Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Mark Schemes

Q1.

(a) Ray enters (prism) along normal ✔

Allow normal explained eg at right angles <u>to surface</u>
Accept "angle of incidence is 0".

1

(b) Treat each point independently.

Prism material/it has/they have same refractive index / <u>optical</u> density as windscreen ✔

Condone 'it has' or 'they have' or just 'same'
Allow "no change of speed between prism and windscreen"
Allow "made from same material"
Do not allow "same refractive index between them"
Treat "monochromatic" as neutral

Prism fitted to windscreen without gaps ✔

Allow "contact between prism and windscreen is clean" etc. Allow "touching the windscreen"
Condone suggestion that any bonding material has same refractive index (as prism and windscreen).
Do not accept 'no boundary'

2

(c) C = arcsin (1/1.52) = arcsin (0.66) = 41(.1)° ✔

The first mark is for the calculation.

45° > critical angle / 41.1° resulting in <u>total internal reflection / tir</u> (at each boundary) ✔

The second is for the discussion but is contingent on obtaining a value for C.
Ecf for any C < 45°
Accept clear reference to angle at point A in place of 45° statement.
Do not allow "angle of incidence> critical angle" on its own.

2

(d) Calculation of critical angle at glass–water boundary (61.0°)

OR

Calculation of possible *n* from glass to water (0.707) or absolute n for glass (1.88)

OR

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Calculation of angle of refraction in water (53.9°) ✔

So total internal reflection no longer takes place
OR
some light escapes/refracts (into water) / less light reflects ✔

(Less light stays within windscreen so less light detected at sensor)

Do not allow suggestion that TIR occurs at critical angle/when angle of incidence=critical angle.

Do not allow "ray/all the light escapes/refracts" or "no light reflects" or "less TIR".

Do not condone "total internal refraction/diffraction"

2

(e) Statement of effect of change in n on the path direction ✔

Eg for MP1

- *Light may change direction inside windscreen*
- *Light may change direction at a windscreen boundary*

(Sensible reference to the variation of a few per cent) leads to the idea that change is unlikely to be significant ✔

Eg for MP2

- *Variation too small to deviate significantly within windscreen – internal effect*
- *Variation too small to affect tir at A without droplet – boundary effect*
- *Variation too small to significantly affect transmission at A with droplet – boundary effect*

Allow discussions that may cause a difference, eg there is a summative effect from multiple reflections etc

MAX 2

(f) **More sensitive because…**
more likely to encounter/detect water drop OR will encounter more water drops ✔
bigger decrease in light intensity, so more sensitive to rain ✔

Less sensitive because…
more likely to encounter imperfections in glass/on surface of glass /dirt on surface of glass ✔
any curvature effects will be greater so may not hit detector ✔
light intensity reduced without presence of water / greater absorption in windscreen due to greater path length ✔

Allow any 2 comments taken from list.

There must be a sense of whether the comment relates to an improvement or decrease in sensitivity.

Treat as list; mark 1 and 2 independently.

Allow idea of larger area

Do not allow a response that discusses travel time of ray.

MAX 2

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Q2.

(a) Central maximum with lower intensity maxima (either side) ✔

MP1 is for comparison of intensity. Condone references to brightness/dimness.

Central maximum is twice as wide/wider than other maxima ✔

MP2 is for comparison of width

Award credit for a drawn answer eg on Fig 1.

Suggestion that pattern due to white light = max 1

Reference to Young's slit or equation = max 1

If only a single maximum is referred to MP2=0 but MP1 can score for description of intensity variation.

2

(b) Wider (central) maxima (maximum) ✔

'The pattern is wider/more spread out' gets 1 mark if no other marks given.

Not "larger pattern".

(Subsequent) maxima further apart ✔

Condone "larger" distances between maxima.

Condone 'maxima more spaced out'

Reference to Young's slit or equation = max 1

Ignore comments related to change in wavelength

2

(c) $d = 1 \times 10^{-3}/500$ $(= 2 \times 10^{-6})$ ✔

Allow POT error for d for MP1

$(\sin \theta = n\lambda/d = 6.5 \times 10^{-7} / 2 \times 10^{-6} = 0.33)$

$\theta = 19°$ ✔

May be seen in diffraction grating equation.

Allow max 1 for use of grating constant rather than d to give 7.45×10^{-11}° if no other credit available.

2

(d) Any two from: ✔ ✔

(Range of wavelengths results in):

Central maximum unchanged in width

Broader maxima/range of angles for each maximum/order

Gradually getting broader/more spread out for greater order maxima

Part of third order maximum suppressed at long wavelengths (for $\theta > 90°$)

Give credit for answer shown in diagram

Evidence for these marks may be seen in calculations

Treat intensity variation as neutral.

2

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