Name of the Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Mark Schemes

Q1.

(a) MAX 2

Uncertainty in one/each reading is 1 mm $_1$✔

Allow the uncertainty in (reading) the position of a spot is 1 mm. $_1$✔

OR
The measurement involves making two readings / there are two uncertainties (to be considered) in this measurement $_1$✔

Owtte

Difficulty / uncertainty in locating (exact) position of (centre of) spot $_2$✔

Or
Difficulty / uncertainty in lining up the (centre of the) spot with a graduation on the ruler $_2$ ✔

Or
Difficulty / uncertainty in locating the position of A / B $_2$✔

Do not allow:

- *because the smallest division is 1 mm*
- *hard to see measurements to less than 1 mm (need to link to position of spot (or A or B)*
- *"because of both sides of the ruler" on its own*
- *"ruler slightly misaligned" too vague*

the uncertainties from two (readings) are added $_3$✔

insufficient includes:

- *uncertainty doubles*
- *uncertainty is twice the smallest division*
- *Random error or human error or error without further detail.*

However:

The uncertainty doubles because there are two readings scores MP1

Also:

The uncertainty doubles because there are two readings with identical uncertainties would score 2 marks.

Mention of range of repeated measurements ÷ 2 is not applicable in this case.

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(b) (Adds the uncertainties =) 4 (mm) $_1$✔

Or
Use of by substitution

(percentage uncertainty=) $\frac{\text{uncertainty}}{\text{value}}$ (×100) (%) $_1$✔

(% uncertainty =) 0.74 **or** 0.7 (c.a.o) $_2$✔ (**1 or 2 significant figures only**)

1st mark
Expect to see:
(percentage uncertainty=) $\frac{4}{544}$ *(×100) (%)*
Maximum 1 mark for
Condone (in substitution):
- *2/289, 2/255, 2/272, 2/544, 4/289, 4/255, 4/272*
- *power of ten errors (POT errors)*
- *must be a recognisable uncertainty*

Maximum 1 mark for
use of
(percentage uncertainty=) $\frac{\text{uncertainty}}{\text{mean (value)}}$ *(value)(×100) (%)*
along with substitutions of
- *2/289, 2/255, 2/272, 2/544, 4/289, 4/255, 4/272, 4/544*
- *power of ten errors*

condone for 1 mark
((2/289 + 2/255) × 100 =)
1.48% or 1.5%
2nd mark
Condone working leading to 2nd mark for:
Use of (percentage uncertainty=) $\frac{2}{272}$
*Do not allow mean of two separate % uncertainties **or** incorrect formula quoted and used in workings*

2

(c) MAX 2

The <u>percentage</u> uncertainty in c is smaller <u>than for a or b</u> because c has a larger value (than a or b separately)$_1$✔

or % uncertainty in c is half the percentage uncertainty in a + b $_1$✔

or The <u>percentage</u> uncertainty in c is smaller <u>because</u> its uncertainty is smaller for the same data value $_1$✔

Insufficient:
- *c has a smaller uncertainty*
- *a + b has a larger uncertainty*
- *The uncertainty of a + b is combined*

c's (% uncertainty =) 0.37 or 0.4 $_2$✔ or *c*'s (% uncertainty =) $\frac{2}{544}$ × 100 $_2$✔

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idea that *c*'s measurement involves fewer readings than the sum of a and b ₃✔
or
idea that c requires fewer measurements than the sum of a and b ₃✔

Accept converse
Where numbers are quoted, these must be consistent with terms used.
4 readings, 2 readings
2 measurements, 1 measurement

2

(d) (when laser is switched on) always stand behind the laser (unless taking readings) ✔

Or
if <u>in front of laser</u> (when switched on) look away from the laser (eg when taking readings) ✔

Or
if <u>in front of laser</u> (when switched on) don't look at/towards the laser (eg when taking readings) ✔

Or
don't look directly into the laser (beam)✔

Or
direct laser towards nearest wall ✔

Or
switch off laser when not in use ✔

Or
ensure (glass) reflective surfaces are covered (prevent reflections) ✔

Or
Do not shine the laser onto a reflective surface ✔

Or
place safety notices outside the laboratory [room] ✔

Or
don't shine laser at eye level ✔

Or
mark positions with pen/pencil and measure after laser switched off ✔

Or
laboratory is normally illuminated (not darkened) ✔

Where a list of safety measures has been given:
- *Treat more than one correct as neutral*
- *Penalise incorrect safety measure in a list that may include correct safety measures.*

Do not credit weak statements:
- *Do not look at the laser*
- *Don't point the laser anywhere except at the grating*
- *Don't look directly at the laser*

Beware of references to "the light".

