



Complete, fold and seal
(see note 2 below)

SURNAME:

DAND.

FORENAME(S):

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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	1810440.
2	Title of Examination Paper	ACDA 5009 ELECTROMAGNETIC RADIATION
3	Module Code	ACDA 5009
4	Date and Time of Examination	3/5/2022
5	Examination Venue	1Q002.
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	21
2	9
3	15
4	16
5	24
6	16
Total	

- (1) (a) Radio waves
Microwaves
Infra red
Visible
Ultraviolet
X-rays
Gamma rays.

7

- (b) Radio - can induce current in a conductor
Microwaves - can induce current in a conductor + heat in a non-conductor
Infra red - can induce heat in a non conductor, cannot induce current.
Visible - Can be seen by the human eye.
Ultraviolet - cannot be seen by the human eye, can cause biological damage.
X-rays - ionising radiation caused by electrons.
Gamma - ionising radiation caused by nuclei.

7

- (c) Refraction - the change in direction of a beam as it passes from one medium to another

- (d) Diffraction - the bending of light ~~as it~~ round a corner or through an aperture. Long wavelengths bend more.

- (e) Dispersion - the separation of wave lengths within a beam.

- (f) Specular reflection - the bouncing of a beam off a reflective surface. The angle of the reflection is the same as the angle of incidence but on the opposite side of a plane normal to the target surface.

(1) (g) Diffuse reflection - The scattering effect of a beam reflecting off a rough surface. Reflected beam scatters in many directions

(h) Transmission - The passage of a beam through a medium without absorption.

(i) Absorption - The energy imparted to a medium by a wave passing through it. As it passes through, if an electron is excited, energy is lost to that electron.

Q1 = 21

(2) (a) $c = \text{speed of light} = 3 \times 10^8$
 $\lambda = ?$
 $f = 433 \times 10^6$

$$c = \lambda f$$

$$3 \times 10^8 = 433 \times 10^6 \lambda$$

$$\frac{3 \times 10^8}{433 \times 10^6} = \lambda$$

$$\frac{300}{433} = \lambda$$

$$\lambda = 692.8 \times 10^{-3} \text{ m.}$$

$$\frac{1}{4} \text{ length antenna} = \frac{1}{4} \lambda$$

$$= 173.2 \times 10^{-3} \text{ m}$$

$$= \underline{\underline{17.3 \text{ cm.}}}$$

(b). Line of sight
 Presence of ground station
 Orientation of antenna

2

(2) (c) $\text{intensity}_1 \times \text{distance}_1^2 = \text{intensity}_2 \times \text{distance}_2^2$

$$\frac{(10 \times 10^{-3}) \times 90^2}{P} = \frac{P \times 270^2}{0.01 \times 3100}$$

$$P = \frac{72900}{72900}$$

$$P = 1.1 \times 10^{-3}$$

$$\frac{\text{intensity}_1}{\text{distance}_1^2} = \frac{\text{intensity}_2}{\text{distance}_2^2}$$

$$\frac{10 \times 10^{-3}}{90^2} = \frac{P}{270^2} \quad P = \frac{(270^2)(10 \times 10^{-3})}{90^2}$$

$$= 90 \times 10^{-3} \text{ W} = \underline{\underline{90 \text{ mW}}}$$

2

(2) Use of a high gain directional antenna.

1

(c) 6 degrees of freedom, 8 bit resolution. 40 kbps data
 $6 \times 8 = 48 \text{ bits/transmission}$

