MARK SCHEME

PHYSICS

AS-Level

PROPERTIES OF WAVES

TEST 1

Mark schemes

1 (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 ✓ ✓ ✓

6th green fringe overlaps with 5th 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]

2 **D** **[1]**

3 **C** **[1]**

4 **C** **[1]**

5 **D** **[1]**

6 **D** **[1]**

7 **D** **[1]**

8 (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]

9 **C**

[1]

10 **C**

[1]

11 **B**

[1]

12 **D**

[1]

13 **C**

[1]

14 **A**

[1]

15 D

[1]

Examiner reports

1 This question required students to be familiar with the interference pattern produced by a double slit arrangement. They were also required to explain factors that affect the pattern observed.

(a) A significant proportion of students appreciated that the fringes would exhibit a range of colours. It was, however, less common for them to identify the central fringe as being white. Some students did try to explain the reason for the formation of the fringes when only a description of the pattern seen was required.

(b) This question produced good discrimination. Weaker students were able to identify the fact that red and green fringes would be seen, but then frequently thought that the spacing of green fringes would be greater. Only the best students were then able to explain that the red spacing would be 20% greater than the green spacing. It was also quite rare to see responses that explained that the central fringe would be a mixture of red and green.

(c) This was a 'levels of response' question and a high proportion of students did at least get into the middle band because they were able to correctly explain the effect of each change on fringe spacing and give some discussion of the effect these changes have on uncertainties. A disappointing number of students (only 3.5%) reached the top band – this was usually because they did not explain how the change in fringe spacing affected the determination of the wavelength of the light and whether the change reduced the overall uncertainty.

2 38.1% of students were able to obtain the correct answer. Both A and C were common wrong answers.

3 Most students selected A as their answer, this being *d* rather than the number of lines per mm as requested. Only 25.5% of students were able to select the correct answer.

4 78.0% correct

5 74.9% correct

6 89.2% correct

7 48.8% correct

8 This question placed the idea of double slit interference in the less familiar context of microwave transmission. Students who failed to make the link with interference found it difficult to make much headway in this question. There was evidence of students ignoring the context and writing in terms of sound or visible light.

(a) It was common to see answers referring to a simple line of sight issue related to the three metal plates, despite references to double slit interference in the stem. This may suggest that students fail to read the stem of a question with sufficient care, a problem that may be alleviated if students were in the habit of underlining key words as they read. Students who understood the context often lost marks by confusing path difference and phase difference. Being familiar with the difference, and relationship, between these two is fundamental to an understanding of interference in waves.

(b) This is a fairly demanding multi-step problem that many found difficult. In order to answer this question, students were required to relate the data in the diagram to the path difference of the waves, specifically 2 x the wavelength. They also had to apply the wave equation to the answer they obtained. Those who managed to make some attempt at an answer commonly missed the double wavelength, or made an arithmetical error in the use of speed = frequency x wavelength.

(c) Many students suggested that total destructive interference cannot occur, without relating it to the different amplitudes of the waves due to their different path lengths. This is probably due to the fact that students commonly picture waves of equal amplitude interfering, irrespective of path length. Incorrect answers included suggestions that other sources of microwaves, including the CMBR, were to blame.

(d) Most students were able to make an attempt to link the phenomenon described in this question to the polarisation of the waves. Some students interpreted the line AE as another sequence of slits and suggested that the microwaves were being blocked. Many had difficulties expressing their answer in terms of the orientation of the microwave and aerial, with some stating that the signal would increase as the aerial was aligned with the maxima.

9 Approximately 35% of students selected distractor A as their answer. Students need to be able to recall that wavelength decreases as velocity decreases as light enters a more optically dense medium.

10 This question was set up to test the students' ability to spot that 35° was not the angle of incidence. This indeed proved to catch a lot of students out, with almost 60% of students selecting distractor A. Errors of this type can be minimised by completing the ray diagram and marking the angle to be determined. Doing this gives the students a chance to take stock of the information, making it less likely to misinterpret the data.

11 The majority of students selected the correct answer. Of those who got it wrong, most of them chose distractor C (20% of all responses); these students could not determine how increasing the distance between the slits and the screen affected the spacing of the maxima. A quick sketch of the grating and typical pattern of the maxima would certainly have aided students in making this connection.

12 Less than 20% of students selected the correct answer. Nearly 40% of students selected distractor C and in doing so failed to notice that the angle required was double 23.6°. Students need to pay close attention to the wording in questions as this type of extra detail is typical of multiple choice questions.