Electromagnetic Spectrum

LEARNING OUTCOMES

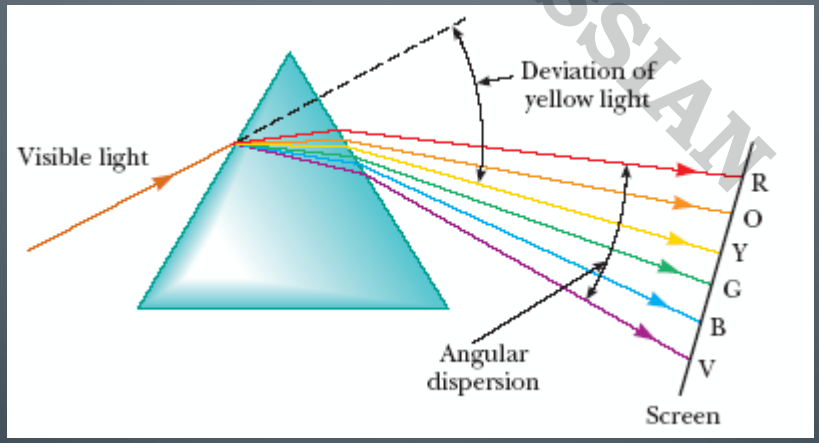
Dispersion of light
Properties of electromagnetic waves
Applications of electromagnetic waves

Dispersion of light

Describe the dispersion of light as illustrated by the action on light of a glass prism.

Dispersion of Light

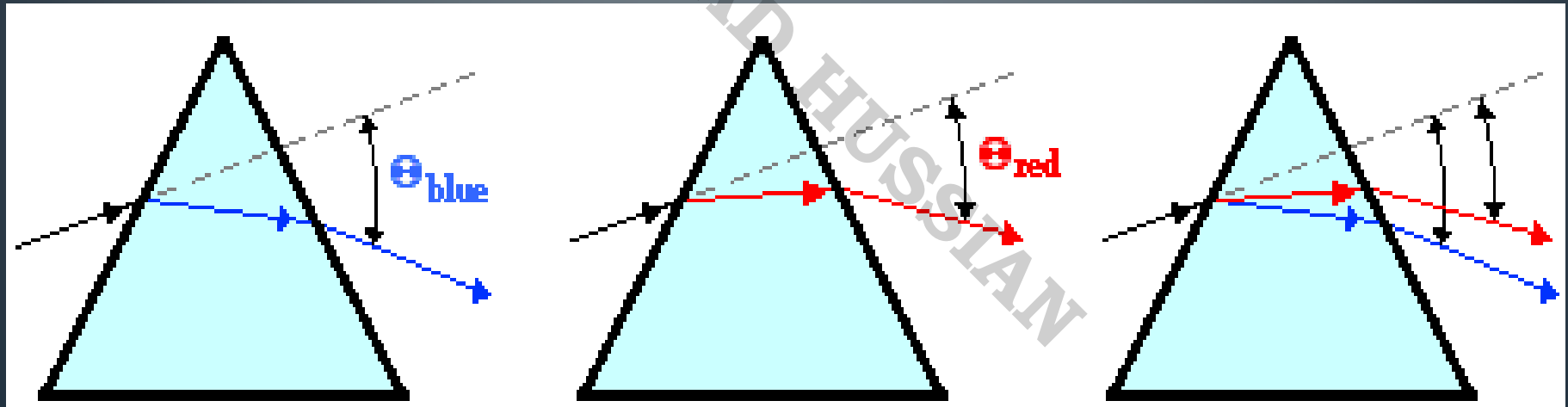
- Dispersion is an effect when a narrow beam of white light passes through a prism and splits intro a range of colour called a spectrum.
- Each color from the original beam of light has its own particular wavelength (or color) and each wavelength is slowed differently by the glass.



Dispersion of light

State the colours of the spectrum and explain how the colours are related to frequency/wavelength.

- The amount of refraction increases as the wavelength of light decreases.
- Shorter wavelengths of light (violet and blue) are slowed more and consequently experience more bending than do the longer wavelengths (orange and red).



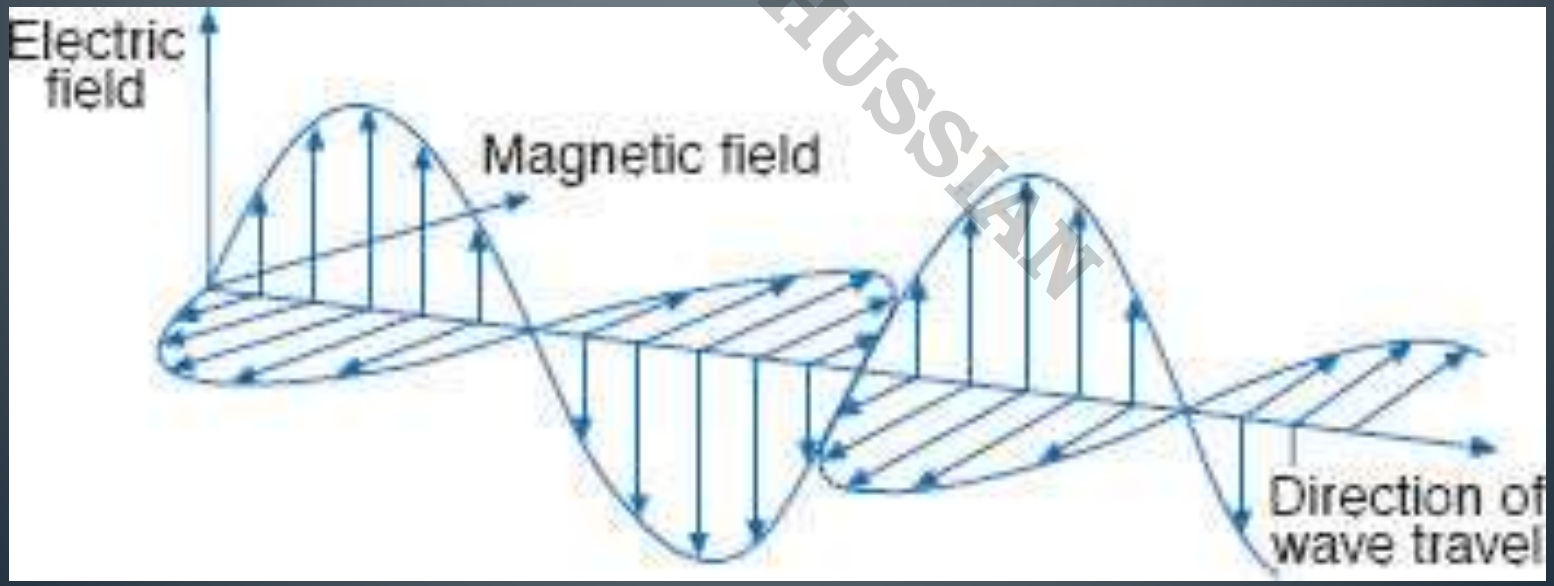
Blue light refracts more than red light due to the difference in wavelength. This causes blue light to deviate from its original path by a greater angle than the red light.

