

PRIFYSGOL CYMRU

Y Drindod Dewi Sant

UNIVERSITY OF WALES

Trinity Saint David

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	P148322
2	Title of Examination Paper	ELECTROMAGNETIC RADIATION
3	Module Code	MSX00941
4	Date and Time of Examination	23.06.17 10:00
5	Examination Venue	502
6	Seat Number	

7	Number of Answer Books handed in	
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List the numbers of the questions you have attempted	Office Use
1	46
2	44
3	60
Total	$\frac{150}{3.00} = 50$

—FOLIO

Complete
section,
remove
strip, fold as
indicated
and SEAL

Please complete this section and SEAL before the examination starts.

(Block Capitals) Forename(s)

Surname _____

1. Population inversion is whereby (Lasers) energy is pumped into a laser cavity in order to excite atoms to a higher energy level. More ~~at~~ ~~electrons become~~ in an excited state than the. This results in more electrons being in the higher 'excited' energy state than in the lower energy state (level) and so more electrons are excited than what would naturally occur in the material. More energy is put into the system than is given out. As electrons lose their energy or fall, they give off energy in the form of a photon. Saturation occurs when as many as possible atoms are in the higher level. This population inversion allows the cavity to build up the energy inside the material to excite electrons very quickly and frequently and release the energy (photons as laser light). Control of the production of light allows for coherent light to be released on demand by either Q-switching. Mode locking enables the build up of energy inside the cavity. Enables design and build of a system that can produce (a laser) a light source with energy in the form of photons that have a coherent emission from the cavity in a focussed path of light. Light can Laser light can be focussed onto a spot.

$$1b. \quad 0.3 \text{ eV} \rightarrow 0.183 \text{ eV}$$

$$0.3 - 0.183 = 0.117 / 1000 = 0.117$$

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

$$c = f\lambda$$

$$f = c/\lambda$$

$$c = hf$$

$$f = hf/\lambda$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$0.117 \times 1.60218 \times 10^{-19} \text{ J}$$

$$0.117 \times 1.60218 \times 10^{-19} = 1.8745506 \times 10^{-20} \text{ J}$$

$$E = 1.8745506 \times 10^{-20} \text{ J} \quad \text{energy}$$

$$P_{\text{flow}} = \frac{1}{2} |E \cdot H|$$

$$H = E^2 / 377 \text{ V}$$

$$P = \frac{1}{2} E^2 / 377$$

$$P = \frac{1}{2} \times (1.8745506 \times 10^{-20} \text{ J})^2 / 377 \times 2$$

$$P = 4.660397814 \times 10^{-43} \text{ J}$$

$$\text{Power} = \text{energy} / \text{time}$$

$$\lambda =$$

$$c = hf$$

$$3 \times 10^8 \text{ m/s} = 6.63 \times 10^{-34}$$

$$f = 3 \times 10^8 / 6.63 \times 10^{-34} = 4.5 \times 10^{41}$$

$$f = c/h = hf/\lambda$$

$$f = f\lambda/\lambda \text{ OR } f = hf/\lambda$$

$$\Delta E = 0.117 / 377 =$$

$$\Delta E = P/\epsilon$$

$$1.8745506 \times 10^{-20} \text{ J} = P/377$$

$$P = 1.8745506 \times 10^{-20} \text{ J} \times 377 = 5.936 \times 10^{-18}$$

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

$$\lambda = c/f$$

$$f = 4.5 \times 10^{41} \text{ Hz}$$

Good start, then lost in the middle

16/40

Q 10^8 inversion
 Pulse $t = 1 \times 10^{-6}$ $f = 100 \text{ Hz}$

$$1 \times 10^8 \times 1.60218 \times 10^{-19} \text{ J} = 1.60218 \times 10^{-11} \text{ J} \quad \times$$

$$\text{Power} = \text{energy} \div \text{time} \quad \text{J/s}$$

$$\begin{array}{l} 100 \text{ discharges per second} \times 1 \times 10^{-6} \text{ s} \\ \text{time} = 1 \times 10^{-4} \text{ on time} \end{array} \quad \checkmark$$

$$\text{Average Power} = 1.60218 \times 10^{-11} \text{ J} \div 1 \times 10^{-4}$$

$$= 1.60218 \times 10^{-7} \text{ W}$$

$$\frac{1.60218 \times 10^{-11} \text{ J} \times 100}{\text{time} = 100 \times 1 \times 10^{-6} \text{ s}} = 1.60218 \times 10^{-9} \text{ J}$$

$$\text{Average Power} = \frac{1.60218 \times 10^{-9} \text{ J}}{1 \times 10^{-4}}$$

