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Complete, fold and seal
(see note 2 below)

SURNAME: ATKINS

FORENAME(S): STUART

Examination Answer Books

12 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, 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	1809912
2	Title of Examination Paper	ELECTROMAGNETIC RADIATION
3	Module Code	ACDA 5009
4	Date and Time of Examination	03/05/22 1000HRS
5	Examination Venue	19 002
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	21
2	10
3	16
4	22
5	23
6	19
~~7~~	
Total	

① a) Radiowaves

Microwaves

Infrared

Visible light

Ultraviolet light

X-ray

Gamma rays

b) Radio frequencies can induce current in a conductor.
Microwaves can induce current in a conductor and heat into non-conductors.

Infrared can induce heat into both conductors and non-conductors.

Visible light can be seen by the naked eye.

Ultraviolet light cannot be seen by the naked eye and can be biologically harmful.

X-rays are ionising produced by electrons.

Gamma rays are ionising produced by nuclei.

c) Refraction - change in direction of a wave ~~from~~ from one medium to another

d) Diffraction - the bending of a wave around a corner or through an aperture.

e) Dispersion - the separation of frequencies within a wave.

f) Specular reflection - Change in direction of a wave that is reflected at a definite angle.

g) Diffuse reflection - occurs on surfaces where light is reflected and scattered in all directions.

h) Transmission - the passage of a wave through a medium without absorption.

i) Absorption - the transfer of energy from a wave to the medium as it travels through.

② a) Wavelength = $\frac{v}{f} = \frac{3 \times 10^8}{433 \times 10^6} = 0.693 \text{ m}$

$\frac{1}{4} \text{ length} = \frac{0.693}{4} = 0.173 \text{ m}$

b) Ground plane / Carrying
Orientation
Line of sight

c) Inverse square Law -

$\frac{10 \times 270^2}{90^2} = 90$ Answer = 90 mW

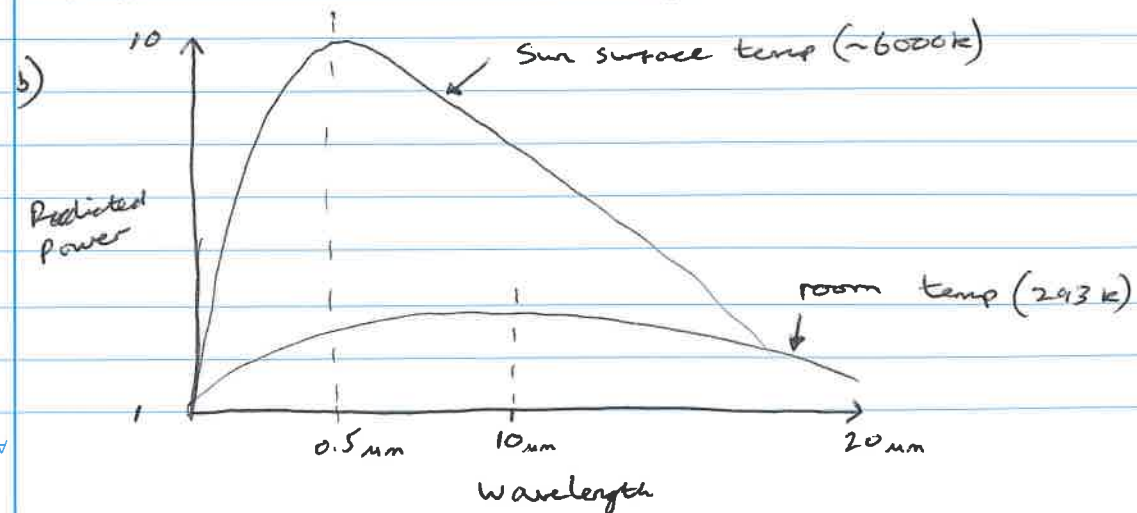
d) Using a high gain directional antennae.

e) $6 \times 8 = 48 \text{ bit}$ 40000 bits/sec

$\frac{40000}{48} = 833.3$

Shortest time interval = $\frac{1}{833.3} = \underline{\underline{1.2 \times 10^{-3} \text{ s}}}$ QL=10

③ a) Black body radiator - absorbs all electro-magnetic radiation that falls upon it, at all frequencies and at all angles of incidence.



