



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

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.
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Complete, fold and seal
(see note 2 below)

SURNAME: RUSSELL

FORENAME(S): FERGUS

GAVIN MURRAY

1	Student Number	1810398
2	Title of Examination Paper	ACDA 5009 ELECTROMAGNETIC RADIATION
3	Module Code	ACDA 5009
4	Date and Time of Examination	3/5/2022 1000 HRS
5	Examination Venue	IQ 002
6	Seat Number	—
7	Number of Answer Books handed in	2

List the numbers of the questions you have attempted	Office Use
1	18
2	8
3	
4	21
5	18
6	
Total	

1a)
+1b)

Radio Waves — Low energy, Low frequency
Long wavelength. Can induce
current in a conductor but
not in a non conductor

Microwaves — Higher energy than radio waves,
Higher frequency than radio
waves, Shorter wave length
than radio waves, Can induce
current in a conductor and
induce heat in some
non conducting materials depending
on certain properties such as
absorption coefficient.

Infra Red — Higher energy than microwaves
Higher frequency than microwaves
Shorter wave lengths than microwaves
cannot induce current in a
conductor but can induce heat
in both a conductor and non
conductor. Can be used for
Short range Line of sight
control such as TV remotes.

Visible Light — Spectrum of colours capable
of being seen by the human
eye. Red light has the
longest wavelength and blue
or violet has the shortest.
Can be separated out using
a prism.
Wave lengths are shorter than
IR,

Ultraviolet — Can cause biological harm. Shorter wave length and Higher energies than IR and visible light.
Can burn Scottish people ~~who~~ who don't apply factor 30 sun block, trust me, I know.

X-Rays — Ionising radiation generated by electrons impacting a target or interacting with material and emitting a X-Ray photon. Wave lengths shorter than UV, Energies higher than UV.

Gamma Rays — Ionising radiation created by radioactive nuclei. Shortest wave length, highest energies, emitted through nuclear fission and fusion reactions and radioactive isotopes.

1c) Refraction — The process of a wave bending as it transfers between mediums such as water and air.

1d) Diffraction — The ability of a wave to bend around an obstacle or through a slit such as the double slit experiment.

1e) Dispersion — The separation of waves that are similar through wave length for example white light separating through a prism into a spectrum.

1f) Specular Reflection — wave bounces off a surface like a mirror the angle of reflection is equal to the angle of incidence.

1g) Diffuse Reflection — wave is scattered off of a surface for example the difference between gloss, satin and matt paints of same colour.

1h) Transmission — The amount of energy a medium transmits of a wave.

1i) Absorption — The amount of energy a material absorbs of a wave.

Q1 = 18

2a)

$$f = 433 \text{ MHz} \quad V = 3 \times 10^8 \text{ m/s}$$

$$\lambda = ?$$

$$\lambda = \frac{V}{f} = \frac{3 \times 10^8}{433 \times 10^6} = 0.692 \text{ m}$$

$$\frac{1}{4} \text{ wave} = 0.692 \div 4 = \underline{0.173 \text{ m}}$$

b) Factors that affect siting the antenna on the missile can include noise generated by internal components such as gyros and electronics, ground planes in the missile body itself, noise generated by the rocket motor igniting and the operation of the rocket motor.

Factors affecting siting the antenna on the ground station include the range terrain, line of sight to the missile, ground loops in the ground station equipment

General considerations can include terrain and local weather conditions

(-2)

2c)

~~$$P_1 D_1^2 = P_2 D_2^2$$~~
~~$$10 \times 270^2 = P_2 \times 90^2$$~~
~~$$P_2 = \frac{10 \times 270^2}{90^2} = 90 \text{ mW}$$~~

$$\begin{aligned} \text{Initial power} &= 10 \text{ mW} = P_1 \\ \text{Desired distance} &= 270 \text{ m} = D_1 \end{aligned}$$

$$\begin{aligned} \text{Desired Power} &= ? = P_2 \\ \text{Actual Distance} &= 90 \text{ m} = D_2 \end{aligned}$$

$$P_1 D_1^2 = P_2 D_2^2 \quad \text{Inverse square law} \quad 2$$

$$10 \times 270^2 = P_2 \times 90^2$$

$$P_2 = \frac{10 \times 270^2}{90^2} = \underline{90 \text{ mW}}$$

2d) The use of a Yagi array antenna can keep power requirements down. Also the use of arrayed antennas across the range to receive the signal and re broadcast back to the ground station. 1

