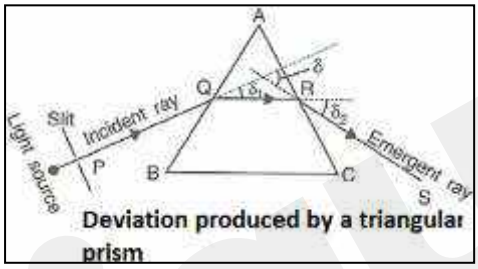
# X PHYSICS SHORT NOTES

# 6. Spectrum

## A) DEVIATION, DISPERSION AND SPECTRUM



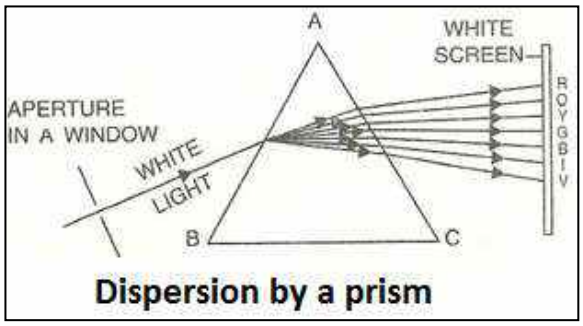
Deviation produced by a triangular prism

- **Deviation produced by a triangular prism:**
  Due to difference in speed of light in the two media, deviation is produced at the boundaries of the two media, on each of the refracting surfaces.
  - **Factors affecting the angle of deviation:**
    There are 3 factors on which the deviation depends:
    - Angle of incidence – First inversely and then directly proportional.
    - Angle of prism – Directly proportional
    - Material or refractive index of prism – Directly proportional
      - Refractive index depends on the colour or wavelength of light.
      - Hence, color or wavelength of light used – Inversely proportional.
- **Wavelength and frequency range of white light:**
  - Wavelength is the characteristic of color irrespective of its origin.
  - The prominent colors are violet, indigo, blue, green, yellow, orange and red.
  - Color is the subjective property of light related to its wavelength.
  - **Frequency and wavelength of different colors in white light:**

| Colour | Frequency range - $10^4$ Hz. | Wavelength range (approx.). |
|---|---|---|
| Violet | 6.73 – 7.5 | 4000 Å to 4460 Å |
| Indigo | 6.47 – 6.73 | 4460 Å to 4640 Å |
| Blue | 6.01 – 6.47 | 4640 Å to 5000 Å |
| Green | 5.19 – 6.01 | 5000 Å to 5780 Å |
| Yellow | 5.07 – 5.19 | 5780 Å to 5920 Å |
| Orange | 4.84 – 5.07 | 5920 Å to 6200 Å |
| Red | 3.75 – 4.84 | 6200 Å to 8000 Å |

- Å is the unit Angstrom.
- 1 Å = $10^{-10}$m = $10^{-8}$ cm
- 1 nm = $10^{-9}$ m = 10 Å
- The wavelength increases from the violet end to the red end of the spectrum.
- **Red** has **longest** wavelength and **least** frequency.
- **Violet** has **shortest** wavelength and **highest** frequency.

