



propagate
to being
lives
light

12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, sign and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either read the script or have it typed and the expense of typing is 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.
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List the numbers of the questions you have attempted	Office Use
Q1	20 ✓
Q2	16 ✓
Q3	15 ✓
Q4	13 ✓
Total	64

(Gweler yr ochr arall am y fersiwn Cymraeg)

Q 1

a)

Electromagnetic waves can propagate without a medium due to being transverse in nature allowing the waves to travel through a vacuum. This can be seen for example by the speed of light travelling constantly through any medium at $3 \times 10^8 \text{ m/s}$.

$$b) \quad P = (-0.2, 0, -2.3)_m$$

$$Q = (0.2, 0.1, -2.5)_m$$

$$\begin{pmatrix} -0.2 \\ 0 \\ -2.3 \end{pmatrix} \cdot \begin{pmatrix} 0.2 \\ 0.1 \\ -2.5 \end{pmatrix} = \begin{matrix} -0.4 \\ -0.1 \\ 0.2 \end{matrix}$$

$$\sqrt{(-0.4)^2 + (-0.1)^2 + (0.2)^2}$$

$$d = 0.458$$

$$\begin{aligned} -0.4 \div 0.458 &= -0.87 \\ -0.1 \div 0.458 &= -0.218 \\ 0.2 \div 0.458 &= 0.437 \end{aligned}$$

$$\vec{f} = \frac{q_1 q_2}{4\pi\epsilon_0 d^2} \hat{a}_{12}$$

$$= \frac{5 \times 10^{-9}}{4\pi \times 8.854 \times 10^{-12} \times (0.458)^2}$$

$$= 214.33 \text{ N}$$

$$\begin{pmatrix} -0.87 \\ -0.218 \\ 0.437 \end{pmatrix}$$

Q1C)

Non ionising and ionising EM radiation depend on the whereabouts on the EM spectrum - Ionising radiation is harmful to the human body (X-Rays and Gamma Rays) - These are normally used for medical treatments at very small dosages due to their small wavelength and high frequency which excites and kills cancer cells for example.

Non ionising is on the lower part of the spectrum with a longer wavelength and lower frequency. Radio waves, microwaves and visible light are all types of non ionising EM radiation. These are often used in communication for walkie talkies or VHF radios, microwaves are also used to heat food in the household by exciting the ions in the food. Visible light is allowing humans to see colour etc through our eyes.

Q2a)

EM waves are transverse in nature allowing them to propagate through any medium / vacuum.

- They are non-mechanical waves
- They obey the law of $c = f\lambda$ for traveling at the speed of light.
- can travel both TE and TM mode 90° to each other.
- can be used for transmitting data across distances.

Q2 b)

Gauss law of electricity

$$\nabla \cdot E =$$

Gauss law of electricity states that the electric field must equate to

ii) Faraday's law of induction.

Faraday law of induction states that

~~is~~.

Q2C)

$$\text{Current } S = 3A, 6A$$

$$\text{distance} = 5\text{cm} / 0.05\text{m}$$

$$\text{permability} = 4\pi \times 10^{-7} \text{ H/m}$$

$$F = \frac{\mu I_1 I_2}{2\pi d}$$

$$F = \frac{4\pi \times 10^{-7} \times 3A \times 6A}{2\pi \times 0.05}$$

$$F = \frac{2\pi \times 10^{-7} \times 3 \times 6}{\pi \times 0.05}$$

$$F = \frac{2 \times 10^{-7} \times 3 \times 6}{0.05}$$

$$F = 72 \times 10^{-4} \text{ N/m}$$

$$F = 72 \mu \text{ N/m}$$

Q2D)

$$NA = 0.48$$

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

$$RI = 1.45$$

$$n = \frac{c}{v}$$

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

$$= \sqrt{0.48^2 + 1.45^2}$$

$$= 1.527$$

$$= 1.53$$

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

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

$$\phi_a = 28.69^\circ$$

Q3A

$$W = 4\text{cm} / 0.04\text{m}$$

$$h = 2\text{cm} / 0.02\text{m}$$

TE 10

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

$$f_c = \frac{c}{2} \sqrt{\left(\frac{0.04}{10}\right)^2 + \left(\frac{0.02}{10}\right)^2}$$

$$f_c = \frac{3 \times 10^8}{2} \sqrt{\left(\frac{0.04}{10}\right)^2 + \left(\frac{0.02}{10}\right)^2}$$

$$f_c = \frac{1.2 \times 10^3}{2} \text{ Hz} \quad f_c = 120 \text{ kHz}$$

$$ii) \lambda = \frac{c}{f_c} = \frac{3 \times 10^8}{120 \times 10^3} = 2.5 \text{ m}$$

Q3b)

Signal modulation is when the properties of a wave are changed, wavelength, frequency or phase to allow data to be added to a carrier signal.

