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GCSE Physics

Edexcel Light and the electromagnetic spectrum

Overview
Edexcel Topic 5

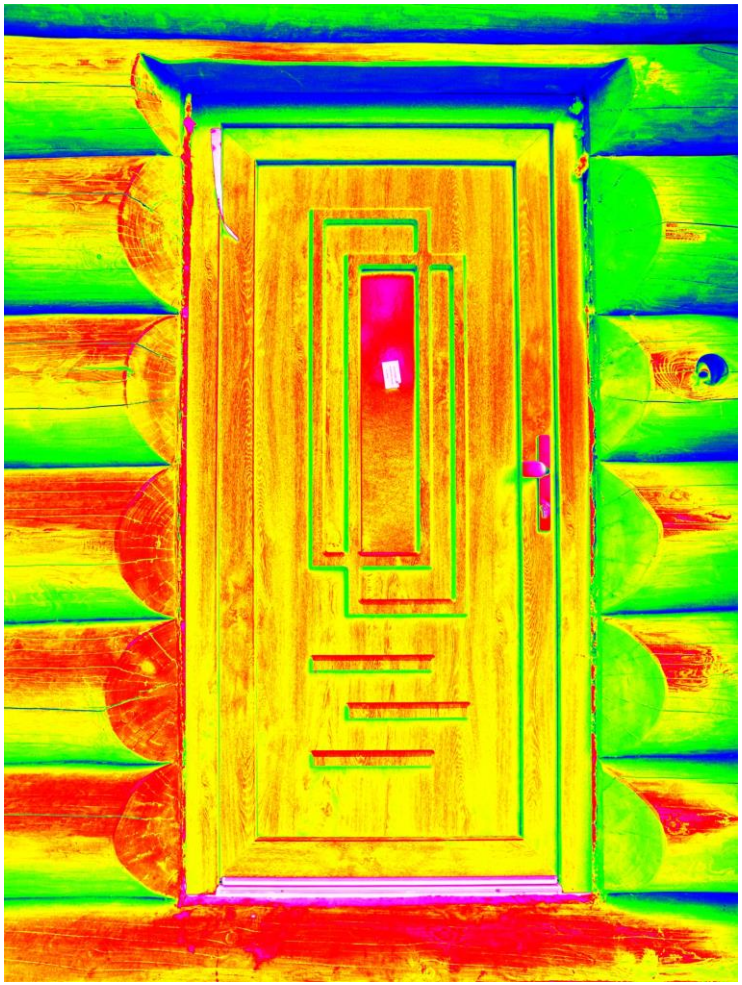
Light and the electromagnetic spectrum

Part 1

- Ray diagrams
- Colour (Physics only)
- Lenses (Physics only)

Part 2

- Electromagnetic spectrum
- Radiation and temperature (Physics only)
- Uses of EM radiation



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Part 1 (Physics only)

- Ray diagrams
- Colour
- Lenses

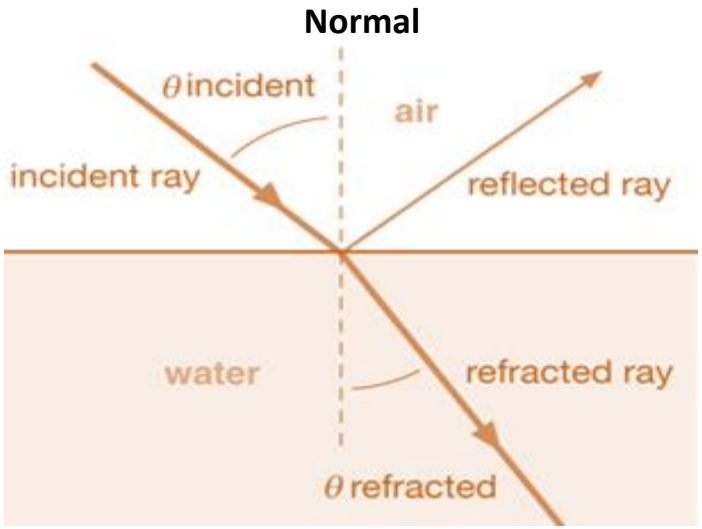
Ray diagrams – refraction (Physics only)

Refraction of waves at a boundary – ray diagrams

When light strikes a transparent material, some of the light may be reflected but some will also be **refracted**.

