# A-Level Physics

## Electromagnetic Waves

### Mark Scheme

**Time available: 43 minutes**
**Marks available: 28 marks**

**1.**

(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)
$= 2.5 \times 10^8 \text{ m s}^{-1}$

*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) $\varepsilon_0$ related to electric field strength (due to charged object) in free space ✓

*Accept vacuum for free space*

$\mu_0$ 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*

$\varepsilon_0$ *related to electric field (in free space)*

*AND*

$\mu_0$ *related to magnetic field (in free space)*

**2**

**[6]**

**2.** (a) Pattern shows:

Maximum at start and shows minimum of zero ( never negative) ✓

Correct periodicity zeros/maxima 180° apart ✓

(ie angles in right places)

Curvature rather than spikes ie  ✓ ×

(The graph should fall to zero – (NB First and last parts should ideally be curved not as illustrated here)

***If negative then can get second mark only***

*Assume that bottom of graph grid is zero unless otherwise stated*

*Must be numbers on x-axis*

*Ignore if graph shows what happens beyond 360*

*If only one minimum shown then loses this mark*

*Allow if shown starting at zero*

*Freehand sketch so allow if clear attempt to show curvature in most of sketch or arches*

**3**

(b) Correct substitution leading to a calculation of the speed of electromagnetic wave

$\frac{1}{\sqrt{(4\pi\times10^{-7})(8.85\times10^{-12})}}$ = 3.0 (2.9986) × $10^8$ m $s^{-1}$

**1**

Comment that this speed agrees with the measured speed of light

Or speed determined from experiments

Or similar to Fizeau's result

**1**

**[5]**

**3.** (a)

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$ seen

AND $\mu 0$ ε0 substituted separately from data booklet ✓

To give value of *c* AND compared with *c* in booklet ✓

*For MP1 condone formula seen AND answer given to at least 5 sf (2.9986 x $10^8$ ($ms^{-1}$))*

*For MP2 need to see a valid comment that compares calculated value with data booklet value with units to at least 3sf*

**2**

(b) Maxwell's model as varying perpendicular E and B fields (transmitting through space) ✓

(Oscillating) current in T indicates presence of (oscillating) E field ✓

*For MP2 allow idea of distribution of charge in T giving rise to electric field*

Oscillating current in T produces (horizontal) B field ✓

*For MP3 allow moving electrons produces a (varying) magnetic field*

Varying (horizontal) B field induces varying emf in loop
OR
Varying (vertical) E field creates a varying emf in loop ✓

*For MP4 allow*

*idea of magnetic field applying force on (moving) charges in the receiver (which is an emf)*

*OR*

*Idea of electric field causing change in charge distribution within the loop (which is an emf)*

**4**

(c) In order to determine speed, need to measure wavelength/ distance between nodes OR antinodes in stationary wave ✓

From frequency of 75 MHz and $c = f\lambda$, wavelength = 4 m

*For MP3 and MP4 allow for correct calculation leading to idea that three waves will fit between transmitter and detector so YES*

OR nodes/antinodes are 2 m apart ✓

Which is less than separation of transmitter and reflector so YES ✓

Answer refers to nodes ✓

*In MP3 allow ecf for incorrect wavelength*

**4**

**[10]**

**4.** (a) two waves in phase in planes perpendicular to each other **(1)**
waves labelled E and B (or similar) **(1)**
direction of propagation shown or stated **(1)**

**3**

(b) (i) magnetic wave causes alternating magnetic field (or flux) through loop **(1)**
induced emf in loop due to changing magnetic flux (in loop) **(1)**

(ii) radio wave is polarised **(1)**
no magnetic flux passes through the loop in new position **(1)**

**4**

**[7]**