2e) 6 degrees of freedom 8 bits per degree. ~~total bits in~~

$$\text{total bits in data packet} = 8 \times 6 = 48$$

$$\text{transmission rate} = 40 \text{ kB/s} = 40000$$

$$\begin{aligned} \text{refresh rate} &= \frac{40000}{48} = 833.3 \text{ times a second} \\ &= \frac{1}{833.3} = 1.2 \times 10^{-3} \text{ s} = \underline{1.2 \text{ ms}} \quad Q2 = 8 \end{aligned}$$

Q4a) Advantages of using fibre optic over copper include:-

Increased levels of security
 Increased levels of reliability,
 Decreasing levels of cost
 Duplex communication through a single fibre

Increased range before requirement of reamplification

Better quality of signal

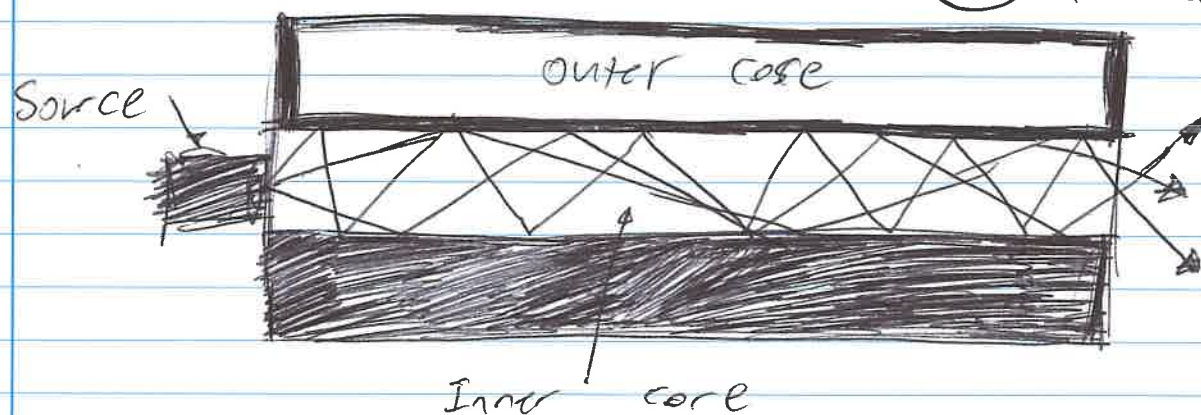
Less cross talk between signals

Decreased weight and increased strength

Less likely to be stolen and sold for scrap.

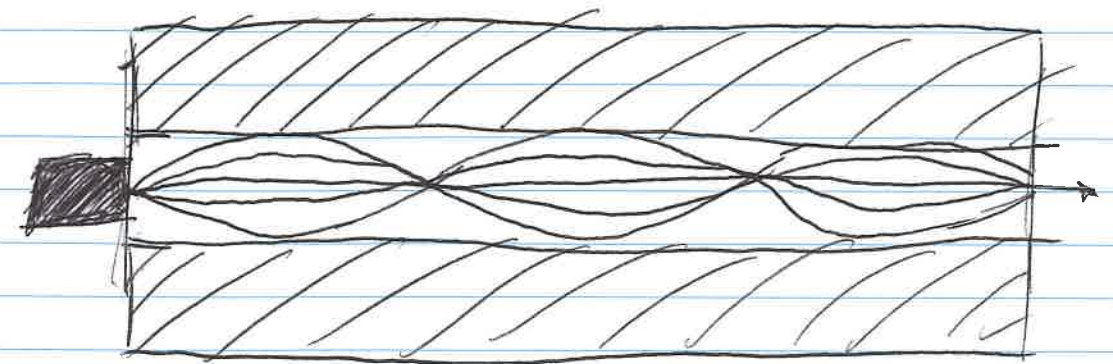
(-1) (Bandwidth)

Q4b)