When light enters a substance of greater density, it will be bent (refracted) **towards the normal line.**

Angle of incidence > Angle of refraction



When light enters a substance of lower density, it will be bent (refracted) **away from the normal line.**

Angle of incidence < Angle of refraction

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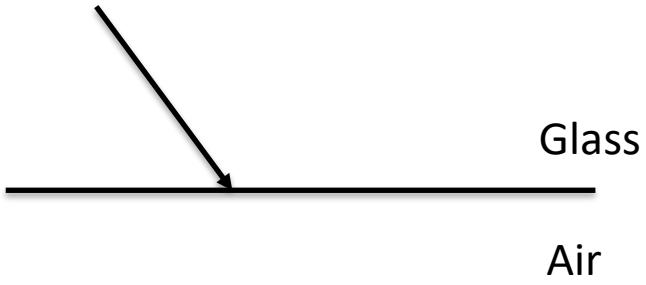
QuestionIT!

Part 1 (Physics only)

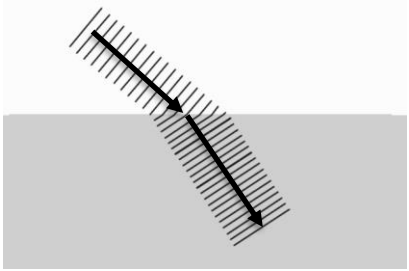
- Ray diagrams
- Colour
- Lenses

Part 1– QuestionIT (Physics only)

1. The light wave shown below meets a boundary between glass and air.
   Continue the light ray to show its path after passing the boundary.



2. The wave front below is travelling from air into water.
   Explain why the wave front bends.



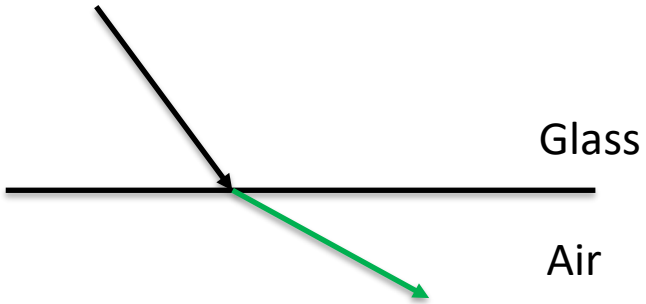
3. Complete the sentences.

When light enters a substance of greater density, it will be refracted …….. the normal line.

When light enters a substance of lower density, it will be refracted …….. from the normal line.

Part 1– AnswerIT (Physics only)

1. The light wave shown below meets a boundary between glass and air.
   Continue the light ray to show its path after passing the boundary.



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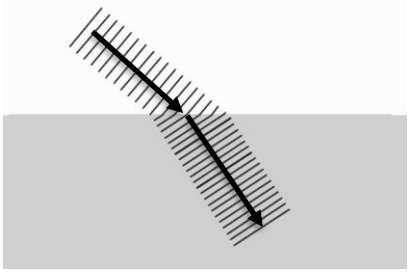

Left side of wave meets the denser material first.
The left side will slow down before the right side.
This will cause the wave to bend.

3. Complete the sentences.

When light enters a substance of greater density, it will be refracted towards the normal line.

When light enters a substance of lower density, it will be refracted away from the normal line.

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LearnIT!
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Part 2