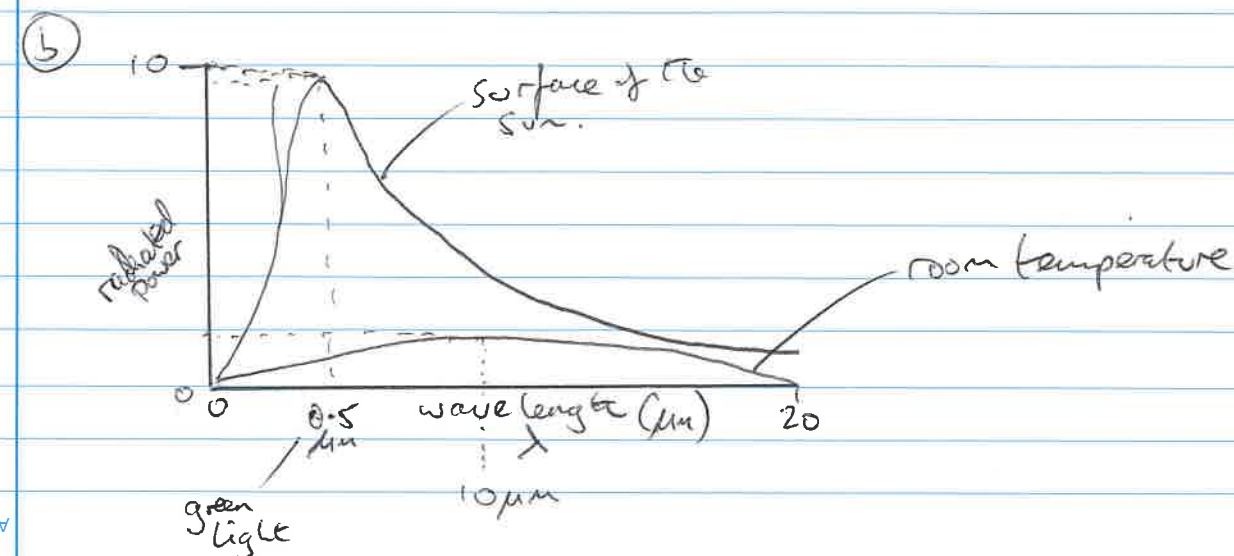
$$\frac{40000}{48} = 833.33 \text{ transmission/second.}$$

$$\frac{1}{833.33} = 0.00125 \text{ time for 1 transmission}$$

Q2 = 9

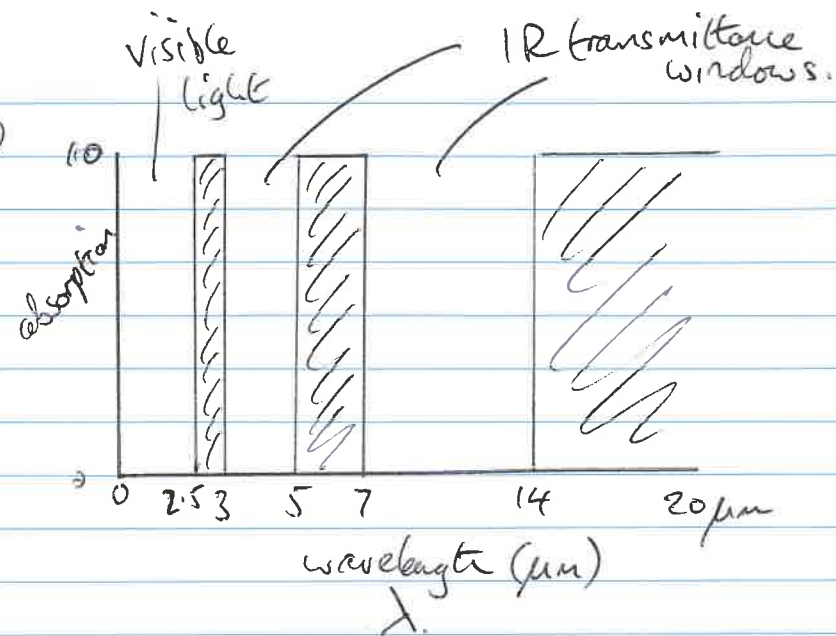
(3) (a) A black body radiator is ~~something~~ something that absorbs all electromagnetic ~~for~~ radiation at all frequencies and all angles of incidence