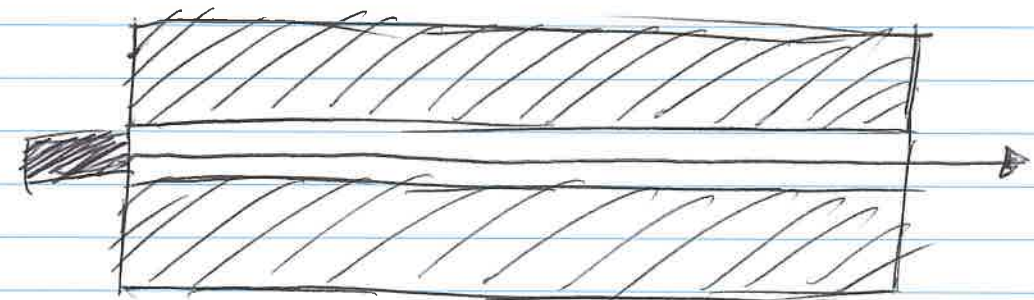
Step index multimode

In stepped index multimode fibres the light scatters all around the inside of the fibre reflecting off the walls as it works its way down the fibre. The cost of this fibre is cheap however it is not capable of transmitting over a large range or carrying a huge amount of data however it is very robust and reliable and good where precision is not a great concern.



Graded index - multimode.

Here the core is made of two different grades of glass and the light "bends" as opposed to reflects. This fibre is capable of increased data rates and ranges and is still robust but not as much as the step index fibre. The cost is also more expensive.



mono mode optical fibre

Light travels through fibre almost directly. Data amount is the largest of the three in the Gbit range and the range is 100km plus. It is the most costly and the best suited to high precision environments.

Q4)

Considerations when selecting a fibre to control spearfish. The highest consideration is the range of the weapon first. Step index isn't suitable as the range of step index is too short, single mode offers the largest range and graded index offers the range as well of 10 km plus.

Next consideration would be data rate and what data needs to be transmitted to and from the torpedo. For example control data isn't very taxing on the cable however in GPS, velocity, orientation and bearing data as well as data relating to health of the torpedo is needed then step index may not cut it, graded index and single mode offer the data capabilities.

~~Reliability~~ Reliability ~ next, it should function all the time therefore a reliable and robust connection is required, step index offers this however doesn't carry the range or data requirements, graded index offers this to a lesser degree however it is the best choice.

Lastly cost, ~~Step~~ step index offers the lowest cost, graded index offers middle cost and single mode is highest cost.

