



ed in

12 Pages

A hand-drawn diagram on lined paper showing a triangle. A vertical red line is drawn from the top vertex to the base. A diagonal green line is drawn from the top vertex to the right side. The lines are drawn with a marker.

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 read legible 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.
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	2114468
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	AE DC 5009
4	Date and Time of Examination	03/05/2023 0920
5	Examination Venue	IQ 112 Swansea Campus
6	Seat Number	N/A
7	Number of Answer Books handed in	

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

$$\frac{62}{100}$$

pl-1

$$62 \overline{) 100}$$

~~180~~

1)

~~An electromagnetic wave is self propagating in nature and has an electrical field and a magnetic field at 90° / perpendicular to the direction.~~

A) An electromagnetic wave is a wave made of electric and magnetic fields and with multiple capabilities. is measured in Hz or frequency.

B) The magnetic field is at 90° to the electric field.
The shorter the wavelength the higher the frequency.
~~It is made~~

C) An electromagnetic wave is self propagating in nature and consists of both an electric field and a magnetic field at 90° or perpendicular at time of propagation.

D) The electromagnetic spectrum is a range of electromagnetic radiation and is split into 6 main forms. - Radio waves, microwaves, infrared, ultraviolet, x-ray and gamma.

Radio waves operate at a frequency of 300 MHz and below
their size is 1mm to 10000km

AM Frequency 50 - 80 MHz

FM Frequency 80 - 110 MHz

Radio waves are most commonly used nowadays in radio transmission and receiving. They are also used in phones.

Q1)

E) TE mode is a transverse Electric mode meaning there is no electric field in the direction of propagation.

- They can also be designed as H modes due to them only having a magnetic field in the direction of propagation.

Q1
1+1+2+2+2+1+2
= 11

Q2

A) polarisation can come in multiple forms.
Horizontal and vertical are the main ones.

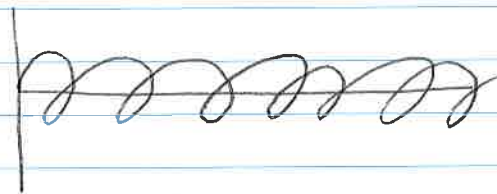
circular ✓

elliptical ✓

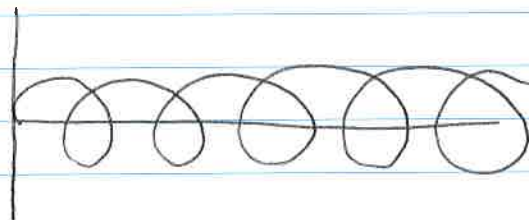
Linear ✓



Linear 3D plane ✓



Elliptical 3D plane ✓



circular 3D plane ✓

polarisation is the direction in which the wave or frequency is set out at i.e. vertical or horizontal polarisation.

Q1

Q2

$$B) \quad Q_1 = -20 \mu C = -20 \times 10^{-6} C \quad Q_2 = 50 \mu C = 50 \times 10^{-6} C$$

$$\vec{P} = (-6, 4, 6)$$

$$\vec{R} = (5, 8, -2)$$

$$\vec{R} = 5a_x + 8a_y - 2a_z$$

$$\vec{P} = -6a_x + 4a_y + 6a_z$$

$$\vec{R} - \vec{P} = 11a_x + 4a_y - 8a_z$$

$$|\vec{R} - \vec{P}| = \sqrt{11^2 + 4^2 + (-8)^2}$$

$$|\vec{R} - \vec{P}| = 14.177$$

$$a_{12} = \frac{\text{vect}}{\text{magnitud}}$$

$$a_{12} = \frac{11a_x + 4a_y - 8a_z}{14.177} = 0.776a_x + 0.282a_y - 0.564a_z$$

$$\vec{F} = \frac{Q_1 Q_2}{4\pi\epsilon_0 d_{12}^2} a_{12}$$

$$\vec{F} = \frac{-20 \times 10^{-6} \times 50 \times 10^{-6}}{4\pi \times 8.854 \times 10^{-12} \times 14.177^2} [0.776a_x + 0.282a_y - 0.564a_z]$$