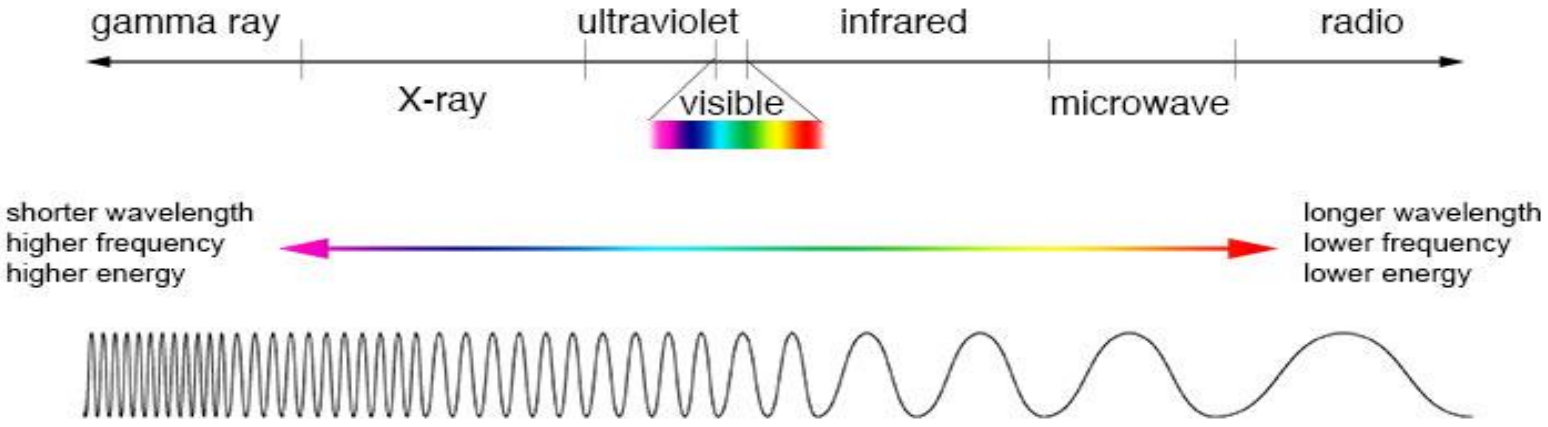
- Electromagnetic spectrum
- Radiation and temperature (Physics only)
- Uses of EM radiation

Electromagnetic spectrum

Electromagnetic waves are transverse waves that transfer energy from the wave source to an absorber.

Electromagnetic waves form a **continuous spectrum** from the shortest gamma waves (< 10^{-11}m wavelength) to radio waves (> 100km wavelength).
Shorter wavelengths have a **higher frequency** and **higher energy**.

All electromagnetic waves travel at the same velocity in a vacuum: 300 000 000m/s.



Our eyes are only able to detect a small range of these waves shown as the visible range above. Some animals can see in ultra violet and some can detect infra red.

