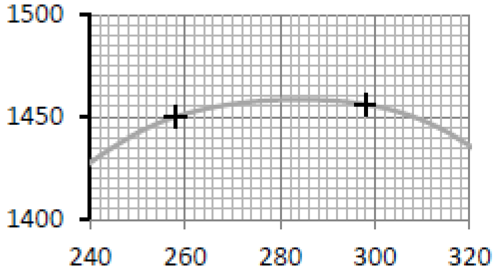
M1.(a) 2 missing points plotted, each to nearest 1 mm (half a grid square); points marked + or × or ⊙; reject thick points, blobs or uncircled dots ✓



(1)

(b) continuous smooth best fit line through all 7 points to 1 mm ✓

allow mis-plotted points to be treated as anomalies; multiple lines or points of inflexion lose the mark

(1)

(c) candidate's value from Figure 2 ± ½ grid square ✓

if multiple lines are drawn condone value if ± ½ grid square of all lines

(1)

(d) finding θ_N from Figure 3 is easy since the result is read off where *G* = 0 ₁✓

or

finding θ_N from Figure 2 is difficult since θ has a range of values for which ε is a maximum ₂✓

accept evidence that $G = 0$ used shown on Figure 3; physics error about how Figure 3 used means no credit for any further valid comment about Figure 2

accept 'curve is shallow at peak' for ₂✓

(Max 1)

(e) method:

correctly determines gradient of Figure 3 or uses gradient result with any point on line to determine (vertical) intercept ₁✓

result in range 9.8 to 10.9 ₂✓

gradient values in the range −0.040 to −0.034 for ₁✓(minus sign essential)

for ₁✓allow the substitution of at least one pair of correct values of G and θ into $G = \beta\theta + \alpha$ to obtain α using simultaneous equations

condone 2sf '10' for ₂✓

(2)

(f) full scale pd = 100 × 1000 = 100000 or 10^5 μV ✓

allow 100 mV or 0.1 V if μV deleted from answer line ✓

(1)

(g) idea that resolution of the meter is not satisfactory ₁✓
because the largest pd that will be measured is less than 1500 μV
OR
only uses 1.5% of the range
OR
pd across meter at full-scale deflection ÷ divisions = $\frac{10^5}{50}$ = 2000 μV per division ₂✓

condone use of 'sensitivity' or 'precision' for 'resolution'; ignore 'meter is not accurate'

allow 'hard to tell different readings apart'

for ₂✓ allow ce for incorrect 02.6

allow 'unable to measure to nearest micro volt'

allow 'resolution of scale should be 1 μV'

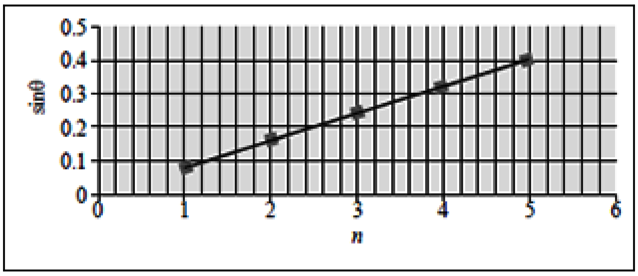
(2)
[Total 9]

M2. (a)

	x / m	sin θ
1	0.173	0.086
2	0.316	0.156
3	0.499	0.242
4	0.687	0.325
5	0.860	0.395

(1)

If angles only calculated 1 / 2



at least 4 points plotted correctly **(1)**
best straight line **(1)**
gradient calculated from suitable triangle, 50% of each axis **(1)**
correct value from readings **(1)**
appropriate use of d sin $\theta = n\lambda$ **(1)**
hence N (rulings per metre) = 1.25 × 10^5 m^{-1} (1.1 to 1.4 ok) **(1)**

max 2 / 6 if no graph and more than one data set used correctly, 1 / 6 only one set
if tan calculated but plotted as sin, mark as scheme
tan or distance plotted, 0 / 6

Max 6

(b) (i) maxima wider spaced [or pattern brighter] **(1)**
sin θ or θ increases with N [or light more concentrated] **(1)**