$$\vec{F} = -0.0447 [0.776a_x + 0.282a_y - 0.564a_z]$$

$$|\vec{F}| = \sqrt{-0.0347^2 + 0.0126^2 + 0.0252^2}$$

$$|\vec{F}| = 0.0447 \text{ N}$$

$$= 44.7 \text{ mN}$$

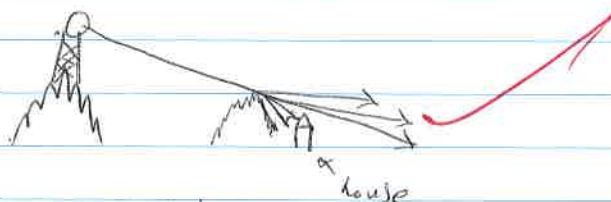
Q2

2+2+2+2+2+2+2=14

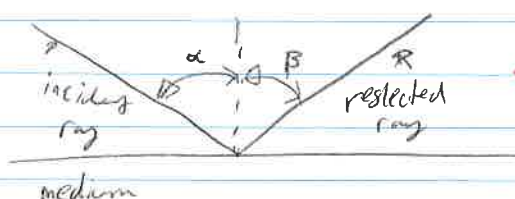
Q3)

A)

- i) Diffraction is when the ray hits a point which scatters it possibly behind objects.

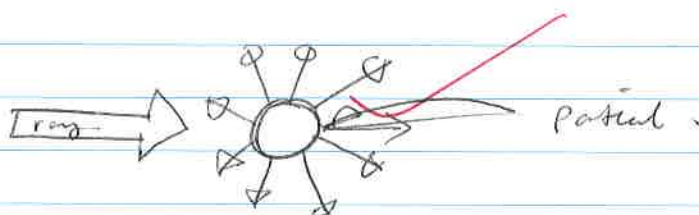


- ii) Total internal reflection is the incident ray bounces off the medium at the same angle as it was bounced on.

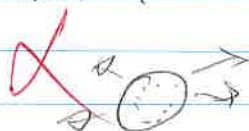


α = Angle of incidence
 β = Angle of reflection

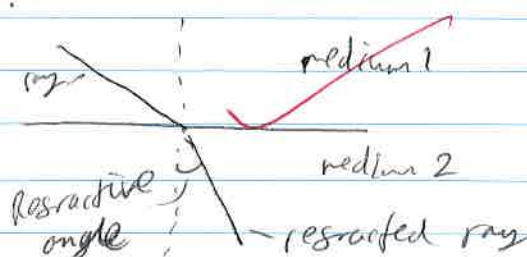
- iii) Scattering is when the ray hits a particle the particle then becomes the center and splits the ray.



- iv) Interference is ~~the~~ when the ray or frequency gets interrupted in channel.

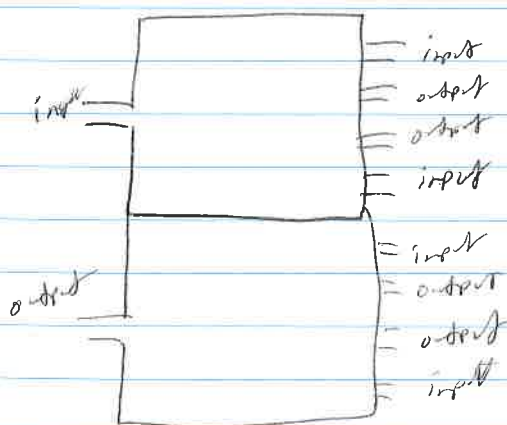
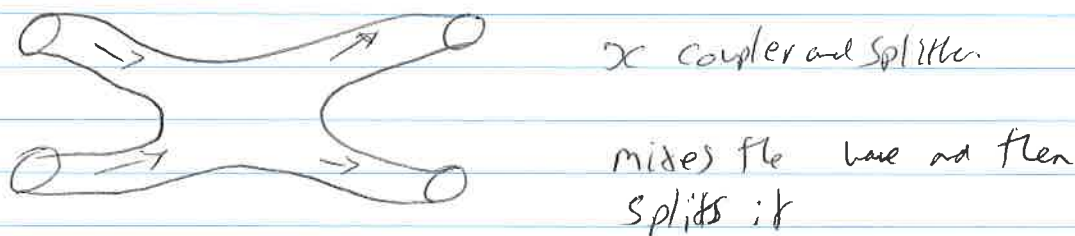
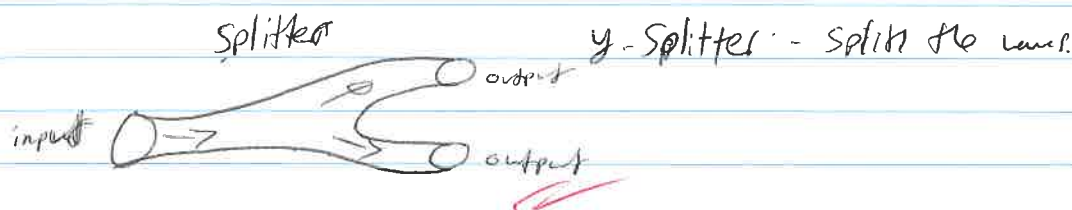
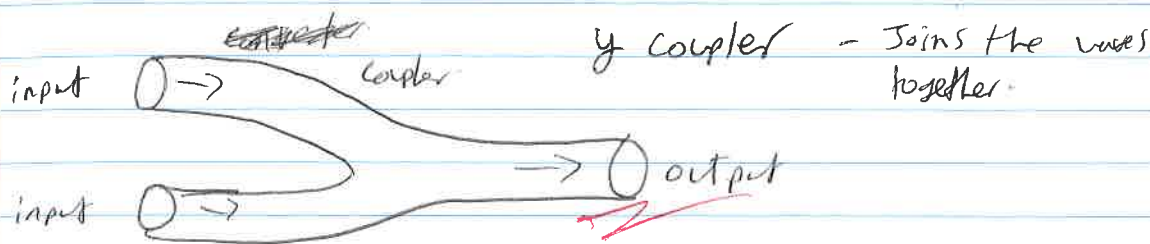


