



SURNAME: GRAHAM

12 Pages

FORENAME(S): FRAZER

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1	Student Number	1907690
2	Title of Examination Paper	EMR
3	Module Code	ACDA 5009
4	Date and Time of Examination	5th May 2023 9:00
5	Examination Venue	IQ310
6	Seat Number	018
7	Number of Answer Books handed in	

[illegible]

①

a) change of direction in a wave due to the density of the passing medium

①

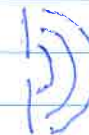
b) Light penetrating water

①

c) The process of a wave spreading out once passing through an aperture

①

d) Light passing through a slit.



①

e) Spreading of white light into its full spectrum of wavelengths

①

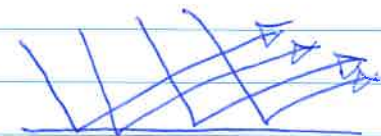
f) Light passing through a crystal



①

g) Specular reflection is a repeating smooth surface which results in the reflection of light

①



h) Light hitting a mirror

①

i) Diffuse reflection is light hitting an uneven surface & being reflected in different directions

①



j) Example are the passive light reflectors on bikes.

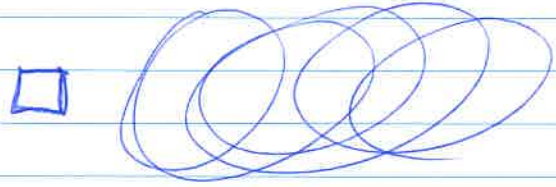
①

①

$$D = 0.05 \text{ m}$$

$$N = 100$$

$$T = 5 \times 10^{-3}$$



$$0.005 \text{ mT} = \text{magnetic flux density} \times \text{Area} = \text{magnetic flux}$$

$$\pi R^2 = \text{area of circle}$$

$$\pi (0.025)^2 = (1.96 \times 10^{-3})$$

$$0.005 \div 1.96 \times 10^{-3} = 2.55 \times 10^{-6} \text{ magnetic flux}$$

②

$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

$$-100 \frac{2.55 \times 10^{-6}}{0.14 \times 10^{-3}} = -18 \text{ MV}$$

$$13.93 \times 10^6 \text{ V}$$

This value seems too large. Magnetic flux must have been calculated wrong.

③

VHF Frequency 30 MHz - 300 MHz
Wavelength 10 m - 1 m

b) Military, Navigation, ship to ship communication, distress signals, radios.

c) Line of sight
Reflection of the stratosphere
Diffraction using the surface of the ground.

d) Line of sight - transmission
Stratosphere - Reflection
Using the ground diffraction

e

f) Wire antenna, ground

g

h

i

j

$$\frac{18}{27}$$

②

⑤

③

③

①

④

⑤

④

②

②

$$\frac{13}{31}$$

4)

- P_r = power transmitted back from target [W]
 P_t = transmitter input power [W]
 G_t = gain of the radar transmitter dimensionless
 σ = radar cross section m^2
 r = distance to target m
 A_{eff} = effective area of the radar receiving target (m^2)

Radar cross section is the area of the radar which can emit a signal. Usually this is the size of the dish. (-5)

c) Directivity, size, reflectivity, geometric shape (-2)

d) Stealth is the ability to avoid reflecting waves back to the radar; & therefore not being picked up. (2)

e) Size $\rightarrow$ larger is more chance for detection

Reflection

- $\rightarrow$ Geometries, and waves bouncing perpendicular back
- $\rightarrow$ Hard surfaces, waves cannot penetrate & therefore reflected. (-2)

Emission of its own waves (5)

Speed $\rightarrow$ If its slow moving gives more chance to be detected

Direction of attack, if it can stick to low stimulating then prevents being detected in open air. Additionally can avoid detection of waves (1)

f. (-4)
(see later page)

(6)

17
28

5)

a) Is a body which absorbs all ~~emr~~ that falls onto and radiates energy with no reflecting power (-3)

b) Effectiveness in emitting energy as thermal radiation (-1)

c) P = Power radiated Watts

e = emissivity no units

σ = Stefan-Boltzmann constant $5.67 \times 10^{-8} W m^{-2} K^{-4}$

A = surface area (m^2) (-1)

T = Temperature Kelvin

d) Shows the visible light reflected at different temperatures & which it can be seen in. Examples are at 6000K a white light will be seen, while at 5000K a red light. However there is no change at 4000K but it can be seen in the IR spectrum. (-2)

e) It can be programmed to ignore it. Alternatively, filters can be applied to remove the sun. The devices can only detect in the pm range. This is a different wavelength the sun emits & so the seeker is blind to it. (-2)

(2)

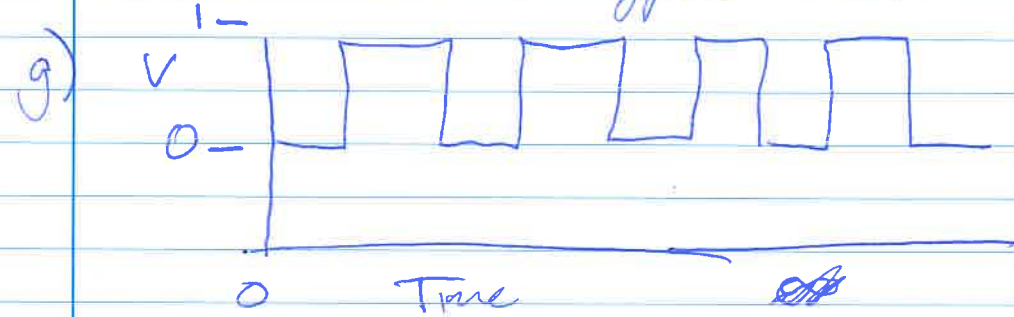
(5)

(1)

(1)

(-2)

f) The sensor is cooled so its own thermal radiation does not affect its own vision.



(-2)

h) The infra-red countermeasure adds a 2nd voltage spike which confuses the computer. This additional voltage generated then causes the missile to turn more sharply thereby its off course.

(2)

(3)

(3)

17
28

4p)

$I = 100 \frac{W}{SR}$

10km

$I = \frac{W}{r^2}$

$100 = \frac{W}{10^2}$
 $10000m^2$

~~Watts = 10000 x 10^3~~

Watts = 10 Gw The power of the transmitter.