(ii) maxima spacing less **(1)**
sin θ or θ decreases with λ [or statement] **(1)**

(iii) maxima wider spaced [or pattern less bright] **(1)**
same θ but larger D [or light more spread out] **(1)**

6

(c) (i) waves in phase from **(1)**
any sensible ref to coherence **(1)**
whole number of wavelengths path difference **(1)**

(ii) use of geometry to show that sin $\theta = \frac{\lambda}{d}$

Max 3
[15]

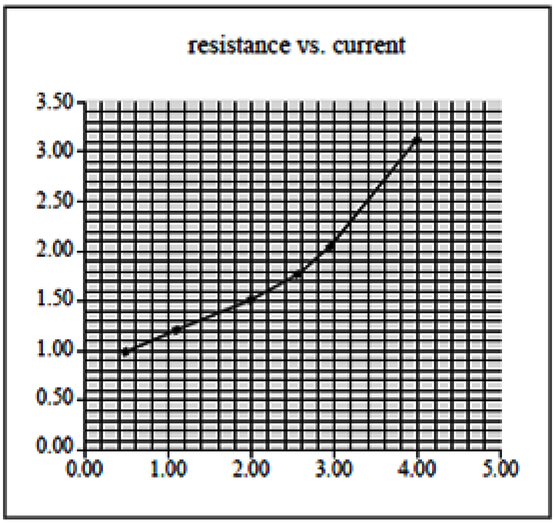
M3.(a)

resistance/Ω	0.98	1.20	1.50	1.76	2.03	3.00

(1) (1)
[deduct one mark for each incorrect value]

2

(b) (i) sensible scales chosen **(1)**
points plotted correctly [deduct one mark for each mistake] **(1) (1)**
line of best fit **(1)**



(ii) 0.90 Ω **(1)**

(iii) 0.22 Ω **(1)**
0.38 Ω **(1)**

(iv) 1.12 W **(1)**
6.0 W **(1)**

Max 8

(c) resistance increases with increasing temperature **(1)**
increase in heat dissipation for 1.0 A to 2.0 A is greater than for 0 to 1.0 A **(1)**
and so a greater corresponding rise in temperature **(1)**

Max 2
[12]

M4. (a) (i) electrical energy produced (in the battery) per unit charge **(1)**
[or potential/voltage across terminals when there is no current]

(ii) there is a current (through the battery) **(1)**
voltage 'lost' across the internal resistance **(1)**

Max 2

(b) (i) $\varepsilon^0 = V + Ir$ **(1)**

(ii) labelled scales **(1)**
correct plotting **(1)**
best straight line **(1)**
ε: intercept on *y* axis **(1)** = 9.2 (± 0.1) V **(1)**

r : (−) gradient = $\frac{9.2}{0.65}$ = 14.2 Ω **(1)** (range 14.0 to 14.3)

8
[10]

M5.(a) (i) diagram to show:
(long) wire fixed at one end **(1)**
mass / weight at other end **(1)**
measuring scale **(1)**
mark on wire, or means to measure extension **(1)**

Max 3

[alternative for two vertical wires:
two wires fixed to rigid support **(1)**
mass / weight at end of one wire **(1)**
other wire kept taut **(1)**
spirit level and micrometer or sliding vernier scale **(1)**]

(ii) measurements:
length of the wire between clamp and mark **(1)**
diameter of the wire **(1)**
extension of the wire **(1)**
for a known mass **(1)**

Max 3

(iii) length measured by metre rule **(1)**
diameter measured by micrometer **(1)**
at several positions and mean taken **(1)**
(known) mass added and extension measured by noting movement of fixed mark against vernier scale (or any suitable alternative) **(1)**
repeat readings for increasing (or decreasing) load **(1)**

Max 5

(iv) graph of mass added / force against extension **(1)**

gradient gives $\frac{F}{e}$ or $\frac{m}{e}$ **(1)**

correct use of data in $E = \frac{Fl}{eA}$ where A is cross-sectional area **(1)**

[if no graph drawn, then mean of readings and correct use of data to give 2_{max}) **(1)**

Max 2
[13]

The Quality of Written Communication marks are awarded for the quality of answers to this question.

