MARK SCHEME

PHYSICS

AS-Level

PROPERTIES OF WAVES
TEST 3

Mark schemes

1 D **[1]**

2 B **[1]**

3 C **[1]**

4 D **[1]**

5 D **[1]**

6 B **[1]**

7 C **[1]**

8 C **[1]**

9 B **[1]**

10 A **[1]**

11 D **[1]**

12 C **[1]**

13 (a) same wavelength / frequency ✓

constant phase relationship ✓ allow 'constant phase difference' but not 'in phase'

2

(b) (i) ($\lambda = \frac{c}{f}$)

Use of speed of sound gets zero

$3.00 \times 10^8 = 9.4\ (10^9)\ \lambda$ OR $\frac{3.00\times10^8}{9.4\times(10^9)}$ ✓

$= 3.2 \times 10^{-2}$ (3.19×10^{-2} m) ✓

Allow 0.03

2

(ii) 3.2×10^{-2} ✓ (m) ecf from bi

Don't allow '1 wavelength', 1λ, etc
Do not accept: zero, 2π, 360 °

1

(c) maximum (at position shown) ✓

allow constructive superposition.
'Addition' is not enough

constructive interference / reinforcement ✓

ecf for 'minimum' or for reference to wrong maximum

(the waves meet) 'in step' / peak meets peak / trough meets trough / path difference is (n) λ / in phase ✓

3

(d) $s = \frac{\lambda D}{w}$

Don't allow use of the diagram shown as a scale diagram

$= \frac{0.0319\times0.42}{0.11}$ ✓ ecf bi

Do not penalise s and w symbols wrong way round in working if answer is correct.

= 0.12 (0.1218 m) ✓

Correct answer gains first two marks.

= **any <u>2sf</u>** number ✓

*Independent sf mark for **any** 2 sf number*

3

(e) a maximum ✓

Candidates stating ' minimum ' can get second mark only

(f × 2 results in) $\lambda/2$ ✓

path difference is an even number of multiples of the new wavelength ($2n\lambda_{new}$) ✓

allow 'path difference is $n\lambda$' / any even number of multiples of the new λ quoted e.g. 'path difference is now 2 λ'

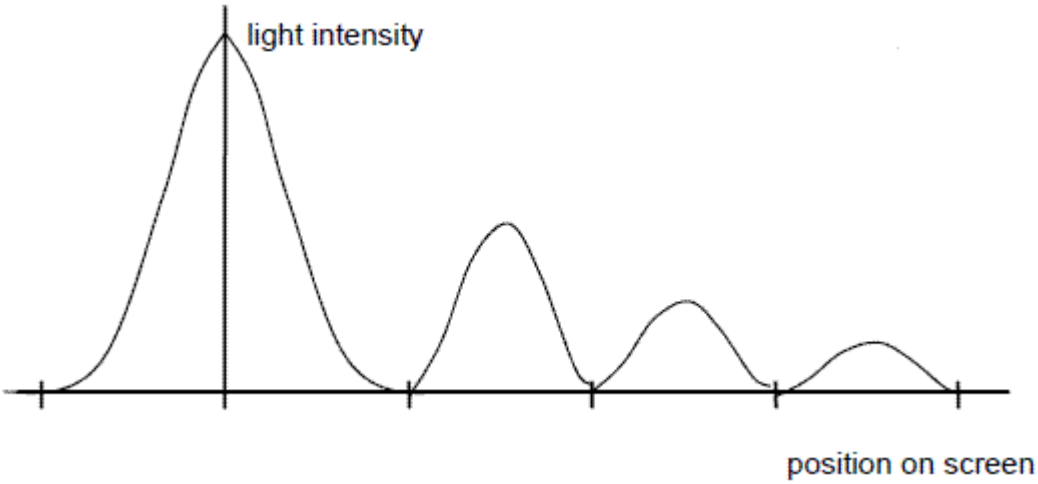
3

[14]

14

(a) 3 subsidiary maxima in correct positions **(1)**

intensity decreasing **(1)**



2

(b) a single wavelength **(1)**

constant phase relationship/difference **(1)**

2

(c) maxima further apart/central maximum wider/subsidiary maximum wider/maxima are wider **(1)**

1

(d) wider/increased separation **(1)**

lower intensity **(1)**

2

(e) distinct fringes shown with subsidiary maxima **(1)**

indication that colours are present within each subsidiary maxima **(1)**

blue/violet on the inner edge **or** red outer for at least one subsidiary maximum **(1)**

(middle of) central maximum white **(1)**

3

[10]

15 (a) showed that light was a **wave** (rather than a particle)/**wave** nature (of light) **(1)**