- v) Refraction is the ray changing its path or frequency from 1 medium to another.



Q3)

B) A wave guide is a component which can alter the direction of the waves. ~~Amplitude of signal~~.



A wave guide can alter the direction or capability of the wave. it can be done through couplers or splitters.

Q3
2+2+2+2+1+1

10
Rhif y Cwestiwn

Q5)

a)

$$\frac{L}{d} = \frac{1.257 \times 10^{-7}}{2\pi} \ln\left(\frac{3 \times 10^3}{1 \times 10^3}\right)$$

$$\frac{L}{d} = 2.19785917 \times 10^{-8}$$

$$= 2.198 \times 10^{-8}$$

$$\frac{L}{d} = 2.198 \times 10^{-8}$$

$$\frac{L}{d} = \frac{\mu}{2\pi} \ln\left(\frac{b}{a}\right) \text{ H/m}$$

$$a = 1 \text{ mm} \times 1000 = 1 \times 10^3 \text{ m}$$

$$b = 3 \text{ mm} \times 1000 = 3 \times 10^3 \text{ m}$$

$$\mu_0 = 4\pi \times 10^{-7}$$

$$\mu_r = 1$$

$$\mu = \mu_0 \mu_r$$

$$1 \times 4\pi \times 10^{-7} = \mu = 1.257 \times 10^{-6}$$

Q5)

B)

characteristic impedance = $524.4 \angle -37^\circ$

Attenuation constant

phase constant.

$$Z_{oc} = 550 \angle -60^\circ$$

$$Z_{sc} = 500 \angle -14^\circ$$

$$Z_0 = \sqrt{Z_{oc} Z_{sc}}$$

$$Z_0 = \sqrt{500 \times 550 \angle \frac{-60^\circ + (-14^\circ)}{2}} = \frac{-74}{2} =$$

$$Z_0 = 524.4 \angle -37^\circ$$

P.T.O

Q5)

B)

part 2)