Assuming hemispherical dispersion.

$2\pi r^2$

$2\pi \times 10000 = 62.83 \times 10^3 m^2$

$10 Gw \div 62.83 \times 10^3 m^2 = 159.16 \times 10^4 W/m^2$
~~1.59 x 10^3 W/m^2~~
 $1.59 \times 10^3 W/m^2$

(-4)

(1)

1p) 1 pa to change $1 \times 10^{-9} \text{ m}$

How many Pa to change 1×10^{-9}

$$\$ \quad 660 \text{ nM} \div 1 \times 10^{-9} = 660 \text{ Pa minimum}$$

~~mpm~~ To ~~change~~ the
660 Pa will cause the deflection to completely
remove the laser.

?

1Q) ~~440 Pa over pressure~~

$$660 \text{ Pa} + 440 \text{ Pa} = 1100 \text{ Pa}$$

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

Examination Answer Books

12 Pages

Instructions to Candidates

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SURNAME: BESWICK

FORENAME(S): THOMAS

1	Student Number	1910566
2	Title of Examination Paper	ELECTROMAGNETIC RADIATION ACDA5009
3	Module Code	ACDA5009
4	Date and Time of Examination	05/05/23 9:00
5	Examination Venue	1Q310
6	Seat Number	019
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

- 1a Refraction bending of a wave passing from one medium to another (1)
- 1b This occurs sharp when light is ~~sharper~~ ^{passed} through a prism, forcing the wave to bend and splitting up to reveal the various wavelengths. (1)
- 1c Bending of a wave around an obstacle or through an aperture (1)
- 1d This occurs with light through the lens of a camera bending light at the edges to produce effects. (1)
- 1e Separation of waves as they pass through a medium (1)
- 1f An example is when red light appears first through fibre optic cable. (1)
- 1g Change of direction where angle of reflection = angle of incidence (1)
- 1h The reflection of light off a mirror which can be easily redirected & aimed. (1)
- 1i Reflection of light off a surface where incidence rays are scattered in many directions (1)
- 1j Reflected light off a matte white wall produces a bright but undirected reflection. (1)
- 1k Passage of a wave with no transfer of energy (1)
- 1l The light waves from the Sun must be transmitted to Earth via space in order for it to be visible to us. (1)

1m Energy passed from a wave into a medium

1n Light from the sun is absorbed by the Earth's surface, later emitted as IR.

o) (-2)³ p) (-5) q) (-5)

2a Measure of Intensity of the field at a point
~~one direction~~

2b SI unit = Tesla
Symbol = B

2c Tesla = One Newton Per Ampere Per metre.
2 Tesla

2d Quantity which signifies how much of a magnetic field passes perpendicularly through an area.

2e) Symbol = Φ
SI unit = Weber

2f Magnetic flux = Magnetic field density $\times$ Area

2g Magnitude of Voltage is proportional to the change in Magnetic flux

2h $E = -N \frac{\Delta \Phi}{\Delta t}$ where E = Induced voltage (V)
 N = No. of loops
 $\Delta \Phi$ = Change in magnetic flux (Φ)
 Δt = Change in time (s)

(-5)

(-5)

(1)

(1)

16/29

(2)

(2)

(2)

(2)

(2)

(2)

(2)

(3)

17

27

3a 30-300 MHz, 10m-1m

3b - Communication
- Aviation
- Maritime
- Military
- Regional

3c Line of sight
Skywaves
Ground wave

3d Refraction - Skywave
Diffraction - Ground wave
Dispersion - Ground wave
Reflection - Skywave
Transmission - Line of sight
Absorption - ~~Ground wave~~ Skywave

3e All 3 can be applied to the VHF frequency

3f 137 MHz - using $\frac{1}{2}$ dipole.

$$\lambda = \frac{3 \times 10^8}{137 \times 10^6} = 2.19 \text{ m}$$

$$\text{Length of antennae} = \frac{2.19}{2} = \underline{\underline{1.09 \text{ m}}}$$

3g This will ensure external effects and noise are kept to a minimum, and reduces to effect of attenuation from the transmitter as the receiver is looking to receive the signal in the same direction as is being transmitted from.

polarisation

(-5)

(2)

(5)

(3)

(3)

(-1)

(4)

3h Man Made noise - Such as power lines acting as antennae (-4)

Solar radiation - Strongest during the day, adding noise to waves.

3i This is a Method of applying rules to the waves to ensure they are sent relative to external conditions (-2)

3j This relates specifically to the orientation of the waves, when they are orthogonal, they have no specific direction. (-2)

4a P_r = Power transmitted back to transmitter (W)

P_t = Transmitter Input Power (W)

G_t = Gain of transmitter

σ = Radar cross sectional area (m^2)

r = Distance to target (m)

A_{eff} = effective area of radio receiver (m^2)

4b Radar cross section is the cross sectional area of a reflecting sphere that would reflect the same energy as the target (-1) (2)

4c Size, Shape, orientation, reflectivity, wave length. (5)

4d Stealth would require a passive radar receiver to ensure the target is not emitting a clear signal. (-2)

4e Active radar receiver, large casing, Metallic finish travelling alongside the detector showing large cross section. (-5) (2)

4f Distance = $\frac{\text{Power}}{\text{Intensity}}$ $I = W \times D^2$
 $D = \frac{P}{I}$ $P = D^2 \times I$ $100 = W \times (10 \times 10^3)^2$
 $P =$ $W = \frac{100}{(10 \times 10^3)^2} = 1 \times 10^{-10} W/m^2$ (-1) (4)

5a A black body will absorb all radiation waves that come into contact with it regardless of type. (-1) (2)

5b Emissivity is an object's ability to emit infrared radiation. (-1) (2)

5c P = Net radiated power

T_r = Temperature of radiator ($^{\circ}K$)

σ = Stefan's constant ($5.6703 \times 10^{-8} W/m^2 K^4$)

A = Radiating area (m^2)