Properties of Electromagnetic Spectrum

State that all electromagnetic waves travel with the same high speed in air and state the magnitude of that speed.

Electromagnetic Waves

- Electromagnetic waves are emitted whenever charged particles oscillate or lose energy in some way.
- Electromagnetic waves are produced by the simultaneous vibration of electric and magnetic field.



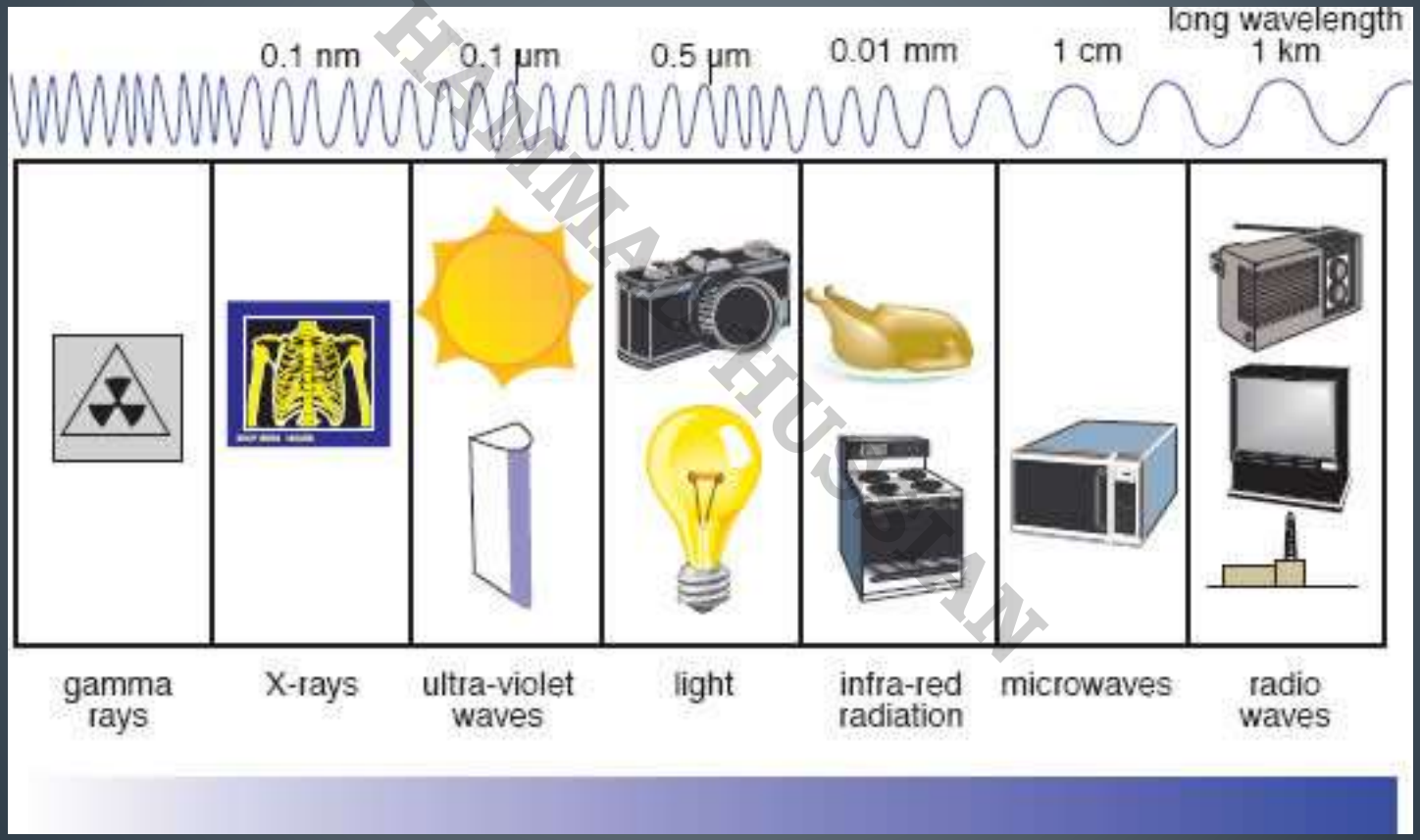
- Common features of all the electromagnetic waves include;
  - All **electromagnetic waves** are **transverse waves**
  - They can travel through a vacuum.
  - They travel through vacuum with the speed of light.
  - They all show wave properties like reflection and refraction.
  - They obey the wave equation $\boldsymbol{v = f \times \lambda}$.
- The shorter the wavelength, the higher the frequency.
- As the frequency gets higher, the energy increases.

Properties of Electromagnetic Specturm

Describe the main components of the electromagnetic spectrum.

Properties of Electromagnetic Wave

- Radio waves, microwaves, infra-red radiation, visible light, ultra-violet radiation, X-rays and gamma rays are all member of electromagnetic waves.
- Each type of radiation is produced and detected in its own special way.
- The wavelengths of electromagnetic waves range from extremely short for gamma rays to very long for radio waves.
- The higher the frequency of oscillation, or the greater the energy changes, the shorter the wavelength of the electromagnetic waves produced.



