M1.(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 <u>both slits</u> ✓

OR

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

1

(iii) <u>superposition</u> 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]

M2.(a) 2.9% ✓

Allow 3%

1

(b) $\frac{1}{3.5\times10^{3}}$ seen ✓

1

0.29 mm or 2.9 x 10^{-4} m✓ must see 2 sf **only**

1

(c) ± 0.01 mm ✓

1

(d) Clear indication that at least 10 spaces have been measured to give a spacing = 5.24 mm✓

spacing from at least 10 spaces
Allow answer within range ±0.05

1

(e) Substitution in $d\,sin\theta = n\lambda$✓

The 25 spaces could appear here as n with sin θ as 0.135 / 2.5

1

d = 0.300 x 10^{-3} m so
number of lines = 3.34 x10^{3}✓

Condone error in powers of 10 in substitution
Allow ecf from 1-4 value of spacing

1

(f) Calculates % difference (4.6%) ✓

1

and makes judgement concerning agreement ✓

Allow ecf from 1-5 value

1

(g) care not to look directly into the laser beam✓
OR
care to avoid possibility of reflected laser beam ✓
OR
warning signs that laser is in use outside the laboratory✓
ANY ONE

1

[10]

M3.C

[1]

M4.(a) Suitable experiment eg diffraction through a door / out of a pipe ✓

1

(b) Using $c = d / t$

t = 2 500 / 480 = 5.2 s ✓

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 $\theta = 0\ ^\circ C$ $c = 331.29\ m\ s^{-1}$

1

Therefore

$331.29 = k\sqrt{273.15}$ ✓

$k = 20.045$ ✓

1

(g) The method and value are published ✓

1

other scientists repeat the experiment using the same method ✓

1

[10]

M5. D

[1]

M6. A

[1]

M7. (a) one of:
(spectral) analysis of light from stars
(analyse) composition of stars
chemical analysis
measuring red shift \ rotation of stars ✓

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.
absorbtion \ 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 / (lines per mm × 10^3)
= 6.757 × 10^{-7} (m) OR 6.757 × 10^{-4} (mm) ✓

(nλ = d sin θ)
= 6.757 × 10^{-7} × 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 × 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 (sin90) / λ OR n = 6.757 × 10^{-7} / 5.25 × 10^{-7} ✓ ecf both numbers from c

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

OR

2 = d (sinθ) / λ OR sinθ = 2 × 5.25 × 10^{-7} / 6.757 × 10^{-7} ✓ ecf both numbers from c

sinθ = 1.55 (so not possible to calculate angle) so no more beams ✓

OR $\sin^{-1}$(2 × (their λ / 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]