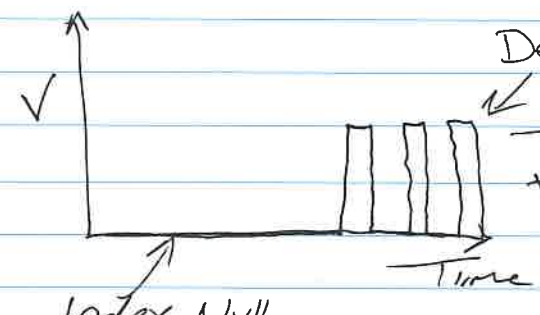
ϵ = emissivity

T_s = Temperature of the surroundings ($^{\circ}K$)

5d Figure 3 shows the reticle of a missile seeker head with a rotating piece that will block, then allow IR onto the detector. The differences between each detection allow the seeker to track the IR signature. (see over) (-1) (2)

5e Due to operating in the 3-5 μm range. The strongest or most intense radiation from the sun is in the 0.4 - 0.8 μm range. When below 3000K the peaks are much closer to 3-5 μm and therefore the seeker will be detecting these ranges far more often. (-2) (1)

5f Infrared radiation is known as the invisible heat wave - Prolonged detection will heat the detector - requiring a cooling system. (-1) (1)

5g  (1) (4)

54. Directing infrared at the detector will confuse the targeting by adding false IR pulses into the detector. The system will be unable to distinguish between the signals and may redirect incorrectly.

(3)

21

28

10. The amplitude of light at C will change due to the air pressure moving the two signals out/in to phase with each other. Assuming they start in phase at Opa B detection, they may be 90° out of phase at a max design range, this takes the wave from constructive at min, destructive at max.

-2

(3)

1P $wl = s \times f$?

5d. Figure 2 shows radiation emitted at ~~various~~ ^{temperatures} of 6000K, 5000K, 4000K and 3000K between 0 - 3 μm wavelengths. It shows that at 6000K the strongest waves are those in the visible light spectrum. As temperature is reduced, the strongest wavelengths move into the infrared.
(noted)

1



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SURNAME: Howe

FORENAME(S): James

1	Student Number	1910319
2	Title of Examination Paper	Electromagnetic Radiation OMR
3	Module Code	ACDAS009
4	Date and Time of Examination	09:00 05/05/2023
5	Examination Venue	310
6	Seat Number	020
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

1. ~~The separation of a light wave into its constituent parts~~
~~on~~ when changing the medium it is travelling in.
- a) ~~The~~ The change in direction of a wave passing from one
 medium to another. (1)
- b) ~~The~~ ~~Water~~ the Light changing ~~the~~ direction
 as it passes through a glass prism. Separating into
 its components. (1)
- c) The bending of waves around the corner of an obstacle
 or through an aperture. (1)
- d) Light from a room entering another room through
 a doorway will experience diffraction. (1)
- e) Separation of frequencies as a wave passes through
 a medium. (1)
- f) When white light travels down an optical fibre,
 the red light will appear first and the blue last. (1)
- g) A change of direction ~~between~~ of light between
 two media where the angle of reflection equals the
 angle of incidence. (1)
- h) Light reflecting off of a smooth surface like a
 mirror. (1)
- i) Reflected light is scattered when ~~off~~ when reflecting
 off of a diffuse (rough) surface. (1)
- j) Light in a room reflecting off of a painted wall
 experiences diffuse reflection. (1)

Next page.

k) Transfer of a wave into a different medium with no transfer of energy. (-1)

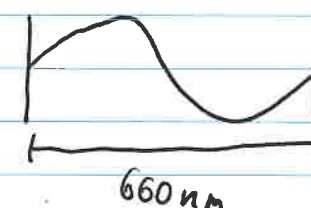
l) Illumination in a room due to Sun light. (-1)

m) Transfer of energy from a wave to a media. (1)

n) Infrared light rays incident on a black plastic sheet will be absorbed, raising the temperature of the sheet. (1)

o) The amplitude of the light at C varies as the input waves ~~can interfere with each other~~ and the reflected waves interfere with each other. Constructive interference ~~will~~ will increase the amplitude and destructive interference will decrease the amplitude. The amplitudes of the original light will also ~~not~~ effect the amplitude at point C. (-1)

p) $1 \times 10^{-9} \text{ m Pa}^{-1}$, $660 \text{ nm} = 660 \times 10^{-9} \text{ m}$



$$\text{max} - \text{min} = 330 \text{ nm} = 330 \times 10^{-9}$$

$$\frac{330 \text{ nm}}{330 \text{ nm}} = \frac{1 \text{ nm moved per Pa}}{330 \text{ Pa}}$$

(-2)

(3)

Next Page

q.) 3 Pa.

(-5)

19/29

2a) Magnetic flux density is the strength of a magnetic field. The magnitude of force acting on a current-carrying wire per unit of length when the wire is placed in a magnetic field.

(1)

(-1)

b) Magnetic flux density is measured in ~~Testo~~ Tesla (T).

(1)

(-1)

$$c) F = BIL \quad B = \frac{F}{IL} \quad \begin{array}{l} F = 2N \\ I = 1 \\ L = 1 \end{array}$$

$$B = \frac{2}{1 \times 1} = 2 \text{ Tesla}$$

(2)

d) Magnetic flux is the measurement of ^{perpendicularly the} total magnetic field which passes through a given area.

(1)

(-1)

e) Magnetic flux unit is the Weber (Wb).

(-1)

(1)

f) Magnetic flux in a given area is the magnetic flux density multiplied by the area.

g) The magnitude of the emf induced in a circuit is proportional to the rate of change of the magnetic flux that cuts across the circuit.

h) $E.m.f = N \frac{\Delta \Phi}{\Delta t}$ $N = \text{number of turns}$
 $\Phi = \text{magnetic flux}$
 $t = \text{time (s)}$

i) $\Phi = B \times A$ $B_m T = 5 \times 10^{-3} T$
 $= 5 \times 10^{-3} \times \pi \times (5 \times 10^{-3})^2$ $S_{cm} = 5 \times 10^{-3} m$
 $= 3.927 \times 10^{-7} Wb$

j) $E.m.f = N \frac{\Delta \Phi}{\Delta t}$
 $= 100 \times \frac{3.927 \times 10^{-7}}{0.14 \times 10^{-3}} = 0.28 V$

3.a) VHF Radio.
 Frequency: 30 MHz — 300 MHz
 Wavelengths: 10m — 1m

b) VHF uses. Marine communications (short range), air traffic control, emergency services, amateur radio, public transport (bus, train and tram drivers).

c) Radio propagation modes: Line of sight, ground wave and sky wave.

d) Line of sight: Transmission

(2)

(2)

(3)

(-2)

(3)

(-2)

(3)

19
27

(2)

(5)

(3)

3. d) Ground wave: absorption

Sky wave: Reflection.

e) VHF band: Line of sight.

f) Dipole antenna. $137 \times 10^6 \text{ Hz}$

$C = f \lambda$ $\lambda = \frac{C}{f} = \frac{3 \times 10^8}{137 \times 10^6} = 2.19 m$

Length of antenna = $\frac{\lambda}{2} = \frac{2.19}{2} = 1.09 m$

g) When aligned it can efficiently radiate or receive the signal at its resonant frequency which maximises the signal strength.