(a) (i) for steel (use of $E = \frac{Fl}{eA}$ (gives) $e = \frac{FL}{EA}$ **(1)**

$$e = \frac{125 \times 2}{2.0 \times 10^{11} \times 2.5 \times 10^{-7}}$$ **(1)**

= 5.0×10^{-3} m **(1)**

(ii) extension for brass would be 10×10^{-3}(m) (or twice that of steel) **(1)**
end A is lower by 5 mm ✓(allow C.E. from (i))

Max 3
[16]

M6.(a) (i) the Young modulus: tensile stress / tensile strain **(1)**

(ii) maximum force or load which can be applied without wire being permanently deformed [or point beyond which (when stress removed,) material does not regain original length] **(1)**

2

(b) (i) graph: suitable scale **(1)**
correct points **(1)** **(1)**
best straight line followed by curve **(1)**

(ii) indication of region or range of Hooke's law **(1)**

(iii) (use of $E = \frac{Fl}{eA}$

values of F and e within range or correct gradient **(1)**

to give $E = \frac{67}{4 \times 10^{-3}} \times \frac{1.6}{8.0 \times 10^{-8}}$ **(1)**

= 3.3(5) × 10^{10} Pa **(1)**

8

(c) (i) work done = force × distance **(1)**
= <u>average</u> force × extension (= ½Fe) **(1)**
[or use work done = area under graph
area = ½ base × height]

(ii) energy stored = $\frac{67 \times 4 \times 10^{-3}}{2}$ **(1)**

= 13.(4) × 10^{-3} J **(1)**

4
[14]

M7. (a) time elapsed = 8.5 ± 0.2 (ms) **(1)**
distance travelled = 3 (m) **(1)** (allow C.E. if d = 1.5 (m))

speed of sound = $\frac{3}{8.5 \times 10^{-3}}$ = 350 m s^{-1} (353) **(1)**

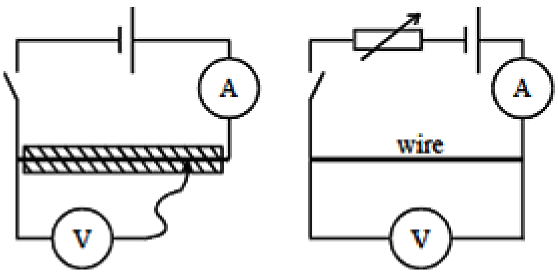
3

(b) connect oscilloscope <u>across</u> ac source (or diagram or ac to Y plates) **(1)**
adjust time base to give trace **(1)**
adjust voltage sensitivity **(1)**
sinusoidal trace shown **(1)**
how to measure T from trace **(1)**

$f = \frac{1}{T}$ **(1)**

Max 5
[8]

M8.(a) (i)



battery, wire, (variable resistor) and ammeter in series **(1)**
voltmeter connected across wire **(1)**

(ii)(α) (with switch closed) measure I and V **(1)**
move contact along the wire **(1)** (or length of wire changed)
measure new (I and) V **(1)**
measure l each time **(1)**

or (β) measure I and V **(1)**
change variable resistor **(1)**
measure new I and V **(1)**
l known **(1)**

(iii) $R = \frac{\rho l}{A}$ or $\rho = \frac{RA}{l}$ or $\rho = \frac{A}{l} \times \frac{V}{I}$ **(1)**

(α) obtain gradient of graph of V or R vs l **(1)**
A (and I) known, hence ρ **(1)**

or (β) gradient of graph of V vs I **(1)**
A and l known, hence ρ **(1)**

[or, for both methods, measure $R = \frac{V}{I}$ for each length **(1)**

take mean and hence ρ **(1)**

9

(b) (use of $V = IR$ gives) $R = \frac{240}{2 \times 10^{-3}}$ **(1)** (= 120×10^3 (Ω))

$$\rho = \left(\frac{RA}{l}\right) = \frac{120 \times 10^3 \times 80 \times 80 \times 10^{-6}}{1.5 \times 10^{-3}} \textbf{ (1)}$$

