Wave Motion

These notes are your ultimate revision weapon to revise Wave Motion. We've distilled years of previous exam questions (PYQs) into one powerful, concise resource. Everything you need to know, nothing you don't.

- **PYQs, Decoded:** All key concepts from past exams, organized and simplified.
- **Revise in Record Time:** Short, precise, and designed for last-minute review.
- **Focus on What Matters:** Master high-probability topics and boost your confidence.

I. Fundamental Wave Types

A. Mechanical Waves

- **Requirement:** Require a material medium (solid, liquid, or gas) to propagate.
- **Example:** Sound waves.
    - Sound travels as vibrations through a material.
    - They are longitudinal mechanical waves.

B. Electromagnetic Waves

- **Requirement:** Do **not** require a medium; they can travel through a vacuum.
- **Composition:** Composed of electromagnetic energy.
- **Speed:** All travel at the same speed in a vacuum: **3×10^8 m/s** (the speed of light).
- **Examples:** Radio waves, Microwaves, Infrared, Visible light, Ultraviolet rays, X-rays, Gamma rays.
- **Key Fact:** Radio waves are electromagnetic in nature and are not deflected by static magnetic fields.

C. Wave Categories Based on Particle Vibration

- **Longitudinal Waves:**
  - Particle vibration is parallel to the direction of wave propagation.
  - Require a medium to travel.
  - **Example:** Sound waves. The amplitude of a sound wave determines its loudness.
- **Transverse Waves:**
  - Particle vibration is perpendicular to the direction of wave propagation.
  - **Example:** Waves on a string (e.g., in a Sitar).
- **Stationary/Standing Waves:**
  - Formed by the interference of two waves traveling in opposite directions.
  - **Example:** The vibrations produced in a Sitar's string when plucked.

II. The Electromagnetic Spectrum

A. General Order and Characteristics

- The spectrum is arranged in order of **increasing frequency and energy**, but **decreasing wavelength**.
- **Order (Longest Wavelength → Shortest Wavelength):**
  Radio waves > Microwaves > Infrared > Visible light > Ultraviolet > X-rays > Gamma rays.
- **Key Characteristics:**
  - **Radio Waves:** Have the **longest wavelength** in the EM spectrum.
  - **X-rays:** Have **more energy** than Visible light, Infrared, and Ultraviolet rays.
  - **Microwaves:** Have frequencies in the range of **1 GHz to 300 GHz**.

B. Detailed Applications and Properties of EM Waves

- **X-Rays**
  - **Wavelength Range:** Approximately 0.01 to 10 nanometers.
  - **Applications:** Used to determine the atomic structure of crystals (crystallography); used in the diagnosis of intestinal diseases.
  - **CT Scan:** A special X-ray test that produces cross-sectional images of the body using X-rays and a computer.
  - **Discoverer:** Wilhelm Röntgen.
- **Infrared Waves**
  - **Property:** Have a longer wavelength than visible light.
  - **Applications:** Used in Night Vision apparatus to see in the dark; commonly used in TV remote controls.
- **Radio Waves & Microwaves**
  - **Radar:** Uses radio waves to detect the position of aircraft, boats, and cars.
  - **Microwave Applications:** Used for telecommunication (point-to-point and satellite communication).
  - **Frequency Ranges:**
    - Microwaves: 300 MHz to 300 GHz.
    - FM Radio Broadcasting: Uses the frequency band of 88-108 MHz.
  - **Wavelength-Frequency Relationship:** $v = c / \lambda$, where *c* is the speed of light (3×10^8 m/s).
    - **Example:** A 30-meter band radio wave has a frequency of 10 MHz.
- **Ultraviolet (UV) Rays**
  - **Types based on wavelength:**
    - UV-A: 320-400 nm
    - UV-B: 280-320 nm (mostly absorbed by the ozone layer)
    - UV-C: 100-280 nm
  - **Ozone Layer Depletion:** Depletion allows more harmful UV radiation (like UV-C at 100 nm or 10^{-7} m) to reach the Earth's surface.

III. Wave Propagation

A. Radio Wave Propagation

- **Long Radio Waves:** Are reflected back to Earth by the **Ionosphere** (a charged layer of the atmosphere 65-400 km above Earth), allowing long-distance communication.
- **Ultra High Frequency (UHF) Waves:** (300 MHz - 3 GHz) use **Space Wave** propagation. They travel in a direct line of sight and cannot follow the ground or be reflected by the ionosphere effectively.
- **Satellite TV Disruption During Rain:** Radio waves used for satellite TV can be disrupted because:

    1. Raindrops **absorb** the energy of the radio waves.
    2. Raindrops **disperse** the radio waves from their original direction.
    3. The signal weakens, making it difficult for small dish antennas to receive it.

B. Sound Wave Propagation

- Cannot be transmitted through a vacuum.
- Require a medium (solid, liquid, gas) where particles can vibrate.

IV. Other Key Concepts

A. Cosmic Rays

- Are **not** electromagnetic waves.
- They are streams of **highly energetic charged particles** (like protons and atomic nuclei) originating from the Sun and outer space.
- They travel at nearly the speed of light.
- **Key Fact:** They have very **high wavelengths**, not short wavelengths.

B. Heat Transfer

- **Radiation** (e.g., EM waves) is the only mode of heat transfer that does **not** require a medium.
- **Convection** and **Conduction** require a medium.

C. Wave Properties

- **Wavelength:** The distance between two successive crests or troughs of a wave.
- **Albedo:** A measure of the **reflecting power** of a surface, indicating the fraction of incident light or radiation that is reflected (e.g., snow has high albedo).

D. Supersonic Waves

- **Not** a type of electromagnetic wave.
- The term "supersonic" refers to objects moving faster than the speed of sound.

V. Summary of Key Facts

- **Sound Waves:** Longitudinal mechanical waves.
- **EM Spectrum Order (by wavelength):** Radio Waves > Microwaves > Infrared > Visible Light > Ultraviolet > X-rays > Gamma Rays.
- **Energy Order:** Reverse of wavelength order (Gamma rays have the highest energy).
- **Key Discoverer:** Wilhelm Röntgen discovered X-rays.

Know More About Wave Motion:

- Wave Motion – Old Year Questions
- Wave Motion One Liner Questions & Answers