Electromagnetic spectrum

Examples of transfer of energy by electromagnetic waves

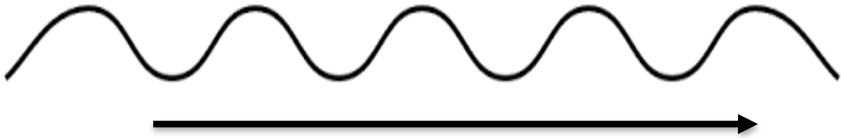
Heater

Infra red waves

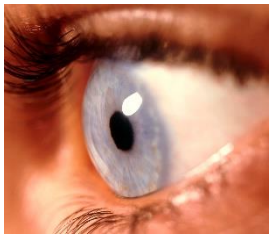
Detected by heat sensors in the hand

Torch

Visible light waves



Detected by cells in the retina

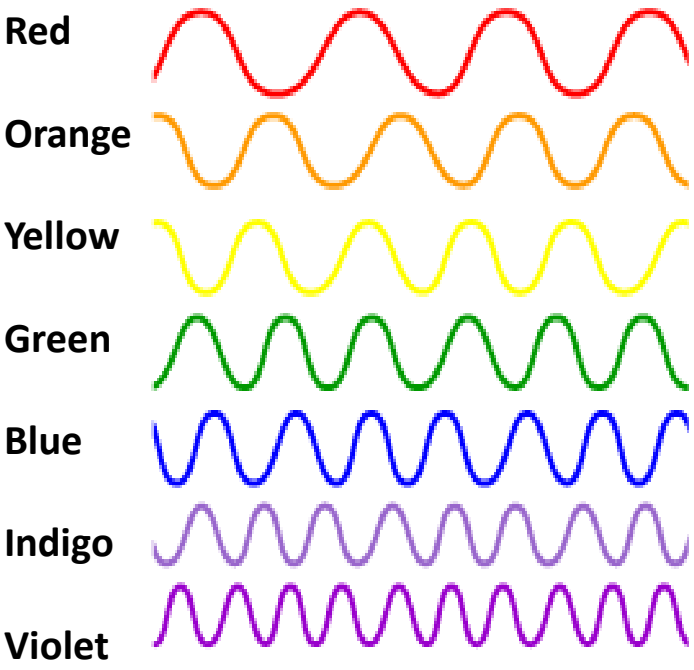


Radio transmitter

Radio waves

Detected by the aerial in the radio

Visible light



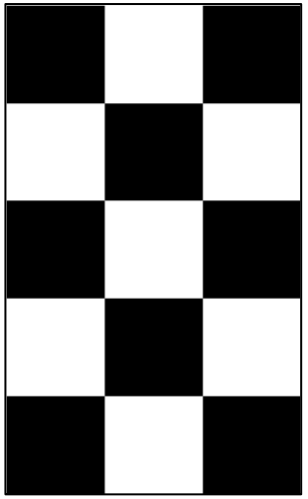
Visible light contains the limited range of frequencies that can be detected by the human eye.

Each colour within the visible spectrum has its own narrow band of **wavelength** and **frequency**.

Colour filters work by **absorbing certain wavelengths** (and colour) and **transmitting other wavelengths** (and colour).

The colour of an opaque object is determined by which wavelengths of light are more **strongly reflected**.
Wavelengths that are **not reflected are absorbed**.

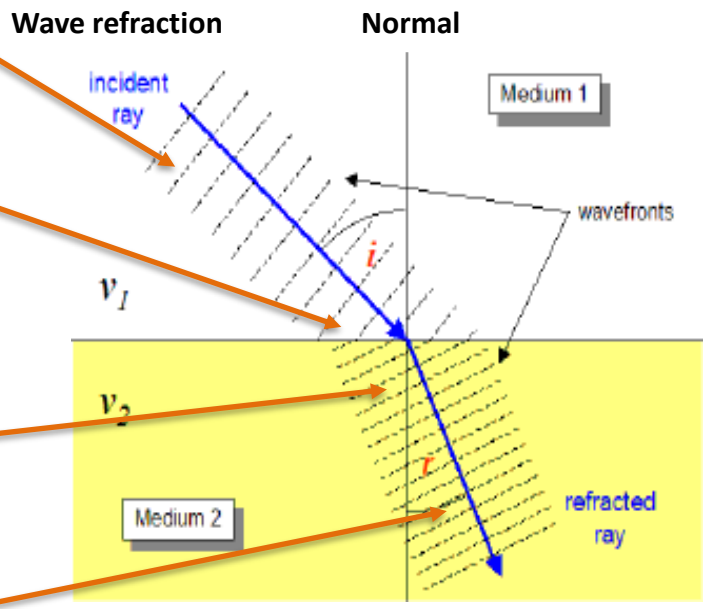
If **all wavelengths are reflected** equally the object will appear **white**. If **all the wavelengths of light are absorbed** equally the object will appear **black**.



Refraction of electromagnetic waves (HT)