- can be used for encrypting data when transmitting.
- can be used to increase the length of transmission / distance of transmission.

Q3c

Phased array -

A Phased array is a system whereby you have multiple antennas phased differently to each other allowing for better coverage and RF transmission patterns.

- Increase efficiency of the transmissions.
- Better distances achieved when using an array
- Transmission pattern is more thorough.
- More efficient and effective.

Q3d)

$$c = f \cdot \lambda$$

$$f = \frac{c}{\lambda}$$

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

$$f = 375 \times 10^{12}$$

$$f = 375 \text{ THz}$$

Q4a)

$$v = \frac{2 f_p d}{2}$$

$$f_p = \frac{2 \times 1000}{2 \times 10^9}$$

$$= 1 \times 10^{-6}$$

Q4b)

$$t_d = 2 \times 10^{-6} \text{ s}$$

$$S_{ol} = 3 \times 10^8$$

$$d = vt$$

$$d = 3 \times 10^8 \times 2 \times 10^{-6} = 600 \text{ m}$$

$$d = \frac{600}{2} = 300 \text{ m}$$

Distance to target = 300m

Q4C

$$f = 5 \text{ GHz} / 5 \times 10^9$$

$$P = 150 \text{ kW} / 150 \times 10^3$$

$$G_{\text{ain}} = 25$$

$$P_{\text{Gain}} = 20$$

$$\text{System loss} = 1.5$$

$$RCS = \sigma = 8 \text{ m}^2$$

$$d = 20 \text{ km} / 20,000 \text{ m}$$

$$i) \quad c = f \lambda$$

$$\triangle \frac{c}{f \lambda}$$

$$\lambda = \frac{c}{f}$$

$$\lambda = \frac{3 \times 10^8}{5 \times 10^9}$$

$$\lambda = 0.06 \text{ m.}$$

$$ii) \quad P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4 L}$$

$$P_r = \frac{(150 \times 10^3) (25) (20) (0.06)^2 (8)^2}{(4\pi)^3 (20,000)^4 \cdot 1.5}$$

$$P_r = 3.628 \times 10^{-14}$$

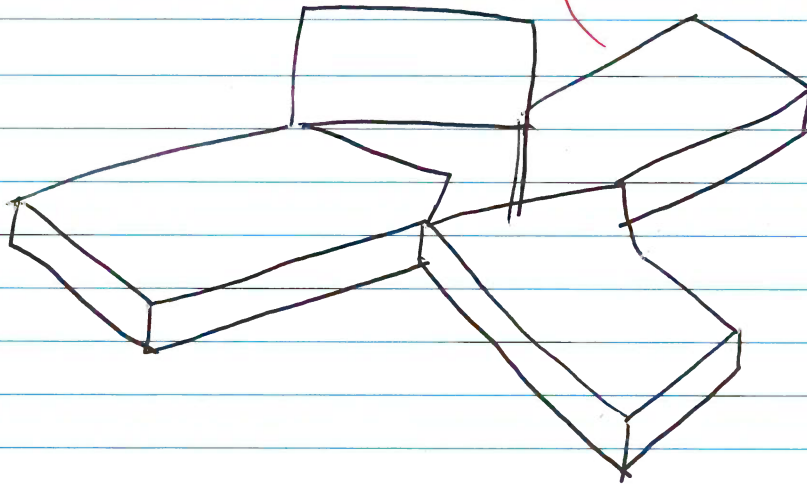
$$= 36.28 \text{ fW}$$

Q4d)

A 4 port magic Tee is used to direct RF in one direction. it has 2 input ports which are co linear and 2 output ports. These can direct RF into a direction.

Port 1 = Co linear ✓
 Port 2 = Co linear ✓
 Port 3 = ~~shut~~ ✓
 Port 4 = Output ✓

- Used to direct and channel comms.



Q4 = 13 ✓



Examiner Only

Question No.

Arholwr yn unig

Rhif y Cwestiwn