Application of Electromagnetic Waves

Discuss the role of radio waves in radio and television communications

Family of Radio Waves

- LW (long wave), MW (medium wave), SW (short wave) are used for AM radio communication.
- VHF (very high frequency) is used for high quality FM stereo radio.
- UHF (ultra high frequency) is used for television broadcast.

Application of Electromagnetic Waves

Discuss the role of microwaves in satellite television and telephone

Satellite Communication & TV

- Microwaves are used for satellite communication and television

Radar Systems

- Radar systems also used microwaves to find the direction and distance of objects.

Microwave Oven

- Microwaves is used for cooking as its wavelength are very strongly absorb by water molecule

Rain disrupts Satellite TV?

Satellite TV uses EM frequencies in the microwave range which is strongly absorbed by water. Rain reduces the strength of the signal, but the broadcaster minimises uplink interference by increasing the power and using multiple uplink stations at different locations, so you'll normally only notice it during very heavy rain that affects downlink reception.

Application of Electromagnetic Waves

Discuss the role of infra-red in household electrical appliances, television controllers and intruder alarms

Electrical Appliances

- When radiant heater is switched on, you can detect the infrared radiation coming from it by the heating effect it produces in your skin.

Remote Control

- The remote unit communicates with the appliance via infra-red pulses which is produced by light emitting diodes (LED)

Intruder Alarms

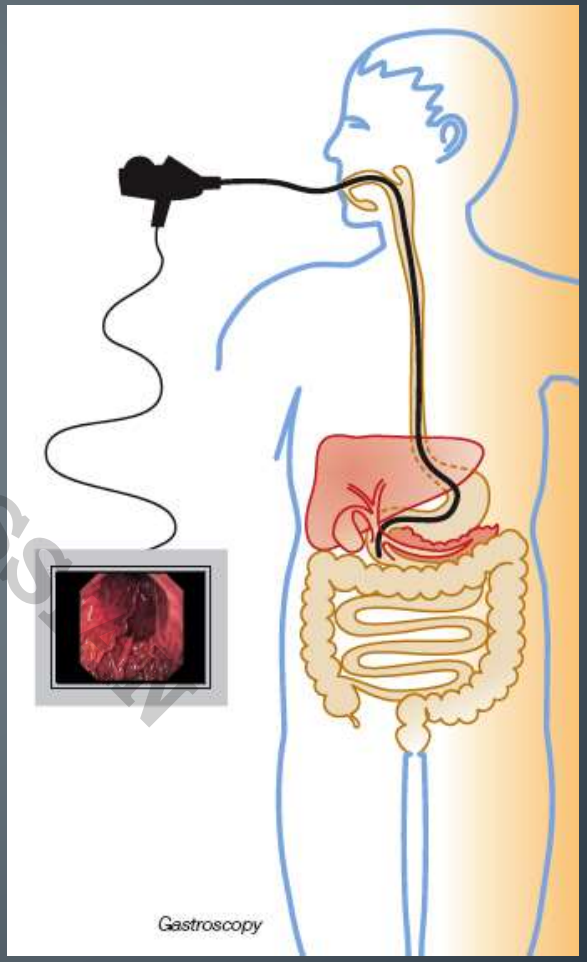
- The alarm system can be switched on by motion sensors that pick up the changing pattern of infrared caused by an approaching person

Application of Electromagnetic Waves

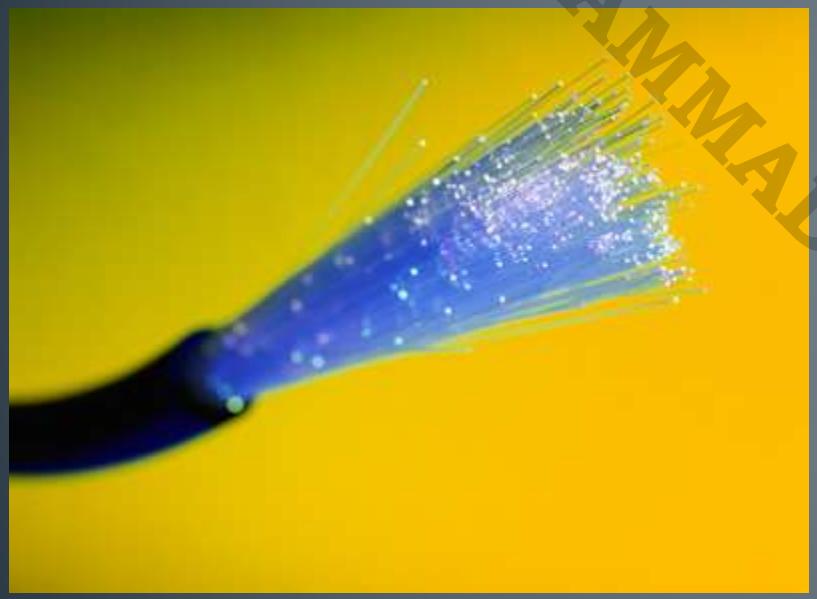
Discuss the role of light in optical fibres for medical uses and telephone

Optical Fibre

- An endoscope is a flexible fibre optic cable through which internal cavities can be viewed.



Optical Fibre



- For long distance transmission, telephone network use optical fibres that can carry digital signals in the form of pulses of light.