Whip antenna can be directional and as such can be aligned to provide the best signal strength. It can be optimised for impedance matching, maximising power transfer. Better signal strength, lower interference and improved signal quality.

h) VHF waves are prone to multipath interference from reflections. COFDM uses subcarriers to ~~stop~~ increase resistance to interference. COFDM uses error correction coding to detect and correct detected errors.

i) The use of error correction coding techniques.

j) The subcarriers are perpendicular to each other.

(-2)

(2)

(1)

(4)

(2)

(4)

(2)

- 4.a) P_r = reflected power (W)
 σ = radar cross section (m^2)
 G = antenna gain
 P_t = Power transmitted (W)
 r = radius of ~~antenna~~ dish (m)
~~Eff~~ A_{eff} = Efficiency.
- b) How detectable an object is by radar.
 Larger cross section = easier to detect.
- c) Size, reflectivity of its surface, directivity of the radar & reflection due to the object's shape.
- d) Stealth means the inability to be detected by radars.
- e) High surface reflectivity material. Large geometric cross section. Geometry of shape is normal to the radar emitter.
- f) Wsr^{-1} = Watts per Steradian.

(6)

(-2)

(1)

(3)

(-1)

(1)

(-3)

(4)

(-5)

15

28

5a) A body that absorbs all incident radiation electromagnetic radiation, regardless of frequency or angle of incidence.

(3)

b) The measure of an object's ability to emit infrared energy.

(-2)

(1)

c) P : Power radiated (W)
 e : emissivity
 σ : Stefan-Boltzmann constant ($Wm^{-2}K^{-4}$)
 T_r : Temperature of radiator
 T_{ss} : Temperature of surroundings.

(-1)

(5)

d) As a radiator increases in temperature the average wavelength emitted decreases and the grouping of wavelengths gets tighter (taller peak).

(-1)

(2)

e) The wavelengths emitted by the sun and earth have been blocked using the reticle.

(-3)

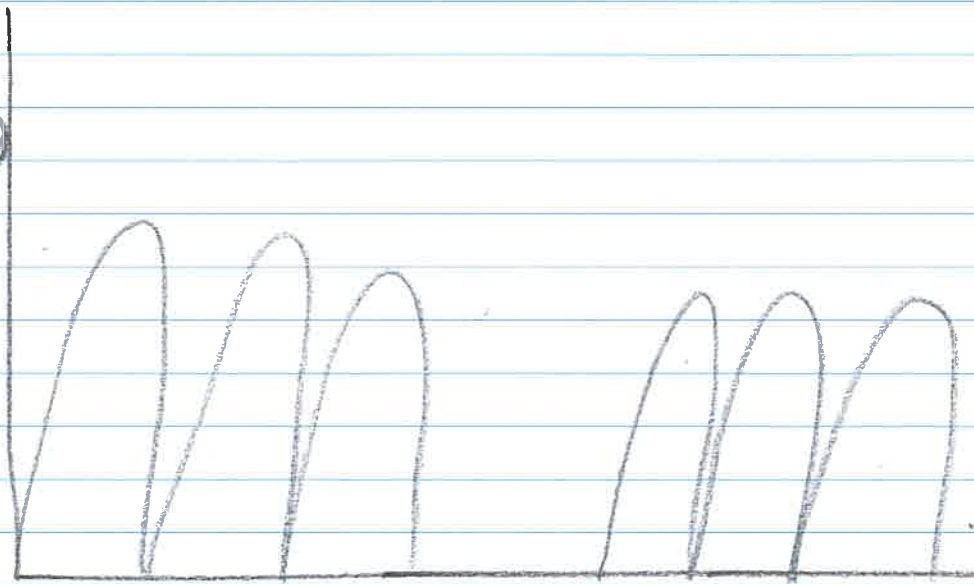
f) The sensor has to be cooled to allow the incident energy to heat it up, allowing for targeting. The same source will not heat up the detector the same amount if it is already warm. ($T^4 - T_c^4$).

(-1)

(1)

5. g)

Voltage (V)



Time (s)

-3

2

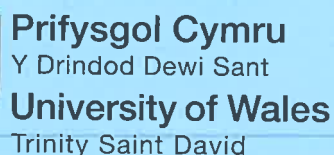
- h) The countermeasure could emit a similar frequency to that of the actual target with a high intensity that causes the missile to lock-on to the incorrect target.

-2

1

15

28



SURNAME:

Hardwood

12 Pages

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2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	ACDA5009
4	Date and Time of Examination	9:00am 05/05/2023
5	Examination Venue	1Q 310
6	Seat Number	014
7	Number of Answer Books handed in	

[illegible]

- ① a) Change of direction of a wave as it travels from one medium to another (1)
- ~~b) the formation of a Rainbow~~
- c) ~~is the change in direction of a wave~~
around a corner
is the bending of waves around corners of objects. (1)
- b) the formation of a Rainbow (1)
- d) a Clouds "Silver lining" (1)
- e) Separation of waves as they travel through a medium (1)
- f) when white light passes through a glass prism it splits into the spectrum of colours (-1)
- g) Change in direction through a medium where the angle of incidence = angle of reflection (1)
- h) ~~when white light is~~ Concave mirrors? (1)
- i) is the reflection of light from a surface such that the incident ray is reflected at many angles. (1)
- j) Bicycle reflectors (-1)
- k) when a wave travels through a medium into a new medium with no transfer of energy (1)
- l) the illumination of a room due to Sunlight. (-1)

m) Transfer of energy of a wave to a ~~medium~~ as the wave passes through it ^{matter}

(1)

n) photo synthesis in plants.