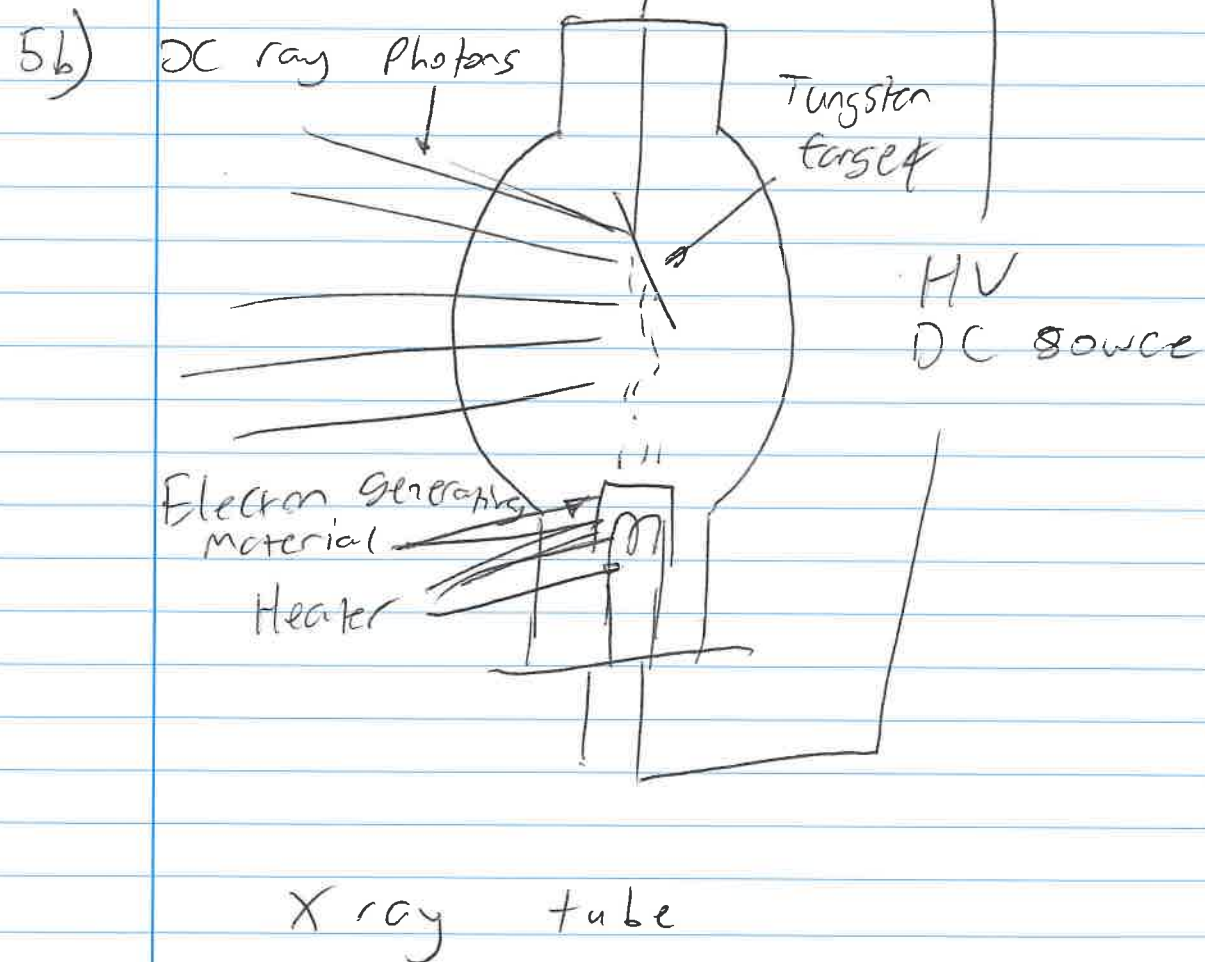
from all these factors I would choose the intermediate graded index fibre as it meets the range, requirements and the data requirements with increased robustness and reduced costs over single mode fibres.

Q4 = 21

5

Q5) a) X rays can be used for non destructive testing such as inspecting components during manufacture or in service surveillance. They can also be used in high speed flash X ray to see what is happening in an explosion or an energetic event. They can also be used in baggage scanners and the EOD environment to detect concealed devices or to get a weapon arrangement for munition breakdown.

Gamma rays can be used for spectroscopy applications.



1

1

1

1

4

5c) The incoming electrons get close to the atoms of tungsten, knock an electron out of orbit, it drops or gains in energy and releases a photon in the form of an X-ray photon. (-2)

2

5d) Scattering of electrons or photons after being impacted, directions are random. (-2)

5e) X ray Energy level

Atomic Number
Atomic mass
Material density
absorption coefficient (-2)

3

5f)

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

μ = absorption coefficient

ρ = material density

A = Atomic Number

Z = Atomic Mass

E = Energy.

4

2

3

4

5 g) The Compton effect of scattered electrons interacting with local conductors.

(-2)

$$Q5 = 18$$



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RUSSELL

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GAVIN

MURRAY

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[illegible]

2042

Question No.

Examiner Only

Qb)
a)

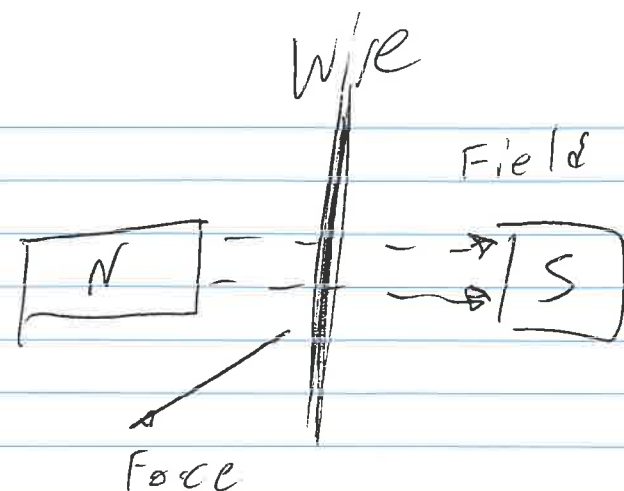
Can't remember its in my revision-
notes though

