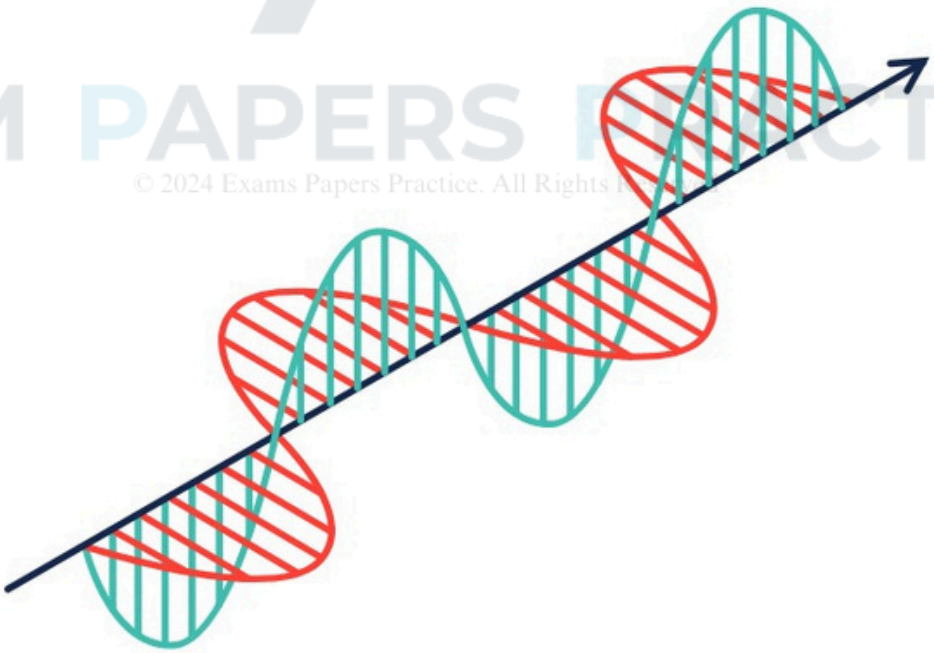
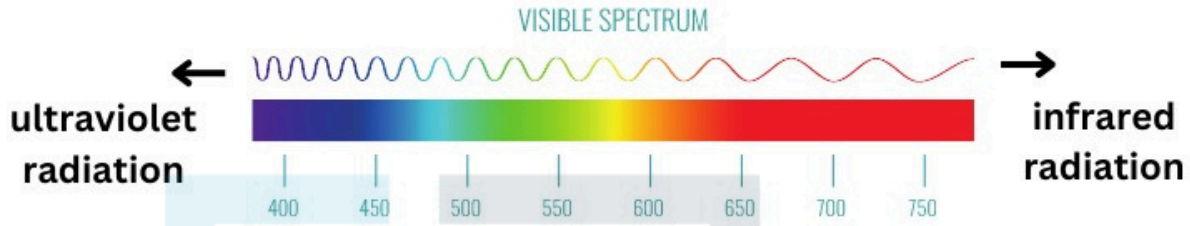
Chapter 15:

Electromagnetic Waves



A. Herschel's and Ritter's experiment - What we can learn from it?

1. There is a type of radiation, invisible to the human eye, beyond the red end of the spectrum, which Herschel named infrared radiation (infra means below).
2. Ritter explored beyond the violet end of the spectrum and discovered ultraviolet radiation (ultra means beyond).



