

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 illegible script 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).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	2030850
2	Title of Examination Paper	Electromagnetic Radiation (OME)
3	Module Code	ACDC5009
4	Date and Time of Examination	08/05/2025 15:00
5	Examination Venue	1Q310
6	Seat Number	6
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	22
2	24
3	20
4	23
Total	89

(Gweler yr ochr arall am y fersiwn Cymraeg)

1) a)

$$\text{Frequency} = 2 \text{ GHz}$$

$$\text{target} = 1000 \text{ m/s}$$

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

Doppler Frequency shift =

$$1000 = \frac{\left(\frac{3 \times 10^8}{2 \times 10^9}\right) \times f_{dp}}{2}$$

$$f_{dp} = \frac{2 \times 1000}{\left(\frac{3 \times 10^8}{2 \times 10^9}\right)} = 13333.3 \text{ Hz} = \text{doppler frequency shift.}$$

b)

Signal Modulation is where the messenger signal is combined with a carrier signal. This allows for more efficient transmission over longer distances and allow digital signals to be transmitted as Analogue before being separated again when undergoing demodulation. phase, Amplitude and Frequency Modulation can all occur.

c)

$$c = f \times \lambda$$

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

$$f = \frac{3 \times 10^8}{800 \times 10^{-9}} = 3.75 \times 10^{14} \text{ Hz}$$

d)

$$\Delta E = \frac{2R}{c}$$

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

$$\Delta E = 2 \times 10^{-6}$$

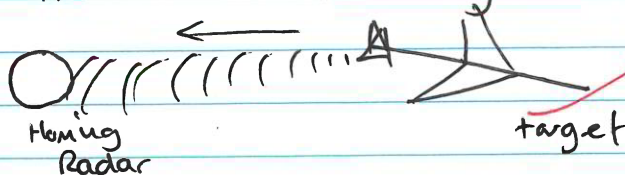
$$\frac{\Delta E \times c}{2} = R = 300 \text{ m}$$

- 1 e) Refractive index = 1.6
 angle of incidence = 45°
 glass refractive index = 1.5
 Critical angle =

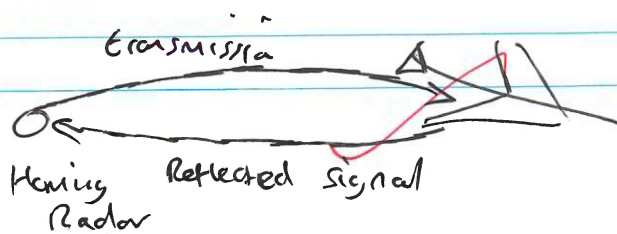
$$\begin{aligned}\phi_c &= \sin^{-1} \left(\frac{n_2}{n_1} \right) \\ &= \sin^{-1} \left(\frac{1.5}{1.6} \right) \\ &= 69.636^\circ = \text{Critical angle}\end{aligned}$$

- f) An Electromagnetic wave propagates in free space by the Electric and Magnetic field being ^{orientated} 90° which ^{are in phase} follows Maxwell's law ^{to occur} and means that the EM wave is transverse and self propagating.

- 2) a) i) passive radar homing is when the seeker only contains a receiver and detects emissions from the target like the target's radar. The homing device does not contain a transmitter as shown below. Ideal for targets with Radar Jamming.



- ii) Active Radar Homing Seeker contains both a transmitter and receiver. This means the target does not require to emit EM waves and the seeker is Fire and Forget. It is susceptible to Radar jamming. The receiver collects reflected waves.



- 2 a b) A Yagi-Uda antenna contains a driven element which is equal to $L = \frac{\lambda}{2}$
 $L = \left(\frac{3 \times 10^8}{200 \times 10^6} \right) / 2 = 0.75 \text{ m}$

The Reflector is 5% larger than the Driven Element so equals 0.7875 m

and the Director is 5% shorter than Driven Element so is 0.7125 m

The distance between Driven element and Reflector = $0.15 \times 1.5 \text{ m} = 0.225 \text{ m}$

The distance between Driven Element and Director is = $0.2 \times 1.5 = 0.3 \text{ m}$

- c) The Right Hand Rule for Electromagnetic radiation is where the Thumb points towards the direction of wave propagation. Fore finger points towards Electric current. Index finger points towards direction of Magnetic field.

Q2 = (24)

3) a) width = 4cm = 0.04m
 Height = 2cm = 0.02m
 TE₁₀

$$\begin{aligned}
 \text{i) cut off frequency} &= \frac{c}{2} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \\
 &= \frac{3 \times 10^8}{2} \sqrt{\left(\frac{1}{0.04}\right)^2 + \left(\frac{0}{0.02}\right)^2} \\
 &= \frac{3 \times 10^8}{2} \times \sqrt{625} \\
 &= \frac{3 \times 10^8}{2} \times 25 \\
 &= 3.75 \text{ GHz} = \text{cut off frequency}
 \end{aligned}$$

$$\begin{aligned}
 \text{ii) cut off wavelength} &= \lambda_c = \frac{c}{f_c} \\
 &= \frac{3 \times 10^8}{3.75 \times 10^9} \\
 \lambda_c &= 0.08 \text{ m}
 \end{aligned}$$

b) NA of fiber = 0.48
 Refractive index of cladding = 1.45
 Refractive index of core =

$$\begin{aligned}
 NA &= \sqrt{n_1^2 - n_2^2} & NA &= 0.48 \\
 & & n_2 &= 1.45
 \end{aligned}$$

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

$$\begin{aligned}
 0.48^2 + 2.1025 &= n_1^2 \\
 n_1^2 &= 2.3329
 \end{aligned}$$

$$n_1 = 1.527 = \text{Refractive index of core}$$

3 b)
continued

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

$$= \sin^{-1} \left(\frac{0.48}{1.527} \right)$$

$$= 18.316^\circ$$

c) TE modes ~~are~~ when the Electric field is perpendicular to the direction of propagation of the wave and Magnetic field is in the same direction.