-10

Arholwr yn unig

Rhif y Cwestiwn

Q6b)



Force on wire is represented by the equation $F = ILB$ where

F = Force in Newtons

I = Current in wire in A

l = length of wire in metres

B = magnetic field strength in Tesla

$$\begin{aligned} \therefore \text{Force in wire} &= ILB \\ &= 1 \times 1 \times 1 \\ &= 1 \text{ N} \end{aligned}$$

c/d)

Inductor 2cm in ϕ

length = 2cm

$$L = 40 \mu\text{H}$$

$$\begin{aligned} \mu &= 4\pi \times 10^{-7} \text{ H/m} \\ &= 12.566 \times 10^{-7} \text{ H/m} \end{aligned}$$

Just incase in wrong the question paper does say 4π (Pi) $\times 10^{-7}$ H/m

$$= 12.566 \times 10^{-7} \text{ H/m}$$

$$N = ?$$

$$\begin{aligned} \text{Area of inductor} &= \frac{\pi D^2}{4} \\ &= \frac{\pi \times (2 \times 10^{-2})^2}{4} \quad (-2) \\ &= 3.142 \times 10^{-4} \text{ m}^2 \end{aligned}$$

$$L = \frac{12.566 \times 10^{-7} \times N^2 \times 3.142 \times 10^{-4}}{2 \times 10^{-2}}$$