- **Dispersion of white light through a prism and formation of spectrum:**



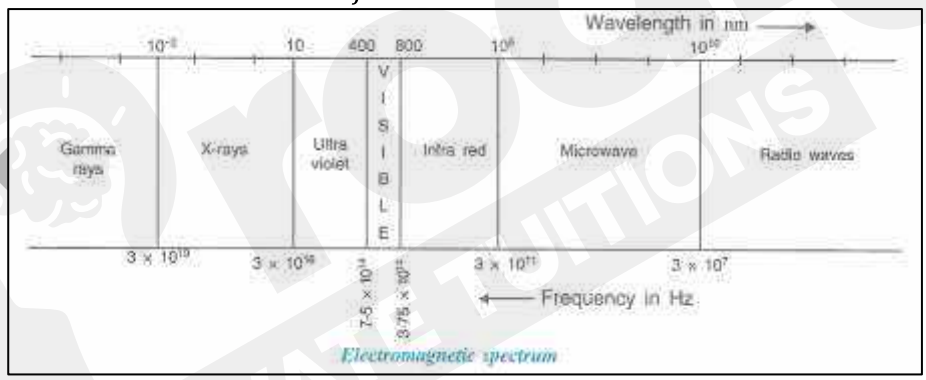

- **Experiment: 1**
  - **Aim:** To show that white light is made up of several colours.
  - **Procedure:**
    - Focus white light from the sun through a small aperture in a window to enter a darkened room and placed a glass prism in its path.
    - Receive the refracted light from the prism on a screen.
  - **Observation:** The screen showed the colors of rainbow, VIBGYOR.
  - **Conclusion:**
    - White light consists of a mixture of seven different colors.
    - Each colour corresponds to a range of wavelength.
    - White light consists of a very large number of wavelengths (different colours). Hence, White light is of polychromatic in nature.
  - **Note:**
    - The colours obtained on the screen overlaps each other.
    - All seven colours are distinctly visible only if viewed through a convex lens, placed between the prism and the screen.
- **Dispersion and spectrum:**
  - **Definition:** The phenomenon of white light splitting into its constituent colors is known as ***dispersion***.
  - **Definition:** The colour band obtained on a screen on passing a white light through a prism is called the ***spectrum.***
  - **Cause of dispersion:**
    - **Cause:** Change in speed of white light with respect to wavelength at boundary of the prism.
  - **Conclusion:**
    - Colours is a property of white light and not of the prism.
    - A prism only causes dispersion; it does not produce colours.
    - The **dispersion** of white light occurs only on the **first** surface of the prism.
    - The **deviation** of the light occurs on **both** the surfaces.

**FORMULAE:**

1. **c** $= f\,\lambda$
2. **V** $= f\,\lambda'$

## B) ELECTROMAGNATIC SPECTRUM AND ITS BRAOD CLASSIFICATION

- **Electromagnetic spectrum:**
  - **Visible spectrum:** The part of the spectrum, which lies between the red and the violet region.
  - **Invisible spectrum:** is the part of the electromagnetic spectrum beyond red and violet ends.
  - ***Infrared spectrum*:** is the portion of electromagnetic spectrum just beyond the red end.
  - ***Ultraviolet spectrum*:** is the portion of electromagnetic spectrum just before the violet end.
  - The speed (c), frequency ($f$) and wavelength ($\lambda$) of the electromagnetic waves are related as: $c = f\lambda$.



Electromagnetic spectrum

- **Properties common to all the electromagnetic waves:**
  - Do not require any material medium for their propagation.
  - They all travel with the same speed in vacuum (or air) = $3 \times 10^8\ ms^{-1}$.
  - They exhibit the properties of reflection and refraction.
  - These waves are not affected by the electric and magnetic fields.
  - These waves are transverse waves.