$$\tanh \gamma = \sqrt{\frac{Z_{sc}}{Z_{oc}}}$$

$$-14 + 60 = \frac{46}{2} = 23$$

$$\tanh \gamma = \sqrt{\frac{500 \angle -14}{550 \angle -6}} = 0.953 \angle 23$$

polar to rectangular

$$r = 0.953 \cos(23) = x = 0.877$$

$$i = 0.953 \sin(23) = jy = j0.372$$

$$x + jy = 0.877 + j0.372$$

$$\tanh x = \frac{e^{2x} - 1}{e^{2x} + 1}$$

$$\tanh x = \tanh \gamma$$

$$\frac{e^{2x} - 1}{e^{2x} + 1} = 0.877 + j0.372$$

$$e^{2x} - 1 = (e^{2x} + 1)(0.877 + j0.372)$$

$$e^{2x} - 1 = 0.877e^{2x} + j0.372e^{2x} + 0.877 + j0.372$$

$$e^{2x} - 0.877e^{2x} - j0.372e^{2x} = 1 + 0.877 + j0.372$$

$$e^{2x}(1 - 0.877 - j0.372) = 1.877 + j0.372$$

$$e^{2x} = \frac{1.877 + j0.372}{(0.123 - j0.372)}$$

$$r = \sqrt{x^2 + y^2}$$

$$\text{rect to polar } \phi = \tan^{-1}\left(\frac{y}{x}\right)$$

$$e^{2x} = \frac{1.914 \angle 11.2^\circ}{0.392 \angle -71.7^\circ}$$

$$e^{2x} = 4.9 \angle 82.9$$

$$\ln[a \angle b] = \ln a + jb$$

Ln both

$$2x = \ln[4.9 \angle 82.9]$$

$$2x = 1.589 + j41.45$$

$$2x = 1.589 + j82.9$$

$$x = 0.795 + j41.45$$

$$\alpha = 0.795$$

$$\beta = 41.45$$

$$2 + 2 + 3 + 3 + 2 + 2 + 2 + 2 = 17$$

Q4)
A)

$$\rho v = 10 z^2 x \sin \pi y \quad (-1 \leq x \leq 2) \quad (0 \leq y \leq 1) \quad (3 \leq z \leq 3.6)$$

$$\rho v = 10 \int_{-1}^2 \int_0^1 \int_3^{3.6} z^2 x \sin \pi y \, dx dy dz$$

$$\rho v = 10 \left[\int_{-1}^2 x \right] \left[\int_0^1 \sin \pi y \right] \left[\int_3^{3.6} z^2 \right]$$

$$\rho v = 10 \left[\frac{x^2}{2} \right] \left[\frac{-\pi \cos \pi y}{\pi} \right] \left[\frac{z^3}{3} \right]$$

$$\rho v = 10 \left[\left[\frac{2^2}{2} - \frac{-1^2}{2} \right] \left[\frac{-\pi \cos(\pi)}{\pi} - \frac{-\pi \cos(0)}{\pi} \right] \left[\frac{3.6^3}{3} - \frac{3^3}{3} \right] \right]$$

$$\rho v = 10 \left[[1.5] [-0.998 - (-1)] \right] [15.552 - 9]$$

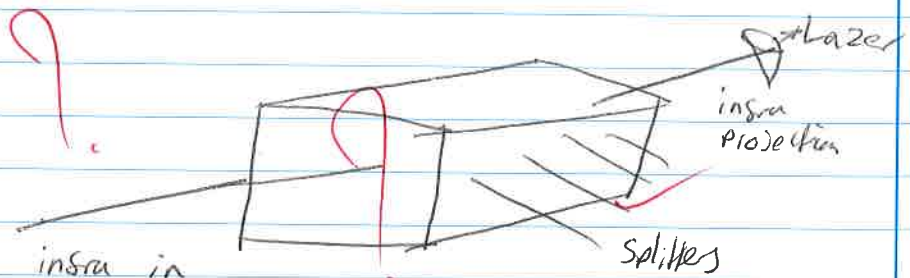
$$\rho v = 0.01497$$

b) Refractive 1.50 core clad 1.47. $\phi_c = \sin^{-1} \left(\frac{n_2}{n_1} \right)$

p to Q4B)
cond.

$$\sin^{-1} \left(\frac{1.47}{1.50} \right) = 78.5^\circ \text{ critical Angle.}$$

- c) The light (infrared rays) are projected into a splitter that splits and the ~~an~~ couples applying the intensity of the laser the box then guides it in a straight line which is the projection of millions of infrared light particles.



- d) The Isolator isolates certain parts of the wave which allow a steady flow with no interaction.

Q4)

B)

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

$$NA = \left(n_2^2 - n_1^2\right)^{\frac{1}{2}} \checkmark$$

$$NA = \left(1.47^2 - 1.50^2\right)^{\frac{1}{2}}$$

$$\sin^{-1}\left(\frac{0.3}{120\pi}\right) = 0.045.$$

$$n_0 = 120\pi$$

$$Q_4 = 2+2+2+2+1+1 = 10$$

Question No.

Examiner Only

Arholwr yn unig

Prifff y Cwestiwn