B. Electromagnetic Waves

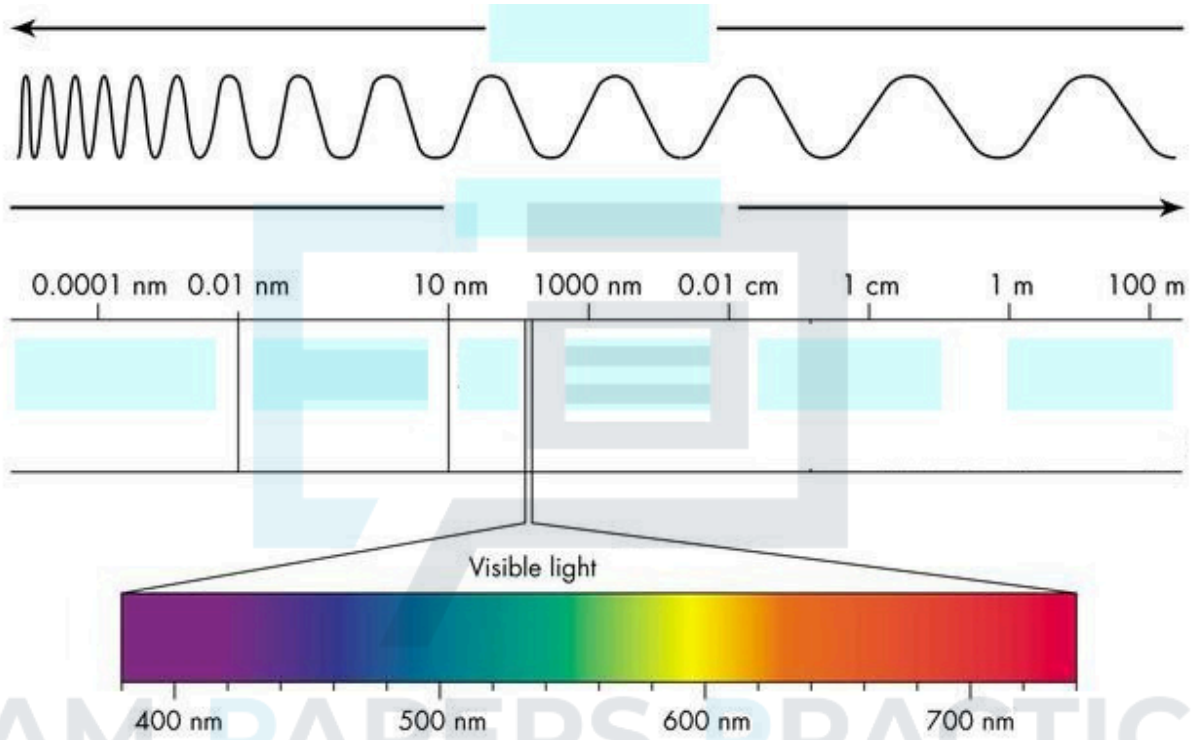
1. Sound can have different pitches - the higher the frequency, the higher the pitch.
2. Similarly, light can have different colors, determined by its frequency.
3. James Clerk Maxwell described light as small oscillations in electric and magnetic fields, which he termed electromagnetic waves.

a. Electromagnetic waves travel at the speed of light (3 x 108 m/s).
b. It is a transverse wave.

4. He discovered that beyond the infrared and ultraviolet spectrum, there must be even more types of electromagnetic waves.

C. Electromagnetic Spectrum

1. By the close of the 20th century, physicists had identified or created various other forms of electromagnetic waves, thereby completing the electromagnetic spectrum.
2. It is a family of radiations similar to light.



D. Uses of electromagnetic waves

Electromagnetic waves	Wavelength	Uses
Radio waves	1mm - 100km	- Broadcast radio and television signals - Wireless data transfer such as Radio Frequency Identification (RFID)
Microwaves	1mm - 100cm	- Microwave oven - Microwaves are absorbed by molecules in food, causing heating - Satellite television broadcasting

		- It can pass through the Earth's atmosphere - Transmit mobile phone signals
Infrared radiation	700nm - 1mm	- Remote controls for television - Grills and toasters - Security alarms - Vein scanner
Visible light	400 nm (violet) - 700nm (red)	- Photography - Optical instruments such as cameras, telescopes, and microscopes - Photosynthesis
Ultraviolet light	180 nm - 420 nm	- Used by forensic scientists to find evidence at crime scenes which is invisible to the human eye - Sterilize water / medical equipment - UV radiation destroys DNA within any bacteria and viruses contained in the water
X-rays	0.01 nm - 10 nm	- Medical imaging - Bone absorbs X-rays more strongly than flesh, so bones appear as a shadow in the image - Security scanners
Gamma rays	Less than 10µm	- Kill cancerous cells - Sterilize medical equipment - Used by engineers to look for cracks in pipes

E. Electromagnetic hazards

Electromagnetic waves	Harms
Infrared radiation	Prolonged exposure to high levels of infrared radiation can cause thermal injuries, such as burns, due to the heating effect on tissues.
Ultraviolet light	Ultraviolet light can damage the DNA in skin cells, leading to sunburn, premature aging, and an increased risk of skin cancer.
X-rays and Gamma rays	Both X-rays and gamma rays are highly penetrating and can damage or destroy cells and DNA, potentially causing cancer and other radiation-induced illnesses.
Microwaves	Exposure to high levels of microwaves can result in thermal injuries, including burns and cataracts, due to the heating of body tissues.