~~TM~~

TM Mode is when Electric field runs the same direction as wave propagation and Magnetic field is perpendicular.

d) An Isolator ~~is a~~ allows for the signal to travel in one direction. This is need for the Gunn oscillator to emit a clear signal

Q3 = 20

4 a) $Q_2 = 40 \text{ nC}$ at point B(4, 8, 2)
 $Q_1 = -20 \text{ nC}$ at point A(-5, 4, 6)

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

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

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

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

$$|\vec{AB}| = \sqrt{(9)^2 + (4)^2 + (-4)^2}$$

$$= \sqrt{161} = 12.689$$

$$= \sqrt{161} = d$$

$$F = \frac{Q_1 \times Q_2}{4\pi\epsilon_0 \times d^2}$$

$$= \frac{(-20 \times 10^{-6}) \times (40 \times 10^{-6})}{4\pi \times 8.854 \times 10^{-12} \times 161}$$

$$= \frac{(-8 \times 10^{-10})}{1.7913 \times 10^{-8}}$$

$$= -0.04466 \text{ N}$$

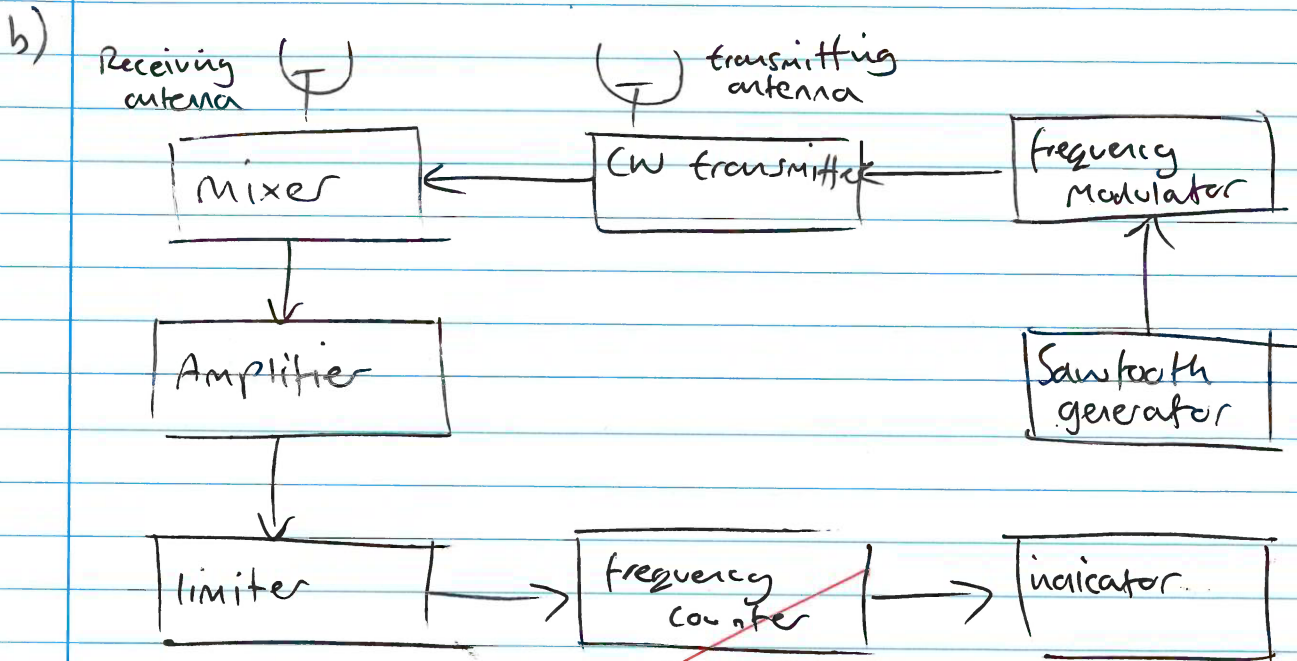
$$= -44.660 \text{ mN} = \text{Force exerted on } Q_2 \text{ by } Q_1 \text{ in Free Space}$$

$$\text{in Vector form } -0.04466 \times \text{unit vector}$$

4 a) $-0.04466 \times \left(\frac{9}{\sqrt{161}} \bar{a}_x + \frac{4}{\sqrt{161}} \bar{a}_y - \frac{8}{\sqrt{161}} \bar{a}_z \right)$

$$= -0.0317 \bar{a}_x N - 0.0141 \bar{a}_y N + 0.0282 \bar{a}_z N$$

= Force in vector form.



a CW Radar emits a ~~cont~~ continuous signal and is used for detecting velocity of target. This is achieved by modulating the signal generated at the sawtooth generator by mixing the signal with a carrier signal by varying frequency. This is then emitted to target where the reflected wave is returned to the receiver where the two signals are mixed and demodulation occurs. This is passed through limiter and then displayed on the indicator.



Question No.

Examiner Only