= 5.1×10^5 Ω m **(1)** (allow C.E. for value of R)

3

(c) four resistors in series **(1)**
$R = 4 \times (120 \times 10^3) = 4.8 \times 10^5 \Omega$ **(1)** (allow C.E. for value of R)

2
[14]

M9.(a) (i) length of card [or distance travelled by trolley A] **(1)**
time at which first light gate is obscured [or time taken to travel the distance] **(1)**

(ii) time at which second light gate is obscured [or distance travelled after collision <u>and</u> time taken] **(1)**

3

(b) momentum = mass × velocity **(1)**
mass of each trolley **(1)**
(check whether) $p_{initial} = p_{final}$ **(1)**

Max 2

(c) incline the ramps **(1)**
until component of weight balances friction **(1)**
[or identify where the friction occurs **(1)**
sensible method of reducing **(1)**]

2
[7]

M10. (a) suitable calculation using a pair of values of *x* and corresponding *t* to give an average of 2.2 m s^{-1} (± 0.05 m s^{-1}) **(1)**
valid reason given **(1)**
(e.g. larger values are more reliable/accurate or use of differences eliminates zero errors)

2

(b) (i) column D (*y*/*t* (cm s^{-1})

186
210
233
259
284
307

all values correct to 3 s.f. **(1)**

(ii) graph: chosen graph gives a straight line (e.g. *y*/*t* against *t*) **(1)**
axes labelled correctly **(1)**
suitable scale chosen **(1)**
minimum of four points correctly plotted **(1)**
best straight line **(1)**

(iii) *u* (= *y* - intercept) = 162 cm s^{-1} (± 4 cm s^{-1}) **(1)**
gradient = 495 (cm s^{-2}) (± 25 cm s^{-2}) **(1)**
k = gradient (= 495 cm s^{-2}) **(1)**

9

(c) (i) *u* : initial vertical component of velocity **(1)**

(ii) *k* : = ½ *g* **(1)**

2

(d) $v^2 = u^2 + 2.2^2$ **(1)**
gives $v = (1.62^2 + 2.2^2)^{1/2}$ = 2.7 m s^{-1} (± 0.1 m s^{-1}) **(1)**

2
[15]

M11. (a) (i) circuit diagram to show:
wire, ammeter, battery, (variable resistor) and switch in series **(1)**
[or potentiometer with ammeter in correct position]
voltmeter across the wire **(1)**

(ii) (method: constant length of wire)
measure length (of wire) **(1)**
measure diameter (of wire) **(1)**
measure voltage (across) and current (through wire) **(1)**
vary resistor to obtain different voltage and current **(1)**
alternative
[(method: variable length of wire)
measure length (each time) **(1)**
measure diameter **(1)**
(for full length of wire) measure voltage and current **(1)**
voltmeter to shorter lengths, measure voltage (and current) **(1)**]

(iii) (use of) $\rho = \frac{RA}{l}$ (to calculate ρ) **(1)** (for either method)
calculate A from (πr^2) **(1)** (for either method)
(method: constant length of wire)
determine $R = \frac{V}{I}$ for (one) length **(1)**
repeat readings (for same length and) take mean of ρ or R **(1)**
[or plot graph of V vs I to give mean R **(1)**
or gradient = $\frac{\rho l}{A}$ **(1)**]
alternative
[(method: variable length of wire)
determine $R = \frac{V}{I}$ for each length **(1)**
calculate ρ for each length and take mean **(1)**
[or graph of R vs l **(1)** with correct gradient **(1)**]

10

(b) (use of $R = \frac{\rho l}{A}$ gives) $\frac{2.0}{4.0} = \frac{1.1 \times 10^{-7}}{7.8 \times 10^{-9}}$ **(1)**

l = 0.035 m **(1)**

2
[12]

M12.(a) (i) $W = 2mg \cos\varphi$ $\therefore m = W/(2g \cos\varphi)$✓

The question says <u>*show that*</u>*, so the candidates must write down both steps.*

1

(ii) Well drawn straight line of best fit.✓

The line should follow the trend of the points with an even scatter of points on either side of the line.