Application of Electromagnetic Waves

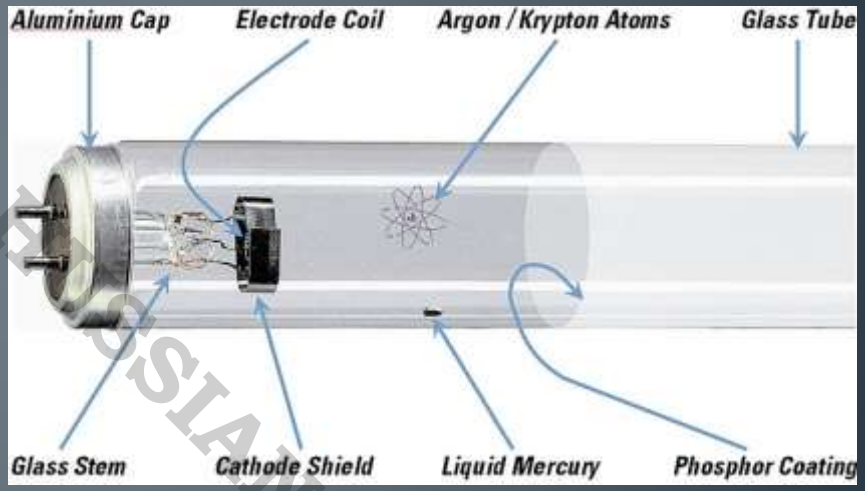
Discuss the role of ultra-violet in sunbeds, fluorescent tubes and sterilisation.

Sunbed

- Our skin responds to ultraviolet radiation by turning darker.
- Darker skins absorb more ultraviolet light, so less ultraviolet radiation reaches the deeper tissues.
- Ultraviolet radiation can cause normal cells to become cancerous.

Fluorescent tubes

- In fluorescent lamps, the inside of the tube is coated with a white powder which gives off light when its absorbs ultraviolet.
- The ultraviolet is produced by passing an electric current through the gas (mercury vapour) in the tube



Sterilising

- Ultraviolet is also used in sterilizing equipment to kill bacteria and viruses.

Application of Electromagnetic Waves

Discuss the role of X-rays in hospital use for medical imaging and killing cancerous cells, and engineering applications such as detecting cracks in metal

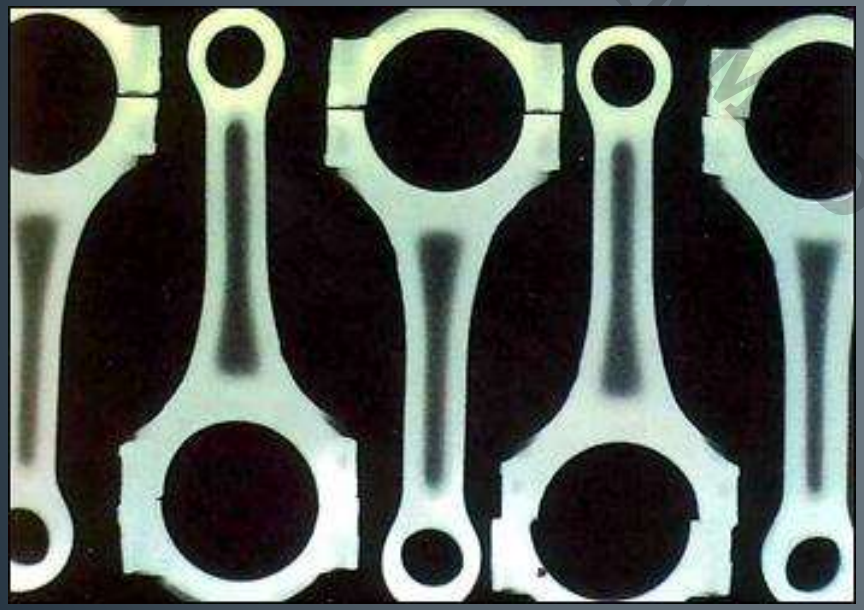
Medical Imaging

- X-ray is emitted when a beam of electrons hits a metal target.
- They can pass through flesh but not bone. So bones will show up on an X-ray photograph.

Radiation Treatment

- X rays can stop the growth of cells and even destroy them altogether.
- They are used to destroy tumors and also treatment of leukemia.

Detecting Cracks



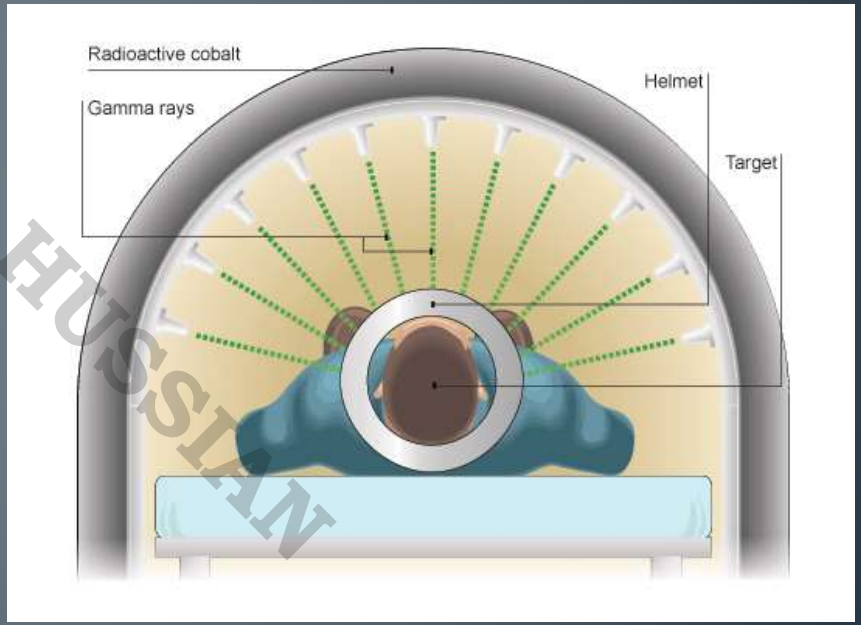
- X-rays are directed at the item to be tested so that they pass through it and captured an image on a film.
- The film is processed showing a series of grey shades which will show any defects.