2



3

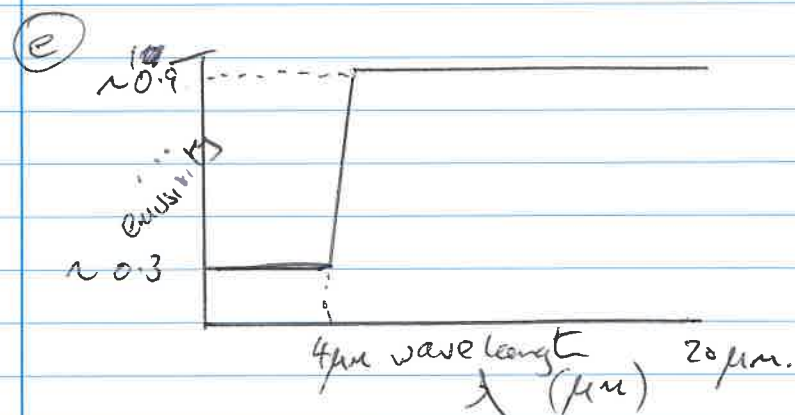
③ ③



IR radiation is absorbed by atmospheric gasses (CO_2 , methane, nitrogen, water vapor, etc.)

④ Emissivity is the ratio of energy radiated vs that of a perfect emitter when viewed under the same conditions and at the same temperature + wavelength.

Approximate emissivity of polished silver ~ 0.2
Approximate emissivity of black paint ~ 0.9 .



⑤ White paint absorbs long wavelengths poorly, but emits short wavelengths well. This means the internal temperature of the container can be more easily regulated.

Q3 = 15

4

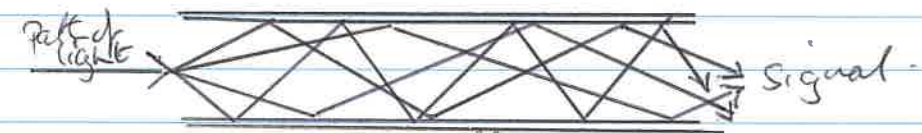
④ ⑤

High bandwidth
Cheaper
More secure
Higher data rate
More reliable
Less susceptible to interception
duplex operations possible

⑦

7

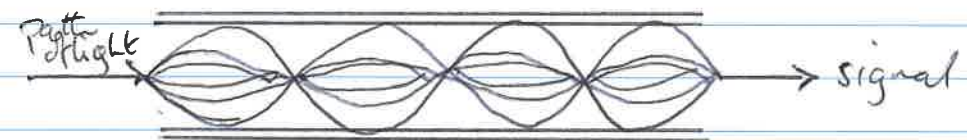
⑥ Step index multimode



Light is transmitted along multiple uncontrolled pathways
Data rate - $\sim 10 \text{ Mbps}$
Distance - $\sim 1 \text{ km}$

Cheap + robust but low data rate + distance of transmission.

Graded index multimode



Graded refractive indices guide the signal along multiple known pathways.
Data rate - $\sim 100 \text{ Mbps}$
Distance - $\sim 10 \text{ km}$.

Intermediate cost, robustness, data rate + distance of transmission

3

3

3

2

1

④ ⑤ contd.

Mono-mode

Plasma flight

→ Signal.

Further grading of refractive indices guides the signal down a single path.