(1)

o) (-5)

p) (-5)

q) (-5)

11/29

Q2 a) the number of lines of force passing through a unit of area of material

(2)

b) Tesla T

(-1)

(1)

c) ~~2T~~ 2T

(2)

d) Magnetic flux is the number of magnetic field lines through a coil area

(2)

e) Weber wb

(-1)

(1)

f) $B = \mu_0 H$

(-2)

g) a relationship that expresses that a changing magnetic field induces a voltage on a circuit

(2)

h) $\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$

(3)

i) Crosssectional area $\times$ number of turns

$$= \pi R^2 = \pi \times 2.5^2$$

$$= 19.635 \text{ cm}^2 \times 100$$

$$= 1963.5 \text{ cm}^2 \text{ in m}$$

$$= 19.635 \text{ m}^2$$

(-3)

(2)

$$\Phi = BA = 0.19635$$

$$= 5 \text{ mT} \times 19.635$$

$$= 9.8175 \times 10^{-4} \text{ wb}$$

$$J) \quad \mathcal{E} = -N \frac{40}{4\pi t}$$

~~$$= -100 \times 40$$~~

$$= -100 \times \frac{9.82 \times 10^{-4}}{0.14 \times 10^{-3}}$$

$$\mathcal{E} = 701.45 \text{ v}$$

(-2) (3)

18
27

3) a) Frequency = 30 to 300 megahertz
Wavelength = 1 to 10 metres

(2)

b) Military communications
Ship to Ship Communications
Radio station
Over the horizon radar
Regional broadcasting

(5)

c) line of sight
~~ionosphere~~ bounce
Skywave ground wave

(-1)

(2)

d) ionosphere bounce reflection
Skywave is dispersion

(-2)

(1)

line of sight is absorption ^{transmission}

e) ionosphere bounce

(-1)

f) V-dipole antennae

(-2)

(2)

~~$$\mathcal{E} = \frac{V}{f}$$~~

~~$$\lambda = \frac{c}{f}$$~~

~~$$\lambda = \frac{3 \times 10^8}{137 \times 10^8}$$~~

~~$$\lambda = 0.027 \text{ m}$$~~

~~$$\text{dipole length} = \frac{\lambda}{2}$$~~

~~$$\lambda = \frac{V}{f}$$~~

~~$$V = \lambda f$$~~

~~$$V = 30143.014 \times 10^8$$~~

$$L = \frac{468}{f}$$

$$L = \frac{468}{137}$$

$$L = \frac{3.42}{\text{m}}$$

$$\mathcal{E} = \frac{\lambda L}{2}$$

$$\mathcal{E} = \frac{3.42}{2}$$

$$\mathcal{E} = 1.7 \text{ m}$$

3 g) When antennas are smaller than their dipole counter parts and receive and output in omnidirectional coverage

as when the transmitter and receiver are aligned they cover all directions around the antenna but

(-5)

When the transmitter and receiver are aligned the focus of the antennae is in one direction so it can receive and produce a clear signal

h) Cofdm implements a guard interval which introduces a short delay between transmissions reducing interference between transmissions

the also are

(-4)

they are also equipped with error correctional coding which can correct processing errors caused by VHF.

j) Orthogonal is when a single stream of data is split into multiple narrow banded sub channels

(2)

i) Coded means that if something attempts to intercept the transmission it would be encrypted until it reaches its intended target

(-2)

14
31

Q4 a) P_r Radar power received (W)

P_t Transmit power (W)

r distance from radar to target (m)

σ Target radar cross section (m^2) of target

A_{eff} = effective area of radar receiving antenna (m^2)

G_t = gain of radar transmit antenna (no unit)

b) is a measure of how detectable an object is by a radar

(-1)

(2)

c) its size,
reflectivity of its surface
directivity of radar's reflection caused by targets geometric shape
aspect angle
frequency
polarisation

(-2)

(3)

d) is to reduce the detectability by a radar

(-1)

(1)

e) heat signature
size
reflectiveness of surface

(-5)

(2)

noise
communications output
the projectiles own radar causing interference

Q4 f)

$$\frac{I_0}{4\pi R^2} = \frac{P}{A}$$

$$\frac{100}{4\pi \times 10^5} = 1.592 \text{ Wm}^{-2}$$

(-3)

(2)

16
28

Q5 a) an object that absorbs all forms of electromagnetic radiation that falls on it from any all angles of incidence

(2)

(-1)

b) is the ratio of energy radiated from a material's surface to that radiated from a perfect emitter

(3)

c) P - Power radiated (watts)

e - emissivity (no units)

(-1)

(5)

σ - ~~Stefan~~ Stefan boltzmann constant (5.67×10^{-8})

A - Surface area (m^2)

T - Temperature (Kelvin)

d) Figure 3 shows the UV, visible and infrared sections of the EM spectrum

illustrating the relationship between a body's intensity to its wavelength

(2)

the curve shows blue, white and red stars with points to at their temperature and frequency

White star at 5270K

blue star at 7000K

Red star at 4000K

(-1)

