

12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore a scribble or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
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1	Student Number	2309516
2	Title of Examination Paper	ELECTROMAGNETIC RADIATION
3	Module Code	ACDC5009
4	Date and Time of Examination	8/05/2025 15:00
5	Examination Venue	310
6	Seat Number	12
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
Q1	18
Q2	7
Q3	16
Q4	7
Total	48

(Gweler yr ochr arall am y fersiwn Cymraeg)

$$1a) \quad v = \frac{\lambda f d p}{2} \quad \lambda = \frac{c}{f} \quad \frac{3 \times 10^8}{2 \times 10^9} = 0.15$$

$$1000 = \frac{\lambda f d p}{2} \quad 1000 = \frac{0.15 f d p}{2}$$

$$f d p = \frac{0.15 \times 1000}{2} = 75 \text{ Hz}$$

b) Signal modulation is the mixing of a message signal with a high frequency carrier signal which allows the message to travel further with less losses.

$$c) \quad \lambda = \frac{c}{f} \quad c = 3 \times 10^8 \quad \lambda = \frac{8 \times 10^7}{8}$$

$$\frac{3 \times 10^8}{8 \times 10^7} = 3.75 \text{ Hz}$$

$$d) \quad \Delta t = \frac{2R}{c} \quad \Delta t = 2 \times 10^{-6} \quad c = 3 \times 10^8$$

$$2 \times 10^{-6} = \frac{2R}{3 \times 10^8}$$

$$2R = 2 \times 10^{-6} \times 3 \times 10^8$$

$$2R = 600$$

$$R = 300 \text{ m}$$

1e) $n_1 = 1.5$, $n_2 = 1.6$

$$\phi_c = \sin^{-1} \left(\frac{n_2}{n_1} \right)$$

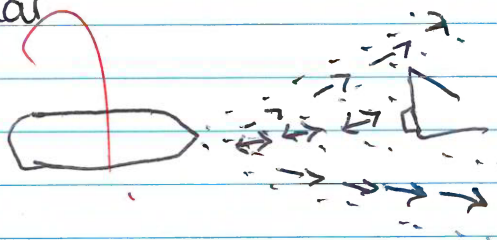
$$\phi_c = \sin^{-1} \frac{1.5}{1.6} = 69.64^\circ \text{ (2d.p.)}$$

f) Electromagnetic waves self propagate in free air in accordance with Ampere Maxwell Something else Maxwell laws. This means that a time vary electric field will induce a magnetic field, and a time varying magnetic field will induce an electric field.

2ai) Passive radar homing means the ~~radio~~ munition doesn't use a transmitter to track a target. Instead it will track sources from the target like heat.



ii) Active radar homing means the munition has both a ^{radar} transmitter and receiver to track a target.



b) $f = 200 \text{ MHz}$

- c) Right hand rule - thumb = propagation
fore finger - electric wave direction
middle finger - magnetic wave direction

Q2 = (7)

$$3a) i) f_c = \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$c = 3 \times 10^8$$

$$m = 1$$

$$n = 0$$

$$a = 4$$

$$b = 2$$

$$f_c = \frac{3 \times 10^8}{2} \sqrt{\left(\frac{1}{4}\right)^2 + \frac{0^2}{2}}$$

$$f_c = 37,500,000 \text{ Hz}$$

$$37.5 \text{ MHz}$$

$$ii) \lambda = \frac{c}{f} = \frac{3 \times 10^8}{37,500,000} = 8 \text{ m}$$

$$3b) NA = \sqrt{n_1^2 - n_2^2}$$

$$0.48 = \sqrt{n_1^2 - 1.45^2}$$

$$NA = 0.48$$

$$n_2 = 1.45$$

$$\text{Acceptance Angle} = \theta_a = \sin^{-1} \left(\frac{NA}{n_0} \right)$$

$$NA = \sqrt{n_1^2 - n_2^2} \quad NA = 0.48$$

$$n_2^2 = \sqrt{1.45^2 - 0.48^2}$$

$$\sin^{-1}$$

$$n_2^2 = 1.37 \text{ (2dp)}$$

$$n_2 = 1.17 \text{ (2dp)}$$

3c

TE ^{transverse}
electricTM ^{transverse}
magnetic

Electric field is Perpendicular to propagation

Magnetic field is perpendicular to propagation

Magnetic field is in direction of propagation of wave

Electric field is in direction of propagation of wave

3d) An isolator is used to only allow signals in one direction. This may ~~allow~~ signals for transmitting but block received signals for example to prevent damage or losses.