1

(b) (i) Triangle drawn with smallest side at least 8 cm in length. ✓
Correct readings taken from the line for the triangle ✓
Gradient in the range 0.45 to 0.49 (0.445 to 0.494) quoted to 2 or 3 significant figures ✓

The size of the triangle can be identified from readings taken from the line.
The third mark is independent of the other two: error carried forward for incorrect readings (or for a poor line of best fit) which give a gradient out of range is not allowed.

3

(ii) Candidate's answer for gradient in (b)(i) correctly multiplied by g (expected answer 4.6)✓
N ✓

No s.f. penalty.
The second mark is for the unit and can be awarded if the numerical answer is incorrect.

2

(c) δx% = 0.2 and δy% = 0.5✓
$\delta(x/y)$% = δx% + δy% = 0.2 + 0.5 = 0.7 ✓
Use of $\delta(x/y)^2$% = 2 × $\delta(x/y)$(%) ✓

Final answer is (±) 1.4 (%) which automatically gains all three marks
Otherwise
Accept only 1 s.f. for 1st and/or 2nd marks.
The third mark is for the method, not the final answer

3

(d) (i) Systematic errors in measurements are errors which show a pattern or a bias or a trend ✓

Some acceptable alternatives

- ***A systematic error*** *is one which deviates by a fixed amount from the true value of a measurement*
- *An error which has the same value in all readings*
- *A difference between the true value of a quantity and the indicated value caused by a fault in the measuring device*
- *Accept a good example of systematic error.*

1

(ii) y would be larger✓
because angle θ would be smaller
or
because friction would be opposing the increasing weight of m✓

2
[13]

M13. (a) (i) the extension produced (by a force) in a wire is directly proportional to the force applied **(1)**
applies up to the limit of proportionality **(1)**

(ii) elastic limit:
the maximum amount that a material can be stretched (by a force) and still return to its original length (when the force is removed) **(1)**
[or correct use of permanent deformation]

(iii) the Young modulus: ratio of tensile stress to tensile strain **(1)**
unit: Pa or Nm^{-2} **(1)**
5

(b) (i) length of wire **(1)**
diameter (of wire) **(1)**

(ii) graph of force vs extension **(1)**
reference to gradient **(1)**

gradient = $\frac{EA}{l}$ **(1)**

[or graph of stress vs strain, with both defined, reference to gradient, gradient = *E]*

area under the line of F vs ΔL **(1)**
[or energy per unit volume = area under graph of stress vs strain]
6
[11]

M14.(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]

M15.(a) (i) 5.1 and 7.1 ✓

Exact answers only

1

(ii) Both plotted points to nearest mm ✓
Best line of fit to points ✓

The line should be a straight line with approximately an equal number of points on either side of the line

2

(iii) Large triangle drawn at least 8 cm × 8 cm ✓

Correct values read from graph ✓
Gradient value in range 0.190 to 0.210 to 2 or 3 sf ✓

3

(iv) ($R = \frac{1}{\text{gradient}}$) = 5.0 Ω Must have unit ✓

Allow ecf from gradient value

No sf penalty

1

(b) (i) 5.04 (Ω) or 5.0 (Ω) ✓

(Allow also 5.06 Ω or 5.1 Ω, obtained by intermediate rounding up of 3.50^2)

From $R = \frac{V^2}{P}$

1

(ii) (Uncertainty in V = 0.29%)

Uncertainty in V^2 = 0.57%, 0.58% or 0.6% ✓

From uncertainty in V = 0.01 / 3.50 × 100%

Uncertainty in P = 2.1% ✓

From uncertainty in P = 0.05 / 2.43 × 100% = 2.1%

Uncertainty in R =2.6%, 2.7% or 3%

Answer to 1 or 2 sf only ✓

2.1 % + uncty in V^2 (0.6%) = 2.7%

Allow ecf from incorrect uncertainty for V^2 or P

3

(iii) (Absolute) uncertainty in R is (±) 0.14 or just 0.1 Ω (using 2.6%) (or 0.15 or 0.2 Ω using 3%) ✓

