

PRIFYSGOL CYMRU

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Examination Answer Book

24 Pages

Instructions to candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right and seal 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	P148323
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	MSX00941
4	Date and Time of Examination	23/6/17 10:00 am
5	Examination Venue	MH502
6	Seat Number	

7	Number of Answer Books handed in	1
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List the numbers of the questions you have attempted	Office Use
Q1	36
Q2	60
Q3	100
Total	196 = 65%

FOLD

Complete
section,
remove
strip, fold as
indicated
and SEAL

Please complete this section and SEAL before the examination starts.

Forename(s)

Surname _____

a)

2. $P_T = 30 \times 10^3$

$G_T = 30 \text{ dB} = G_R$

$f = 10 \times 10^9 \text{ Hz}$ $\lambda = \frac{c}{f} \therefore \lambda = \frac{3 \times 10^8}{10 \times 10^9} \lambda = 0.03 \text{ m}$

$\text{SNR}_d = 10 \text{ dB}$

$L_{\text{ges}} = 0.9$

$\text{SNP}_{\text{dBW}} = -90 \text{ dBW}$ $P_{\text{Rmin}} = -90 \text{ dBW} + 10 \text{ dB} = -80 \text{ dB} \therefore 1 \times 10^{-8} \text{ W}$

$\sigma = 200 \text{ m}^2$

$P_{\text{Rmin}} = 1 \times 10^{-8} \text{ dBW}$

$$r_{\text{max}} = \sqrt[4]{\frac{P_T G_T G_R \sigma \lambda^2}{(4\pi)^3 P_{\text{Rmin}} L_{\text{ges}}}}$$

$$r_{\text{max}} = \sqrt[4]{\frac{30 \times 10^3 \cdot 30 \cdot 30 \cdot 200 \cdot (0.03)^2}{(4\pi)^3 \cdot 1 \times 10^{-8} \cdot 0.9}}$$

$r_{\text{max}} = 722.26 \text{ m}$

$\frac{48}{80}$

b) X-band radar is useful for small maritime craft as the wavelength, commonly 3cm is small so that it can reflect off of a small scattering area, known as radar-cross-section.

The X-band spectrum is commonly CW (Continuous wave), so that X-band is used for phase shifting of the Tx/Rx signal in order to calculate velocity of objects or maritime craft approaching rapidly, this phase-shifting is known as the doppler effect. Time taken to receive signal back (Rx) is quicker compared with other radar spectrums. X-band 3cm λ radar is useful for propagating high energy in a shorter distance compared to L-band. *Not a chance!*

The far field distance for radar is shorter compared with other band radar's. This is particularly useful for close-in vessels.

$\frac{12}{20} // \frac{60}{1.00}$

3)

a) $I = 1 \text{ W/m}^2 = P$

$$Z_0 = \frac{E}{H} \therefore Z_0 \cdot H = \frac{E}{H} \times H \therefore \frac{Z_0 \cdot H}{Z_0} = \frac{E}{Z_0}$$

$$Z_0 = 377 \Omega$$

$$P = \frac{1}{2} \cdot |E| \cdot |H|$$

$$\therefore H = \frac{E}{Z_0}$$

$$P = \frac{1}{2} \cdot E \cdot \frac{E}{Z_0} \therefore P = \frac{1}{2} \cdot \frac{E^2}{Z_0} \therefore P = \frac{E^2}{2Z_0}$$

$$1 = \frac{E^2}{2 \cdot 377 \Omega} \therefore 1 \cdot 754 \Omega = E^2 \therefore \sqrt{1.754} = E$$

$$E = 27.459 \text{ V/m}$$

use of dot notation for product is annoying!