Explaining refraction using wave front diagrams

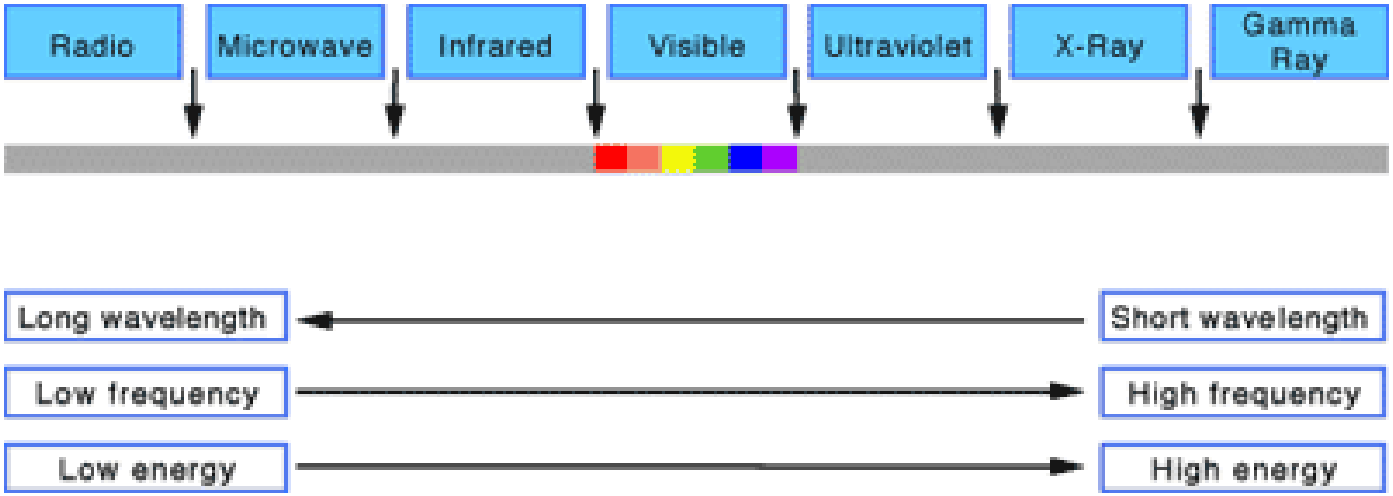
- The incident ray is shown as wave fronts where all the waves are in phase with each other. This is drawn as a wave line at right angles to the direction in which the wave is travelling.
- The incident ray strikes the denser medium 2 at an angle.
- When the wave front hits a denser material it slows down. One side of the wave front hits before the other side, so slows down first.
- This causes the wave front to bend towards the normal line. Wave fronts will be closer together as the velocity is decreased. Frequency is unchanged.



Health risks of electromagnetic waves

Health risks of high energy electromagnetic radiations: High frequency radiations have **high energy**. They can have a **hazardous** effect on **human tissue**.

- **microwaves**: can cause internal heating of body cells
- **infrared**: can skin burns
- **ultraviolet**: can damage to surface cells and eyes, leading to skin cancer and eye conditions
- **x-rays** and **gamma rays**: can cause mutation or damage to cells in the body



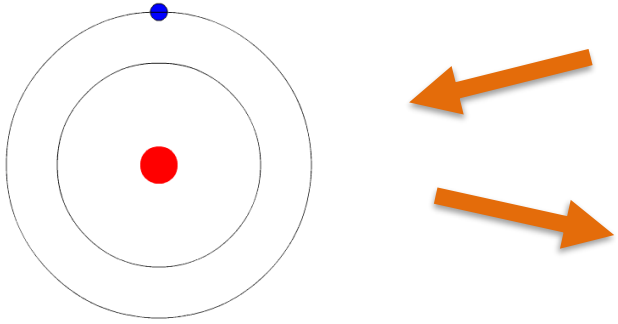
The hazard from high energy radiations also depends on the **dose**.
Radiation dose is a measure of the risk when exposed to these radiations.
Radiation dose is **measured in Sieverts**.

Uses of electromagnetic waves

	Type	Application
Low frequency low wavelength	Radio	Television, radio broadcasting and satellite transmissions
	Microwave	Cooking, communications and satellite transmissions
	Infrared	Cooking, thermal imaging, short range communications, optical fibres, T V controls and security systems
	Visible	Vision, photography and illumination
	Ultraviolet	Security marking, fluorescent lamps, detecting forged bank notes and disinfecting water
	X-rays	Observing the internal structure of objects, airport security scanners and medical x-rays
High frequency short wavelength	Gamma rays	Sterilising food and medical equipment, and the detection of cancer and its treatment

Changes in atoms and nuclei

Atoms and electromagnetic waves



Input energy could be:
light, heat, electricity, X rays etc

Energy out will be a type of electromagnetic radiation i.e.
X ray, ultra violet, visible,
infra red, microwave or radio waves.

Changes within the nucleus of an atom can result in the emission of gamma waves. This occurs during the radioactive decay of some unstable atoms.

Atoms can receive energy from external sources.
This energy can cause electrons to "jump" to a **higher energy level**.
When the electron falls back to its original energy level it will release the stored energy in the form of a **photon of electromagnetic radiation.**

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QuestionIT!