Must have unit (Ω)

Must be to 1 or 2 sf and must be consistent with sf used from (ii)

No penalty for omitting ± sign

1

(iv) Works out possible range of values of R based on uncertainty in (iii), e.g. R is in range 5.0 to 5.2 Ω using uncertainty of ± 0.1 Ω ✓

No credit for statement to effect that the values are or are not consistent, without any reference to uncertainty

Allow ecf from (iii)

Value from (a)(iv) is within the calculated range (or not depending on figures, allowing ecf) ✓

Allow ecf from (a)(iv)

2

[14]

M16.(a) extension of wire Q = 2.7 (mm) ✓

ignore any precision given eg ± 0.1 mm

if > 2 sf condone if this rounds to 2.7

1

(b) mass = 5.8 (kg) ✓

allow ce for incorrect 0.1.1 (only look at 01.1 if answer here is incorrect)

allow ± 0.1 kg

1

(c) 0.51 (mm) ✓

ignore any precision given eg ± 0.005 mm

1

(d) method 1:

use of $E = \frac{\text{(tensile) stress}}{\text{(tensile) strain}}$ ₁✓

for ₁✓ expect to see some substitution of numerical data

cross – section area from $\frac{\pi \times d^2}{4}$ ₂✓

correct use of diameter for ₂✓; ignore power of ten error; expect CSA = 2.0(4) × 10^{-7}; allow ce from 01.3 (eg for d = 0.37 mm CSA = 1.0(8) × 10^{-7} m^2)

(tensile) stress = $\frac{mg}{\text{CSA}}$ ₃✓

penalise use of g = 10 N kg^{-1}

(tensile) strain = $\frac{\Delta l}{l}$ ₄✓

value of Δl must correspond to Figure 2 value of m; answers to 01.1 and 01.2 are acceptable

expect l = 1.82 m but condone 182 etc; accept mixed units for l and Δl

Max 3

method 2:

evidence of $\frac{\Delta l}{\Delta m}$ from Figure 2 to calculate gradient ₁✓

expect gradient between 0.45 to 0.48 mm kg^{-1}

$E = \frac{g \times \text{original lenght}}{\text{CSA} \times \text{gradient}}$ ₂✓ ₃✓

missing g loses ₃✓

substitution of l = 1.82 m ₄✓

condone 182 etc ₄✓

cross-sectional area from $\frac{\pi \times d^2}{4}$ ₅✓

correct use of diameter for ₂✓; ignore power of ten error; expect CSA = 2.0(4) × 10^{-7}; allow ce from 01.3 (eg for d = 0.37 mm CSA = 1.0(8) × 10^{-7} m^2)

Max 3

result in range 1.84×10^{11} to 1.91×10^{11} $_5$✓

condone 1.9×10^{11}

$_5$✓ mark requires correct working and no power of ten errors: allow ce for error(s) in 01.1, 01.2 and for false/incorrect CSA (eg for d = 0.37 mm allow result in range 3.49×10^{11} to 3.63×10^{11}, 3.5×10^{11} or 3.6×10^{11})

1

(e) (smaller diameter) produces larger extensions $_1$✓
reduces (percentage) uncertainty (in extension and in result for Young Modulus) $_2$✓

(smaller diameter) increases (percentage) uncertainty in diameter **or** cross sectional area is smaller **or** increases (percentage) uncertainty in cross sectional area $_3$✓
increases (percentage) uncertainty (in result for Young Modulus) $_4$✓

(smaller diameter) increases likelihood of wire reaching limit of proportionality or of wire snapping or reduces range of readings $_5$✓
increases (percentage) uncertainty (in result for Young Modulus) $_6$✓

outcome and correct consequence for 2 marks, ie $_1$✓ followed by $_2$✓, $_3$✓ followed by $_4$✓ etc

dna 'error' for 'uncertainty'

no mark for consequence if outcome not sensible, eg 'it gets longer and reduces uncertainty' earns no mark for 'diameter smaller so uncertainty greater' award $_1$✓ (need to see further mention of uncertainty to earn $_2$✓)

