

23

12 Pages

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1	Student Number	2115523
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	ACDC5009
4	Date and Time of Examination	08/05/2025 15:00
5	Examination Venue	1Q310
6	Seat Number	27
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

$\frac{56}{100}$
~~He~~
 p21

1. a) $f_c = 2 \times 10^9$

$$\lambda = \frac{3 \times 10^8}{2 \times 10^9}$$

$$\lambda = 0.15 \text{ m}$$

$$V = \frac{\lambda f_{dp}}{2}$$

$$f_{dp} = \frac{2V}{\lambda} \quad \text{or} \quad f_{dp} = 13.33 \text{ kHz}$$

b) Signal modulation is a way of converting data to a transmittable signal in the form of carrier waves. RF communication is beneficial as it is easy to transmit and receive and easy to demodulate.

c) $800 \times 10^{-9} \text{ m}$ $f = \frac{c}{\lambda} = \frac{3 \times 10^8}{800 \times 10^{-9}}$

$$f = 3.75 \times 10^{14} \text{ Hz}$$

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

$$R = 600 \text{ m}$$

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

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

$$\theta_c = 69.636^\circ$$

f) Electromagnetic waves are able to operate in free space by being transverse, where a changing electrical field generates a magnetic field and a changing magnetic field generates an electric field.

$$Q_1 = \frac{24}{30}$$

$$Q_1 = 20$$

2. a) (i)

(ii)

b) $f = 200 \times 10^6 \text{ Hz}$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{2 \times 10^8}$$

$$\lambda = 1.5 \text{ m}$$

driven element to the director $= 0.2\lambda = 0.3 \text{ m}$

driven element to the reflector $= 0.15\lambda = 0.225 \text{ m}$

$$L = \frac{\lambda}{2} = 0.75 \text{ m} = \text{length of antenna}$$

$$L = \frac{\lambda}{10} = 0.15 \text{ m} = \text{length of driven element}$$

$$0.15 \times 0.95 = 0.1425 \text{ m} = \text{length of reflector}$$

$$0.15 \times 0.9 = 0.135 \text{ m} = \text{length of director}$$

c) The right hand rule shows the relationship between the direction of the waves, magnetic field, and electric field. Where the thumb points up for the direction of the waves, forefinger points straight for the direction of the electric field, and middle finger points left/inwards for the direction of the magnetic field. All 3 should be perpendicular to one and other.

3. a) (i) $m = 4$ $n = 2$ ~~the~~ $a = 1$ $b = 0$

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

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

$$f_c = \frac{3 \times 10^8}{2} \times 4$$

$$f_c = 600 \text{ MHz or } 6 \times 10^8 \text{ Hz}$$

4) (ii) $\lambda_c = \frac{c}{f_c}$ $\lambda_c = 0.5 \text{ m}$

b) $NA = 0.48$ ~~the~~ $n_2 = 1.45$

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

$$0.48^2 = n_1^2 - n_2^2$$

$$0.2304 = n_1^2 - 2.1025$$

$$n_1^2 = 2.3329$$

$$n_1 = 1.527$$

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

$$\theta_a = \sin^{-1} (0.48) \quad \theta_a = 28.685$$

c) ~~Trans~~ For transverse electric modes, the electric field is perpendicular to the direction of the waves. The changing electric field generates a magnetic field. For transverse magnetic modes, the magnetic field is perpendicular to the direction of the waves. The changing magnetic field generates an electric field.

d) The isolators function is to cutoff the microwaves when they aren't needed

Q3 = (14)

4.a) $Q_1 = -20 \mu\text{C}$ $A(-5, 4, 6)$
 $Q_2 = 40 \mu\text{C}$ $B(4, 8, -2)$

$$\vec{F} = \frac{Q_1 Q_2}{4\pi\epsilon_0 d^2} \vec{a}_{12}$$

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

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

$$\vec{AB} = \vec{B} - \vec{A} = (4 - (-5))\vec{a}_x + (8 - 4)\vec{a}_y + (-2 - 6)\vec{a}_z$$

