1

(iii) superposition of waves from two slits ✓

phrase 'constructive superposition' = 2 marks

diffraction (patterns) from both slits overlap (and interfere constructively) ✓ (this mark may come from a diagram)

constructive interference / reinforcement (at bright fringe)

peaks meet peaks / troughs meet troughs ✓ (any reference to antinode will lose this mark)

waves from each slit meet in phase

OR path difference = $n\lambda$ ✓

4 max 3

(c) (i) $D = \frac{ws}{\lambda} = \frac{0.004 \times 5.0\,10^{-5}}{405 \times 10^{-9}}$ ✓ **do not penalise any incorrect powers of ten for this mark**

= 0.5 (m) ✓ (0.4938 m)

numbers can be substituted into the equation using any form

note 0.50 m is wrong because of a rounding error

full marks available for answer only

2

(ii) fringes further apart or fringe / pattern has a greater width / is wider ✓

ignore any incorrect reasoning

changes to green is not enough for mark

1

(iii) increase *D* ✓

measure across more than 2 maxima ✓

several / few implies more than two

added detail which includes ✓

explaining that when *D* is increased then *w* increases

Or

repeat the reading with a changed distance *D* or using different numbers of fringes or measuring across different pairs of (adjacent) fringes

Or

explaining how either of the first two points improves / reduces the percentage error.

no mark for darkened room

3

[13]