Part 2

- Electromagnetic spectrum
- Radiation and temperature (Physics only)
- Uses of EM radiation

Part 2 – QuestionIT

1. What type of waves are electromagnetic waves?

2. List the main electromagnetic waves in order from lowest to highest frequency.

3. Which of the following is the speed of electromagnetic waves in a vacuum?

   300 m/s 300 000m/s 300 000 000m/s

4. Which colour of light has the longest wavelength?

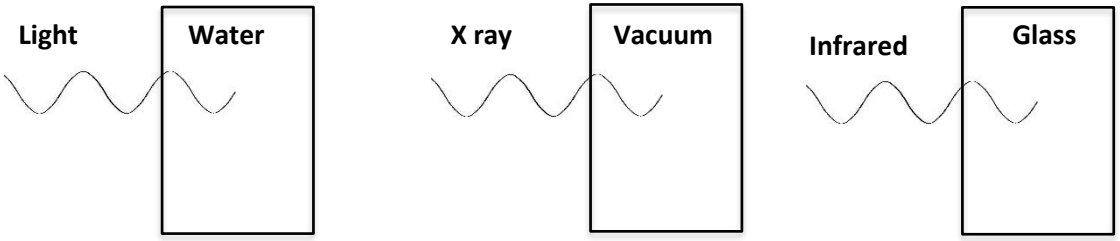
5. Describe one piece of evidence to show that light waves do not need a medium to travel from one place to another.

6. The four surfaces below are heated equally with infrared (IR) heat.

a. Which surface will absorb the most IR radiation?

b. Which surface will reflect the most IR radiation?

7. The diagrams show three waves travelling from air into different materials.



Which wave will be travelling the slowest?

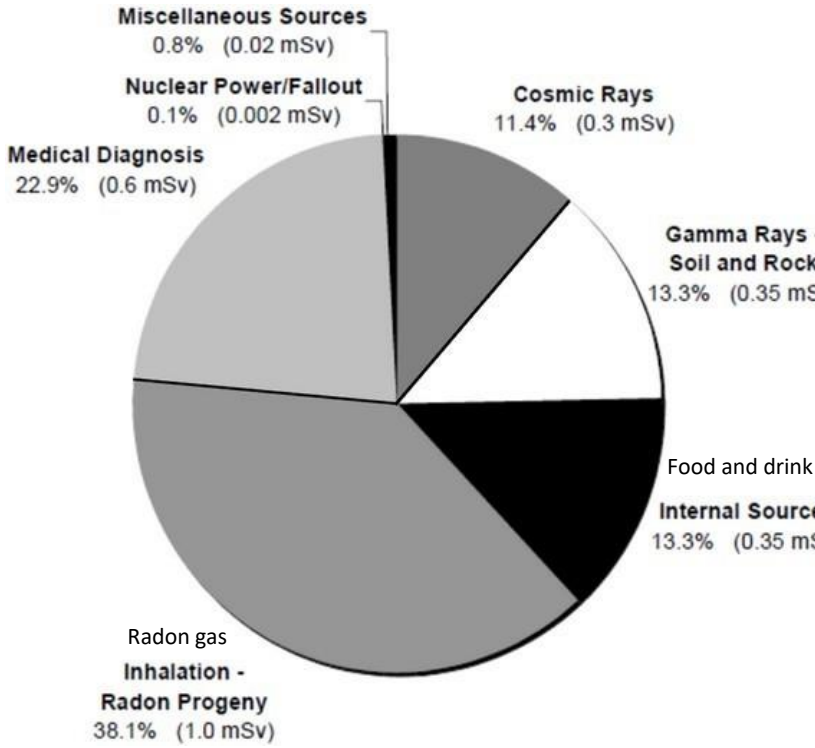
14. Which three types of electromagnetic waves can cause damage to cells in the body?

15. What is meant by radiation dose?

16. The chart shows the average radiation dose a UK person is exposed to in a year.

a) What percentage of the radiation dose comes from natural sources?

b) Give **two** reasons why a person could receive a higher dose of background radiation.



17. Complete the table for uses of electromagnetic waves.

Type	Application
Radio	
Microwave	
Infrared	
Visible	
Ultraviolet	
X-rays	
Gamma rays	

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AnswerIT!

Part 2

- Electromagnetic spectrum
- Radiation and temperature (Physics only)
- Uses of EM radiation

Part 2 – AnswerIT

1. What type of waves are electromagnetic waves?
   Transverse.
2. List the main electromagnetic waves in order from lowest to highest frequency.
   Radio microwave infrared visible ultraviolet X ray gamma ray
3. Which of the following is the speed of electromagnetic waves in a vacuum?