1

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(e) $(\tan\theta = \frac{0.544}{1.280} \Rightarrow \theta =) 23.0(^\circ)$ ✔

allow 2 or more significant figure answer

acceptable common answers:

23, 23.0, 23.03, 23.025, 23.0255

Where more than 3 sf quoted, the number must be correct.

alternative method

*(valid attempt to determine distance from grating to spot **E**, eg*

(distance = $(\sqrt{0.544^2+1.280^2})$ *= 1.391)*

(sin $\theta = \frac{0.544}{1.391}$ *= 0.391)*

(θ *=) 23.0(°)* ✔

allow 2 or more significant figure answer

acceptable common answers:

23, 23.0, 23.03, 23.025, 23.0255

Condone mid-calculation rounding leading to errors in 4th sf where quoted.

1

(f) use of $n\lambda = d\sin\theta$ $_1$✔

or

(if nothing else seen) d = 3.3×10^{-6}m $_1$✔

Use of:

Correct rearrangement where subject would be λ

or correct substitution of n, d and θ

Expect to see n = 2 , $d = 3.3(3) \times 10^{-6}$ *,* $\theta = 23(.0)$

*Condone **one** error in substitution for n or d in a correctly rearranged equation where subject would be* λ

(or where answer indicates the correct working for incorrect numbers, d *error leads to* 5.86×10^4*)*

Condone power of ten errors in working

λ = $6.5(2) \times 10^{-7}$ (m) $_2$✔ ecf

2 or 3 sf only

where 3 sf quoted answer must be in range 651 to 652 nm (or ecf)

Common ecf (sin θ *error in 1.5):*

Expect to see an answer that rounds to 7.1×10^{-7}*m to 2 sf*

2

(g) The second mark ($_2$✔) is contingent on the award of the first mark ($_1$✔).

Increase distance from grating to screen / increase y $_1$✔

(This will increase distance y (and/or c) therefore) decreasing the percentage uncertainty in y / c / fringe spacing / θ / sin θ $_2$✔

Do not accept:

- *darkened room*
- *use a (vernier) caliper*
- *use a travelling microscope*

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- *Repeat*
- *Repeat and average*
- *Computer / data logger / camera*
- *Ruler with smaller divisions*
- *Make the maxima further apart (details on how this is achieved are required)*
- *Increase distance between laser and screen.*

Decreases the <u>percentage</u> uncertainty in y $_2$✔

Or

Use a higher-order spot $_1$✔

(This will increase distance from centre spot to higher-order spot therefore) decreasing the <u>percentage</u> uncertainty in the fringe spacing/θ /sin θ $_2$✔

Condone reference to this distance as c

Or
Measure distance between A and E $_1$✔

(This increases the distance therefore) decreasing the <u>percentage</u> uncertainty in c $_2$✔

No details of determination of c are required.

2

[12]

Q2.

(a) Neutron number increases by one **and** proton number decreases by one $_1$✔

Or

A proton changes/decays to a neutron $_1$✔

(because) up (quark) changes to a down (quark) $_2$✔

Allow use of symbols: N increases by one and Z decreases by one

Allow this expressed as an equation symbols for proton and neutron.

Allow u (quark) changes to d (quark)

Allow uud → dud

Where decay equation is attempted, condone incorrect leptons (quarks must be correct).

2

(b) Conversion of 0.52 MeV to eV seen $_1$✔

Or

Conversion of 0.52 MeV to J $_1$✔

Or

Use of $p = \frac{E}{c}$ $_1$✔

(p =) 2.77×10^{-22} or 2.8×10^{-22} $_2$✔ **c.a.o**

5.2 × 10^5 (eV) seen for MP1

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Condone POT error in conversion to joule

Expect to see: 8.32×10^{-14} (J) for MP2

With substitution of student's value for E (where conversion hasn't been completed or completed incorrectly)

2

(c) Shades detector opposite **P** ✔

The leader line from label 'patient's head' passes through a box.

Expect to see shaded the box below the 'leader line' box.

Allow either of the boxes adjacent to expected box.

Penalise more than one box shaded.

1

(d) 2 photons (are produced) / Photons must move off in opposite directions (along the same line)$_1$✔

The photons must have equal and opposite momentum / must conserve momentum $_2$✔

2

(e) Use of $\left(\text{gradient}=\right)\frac{\Delta v}{\Delta t}$ $_1$✔

Condone power of ten errors and leaving time in hours (or incorrect conversion to seconds)

Correct read off; condone errors in read off that lead to ± 1mm s^{-1} in Δv and ±0.02 h in Δt.

For 1 mark expect to see

(79-60) ÷ 1.18

(65-60) ÷ 0.3

(70-60) ÷ 0.6

(75-60) ÷ 0.92

(76-60) ÷ 1

***Max 1** for answer where there is failure to notice false origin. MP2 is available in this case where there is only the false origin error.*

4.5(1) × 10^{-6} (m s^{-2}) $_2$✔

Range = $4.40 \times 10^{-6} \leq accepted\ value < 4.65 \times 10^{-6}$

2

(f) Acceleration increases$_1$✔

Condone correct acceleration statement linked to incorrect explanation.

Larger change in momentum (because more photons are reversing direction of motion) <u>therefore</u> a larger force on solar sail $_2$✔

Or

More momentum gained per second (from the photons) $_2$✔

Or

Larger force on photons <u>therefore</u> larger force on sail $_2$✔

2

[11]

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