

M1.A

[1]

M2.C

[1]

M3.(a) Suitable experiment eg diffraction through a door / out of a pipe ✓

1

(b) Using $c = d / t$

$$t = 2500 / 480 = 5.2 \text{ s } \checkmark$$

1

(c) (Measured time is difference between time taken by light and time taken by sound)

Calculation assumes that light takes no time to reach observer, ie speed is infinite ✓

Do not allow "could not know speed of light"

1

(d) Sound from gun is a mixture of frequencies. ✓

Alternative for 1st mark 'so speed is independent of frequency) the sound of the gun is similar when close and far away'

1

All the sound reaches observer at the same time, ✓

1

(e) More accurate, as it is closer to the accepted value. ✓

1

(f) When $\theta = 0^\circ\text{C}$ $c = 331.29 \text{ m s}^{-1}$

1

Therefore

$$331.29 = k \sqrt{273.15} \checkmark$$

$$k = 20.045 \checkmark$$

1

(g) The method and value are published \checkmark

1

other scientists repeat the experiment using the same method \checkmark

1

[10]

M4.D

[1]

M5.(a) one of:

(spectral) analysis of light from stars

(analyse) composition of stars

chemical analysis

measuring red shift \ rotation of stars \checkmark

insufficient answers:

'observe spectra', 'spectroscopy', 'view absorption \ emission spectrum',

'compare spectra', 'look at light from stars'.

Allow : measuring wavelength or frequency from a named source of light

Allow any other legitimate application that specifies the source of light. E.g.

absorption \ emission spectra in stars,

'observe spectra of materials'

1

(b) (i) first order beam

first order spectrum

first order image

✓

Allow 'n = 1', '1', 'one', 1st

1

- (ii) the light at A will appear white (and at B there will be a spectrum)
OR greater intensity at A ✓

1

- (c) ($d = 1 / (\text{lines per mm} \times 10^3)$)
 $= 6.757 \times 10^{-7}$ (m) OR 6.757×10^{-4} (mm) ✓

($n\lambda = d \sin \theta$)

$= 6.757 \times 10^{-7} \times \sin 51.0$ ✓ ecf **only** for :

- incorrect power of ten in otherwise correct calculation of d
- use of $d = 1480, 1.48, 14.8$ (etc)
- from incorrect order in bii

$= 5.25 \times 10^{-7}$ (m) ✓ ecf **only** for :

- incorrect power of ten in otherwise correct d
- from incorrect order in bii

Some working required for full marks. Correct answer only gets 2

Power of 10 error in d gets max 2

For use of d in mm, answer =

5.25×10^{-4} gets max 2

n = 2 gets max 2 unless ecf from bii

use of d = 1480 yields wavelength of 1150m

3

- (d) $n = d (\sin 90) / \lambda$ OR $n = 6.757 \times 10^{-7} / 5.25 \times 10^{-7}$ ✓ ecf both numbers from c

$= 1.29$ so no more beams observed ✓ or answer consistent with their working

OR

$2 = d (\sin \theta) / \lambda$ OR $\sin \theta = 2 \times 5.25 \times 10^{-7} / 6.757 \times 10^{-7}$ ✓ ecf both numbers from c

$\sin \theta = 1.55$ (so not possible to calculate angle) so no more beams ✓

OR $\sin^{-1}(2 \times (\text{their } \lambda / \text{their } d))$ ✓

(not possible to calculate) so no more beams ✓ ecf

Accept 1.28, 1.3

Second line gets both marks
Conclusion consistent with working

2

[8]

M6.(a) single frequency (or wavelength or photon energy) ✓

not single colour

accept 'very narrow band of frequencies'

1

(b) subsidiary maxima (centre of) peaks further away from centre ✓

For second mark: One square tolerance horizontally. One whole subsid max seen on either side.

subsidiary maxima peaks further away from centre **AND** central maximum twice width of subsidiaries **AND** symmetrical ✓

Central higher than subsid and subsid same height + / - 2 squares. Minima on the x axis + / - 1 square.