   300 m/s 300 000m/s 300 000 000m/s

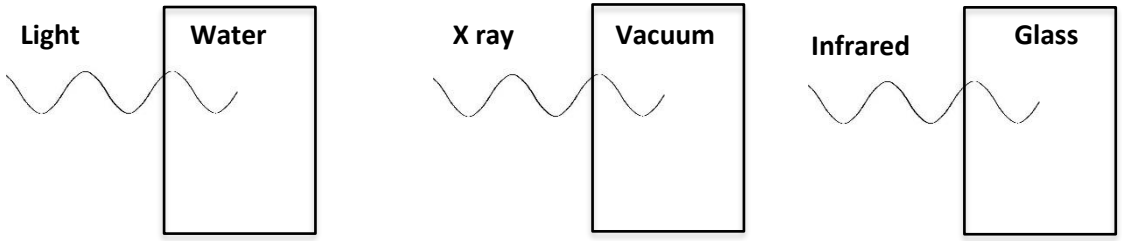
4. Which colour of light has the longest wavelength?
   Red.
5. Describe one piece of evidence to show that light waves do not need a medium to travel from one place to another.
   Light waves travel through space which is a vacuum.

6. The four surfaces below are heated equally with infrared (IR) heat.

a. Which surface will absorb the most IR radiation? Matt black.

b. Which surface will reflect the most IR radiation? Shiny silver.

7. The diagrams show three waves travelling from air into different materials.



Which wave will be travelling the slowest? Glass.

14. Which three types of electromagnetic waves can cause damage to cells in the body?

Gamma waves, X rays and Ultraviolet.

15. What is meant by radiation dose?

A measure of the risk of harm from exposure to radiation.

16. The chart shows the average radiation dose a UK person is exposed to in a year.

a) What percentage of the radiation dose comes from natural sources?

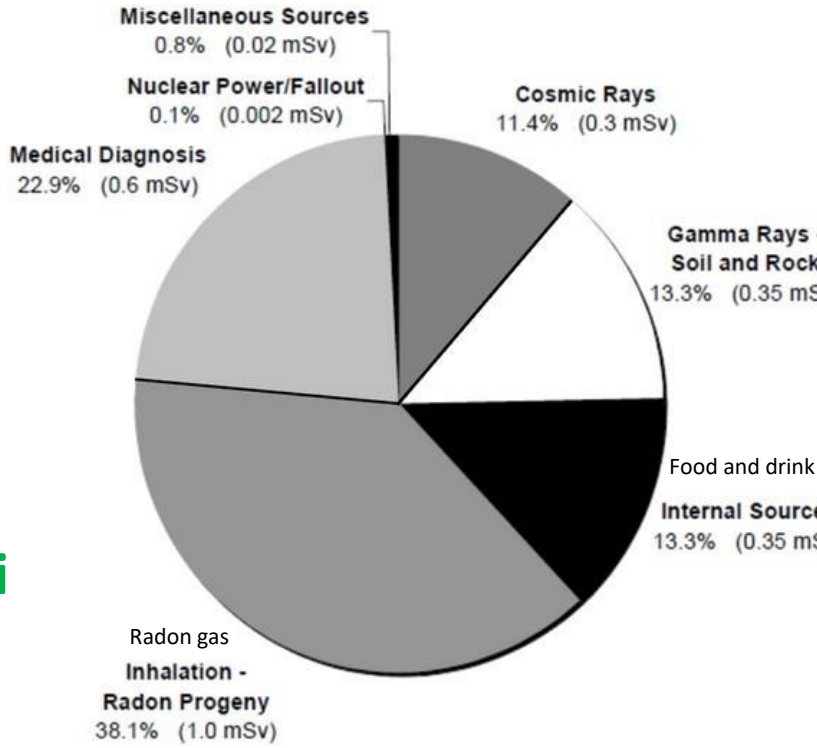
70 – 80%

b) Give **two** reasons why a person could receive a higher dose of background radiation.

Receive increased medical diagnosi

Live in a higher radon area.

Increased cosmic rays from flying.



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