F. Communication using electromagnetic waves

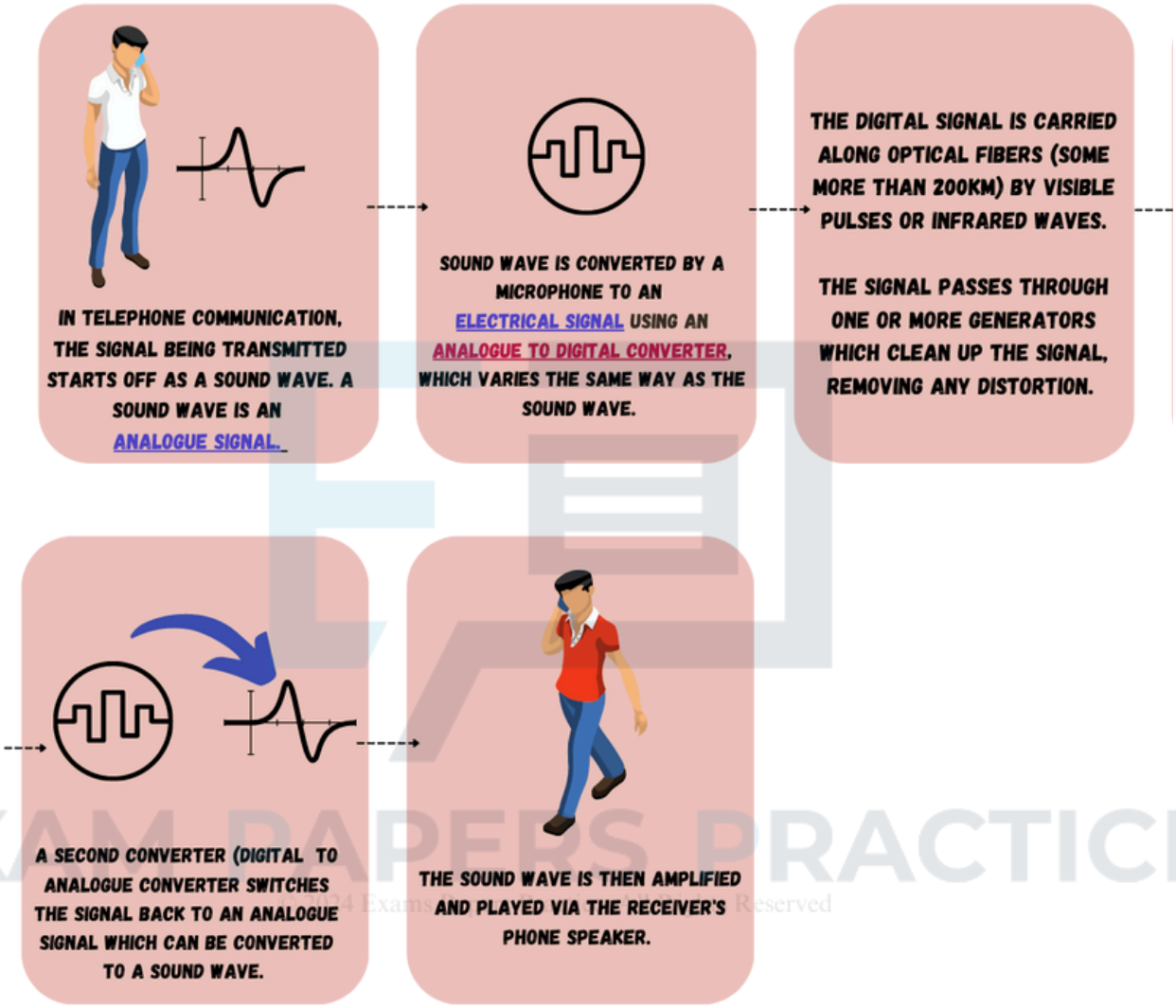
Satellites

1. **Geostationary Orbits** - Positioned 35,000 km above the Earth's surface:
    a. They rotate at the same rate as the Earth, maintaining a fixed position above a specific point on the Earth's surface.
    b. These satellites are robust and can handle large volumes of data transmission.
    c. This capability makes them ideal for satellite television and satellite phone services.
    d. Although they move quickly, the long distance to the satellite can complicate real-time conversations.

2. **Low Earth Orbits** - Positioned 2,000 km above the Earth's surface:
    a. They offer immediate communication with no delay.
    b. However, they cannot transmit data as quickly as geostationary satellites and are not suitable for television broadcasting.

Communication tools	**Types of waves involved**
Mobile phones and wireless internet	Microwaves (because they can pass through most walls)
Bluetooth	Radio waves (signal weakened when it passes through walls)
Optical fibers (for cable television and high-speed internet)	Infrared radiation and visible light

How electromagnetic waves allow mobile phones to work - Analogue and digital signals



Definition:

1. Analogue signal – A signal that represents continuous data using a continuously varying electrical signal
2. Digital signal - encodes data as discrete binary values, typically represented as sequences of 0s and 1s.