2

3

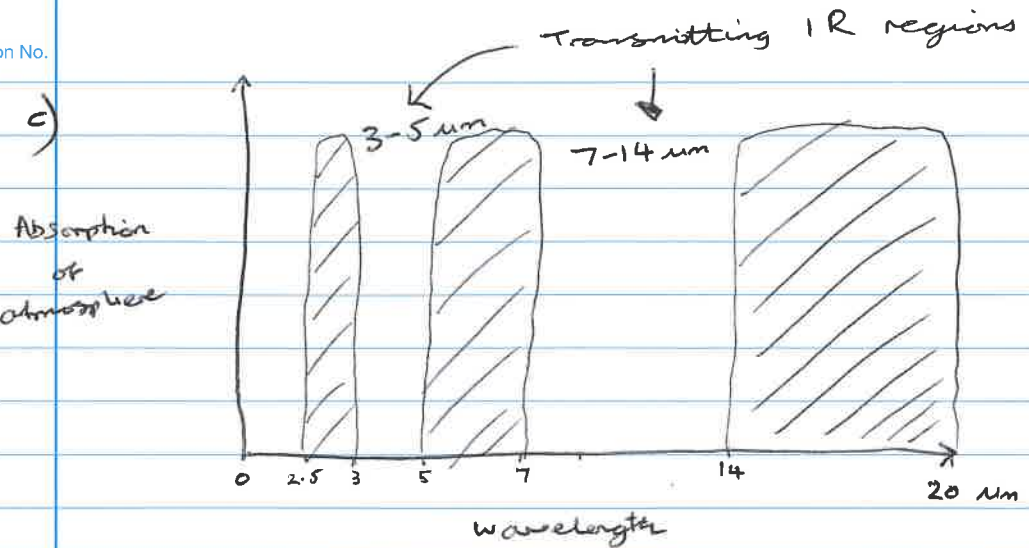
2

1

2

2

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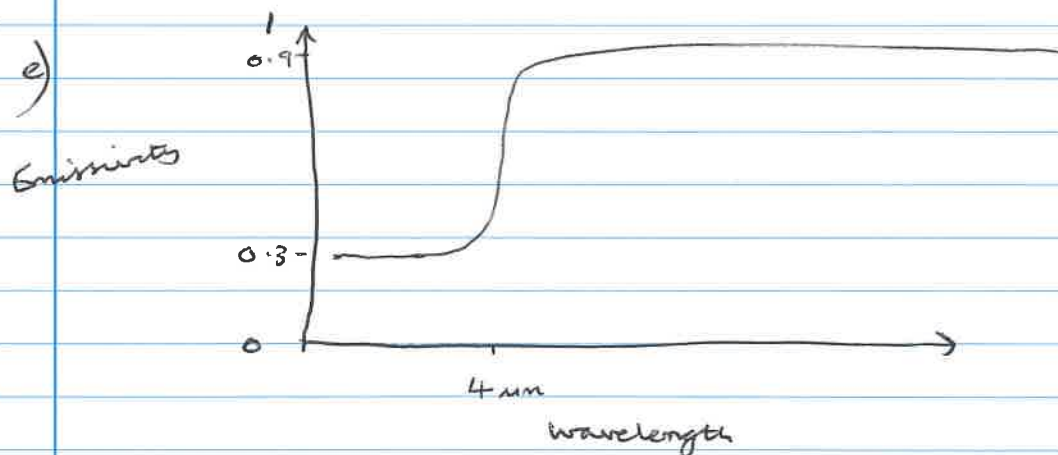
Absorption is because gases in the atmosphere absorb specific frequencies.

4

d) Emissivity - The ~~ratio~~ ratio of energy radiated from a materials surface to that which is radiated from a perfect emitter.

3

Polished silver emissivity - 0.02
Black paint " - 0.98



2

f) White paint aims to absorb shorter wavelengths poorly but emit longer wavelengths well, ~~and~~ thereby emitting heat relating to its internal temperature and reflecting heat which corresponds to the sun.

2

Q3 = 16

- ④ a) Higher data-rate
 higher range
 cheaper
 More Secure
 More reliable
 Smaller diameter (lighter)
 less susceptible to interference
 Multi-direction signal.

b) Step index multi-mode - Inexpensive and robust. Range of 1km with data-rate of 1Mbps. Used for short distance, low speed applications. Light travels many pathways (zig-zags) through the fibre core.

Graded index multi-mode - More expensive and less robust. Range of 10km with data-rate of 100Mbps. Light is refracted and bent towards the fibre axis.

Mono-mode - More expensive than the others with high precision. Range of 100km and data rate of 1Gbps. This fibre has a narrow core diameter. ~~lighter~~.

c) Factors to consider - Cost, range and max data rate, robustness.

Robustness is important as the fibre optic cable must survive the conditions it faces, and therefore mono-mode may not be suitable. In addition to this, the torpedo will not need a range of 100km or require ~~large~~ data transfer.