$$40 \times 10^{-6} = \frac{3.948 \times 10^{-10} N^2}{2 \times 10^{-2}}$$

$$40 \times 10^{-6} \times 2 \times 10^{-2} = 3.948 \times 10^{-10} \times N^2$$

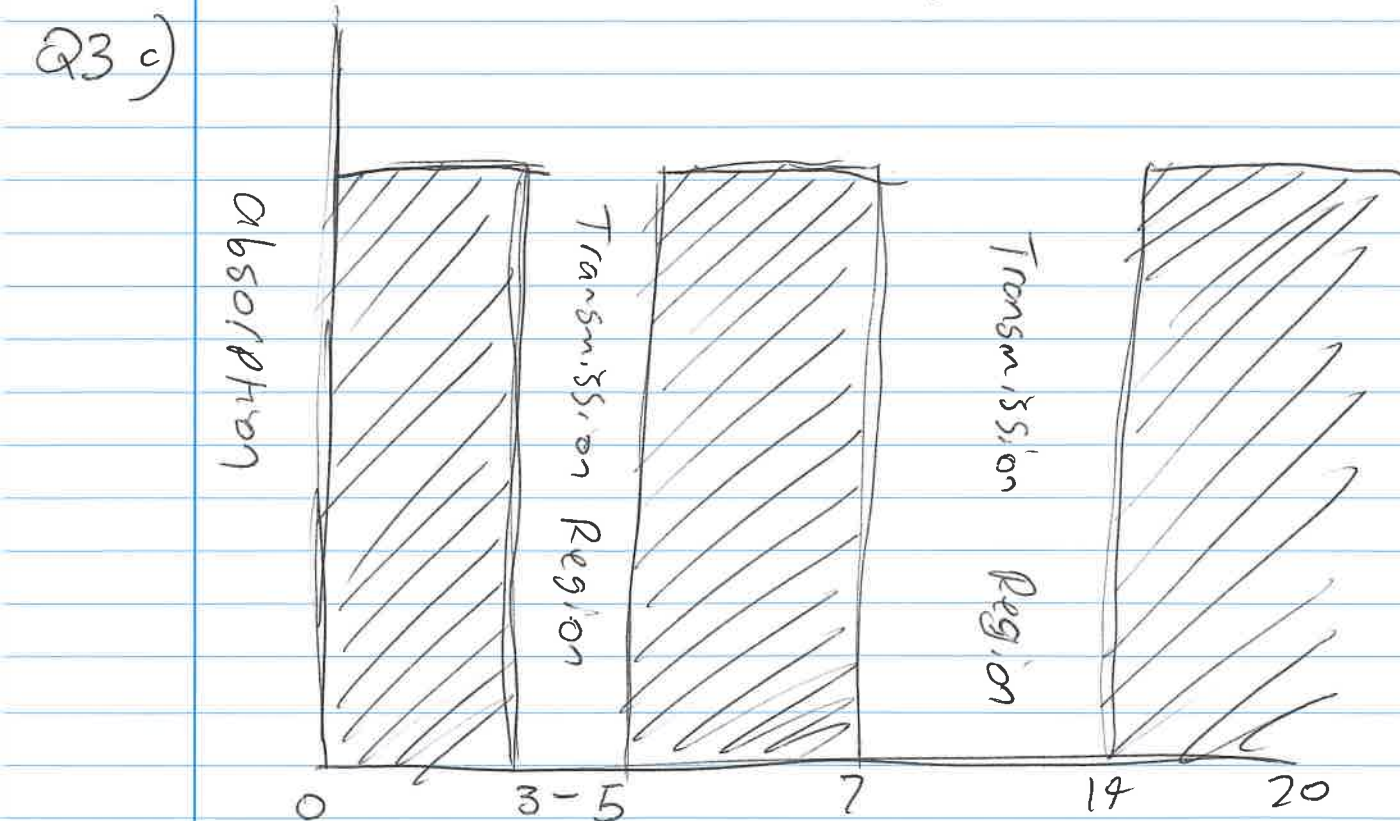
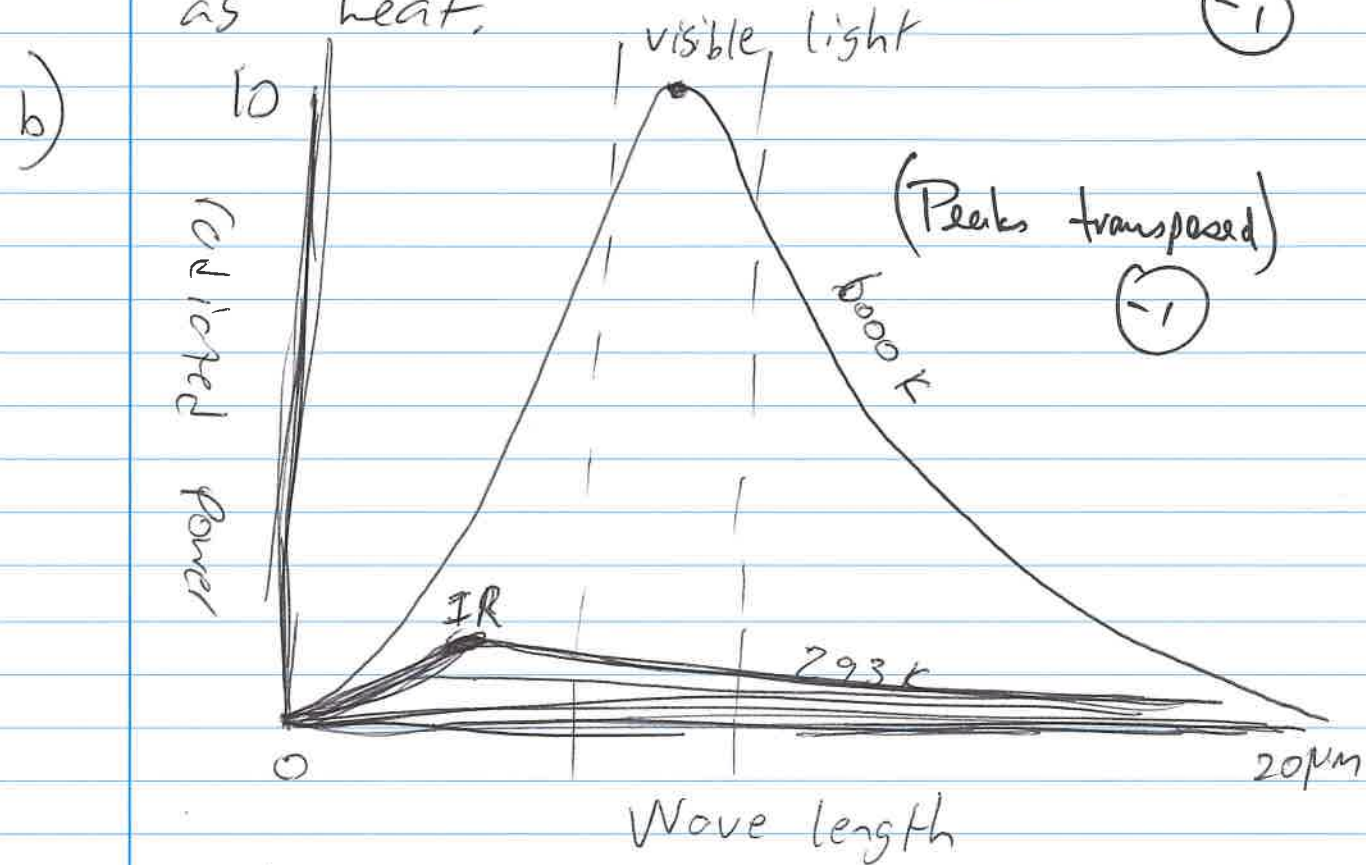
$$8 \times 10^{-7} = 3.948 \times 10^{-10} \times N^2$$