White star is similar to earth's sun

5 e) Infrared missile focus of narrow bands in the IR and UV Spectrum

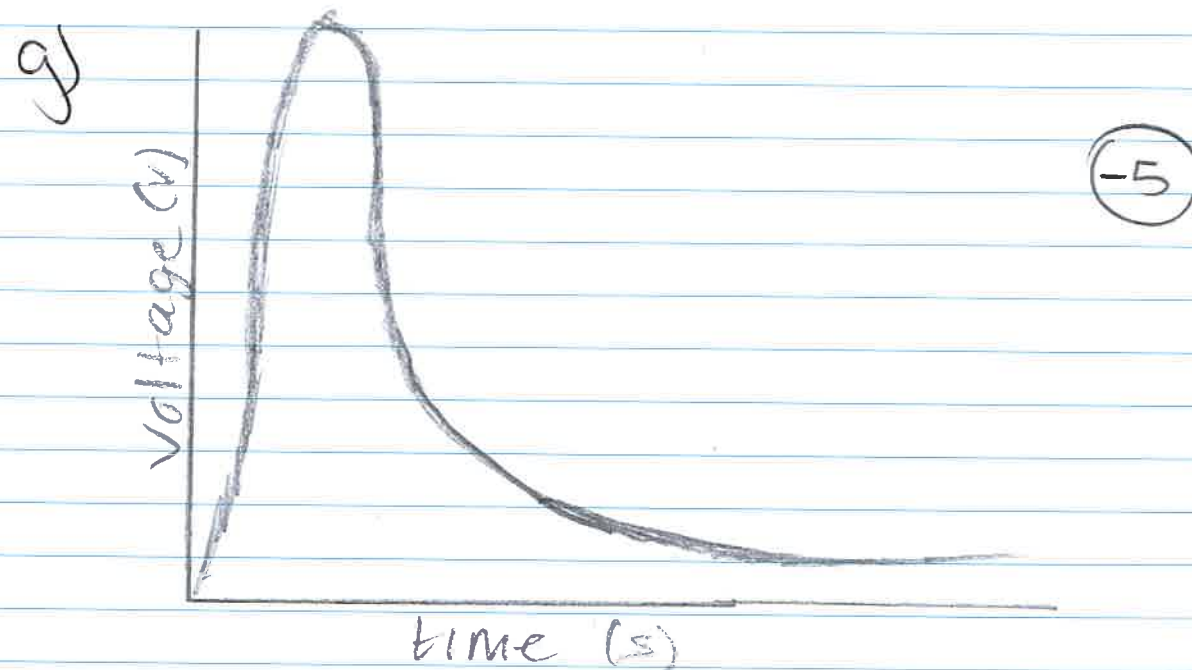
these bands match the targets heat signatures

(-1) (2)

the suns IR bands are outside of the focused band which the missiles search for

f) IR sensors are cooled in order to reduce thermal noise which so reducing the IR radiation from sources other than the intended target.

(2)



(-5)

h) DIRCM produce heat signatures similar to that of the targets engine/exhaust which distracts the missile from its intended target

(-2)

(1)



SURNAME:

~~knight~~ knight

FORENAME(S):

Charlotte

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2. Enter your name in the space provided to the right, fasten the book with the tag provided and seal down (using the label provided) to hide your name.
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1	Student Number	915 1907828
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	ACDAS009
4	Date and Time of Examination	9:00am 5/5/2023
5	Examination Venue	310
6	Seat Number	15
7	Number of Answer Books handed in	1

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

1.

a) Refraction is the change in direction of a wave passing through one medium to another caused by its change in speed.

(1)

b) Refraction example = rainbow

(1)

c) Diffraction is the bending of waves around an obstacle or through an aperture.

(1)

d) Diffraction example: a sunset

(1)

e) Dispersion is the separation of frequencies as a wave passes through a medium.

(1)

f) Dispersion example = petrol spilt on water

(1)

g) Specular reflection - A wave's change of direction between two media where ~~the~~ upon reflection the light is at one definite angle (and often the angle of incidence is equal or similar to the angle of reflection).

(1)

h) A mirror.

(1)

i) Diffuse reflection is a wave change of direction where the incident ray is scattered from where it originated.

(1)

j) Reflection from ~~dirty~~ dusty surfaces e.g. dust metal.

(1)

k) Transmission is the passage of a wave with no energy transfer.

(1)

l) light through a window.

(1)

m) ~~Absorption~~ Absorption is where energy is transferred from an EM wave to a medium.

(1)

n) ~~photo synthesis~~ A black object e.g. a car.

(1)

o) Positive interference, amplitude doubled ⁽⁻³⁾ negative interference, amplitude = 0.

(2)

p)
$$\frac{3 \times 10^8}{660 \times 10^{-9}} = 4.5 \times 10^{14} \text{ Hz}$$

(-5)

(-5)

15
29

2. a) magnetic flux ~~is the~~ density = the measure of intensity of a magnetic field at a point, defined as the density ~~between~~ of the magnetic field lines.

(2)

b) Unit = the Tesla. (T)

(-1)

(1)

d) Magnetic flux is the quantity which signifies how much a magnetic field passes ~~through~~ perpendicularly through an area.

(2)

e) Si unit = Weber (Wb)

(-1)

(1)

c) $T = N \times A \times m$.

$$2 \times 1 \times 1 = 2T$$

(2)

f) A flux density of one $Wb m^{-2}$ is one Tesla.

(2)

g) Faraday's law = a changing magnetic field produces an electric field

h)

A voltage is induced in a circuit whenever relative motion exists between a conductor and a magnetic field and the magnitude of this voltage is proportional to the rate of change of the flux

(2)

h)

$$\epsilon = - \frac{\text{no. of loops}}{1} \frac{\Delta \Phi}{\Delta t} \quad \begin{matrix} \text{change magnetic flux} \\ \text{time} \end{matrix}$$

induced voltage.

(3)

i) 2 coils
100 turns
magnetic flux density = 5mT.

~~100~~

$$5mT = 5mW$$

$$= 5 \times 10^{-3} Wb/m^2$$

$$5 \times 10^{-3} \times 0.05 = 2.5 \times 10^{-4} Wb$$

(-1)

(4)

j) Assuming flux = 5mWb

$$\epsilon = -100 \times \frac{2.5 \times 10^{-4}}{5 \times 10^{-3}} = \frac{2.5 \times 10^{-4}}{0.14 \times 10^{-3}} = \frac{2.5}{0.14} V$$

(-2)

(3)

$$-178.57V$$

$$= -17.6V$$

22

27

3. ~~1/1~~

a) VHF = 10m - 1m, 30 - 300 MHz

- b)
- marine radio
 - FM radio
 - TV broadcasting
 - Digital audio broadcasting
 - 2 way land mobile radio system

- c)
- line of sight
 - bouncing off the ionosphere
 - sky scanner

- d) line of sight = diffracted, ~~refracted~~,
~~reflected~~, ~~absorbed~~,
 bouncing off ionosphere = reflected
 skywave = refracted

- e) For VHF = ~~transmission only~~ diffraction

- f) 137 MHz easy to disguise

$$\frac{3 \times 10^8}{137 \times 10^6} = 2.19 \text{ m}$$

half dipole antennae =

$$2.19 \times \frac{1}{2} = 1.094 \text{ m} = 1.1 \text{ m}$$

(2)

(5)

(-1)

(2)

(-2)

(1)

(-1)

(4)

g)

Whip antenna are monopole, and have an omnidirectional radiation pattern. Therefore, they ~~transmit~~ radiate equal power in all directions, therefore it does not matter if they are aligned or not, as they are non-directional.