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

$$|\vec{AB}| = \sqrt{(4 - (-5))^2 + (8 - 4)^2 + (-2 - 6)^2}$$

$$= \sqrt{81 + 16 + 64} = 12.689$$

$$\vec{a}_{AB} = \frac{\vec{AB}}{|\vec{AB}|} = \frac{9\vec{a}_x + 4\vec{a}_y - 8\vec{a}_z}{12.689}$$

$$\vec{a}_{AB} = 0.709\vec{a}_x + 0.315\vec{a}_y - 0.63\vec{a}_z$$

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 d^2} = \frac{-20 \times 10^{-6} \times 40 \times 10^{-6}}{4\pi \times 8.85 \times 10^{-12} \times d^2} = -0.0442 \text{ N}$$

$$\sqrt{6.381^2 + 1.26^2 + (-5.04)^2} = \sqrt{40.717161 + 1.5876 + 25.4016}$$

$$d = 8.228$$

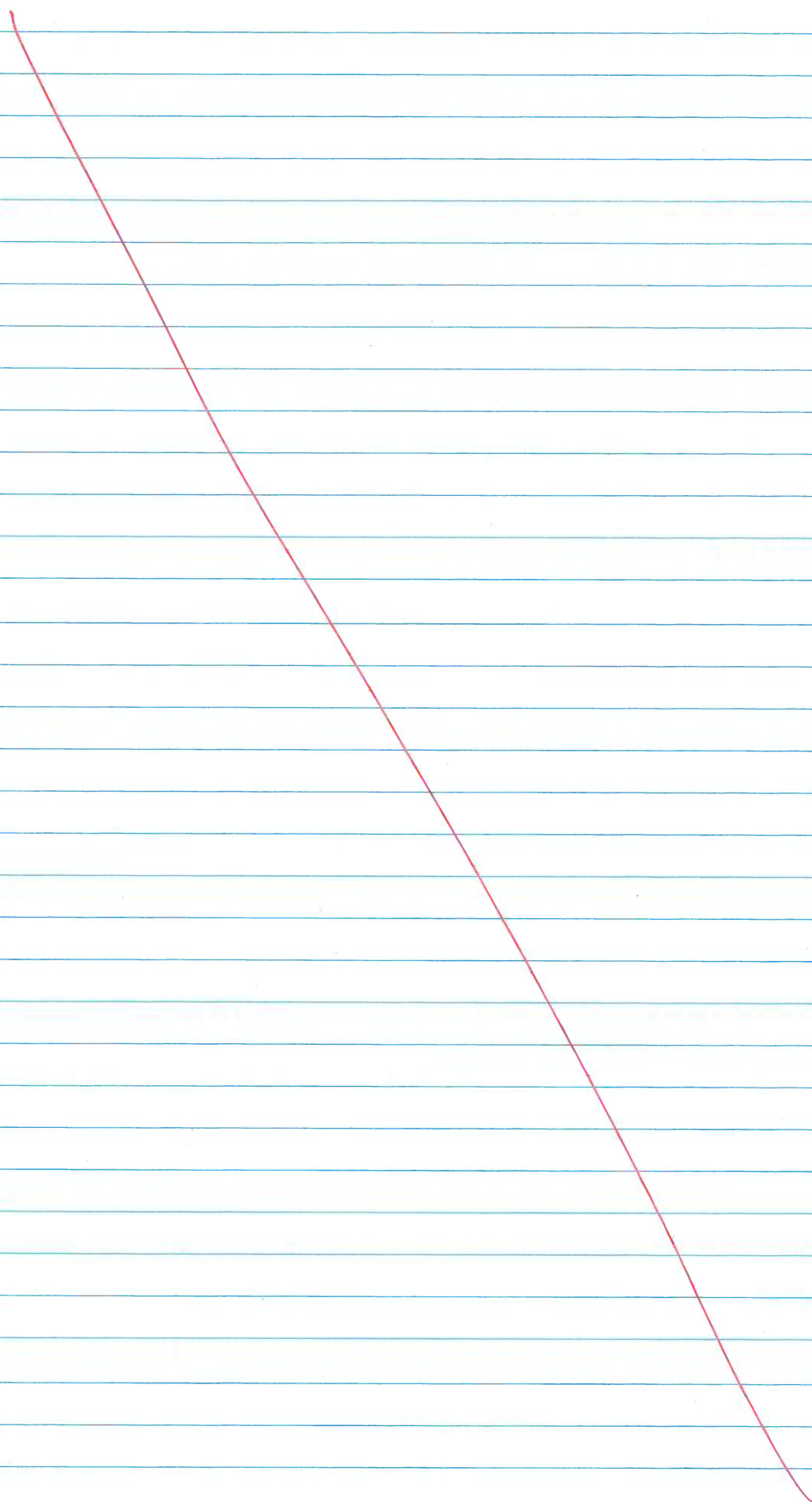
$$F = -0.106 \text{ N}$$

b)



Question No.

Examiner Only



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