$$\left(\frac{50}{50} \right)$$

b) $P_{\text{density}} = ?$

$$P = \frac{1}{2} \cdot |E| \cdot |H|$$

$$H = \frac{E}{Z_0}$$

$$E = 10^7 \text{ V/m}$$

$$\therefore P = \frac{1}{2} \cdot \frac{E^2}{Z_0}$$

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

$$11 \mu\text{m spot} = 11 \times 10^{-6} \text{ m}$$

$$P = \frac{1}{2} \cdot \frac{E^2}{Z_0} \therefore P = \frac{(10^7)^2}{754} \quad P = 1.326 \times 10^{11} \text{ W/m}^2$$

$$\text{J/s m}^2 = 1.326 \times 10^{11} \text{ W/m}^2 \times 2 \times 10^{-6} \text{ s} = 2.652 \times 10^5 \text{ J/s m}^2$$

$$A = \frac{\pi \cdot d^2}{4} \quad A = \frac{\pi \cdot (11 \times 10^{-6})^2}{4} \quad A = 9.503 \times 10^{-11} \text{ m}^2$$

$$E_0(\text{J}) = 2.652 \times 10^5 \text{ J/m}^2 \times 9.503 \times 10^{-11} \text{ m}^2$$

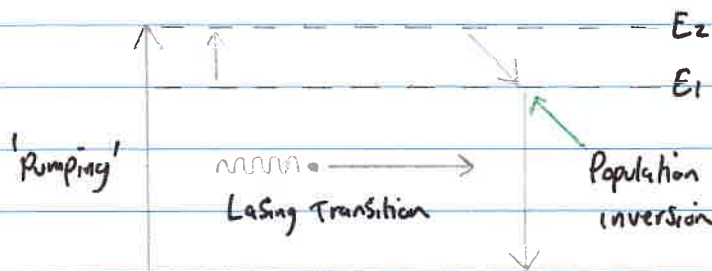
$$E_0(\text{J}) = 25.202 \mu\text{J}$$

Variance is due to chosen precision of number presentation

$$\left(\frac{50}{50} \right)$$

$$\left(\frac{1.00}{1.00} \right)$$

1) a) Population inversion is the state to which the excited atoms in the upper threshold releases an electron to transverse into a photon for lasing. This is called emission to where the lasing occurs. ✓



it's defined as population inversion because the populated ~~electrons~~ atoms in the upper threshold revert back to their normal equilibrium state, known as inversion. it is done quickly so that all of the energy in the populated atoms can lase and produce an intense pulse of photon energy. ✓

b) $E_2 - E_1 = hf$ $E_2 - E_1 = h\nu$

$h = \text{plank's constant } (6.63 \times 10^{-34})$

$E_2 = 1\text{eV}$?

$E_1 = 0.183\text{eV} - 0.3\text{eV}$ ✓ $\therefore E_1 = 0.2415\text{eV}$ ✗ 0.117

$E_2 - E_1 = hf$ $\therefore \frac{E_2 - E_1}{h} = \frac{hf}{h}$ $\therefore f = \frac{E_2 - E_1}{h}$ ✓

$\therefore \frac{1 - 0.2415}{6.63 \times 10^{-34}} = 1.144 \times 10^{33} \text{ Hz}$?

Got the idea, but simple mistakes. ✓

c) Pop Inv = 10^8

$10^8 \times 1\text{eV}$ ✗

$1\text{eV} = 1.60218 \times 10^{-19} \text{ J}$

Pulse = $1\mu\text{s} (1 \times 10^{-6} \text{ s})$

$\therefore 10^8 \times 1.60218 \times 10^{-19}$

$f = 100$

$= 1.60218 \times 10^{-11} \text{ J}$

$P_{\text{inv}} = ?$

Avg Pwr = ?

What =

$1.60218 \times 10^{-11} \text{ J} \times 1 \times 10^{-6} \text{ s} = 1.60218 \times 10^{-17} \text{ J}$ ✓

$\therefore 1.60218 \times 10^{-17} \text{ J} \times 100 \text{ Hz} = 1.6218 \times 10^{-15} \text{ J}$

862
40
36

4) $n = 1.51$ @ 400nm

a) $n = 1.49$ @ 600nm

1010

$$V_g = V_p + \frac{V_p \lambda}{n} \frac{\partial n}{\partial \lambda} = V_p \left(1 + \frac{\lambda}{n} \frac{\partial n}{\partial \lambda} \right)$$

$$\lambda = \text{Avg } \lambda = \frac{400 + 600}{2} = 500\text{nm}$$

$$n = \text{Avg } n = \frac{1.51 + 1.49}{2} = 1.50$$

$$\partial n = 1.51 - 1.49 = 0.02$$

$$\partial \lambda = 600 - 400 = 200\text{nm}$$

∴

$$V_g =$$