Mark schemes

Q1.

Max 2 ✓✓

- Identified transmitter and detector as used by Hertz e.g. spark gap or dipole transmitter and dipole or loop receiver.
- Correct placement of a (metal) reflector
- Creation of a stationary (radio) wave with a reflector
- Use a **movable** detector

λ = 2 × max to **adjacent** max OR 2 × min to **adjacent** min OR 4 × max to **adjacent** min (divided by any multiples used in MP4) ✓

Award 0 marks for answers which do not use radio waves.

Ignore references to other experiments e.g. Fizeau.

Ignore reference to use of computers or oscilloscopes.

*Evidence for MP1 and MP2 may come from a **labelled** diagram*
Condone MP1 and MP2 from other experiments with radio waves.

*Do **not** allow mirror for metal reflector in MP1 or MP2 but only penalise once.*

Use of a reflector (condone mirror)
AND measure distance from (multiples of)
max to max
or min to min
or max to min ✓

Use of a reflector (condone mirror)
AND an attempt at a realistic measurement of *λ*
AND *c* = *f* λ ✓

In MP3 and MP4 allow node for min and anti-node for max.

A labelled diagram with λ clearly marked with an arrow (or equivalent) can gain MP3

Do not allow MP4 if first harmonic is used.

MP4 may come from the diagram but a reference to what is measurement not just λ is required.

*Do **not** allow any reference to* $v = \frac{s}{t}$ *for MP5*

[5]

Q2.

(a) Sinusoidal electric field in vertical plane, in phase with magnetic field

AND

Indication of direction perpendicular to both fields ✓

Expect to see arrow at either end of long axis line

Condone only one of E or 'direction of propagation' not labelled. Accept 'direction' for 'direction of propagation'.

Accept lower case e for E

1

(b) Maxwell ✓ CAO

1

(c) Light is made of <u>corpuscles</u> ✓

When corpuscles meet boundary

[any 2 from] ✓
- component of velocity/momentum parallel to surface unchanged
- Component perpendicular to surface increases
- (short range) force of attraction (to surface)
- light travels faster in glass

When corpuscles meet boundary

[all 4] ✓
- component of velocity/momentum parallel to surface unchanged
- Component perpendicular to surface increases
- (short range) force of attraction (to surface)
- bends towards the normal / angle of refraction < angle of incidence

Marks can be awarded for suitable labelled diagram

Allow particles for corpuscles in MP2 and MP3 but not MP1.

Condone references to horizontal/vertical components in MP2 but not MP3 unless clarified in diagram or text.

Condone attracted / attraction for force of attraction

Do not accept force of gravity but can still gain MP2 if 2 other points are made.

Condone light bending wrong way for MP2 but not for MP3.

*Ignore short-range force of attraction to <u>normal</u> for MP2 but do **not** allow for MP3*

If no other marks condone light is made of particles and one bullet from MP2 for 1 mark.

3

(d) Diffraction/interference experiment described ✓

describe / show in labelled diagram a feature that is only explained by waves e.g. series of maxima and minima, bright and dark, series of fringes, spectra (from diffraction grating not prism), bright spot in centre of double slit, intensity graph ... ✓

diffraction/interference/superposition is a wave phenomenon **AND** describe how the feature would look with particles e.g. two bright spots, no bright spot in the centre, etc ✓

MP1 is for the set up.

MP2 is for what is seen.

MP3 is for showing why Newton's theory is not correct.

Marks can be awarded for suitable labelled diagram

Expect description of Young's double slits experiment but allow any suitable diffraction experiment, eg single slit or grating.

Stating 'Young's Double Slits' is insufficient.

For MP1 experiment must be consistent with description given in MP2 and MP3.

Ignore experiment to measure speed of light in glass or any reference to refraction including producing a spectra from a prism.

Ignore references to polarisation.

Interference pattern is not enough for MP2.

If no other marks allow 1 mark for 2 from

- *Young's double slits*
- *Interference/diffraction*
- *Interference/diffraction is a wave phenomenon*

3

[8]

Q3.

(a) Light consists of corpuscles that travel in straight lines ✓

Condone 'particles' for 'corpuscles'

Accept description of travelling in straight lines.

(which means that) shadows are formed with sharp edges ✓

*In MP2 accept: no diffraction, **only/just** 2 lines/fringes seen, sharp shadows, lines are distinct*

Treat references to interference as neutral.

2

(b) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.**

Mark	Criteria
6	All three areas covered well. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to cover all 3 areas, but one area may only be covered partially.
4	Two areas successfully covered, or one covered and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
3	One area covered and one covered partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	One area covered, or two covered partially
1	Only one area partially covered.
0	No relevant analysis.

Accept information seen in an appropriate diagram.
The following statements are likely to be present.

A alterations to experiment
Slits separation / width should be closer to wavelength of wave.
Make slits narrower and closer together.
Use monochromatic (red) light.
Use a single slit (to make the light coherent).
Use a laser as it is coherent/ monochromatic.

B description of Huygens' theory
Light is a wave.
The theory uses the idea of (secondary) wavelets.
Every point on wavefront acts as source of secondary wavelets.

C explanation in terms of Huygens
(When wave reaches slit) each point at slit produces secondary wavelets.
Wavelets overlap on screen.
Path difference due to different distances between a point on the screen and the two slits.
Path difference introduces phase differences.
Bright fringes form where path difference is whole number of wavelengths/waves arrive in phase.
Dark fringes where path difference is odd number of half wavelengths/waves arrive in antiphase. Do not accept 'out of phase'.

The mention of destructive/constructive interference or diffraction on its own does not gain credit.

6

(c) (Most of the screen dark)

Newton's theory predicts:

(bright) central spot surrounded by partial shadow ✓

Credit labelled additions to diagram

Condone MP1 for any suggestion of gradual decrease in brightness moving out from central region, e.g. suggestion it resembles a central maximum with no other maxima. Do not accept fringe.

Huygens' theory predicts:

(bright region with) fringes around the edge ✓

edge of bright region / fringes coloured ✓

3

[11]

Q4.

(a) Frequency (of rotation) of W when no reflected light seen ✓

and idea that this is the lowest frequency ✓

MP2 is contingent on MP1

Do not accept 'first frequency' for MP2

2

(b) Either

Calculate using equation (max measurable speed) = 2.5×10^8 m s^{-1}

Condone alternative methods e.g. comparison of times etc.

OR

Calculate value of f_0 (needed) = 12(.25) Hz/735 rev min^{-1} ✓

Unit needed for MP1

Conclusion: No as

the largest possible speed is less than the speed of light

OR

the frequency required to find the speed of light is greater than the maximum frequency. ✓

Condone ecf in MP2 only for an arithmetic error in MP1 e.g. incorrect conversion to Hz.

2

(c) ε_0 related to electric field strength (due to charged object) in free space ✓

Accept vacuum for free space

μ_0 related to magnetic flux density/magnetic field strength (due to current carrying wire) in free space ✓

If no other mark given, award MAX 1 for

ε_0 *related to electric field (in free space)*

AND

μ_0 *related to magnetic field (in free space)*

2

[6]