Application of Electromagnetic Waves

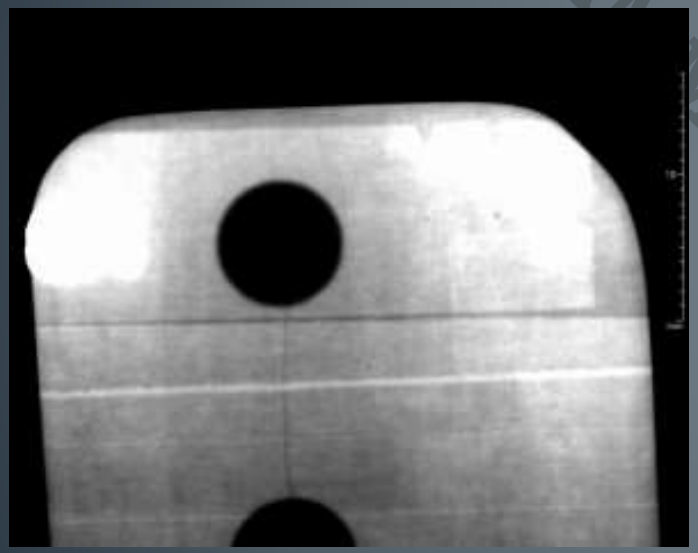
Discuss the role of gamma rays – medical treatment in killing cancerous cells, and engineering applications such as detecting cracks in metal.

Radiation Treatment

- Gamma rays damage cells whether they are normal or cancerous.
- A wide beam of gamma rays are rotate around the patient, keeping the tumour at the centre.
- This concentrates the gamma rays on the cells that need to be killed.



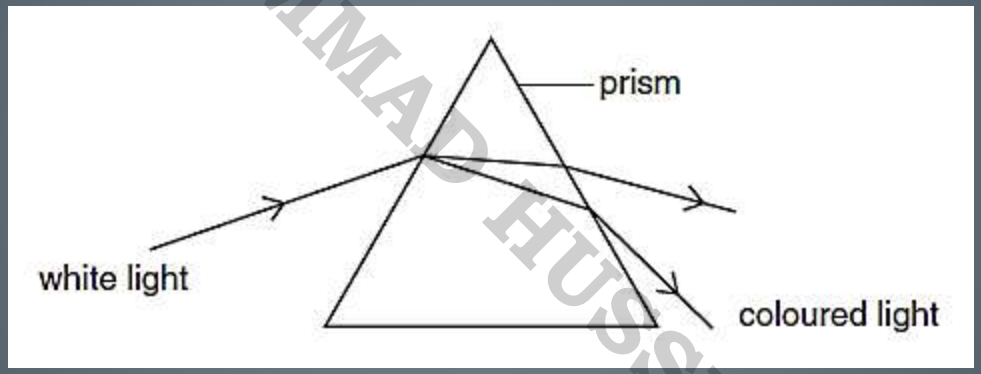
Detecting Cracks



- When photographic film is exposed to gamma-rays a 'latent image' is produced in film emulsion.
- The areas so exposed become darker when the film is immersed in a developing solution.

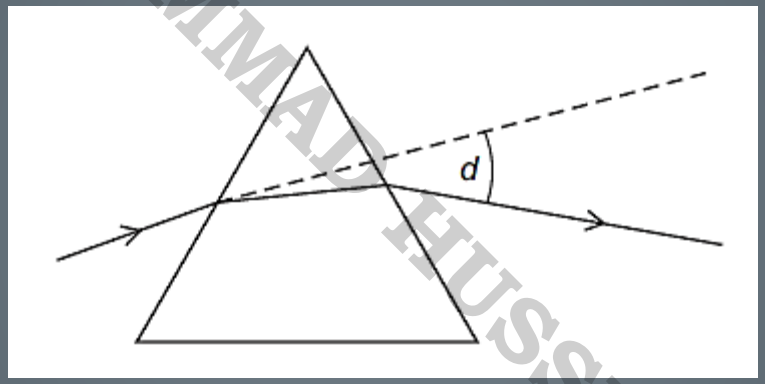
Radiation	Wavelength / m	Uses
Radio wave	10^{-1} - 10^{5}	1. Radio and television communication
Microwave	10^{-3} – 10^{-1}	1. Satellite television 2. mobile phone networks
Infra-red rays	10^{-7} – 10^{-3}	1. Remote control of electrical appliances 2. Intruder alarm 3. Radiant heater
Visible light	10^{-7}	1. Optical fibres for medical uses and telecommunications
Ultra-violet rays	10^{-8} – 10^{-7}	1. Sun beds 2. Sterilisation 3. Fluorescence effect
X-rays	10^{-13} – 10^{-8}	1. Medical /dental inspections 2. Checking cracks 3. Treatment of cancer
Gamma rays	10^{-14} – 10^{-10}	1. Treatment of cancer 2. Checking welds