Data rate - $\sim 1 \text{ Gbps}$

Distance - $\sim 100 \text{ km.}$

Very high data rate and signal distance

Very expensive and not as sturdy as other modes

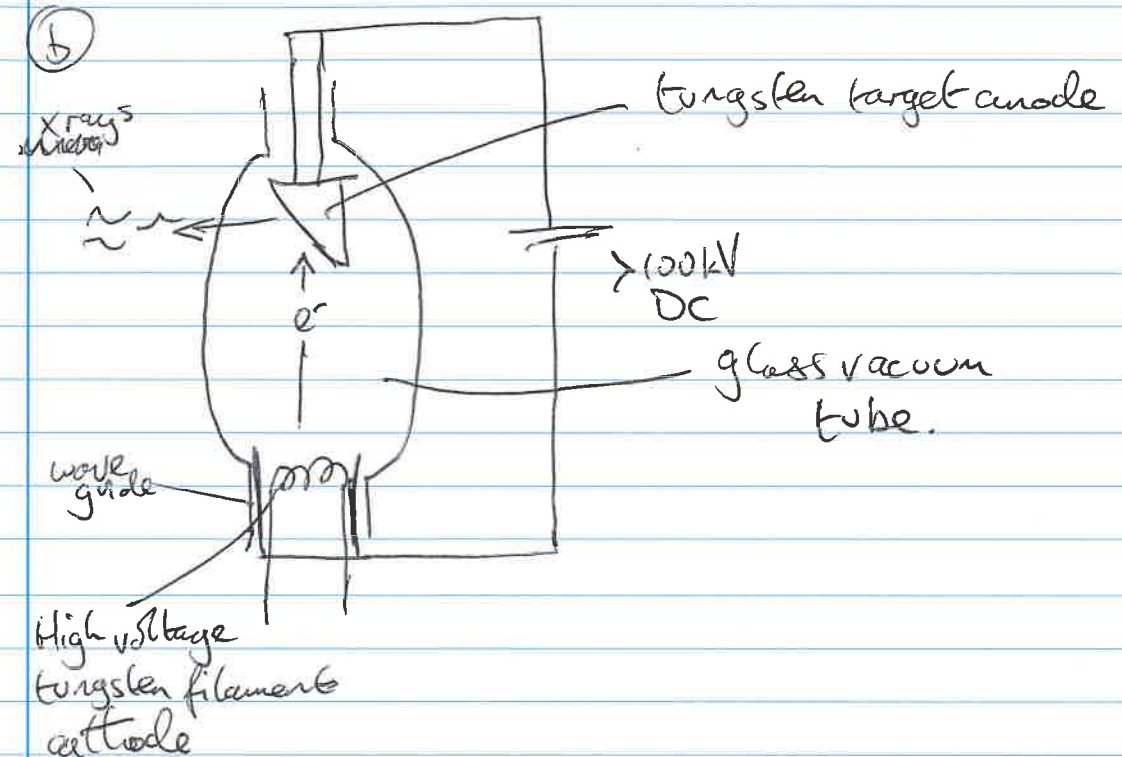
③

-5

- ⑤ ① Inspection of internal assemblies for QC. ✓
Security scanning ✓
Flash xray for high speed events. ✓
Crystallography for material properties. ✓

4

3



4

- ② High voltage excites the electrons in the cathode, which strip away + impact the target surface. These electrons displace electrons from the outer shell towards the inner shell, which ejects its electrons in the form of x-rays. (-2)

2

- ③ The Compton effect is the scattering of a photon when it interacts with a charged particle (normally an electron). This scattering effect results in a reduction in energy of the photon.

2

- ④ Thickness of the medium.
Atomic electron mass
Atomic number
Density of material
Energy of the x-ray.

5

(5) f

$$\mu \sim \frac{\rho Z^4}{A E^3}$$

μ = coefficient of absorption
 ρ = density of material
 Z = Atomic mass of material
 A = Atomic number
 E = Energy of x-ray.

4

- g A nuclear explosion produces gamma rays which react with charged particles in the atmosphere + scatter the particles. This creates ~~electric~~ change in electric field over time. As a time varying electric field induces a magnetic field, EMP is produced.

3

Q5 = 24

- (6) a Strength of a magnetic field is proportional to:

- length of the conductor
- Strength of the current

2

2

(-1)

- angle of the current against that of the magnetic field

2

Strength of a magnetic field is inversely proportional to:

- distance of conductor from magnetic field

3

- b 1 Newton.

5

(c) + (d)

$$L = 40 \times 10^{-6}$$

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

$$A = 2\pi \times 10^{-2}$$

$$l = 0.1$$

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

$$Ll = \mu N^2 A$$

$$\frac{Ll}{\mu A} = N^2$$

$$\sqrt{\frac{Ll}{\mu A}} = N$$



(6) (c) + (d)

$$N = \sqrt{\frac{Ll}{\mu A}}$$

$$N = \sqrt{\frac{(40 \times 10^{-6}) \times 0.1}{(4\pi \times 10^{-7}) \times (2\pi \times 10^{-2})}}$$

$$= \sqrt{\frac{4 \times 10^{-6}}{1.26 \times 10^{-6} \times 62.38 \times 10^{-3}}}$$

$$= \sqrt{\frac{4 \times 10^{-6}}{7.9 \times 10^{-9}}}$$

(-3)

2

$$= \sqrt{\frac{4}{7.9 \times 10^{-3}}}$$

$$= \sqrt{\frac{4}{0.0079}} = \sqrt{506.33}$$

$$N = 22.5 \text{ coils.}$$

$$= 22.5 \times 10^{-3}$$

Q6 = 16