Max 4
[11]

M17.(a) 2.9% ✓

Allow 3%

1

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

1

0.29 mm or 2.9×10^{-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

$d = 0.300 \times 10^{-3}$ m so
number of lines = 3.34×10^{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]

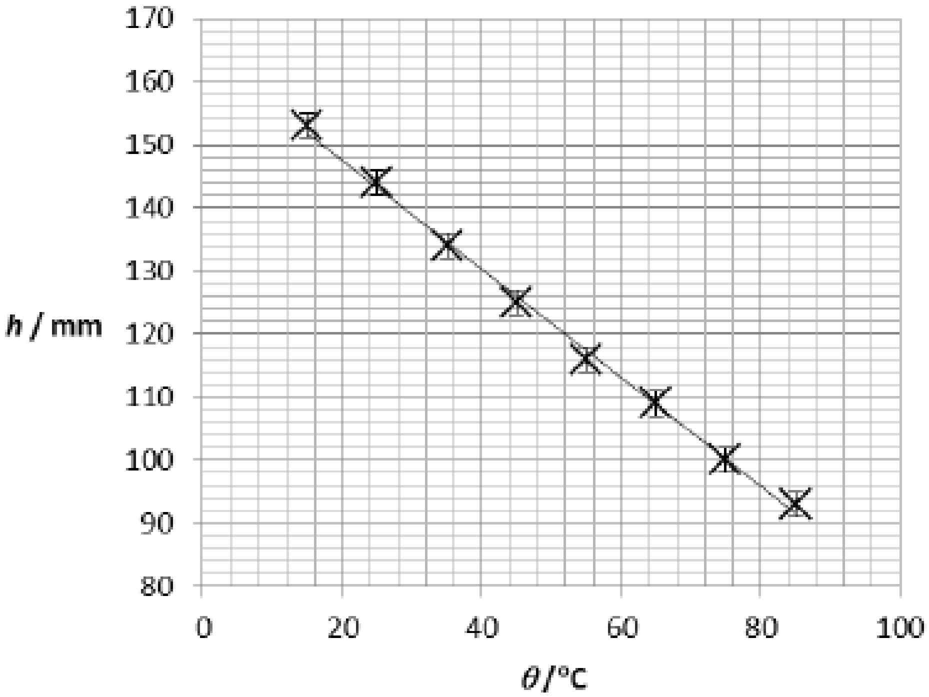
M18. 1 mark each correct row

[3]

M19.B

[1]

M20.(a) Straight line of best fit passing through all error bars ✓



Look for reasonable distribution of points on either side

1

(b) h_0 = 165 ± 2 mm✓

1

(c) Clear attempt to determine gradient ✓

1

Correct readoffs (within ½ square) for points **on line** more than 6 cm apart and correct substitution into gradient equation ✓

1

h_0k gradient =(-) 0.862 mm K^{-1} and
negative sign quoted ✓

Condone negative sign
Accept range -0.95 to -0.85

1

(d) $k = \frac{\text{candidate value for } h_0 k}{\text{candidate value for } h_0}$

= 5.2 x 10^{-3} ✓

Allow ecf from candidate values

1

K^{-1} ✓

Accept range 0.0055 to 0.0049

1

(e) for h = 8000 mm, $d^{-1} = \frac{8000}{14.5}$ ✓

1

d = 1.8 x 10^{-3} mm ✓

1

(f) Little confidence in this answer because
One of
It is too far to take extrapolation ✓
OR
This is a very small diameter ✓

1
[10]

M21.C

[1]

M22.

Quantity	Vector or Scalar	S.I. Unit
force	vector	newton
displacement	vector	metre
kinetic energy	scalar	joule
power	scalar	watt

allow capital letters, misspellings and plural units

accept v, s for vector and scalar

[3]

M23. B

[1]