1. One of the effects of passing a ray of white light through a prism is to split the light into colours.



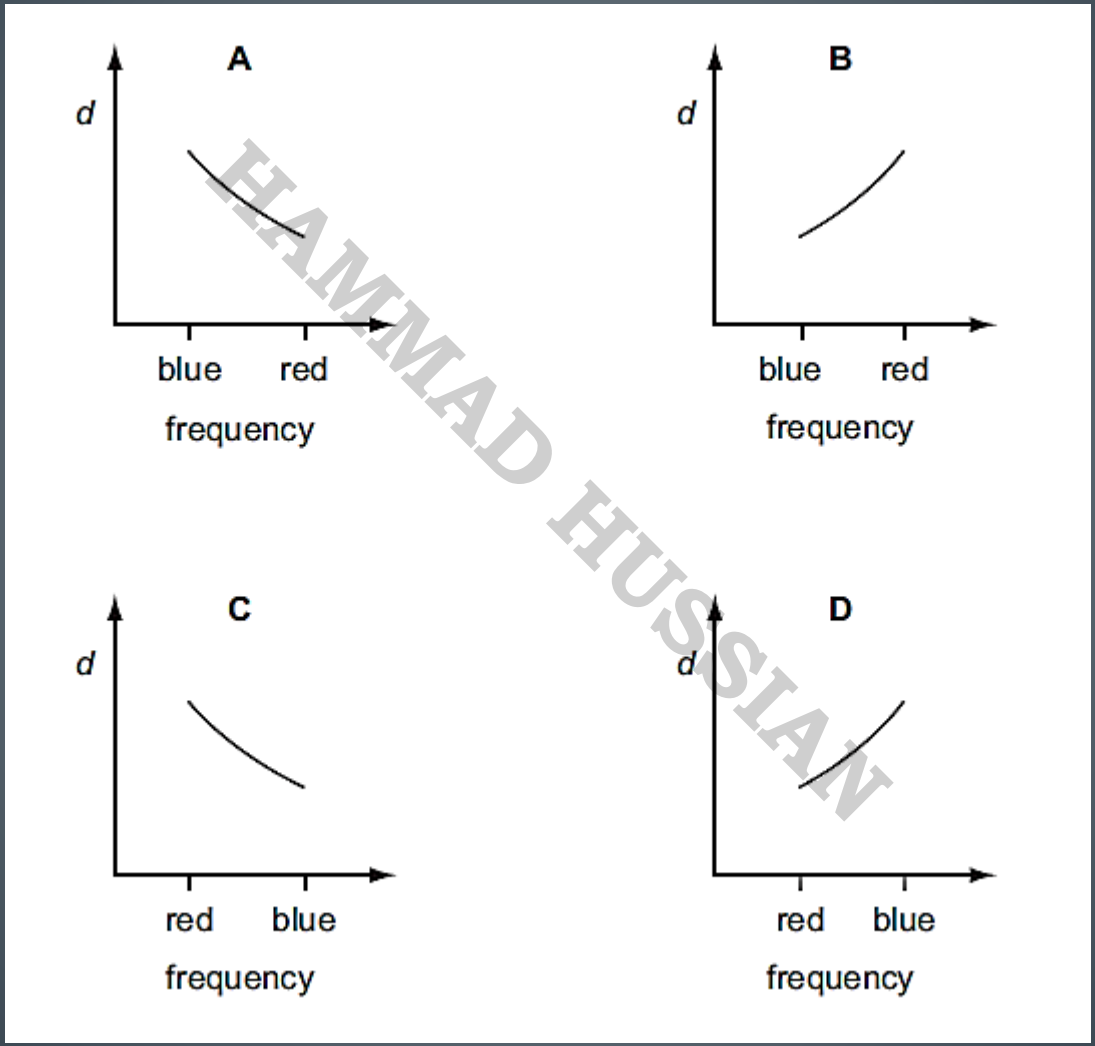
1. What is the name given to this effect?
   A. deviation
   B. dispersion
   C. reflection
   D. refraction

2. Light rays are deviated by a prism.



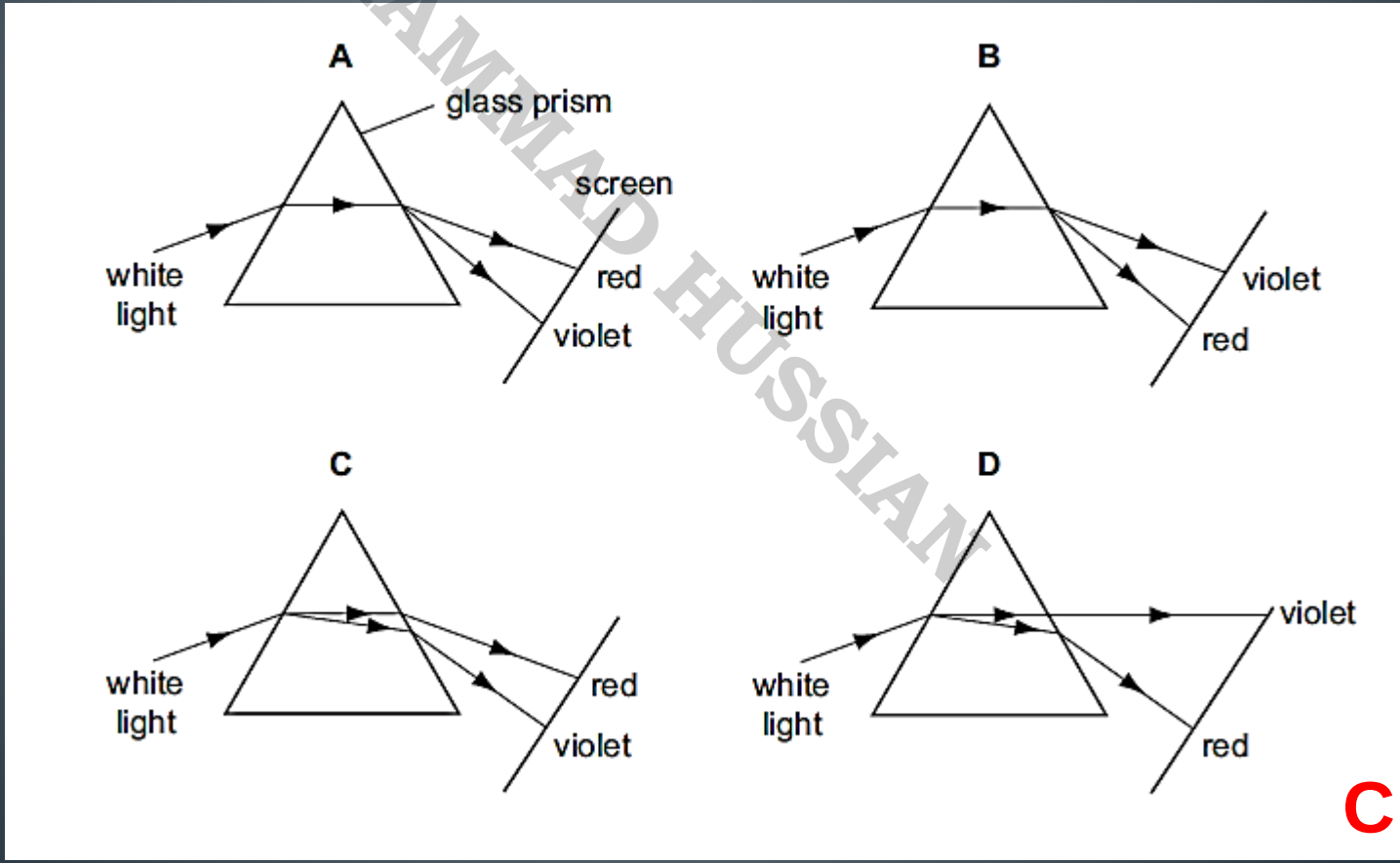
1. The deviation angle d is measured for light rays of different frequency, including blue light and red light.