Must see 1 whole subsidiary for second mark

2

(c) ONE FROM:

- don't shine towards a person
- avoid (accidental) reflections
- wear laser safety goggles
- 'laser on' warning light outside room
- Stand behind laser
- other sensible suggestion ✓

allow green goggles for red laser, 'high intensity goggles', etc.

not 'goggles', 'sunglasses'

eye / skin damage could occur ✓

2

(d) 3 from 4 ✓✓✓

- central white (fringe)
- each / every / all subsidiary maxima are composed of a spectrum (clearly stated or implied)
- each / every / all subsidiary maxima are composed of a spectrum (clearly stated or implied) **AND** (subsidiary maxima) have violet (allow blue) nearest

central maximum **OR** red furthest from centre

- Fringe spacing less / maxima are wider / dark fringes are smaller (or not present)

allow 'white in middle'

For second mark do not allow 'there are colours' or 'there is a spectrum' on their own

Allow 'rainbow pattern' instead of spectrum but not 'a rainbow'

Allow 'rainbow pattern' instead of spectrum but not 'a rainbow'

If they get the first, the second and third are easier to award

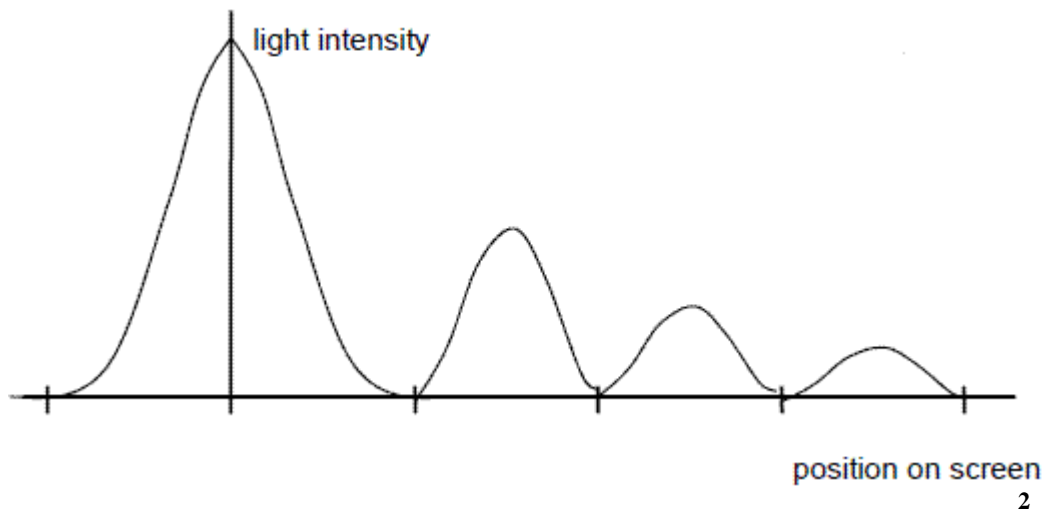
Allow full credit for annotated sketch

3

[8]

M7. (a) 3 subsidiary maxima in correct positions (1)

intensity decreasing (1)



(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]

M8. (a) λ correct **(1)**

d correct **(1)** arrow or line needed, both ends extending beyond central black line

2

(b) angle θ gets smaller **(1)**

because path difference gets smaller/**d constant**, (λ smaller) so $\sin \theta$ smaller **(1)**

max 1 for correct explanation for λ increasing

2

(c) boxes 1,5,6 **(1)(1)**

two correct 1 mark

4 ticks max 1

5 or 6 ticks gets 0

2

(d) (i) 3.3×10^{-6} m **(1)** ($1/300 = 3.33 \times 10^{-3}$ mm, 3300 nm) DNA 1 sf here
 DNA 1/300 000 as answer

accept $3 \frac{1}{3} \times 10^{-6}$, 3.33×10^{-6} recurring, etc

1

$$(ii) \quad (\sin \theta =) \frac{540 \text{ to } 560 \times (10^{-9})}{((d)(i))} \quad (1)$$

correct wavelength used and seen (**545 to 548 × 10⁻⁹**)

and 9.4 to 9.6 (°) (1) ecf (d) (i), for correct wavelength only
(545 to 548 × 10⁻⁹)

2

[9]

M9. $\sin \theta = n\lambda/d$ in this form/correct calculations of $d/d = 1/300$

C1

substitutes correctly – condone powers of 10

C1

18.9

C1

2 or 3 sf only

A1

[4]