1

(b) (i) single wavelength (or frequency) **(1)**

1

(ii) (waves/source(s) have) constant phase difference **(1)**

1

(iii) any sensible precaution, eg do not look into laser/do not point the laser at others/do not let (regular) reflections enter the eye/safety signs/suitable safety goggles **(1)**

1

(c) (0.16/8) = 0.02(0) **(1)**

$= \frac{0.020 \times 0.30 (\times 10^{-3})}{10.0}$ **(1)** ecf from calculation of fringe spacing

$= 6.0 \times 10^{-7}$ m **(1)** (= 600 nm) ecf from calculation of fringe spacing

3

(d) maxima closer together **(1)**

(quotes equation and states that) spacing is proportional to wavelength/ *D* and *s* are constant therefore as λ decreases so ω decreases **(1)**

or links smaller wavelength to smaller path difference **(1)**

2

[9]

Examiner reports

11 57% of students correctly identified D as the appropriate answer. The other students were split almost evenly between the distractors, with A being slightly more popular.

12 It was pleasing to note that 74% of students were sufficiently familiar with white light single slit diffraction to give the correct answer here. Approximately 10% of students gave the answer D, suggesting that they were unaware that any effect would occur.

13 (a) The explanation of coherent should include 'constant phase relationship' and 'same frequency'. Many only picked up one mark for stating one of these. Many said that the waves were 'in phase' which was not enough for the mark.

(b) (i) Some did not realise that the speed of light was given on the data sheet. There were many mistakes with the powers of ten; 'M' was often interpreted as 10^{6}, 10^{12} or even 10^{15}.

(ii) Many did not attempt this. Some may have run out of time but many did not understand the concept of path difference.

(c) Some felt that although the waves arrived in phase, the point where they meet is 'zero displacement' for both of them and therefore gives a zero reading.

Nodes and antinodes were often referred to as the peaks / troughs and points of zero displacement on a progressive wave, e.g. two troughs meet to give destructive interference. Nodes and antinodes were often mixed up – 'anti' wrongly associated with 'minimum' perhaps?

(d) Quite a few did not express their answer to 2sf, believing that 3sf was appropriate or that 2 d.p. was required.

To help students remember to address the significant figure issue, one could advise them to draw a line between the instruction: '...appropriate number of significant figures' and the answer line as soon as they read it in the question.

If the student is uncertain about which symbol represents slit separation and which represents fringe spacing, they may still get the right answer and this was not penalised. However, it is essential that *s* and *D* are not interchanged and this mistake led to many candidates failing to access 2 of the marks.

14 Most candidates gained at least one mark in part (a) for showing that the intensity of peaks reduced with distance from the centre. However, many did not recall the key difference between the pattern for single and double slits – the single slit pattern has a central maximum which is double the width of the subsidiary maxima.

There were many correct definitions of monochromatic and coherent in part (b). A few stated 'same colour' for monochromatic and 'in phase' for coherent. Neither of these were accepted.

In part (c), many candidates incorrectly used the equation for two slits to show that the maxima were further apart. This was not penalised since an explanation was not asked for.

Many candidates got part (d) the wrong way around, saying that the fringes would be more closely spaced and more intense. There seemed to be some guess work evident here. Candidates need to be able to describe the appearance of the single slit pattern and be aware of how it will change for different wavelengths, slit widths and for monochromatic and white light. Some teachers introduce the equation for the single slit although it is not in the specification. This is not necessary but can certainly help the more mathematically minded students. To illustrate the change in the pattern, a simple demonstration can be carried out with a red and a green laser shone through the same slit onto a screen.

A pleasing number of candidates produced very detailed and high quality answers to part (e), with many gaining all three marks. Some drew a graph of intensity, which did not gain a mark on its own.

15

Part (b) (i) was the definition of monochromatic. Most had no problem with this but a significant number simply said ‘one colour’ and this was not enough.

In part (b) (ii) ‘constant phase relationship’ or ‘difference’ was expected but many candidates said ‘in phase’ which was not given credit.

80% picked up the mark for a sensible suggestion in part (b) (iii) such as ‘never point the laser at someone’. The other 20% suggested ‘goggles’, ‘safety goggles’, ‘tinted goggles’ which was not enough. A few candidates said ‘specialised goggles’ or ‘goggles designed for use with lasers’ which was given credit.

Part (c) was a calculation using the two slit formula. 35% scored full marks. Common errors included converting 0.30 mm to 3×10^{-3} m, using 0.16 as w, or using $w = 0.16/9$ rather than 0.16/8 due to counting dots rather than gaps and incorrectly rearranging the formula.

In part (d), the majority of candidates scored the first mark but were unable to explain why in a convincing manner.