4a) Q1 $-20 \mu\text{C}$ $(-5, 4, 6)$

Q2 $40 \mu\text{C}$ $(4, 8, -2)$

$$\vec{P} = -5\vec{a}_x + 4\vec{a}_y + 6\vec{a}_z$$

$$\vec{Q} = +4\vec{a}_x + 8\vec{a}_y - 2\vec{a}_z$$

$$9\vec{a}_x + 4\vec{a}_y - 8\vec{a}_z$$

$$\vec{PQ} = \vec{Q} - \vec{P} = 9\vec{a}_x + 4\vec{a}_y - 8\vec{a}_z$$

$$|\vec{PQ}| = \sqrt{9^2 + 4^2 + (-8)^2} = 5.74 \text{ (2dp)}$$

$$\frac{\vec{PQ}}{|\vec{PQ}|} = \frac{9\vec{a}_x + 4\vec{a}_y - 8\vec{a}_z}{5.74} = 1.25$$

$$\frac{\vec{PQ}}{|\vec{PQ}|}$$

1.57

$$F = \frac{Q_1 Q_2}{4\pi \epsilon_0 d^2} \bar{a}_r$$

$$Q_1 = -20 \mu\text{C} \quad \epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

$$Q_2 = 40 \mu\text{C} \quad d = 5.74$$

$$a_r = 1.57$$

$$\frac{(-20 \times 10^{-6}) \times (40 \times 10^{-6})}{4\pi \times 8.854 \times 10^{-12} \times 5.74^2} \times 1.57$$

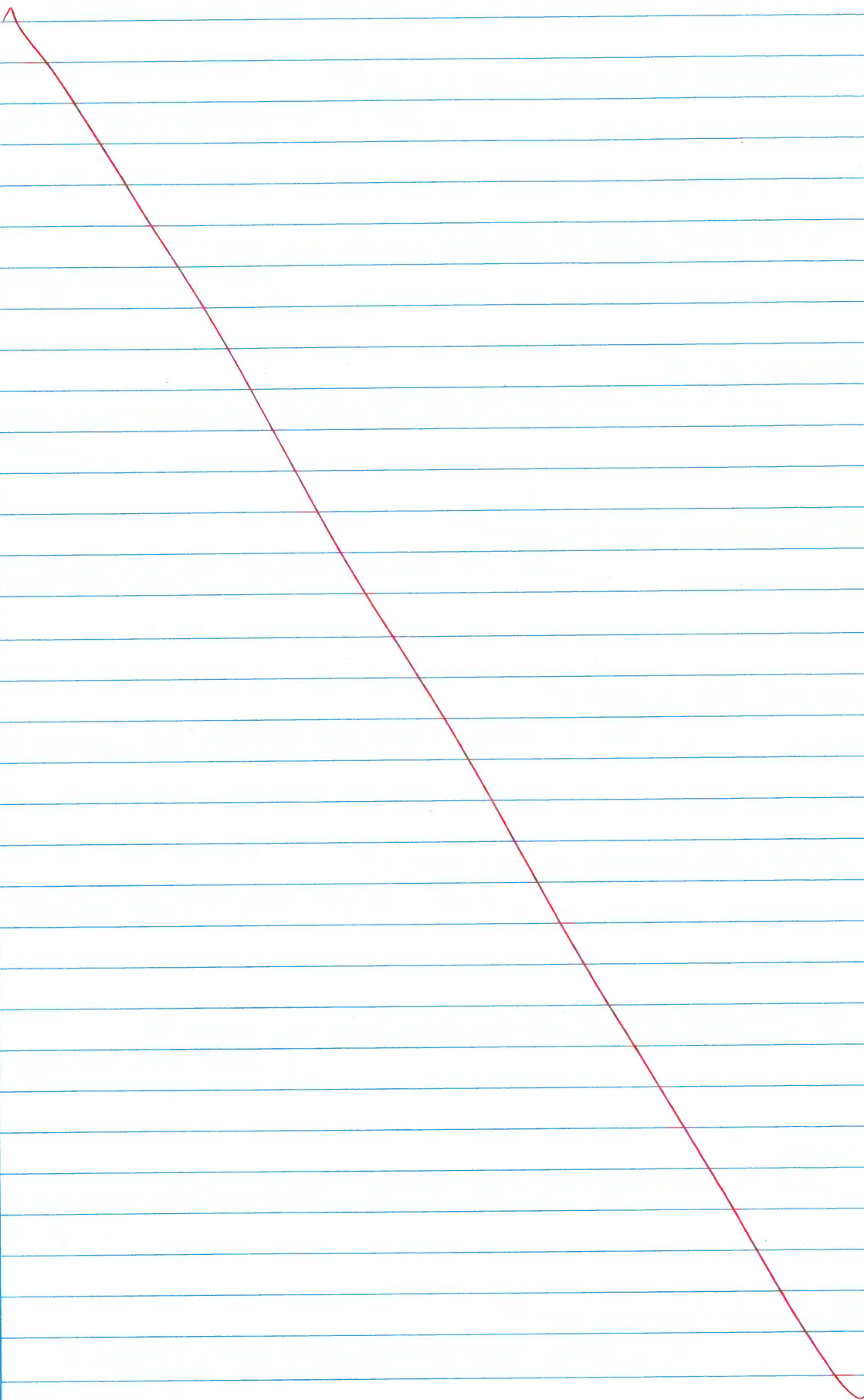
$$= -0.34 \text{ (2dp)}$$

$$Q_4 = 7$$



Examiner Only

Question No.



Rhif y Cwestiwn

Arholwr yn unig