(-4)

(1)

h)

VHF does not:

- work well indoors
- penetrate walls / large structures.

(-4)

COFDM allows the signal to penetrate buildings, and can relay the signal easily. Enable non line of sight transmission, meaning it can bounce off ionosphere, going on large structures. Why?

i)

Orthogonal = when 2 transmissions have no influence on one another

(2)

Coded = where a communications channel is encoded to ensure error free transmission.

(2)

19
31

4. Power transmitted from target / (W)

a) $P_r = \frac{P_t G_t}{4\pi r^2} \sigma \frac{A_{eff}}{4\pi r^2}$

Transmitter input power (W)

gain of radar transmitter (dimensionless)

max radar range (m)

distance to target (m)

radar cross section (m²)

effective area of radar receiving target (m²)

b) The area intercepting that amount of power, which if radiated isotropically, produces the same received power in the radar (how detectable the object is by radar).

c) Factors:

- size
- reflectivity of surface
- ~~direction~~ shape of target
- material of target
- incident angle of beam hitting target
- reflected angle of beam from target
- polarization of transmitted signals.

d) Stealth = reducing the distance the person/vehicle can be detected (e.g. by radar).

e) Projectile easy to track:

- made of metal
- reflectivity of surface
- large size
- moving (fast).
- curvy surfaces
- some protrusions (fins)
- large surface area

f) $S_e = \frac{P}{R}$

$r = 100 = 10^2$

~~$10 \times 10^2 = 10^3$~~

~~$R = \pi r^2 = 314.2$~~

Area circle = $\pi 10^2$

Area sphere = $4 \times \pi \times 10^2 = 1256.6m$

$R = \frac{314.2m}{100} = 3.142m$

(Continued on back page)

5.

a) Black body = A hypothetical perfect absorber and radiator of energy with no reflecting power. (1) (2)

b) The measure of an object's ability to emit infrared energy. (1) (2)

c)

$$P = \epsilon \sigma A (T_r^4 - T_s^4)$$

ϵ emissivity (1 = black body)
 σ Stefan Boltzmann constant $5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$
 A radiating area (m^2)
 T_r temp of radiator (K)
 T_s temp of surroundings (K)
 P net radiated power (W)

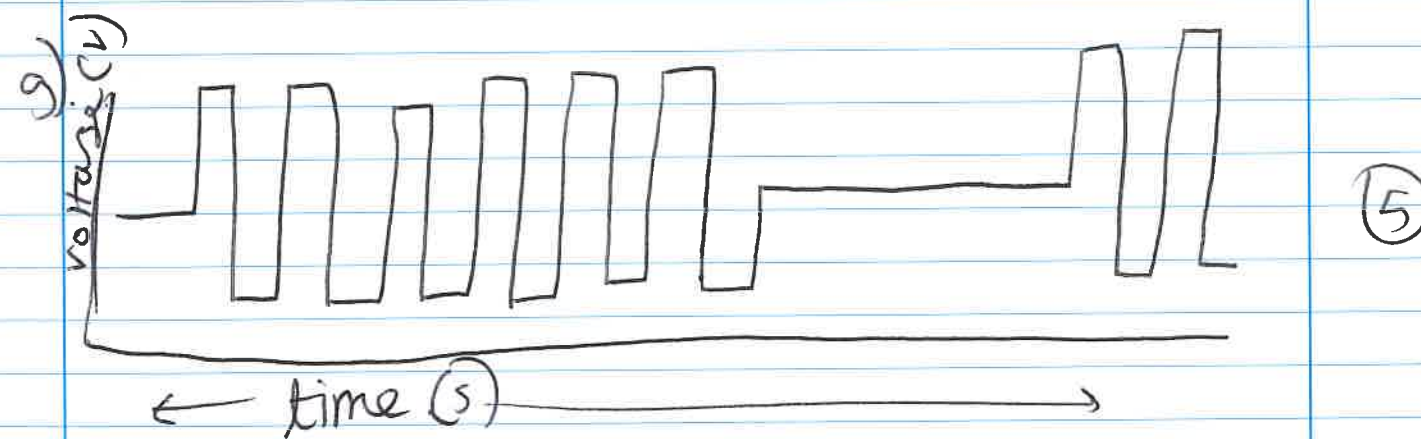
(6)

d) A black body radiation graph for the UV-IR part of the spectrum. The hotter the object, the shorter the wavelength emitted. It shows radiation is emitted through all wavelengths. The area under the graph is the total energy amount radiated per unit of time per the surface. (2) (1)

area by the object at that temperature.

e) Won't go to sea/earth as only searching in the 3-5 μm range. This range will be 'tuned' for the target set, and so the sun/earth won't be emitting in these regions, so the missile won't turn towards them. (3)

f) Sensor is ~~not~~ cooled so its own IR radiation from its own heat does not interfere with what it's sensing. (2)



h) The DIRCM ^{uses a laser} ~~could~~ emit the same IR wavelengths as the target. This causes the missile to follow the ~~missile~~ ^{laser}, not the target, saving the target. (1) (2)

23
28

4.
f.

$$I = \frac{P}{\Omega}$$

$$\Omega = \frac{\text{area cone on surface}}{(\text{sphere radius})^2}$$

$$= \frac{\pi \times (10^3)^2}{(10^3)^2}$$

(5)

$$= \frac{100}{4\pi} = 7.96 \text{ Wm}^{-2}$$



SURNAME: Atkins

FORENAME(S): George

Instructions to Candidates

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1	Student Number	P144201
2	Title of Examination Paper	Electromagnetic Radiation
3	Module Code	ACDA5009
4	Date and Time of Examination	0900 5 th May '23
5	Examination Venue	IQ 310
6	Seat Number	25
7	Number of Answer Books handed in	