1. Which graph is correct?



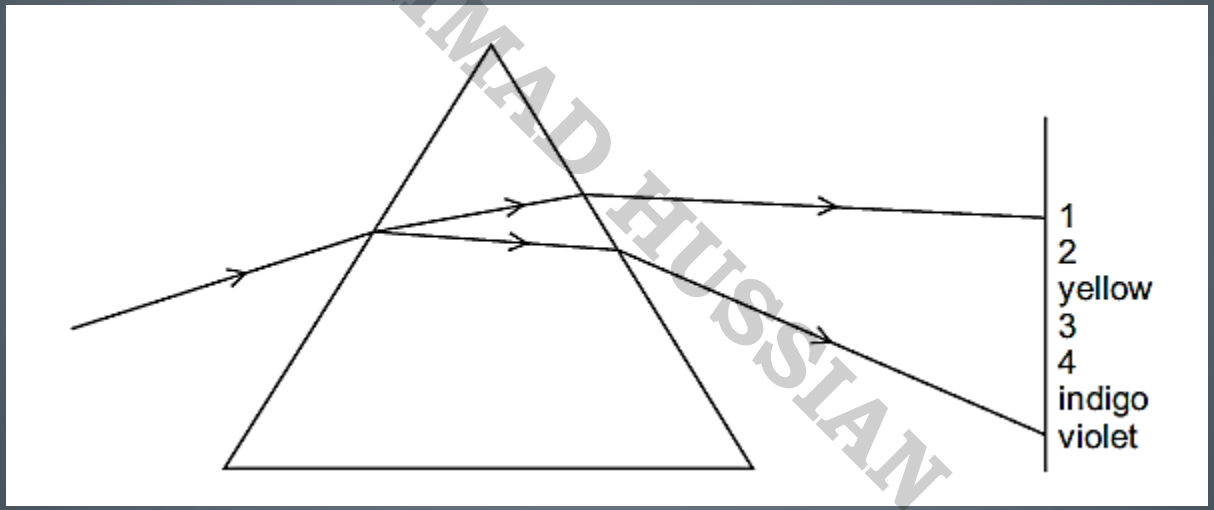
D

3. Which diagram correctly shows the dispersion of white light by a glass prism?



C

4. The diagram shows the spectrum produced when white light is dispersed by a glass prism.

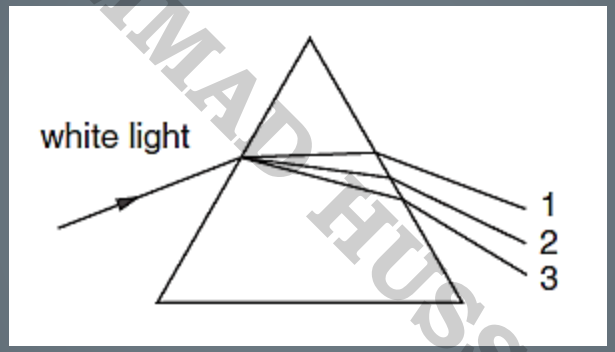


1. What are the numbered visible colours?

	1	2	3	4
A	infra-red	red	green	ultra-violet
B	red	green	orange	blue
C	red	orange	green	blue
D	red	orange	green	ultra-violet

C

5. A spectrum is formed when white light passes through a prism.



1. In which position are the colours green, red and yellow seen?

	1	2	3
A	green	red	yellow
B	green	yellow	red
C	red	green	yellow
D	red	yellow	green

D

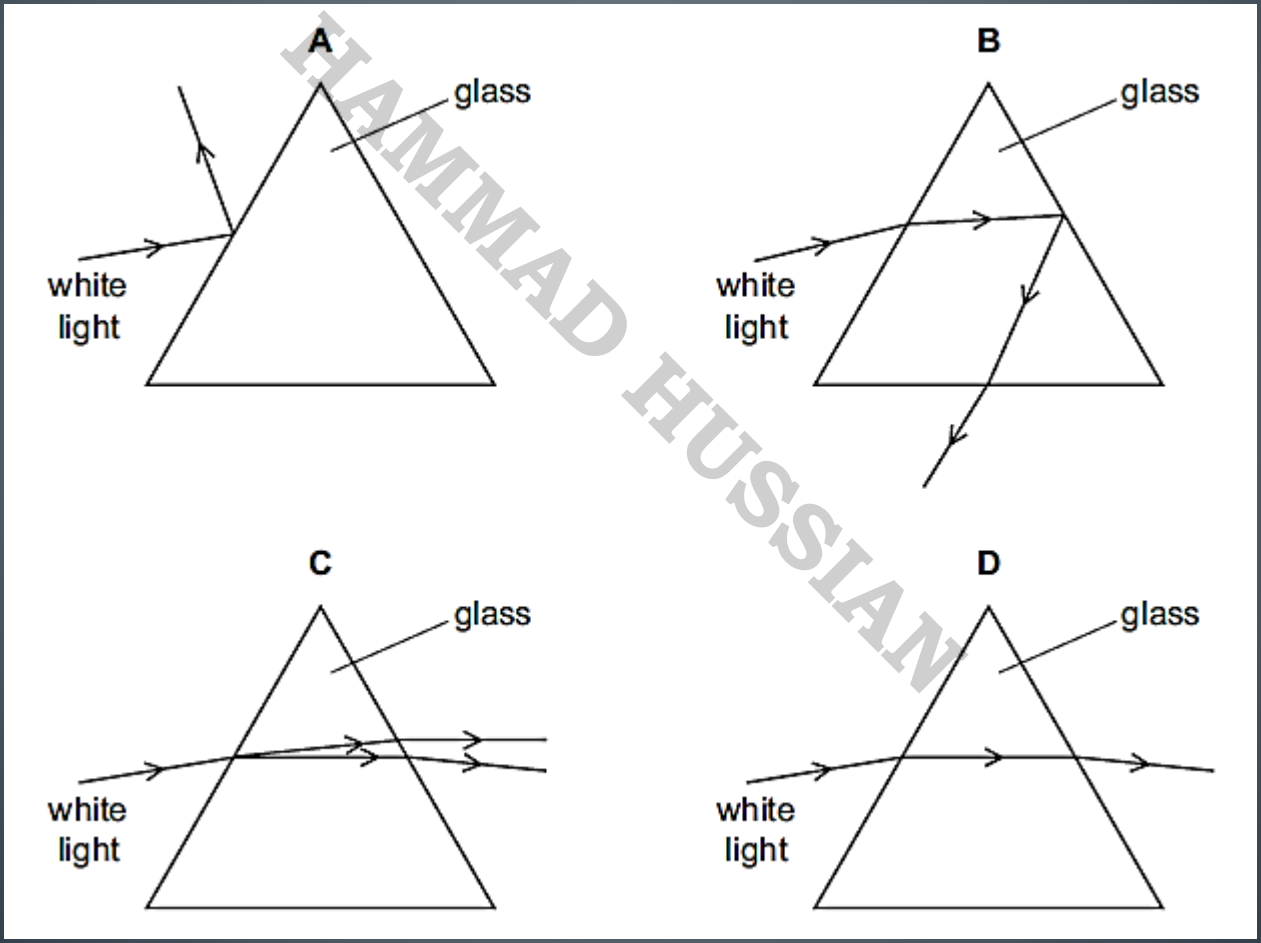
6. Which colour, red or blue, has the higher frequency and which has the longer wavelength?