~~Due to the low data~~

~~I would recommend Graded index~~

Q4 = 22

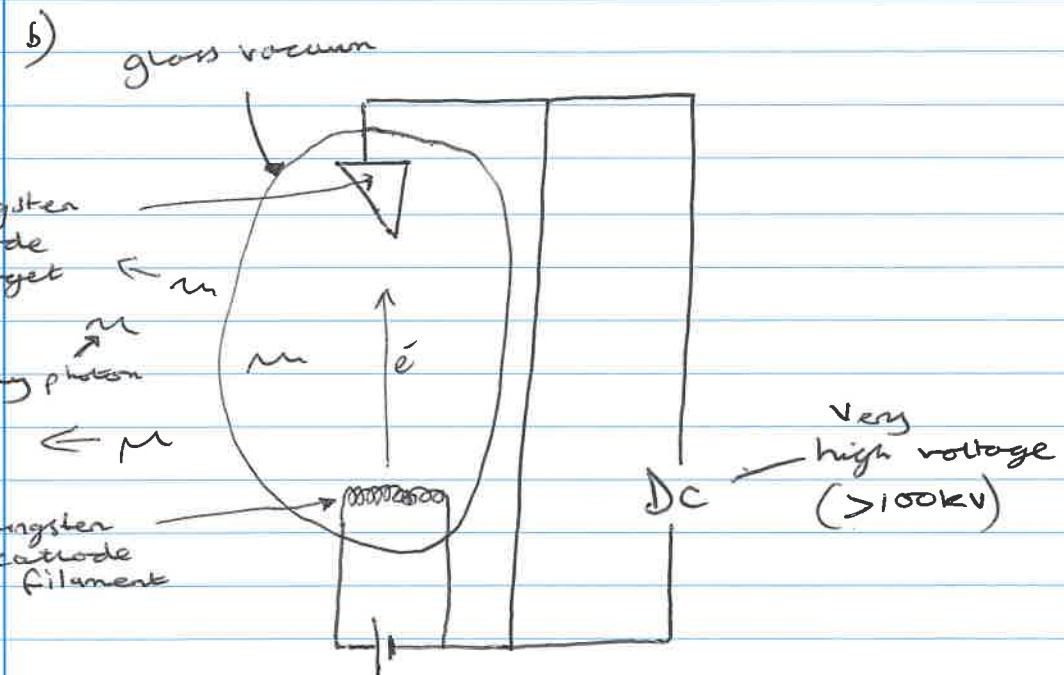
8

9

5

I would recommend step index ~~multi-mode~~ optical fibre as this is the cheapest and most robust and is sufficient to handle the required data. ~~Range of 1km~~ If targets are at a distance greater than 1km then graded index fibre should be used.

- ⑤ a) Security / Detection
 Inspection, Non-destructive testing
 Crystallography
 From x-ray



c) When sufficient voltage is applied it knocks an electron off of the inner shell. An electron from the outer shell then moves to the inner shell to 'fill the void' and replaces it. It is this that creates the x-ray to be produced. (-1)

d) The Compton effect is the scattering of photons caused by an interaction with a charged particle resulting in a decrease in photon energy.

4

4

3

2

- e) Medium thickness
Medium density
X-ray energy
Atomic number
Atomic Mass.

5

f) $\mu \propto \frac{\rho Z^4}{A E^3}$

Annotations:
 ρ : Density
 Z : Atomic number
 E : X-ray energy
 A : Atomic mass
 μ : Absorption Co-efficient

4

- g) In a nuclear explosion, electrons released due to the Compton effect, induce current in nearby conductors.

1

(-2)

Q5 = 23

- 6) a) Magnitude of Magnetic induction is

- Directly proportional to current ✓
- Directly proportional to the conductor length
- Directly proportional to the angle between the conductor and the magnetic field (-1)
- Inversely proportional to the distance squared.

2

2

2

3

- b) Lorentz law states -

1 Tesla is the magnetic field strength required to produce 1N on 1C of charge at 1m/s (1A) perpendicular to the current.

5

$\therefore \text{Force} = \underline{\underline{IN}}$

c)

d) $L = \frac{\mu N^2 A}{l}$

Area = πr^2
 $= \pi (0.01)^2$
 $=$

$N = \sqrt{\frac{L l}{\mu A}} = \sqrt{\frac{46 \times 10^{-6} \times 0.1}{4\pi \times 10^{-7} \times 3.141 \times 10^{-4}}}$

$= \sqrt{\frac{4 \times 10^{-6}}{3.947 \times 10^{-10}}} = \sqrt{10134.279}$

$= 100.669 \text{ turns}$

5

Q6 = 19