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

- 1a) Refraction is the change of direction of a wave as it moves from one medium to another. (1)
- b) Refraction occurs in light when it moves from air into water, which is why objects don't appear to be where they are. (1)
- c) Diffraction is the bending of waves ~~to~~ round a corner or through an aperture. (1)
- d) Diffraction occurs in light when you shine it through a slit, you don't just get a beam of light, you get a slight cone. (1)
- e) Dispersion is the separation which is caused by lower frequency waves having a higher velocity than higher frequency waves. (1)
- f) Dispersion occurs in light in space. No - not in vacuum. (1)
- g) Specular ~~to~~ reflection is the change of direction of a wave where the angle of incidence is equal to the angle of reflection. (1)
- h) Specular reflection occurs in light when the light wave strikes a mirror. (1)
- i) Diffuse reflection is the change of direction of a wave where the reflections are scattered randomly. (1)
- j) Diffuse reflection occurs in light when the light wave strikes a wall. (1)
- k) Transmission is the passage of a wave through a medium without absorption. (1)
- l) Transmission in light occurs as light travels from the sun to Earth. (1)

1) 1m) Absorption is the energy lost by a wave as it travels through a medium.

1) n) Absorption occurs in light as it travels through water. And why the bottom of the sea is dark.

o) 1×10^{-9} m per Pascal

5) Amplitude can either double if the wave is sent back in phase as constructive interference or it can be reduced to 0 if it is reflected 180° out of phase as destructive interference.

4) p) $660 \times 10^{-9} \text{ m} \div 2 = 330 \text{ nm}$ (-1)

3) q) ~~$3 \times 10^{-9} \text{ Pa}$~~
3 Pa. (-2)

25
29

2a) Magnetic flux density is the amount of magnetic lines in a given area.

b) Tesla T (-1)

c) 2 Tesla

d) Magnetic flux is the number of magnetic lines in an area, ~~over a time~~

e) Weber Wb (-1)

f) Directly proportional to one another (-1)

g) The magnitude of the emf induced in a circuit is proportional to the rate of change with time of the magnetic flux that cuts across the circuit. (2)

h) $\mathcal{E} = \frac{d\Phi}{dt}$ $\mathcal{E} = \text{emf}$
 $d\Phi = \text{change magnetic flux}$
 $dt = \text{change in time}$

i) Area of coil = $2 \times 10^{-3} \text{ m}^2$
5 mT
Flux capacitor? (-2)

j)

(-5)

17
27

3a) 30 MHz to 299 MHz
1m to 10m

- b) Short Range communications
- Small ship/boat to boat
 - Walkie talkies
 - DAB radio
 - TV broadcasting

- c)
- line of Sight
 - Ground wave
 - Ionospheric Propagation (Skywave)

- d)
- line of Sight is using straight transmission, though it is subject to absorption on the way.
 - Ground wave uses diffraction to bend the radio wave around the Earth's curvature
 - Sky wave uses reflection to bounce the radio waves off the ionosphere.

e) line of Sight.

f) $C = f \lambda$
 $\frac{3 \times 10^8}{137 \times 10^6} = \text{wave length} = 2.2 \text{m.}$ Half dipole antenna
 Therefore max length is 1.1m.

g) Best performance will happen when aligned because the wave won't be polarised and the full amplitude of the wave length will strike the antenna

(2)

(5)

(3)

(3)

(1)

(4)

(5)

3h) Single way traffic will be overcome by multi-plex, allowing data to be transmitted both ways simultaneously. It also can overcome data loss due to the coding. -4

i) Extra bits of data are added, which adds redundancy. if the extra bits are lost in transmission the original message can still be made out. (2)

ii) Orthogonal means at right angles to. (2)

(2)

(2)

27
31

- 4a) P_r = Power received by Radar (watts) ✓
 P_t = Transmitted power (watts) ✓
 G_t = Gain ✓
 r = Distance to target (metres) ✓
 σ = radar cross section (metres²) ✓
 A_{eff} = effective area (metres²) ✓

b) RCS of target is the equivalent area seen by a radar. (-2) (1)

c) distance between radar and target.
 Scattered field strength at radar.
 incident field strength at radar. (-5)

d) Minimisation of Radar Cross-Section of a target so it is harder for radar to detect. (-1) (1)

e) If the projectile was large ✓
 If the projectile was finished with a reflective surface. (-3) (4)
 If the projectile was slow ✓
 If the projectile was orientated in such a way it provided a large RCS ✓

f) Inverse Square law (-4) (1)

(6)

(1)

(-5)

(1)

(4)

(1)

13/28

5a) A black body radiator is an object that absorbs all electromagnetic radiation at all frequencies and all angles of incidence. (3)

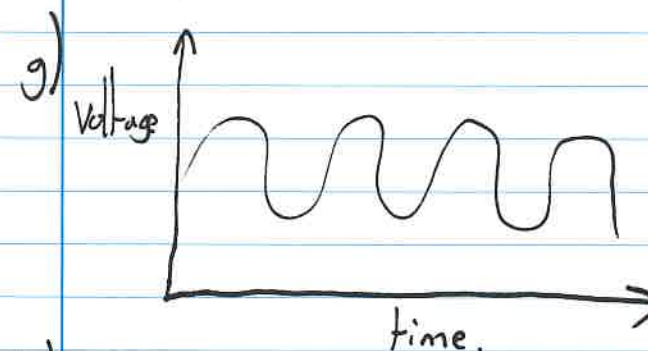
b) Emissivity is the measure of an object's ability to emit infrared energy. (-1) (2)

c) P = Power.
 e = emissivity
 σ = Steffin - boltzman constant
 A = Area
 T_i = Temperature
 T_s = Temperature (6)

d) It shows that, if the black body radiator has a higher temperature then it emits higher intensity wavelengths. (-1) (2)

e) Because at the earth the predominant wavelength of light is in the visible spectrum which is outside the 3-5 μm range. (-1) (2)

f) The sensor is cooled so it doesn't start tracking itself as an IR source. (2)



← not a clue! (-3) (2)

h) DIRCM could cause missile malfunction by giving the sensor multiple targets and it won't know which to course correct to, resulting in a miss. (-3) (2)

(3)

(2)

(6)

(2)

(2)

(2)

(2)

(2)

19/28