	higher frequency	longer wavelength
A	blue	blue
B	blue	red
C	red	blue
D	red	red

B

7. When white light is dispersed by a prism, compared with blue light, the red light is
   A. slowed down less and refracted less.
   B. slowed down less and refracted more.
   C. slowed down more and refracted less.
   D. slowed down more and refracted more.

8. Which diagram shows the dispersion of white light?



C

9. Which wave is part of the electromagnetic spectrum?

	speed / m/s	type
A	330	longitudinal
B	330	transverse
C	3×10^8	longitudinal
D	3×10^8	transverse

D

10. Which statement is true for all electromagnetic waves?

A. They are longitudinal.
B. They can be seen.
C. They have the same frequency in air.
D. They travel at the same speed in a vacuum.

11. Which group contains only transverse waves?

A. infra-red waves, light waves, sound waves
B. infra-red waves, light waves, ultra-violet waves
C. infra-red waves, ultra-violet waves, sound waves
D. light waves, sound waves, ultra-violet waves

12. The diagram represents some of the main parts of the electromagnetic spectrum.

1. What are the numbered parts?

	1	2	3	4
A	radio waves	ultraviolet	visible light	X-rays
B	radio waves	visible light	ultraviolet	X-rays
C	visible light	ultraviolet	X-rays	radio waves
D	visible light	ultraviolet	radio waves	X-rays

B

13. Radio waves, visible light and X-rays are all part of the electromagnetic spectrum.

14 What is the correct order of increasing wavelength?

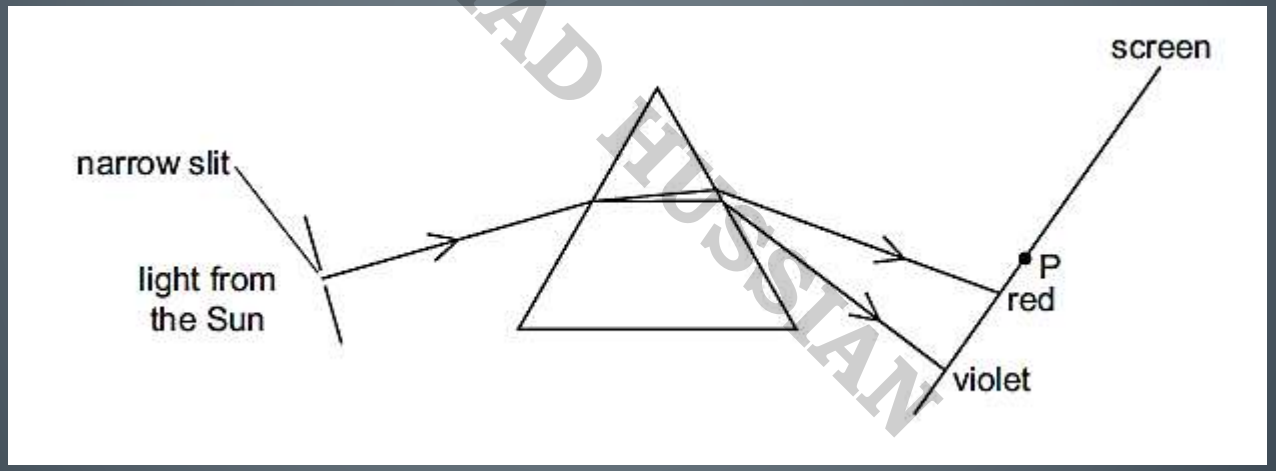
	shortest →		*longest*
A	radio waves	visible light	X-rays
B	radio waves	X-rays	visible light
C	X-rays	radio waves	visible light
D	X-rays	visible light	radio waves

D

14. Which type of radiation lies between visible light and microwaves in the electromagnetic spectrum?

A. infra-red
B. radio waves
C. ultra-violet
D. X-rays

15. Light from the Sun passes through a prism and a spectrum is produced on a screen.



1. A thermometer placed at P shows a large temperature rise.
2. Which type of radiation causes this?

A. infra-red
B. microwave
C. ultra-violet
D. visible light

16. Which does not normally use infra-red radiation?

A. electric grill
B. intruder alarm
C. television remote controller
D. sunbed

17. Which type of wave is used to send telephone signals to and from a satellite?
    A. infra-red waves
    B. light waves
    C. microwaves
    D. sound waves