$$2026.342 = N^2$$

$$N = \sqrt{2026.342} = 45.014 \text{ Turns}$$

Q6 = 8

Q3) a) Black body radiator absorbs energies of all frequencies and angle of incidence and radiates it all as heat. (1)



Q3) d)

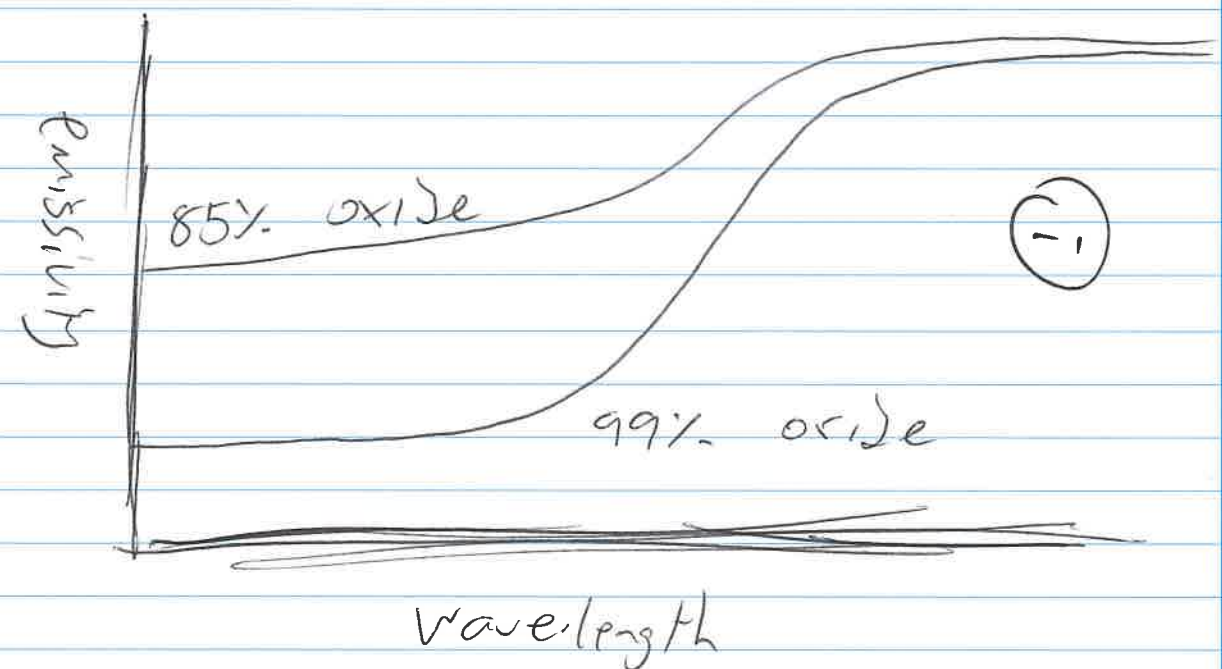
IR is absorbed in the atmosphere by water molecules ...

Q3) e)

emissivity is a ratio of how much energy is absorbed and reflected. A black block will have an emissivity of near 1 and a silver block will be near 0

2

e)



f)

The white green paint will absorb all energy and frequency whereas the white will reflect the wavelengths most emitted by the sun and radiate out at its own temperature.

Q3=13

4