## ➢ Summary of Electromagnetic spectrum:

| Name of the wave. | Wavelength | Frequency in Hz. | Discoverer. | Source | Uses | Harmful effects |
|---|---|---|---|---|---|---|
| Gamma rays | Less than 0.1 Å | Above $3\times 10^{19}$ | Becquerel & Curie. | Radioactive substances. Cosmic radiations. | **Medical use** - Kills cancer cells (radio therapy). **Industrial use** - Checks welding. | Cause immense biological damage. |
| X-rays | Between 0.1 Å to 100 Å. | $3\times 10^{19}$ – $3\times 10^{16}$ | Roentgen. | Cathode rays stopped by a heavy metal target of high melting point. | **Medical use** – Detection of fracture in bones, teeth etc. (radiography). Diagnostic purposes like CAT scan. **General use:** Study atomic arrangement in crystals and other complex molecules. To detect concealed precious metals by detective and government agencies. | Carcinogenic if exposed to the rays frequently. |
| Ultraviolet or actinic rays | Between 100 Å to 4000 Å. | $3\times 10^{16}$ – $7.5\times 10^{14}$ | Ritter. | The electric arc and sparks. A mercury vapor lamp. Sun. | **Medical use** – Sterilization process. Produce vitamin D in plants and animals. **General use:** Detecting the purity of food like eggs, ghee etc. and also gems stones. | Cause skin cancer if human body is exposed to them for a long period. |
| Visible light | Between 4000Å to 8000 Å. | $7.5\times 10^{14}$ – $3.75\times 10^{14}$ | Newton. | The sun, Electric bulb, flame and White hot bodies. | **General use:** For Photography For viewing objects around us. Photosynthesis by plants | – |
| Infrared waves | Between 8000Å to $10^7$Å. | $3.75\times 10^{14}$ - $3\times 10^{11}$ | Hershell. | All heated bodies such as heated iron ball, flame, fire, thoriated filament etc. Sun. Red hot bodies | For therapeutic purposes by doctors. For night photography and in mist and fog. For developing photographs in dark room. They are used as signals during war. They are used in remote control of electronic gadgets. | A high dose causes skin burns. |
| Microwaves | Between $10^7$ Å to $10^{11}$ Å. | $3\times 10^{11}$ – $3\times 10^7$ | Hertz. | Crystal oscillators and klystron tube. | Satellite and Radar communication. Analysis of atomic and molecular structure. Cooking in microwave ovens. | - |
| Radio waves | Above $10^{11}$ Å. | Below $3\times 10^7$ | Marconi. | Radio and TV transmitter. | Radar commu-nication, Radio and television communication. | - |

## ➢ Distinction between the ultraviolet, visible and infrared radiations:

| Ultraviolet radiations | Visible radiations | Infrared radiations |
|---|---|---|
| 1. They can pass through quartz but are absorbed by glass. | 1. They can pass through glass. | 1. They can pass through rock salt, but are absorbed by glass. |
| 2. They cause skin cancer. | 2. They do not affect the body. | 2. They cause skin burns. |
| 3. They do not produce heating effect. | 3. They produce slight heating effect. | 3. They produce strong heating effect. |
| 4. They cause fluorescence on zinc sulphide screen. | 4. They do not cause fluorescence. | 4. They do not cause fluorescence. |
| 5. They affect the photographic film. | 5. They affect the photographic film | 5. They do not affect the photographic film. |
| 6. They are invisible. | 6. They are visible. | 6. They are invisible. |
| 7. They have wavelength range of 100 Å to 4000 Å. | 7. They have wavelength range of 4000 Å to 8000 Å. | 7. They have wavelength range of 8000 Å to $10^7$ Å. |

## C) SCATTERING OF LIGHT AND ITS APPLICATIONS.

CANCEL

- **Scattering of light:**
  - **Definition:** The process of absorption and re-emission of light energy is called scattering.
  - **Discoverer:** Sir Rayleigh
  - The air molecules of size **smaller** than the wavelength of incident light absorbs the energy of the incident light and re-emits it **without changing its wavelength**.
  - **The Violet light is scattered the most and the red light is scattered the least.**
  - The intensity of scattered light is inversely proportional to the fourth power of wavelength of light ( $I \propto 1/\lambda^4$).
  - **Thus violet light is scattered 16 times more than the red light.**
- **Applications of scattering:**
  - Red colour of sun at sunrise and sunset
  - White colour of sky at noon
  - Blue colour of sky
  - **Appearance of sky:**
    - **At night:** The sky appears black at night.
    - **On the moon surface:** The sky will have no colour and will appear black to an observer on a moon surface.
    - **Astronaut's vision above the atmosphere of the earth:** He sees the sky black.
  - White colour of clouds
  - Grey colour of clouds
  - Use of red colour for the danger signal