$$= 1.60218 \times 10^{-5} \text{ J/s}$$

$$= 1.60218 \text{ W}$$

$$= 1.60218 \times 10^{-5} \text{ W} \quad \times$$

$$0.000160218$$

$$0.000160218 \times 10^{-3} \text{ W}$$

$$0.16 \text{ mW}$$

$$0.000160218 \text{ W}$$

$$\text{Peak Average Power} = 0.016 \text{ mW}$$

$$\text{Average Power}$$

$$1.60218 \times 10^{-11} \text{ J} \times 100 = 1.60218 \times 10^{-9} \text{ J}$$

$$1.60218 \times 10^{-9} \text{ J} \div 1 \times 10^{-4} = 1.60218 \times 10^{-5} \text{ W} \quad \times$$

$$\text{Peak power} = 0.02 \text{ mW}$$

$$\text{Average power} = 0.02 \text{ mW} / 10 = 0.002 \text{ mW}$$

$$(10/40) \times 0.002 \text{ mW}$$

2.

$$d_{\max} = \frac{\lambda}{1 + \sin \theta}$$

$$Power = 30 \times 10^3 W$$

$$f = 10 \times 10^9 Hz$$

$$G = 200 m^2$$

$$-90 dB + 30 dB = -60 dB$$

$$c = f\lambda$$

$$\lambda = c/f$$

$$\lambda = 3 \times 10^8 / 10 \times 10^9 Hz$$

$$\lambda = 3/100$$

$$\lambda = 0.03 m$$

$$G_t = G_r = 10 dB$$

$$r_{\max} = \sqrt[4]{\frac{(30 \times 10^3 \times 10 \times 10 \times 200 \times (0.03)^2)}{((4\pi)^3 \times 1 \times 10^{-6} \times 0.9)}}$$

$$P_{R \min} = 10^{dB/10} = 10^{-60/10} = 10^{-6} = 1 \times 10^{-6} W$$

$$r_{\max} = \sqrt[4]{\frac{540000}{1.785961537 \times 10^{-3}}}$$

$$r_{\max} = 131.87 m$$

b) X-band radar uses a very small wave length and so very high frequency signal is emitted. This allows for detection of larger objects such as large ships nearby. The smaller frequencies can detect (locally) larger surfaced (cross-sectional area) objects. The X-band radar can easily be mounted onto small boats as it is not a too large antenna.

$$3) a) P = \frac{1}{2} |E| |H|$$

~~Hz~~

$$H = E / 377$$

$$P = \frac{1}{2} E \times E / 377$$

$$P = \frac{1}{2} E^2 / 377$$

$$= E^2 / 754$$

$$1 \text{ W/m}^2 = E^2 / 754 \text{ V}^2$$

$$E^2 = 1 \text{ W/m}^2 \times 754 \text{ V}^2 = 754$$

$$E = \sqrt{754} = 27.46$$

$$E = 27.46 \text{ V/m}$$

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

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

$$H = 2P / E$$

$$H = E^2 / 377$$

Energy $\rightarrow$ 4

$$\text{Power} = \text{energy} \div \text{time}$$

$$r = 11 \times 10^{-6} \text{ m} / 2 = 5.5 \times 10^{-6} \text{ m}$$

$$\text{Spot Area} = \pi r^2$$

$$= \pi \times (5.5 \times 10^{-6} \text{ m})^2$$

$$\text{Area} = 9.503 \times 10^{-11} \text{ m}^2$$

$$\text{Density} \times \text{Power} = \text{energy} \times \text{time}$$

$$\text{Area} = 9.503 \times 10^{-11} \text{ m}^2$$

$$\text{Density} = \text{Power} / \text{area}$$

$$1 \times 10^7 \text{ V/m} =$$

$$dH = 2 \times$$

$$E = -\mu \cdot \frac{dH}{dt} =$$

10/25

$$|H| = E^2 / 2 \times 377$$

$$= (1 \times 10^7)^2 / 754$$

$$= 1 \times 10^{14} / 754$$

$$|H| = 1.326259947 \times 10^{11}$$

$$P = 1/2 \times E \times H$$

$$P = 1/2 \times 1 \times 10^7 \text{ V/m} \times 1.326259947 \times 10^{11}$$

$$P = 6.631 \times 10^{17} \text{ W}$$

$$\text{Power density} = 6.63 \times 10^{17} \div \text{Area}$$

$$= 6.631 \times 10^{17} / 9.503 \times 10^{-11} \text{ m}^2$$

$$= 6.98 \times 10^{27} \text{ W/m}^2$$

Mixed the energy
density calculation

10
10

60
100