TOPIC 14 Electromagnetic Spectrum

Objectives

Candidates should be able to:

(a) state that all electromagnetic waves are transverse waves that travel with the same speed in vacuum and state the magnitude of this speed
(b) describe the main components of the electromagnetic spectrum
(c) state examples of the use of the following components:
  (i) radiowaves (e.g. radio and television communication)
  (ii) microwaves (e.g. microwave oven and satellite television)
  (iii) infra-red (e.g. infra-red remote controllers and intruder alarms)
  (iv) light (e.g. optical fibres for medical uses and telecommunications)
  (v) ultra-violet (e.g. sunbeds and sterilisation)
  (vi) X-rays (e.g. radiological and engineering applications)
  (vii) gamma rays (e.g. medical treatment)
(d) describe the effects of absorbing electromagnetic waves, e.g. heating, ionisation and damage to living cells and tissue

NOTES

14.1 Components of the Electromagnetic Spectrum

1. All electromagnetic waves (EM waves) are transverse waves that travel at the speed of light (3×10^8 m/s) in vacuum and slow down in other media.

2. EM waves do not require a medium for propagation.

3. EM waves can be absorbed or emitted by matter.

4. The main components of the electromagnetic spectrum are as follows:

EM Wave	Order of Magnitude of Wavelength, λ/m	Application
γ-ray (Gamma ray)	10^{-3}	Manufacturing: Checking of cracks/ holes in metal plates. Medical: Radiotherapy.

EM Wave	Order of Magnitude of Wavelength, λ/m	Application
X-ray	10^{-10}	Medical: Inspection of bones for signs of fractures.
Ultraviolet (UV)	10^{-8}	Medical: Production of vitamin D in the body.
Visible light spectrum: *Violet* *Indigo* *Blue* *Green* *Yellow* *Orange* *Red* ↓ In increasing order of λ	10^{-7}	
Infrared radiation (IR)	10^{-4}	Remote control for television sets.
Microwave	10^{-2}	Microwave oven for cooking.
Radio Wave	10^{-2} to 10^{3}	Telecommunication.

14.2 Harmful Effects of Absorbing EM Waves

1. EM waves transmit radiation energy from one region to another.

2. Radiation may damage living cells and tissues through heating and ionisation.
   (a) Heating: Organic molecules in tissue gain kinetic energy from incident radiation. The energy increase is detected by a temperature rise. When the temperature gets too high, the molecules break apart and the tissue gets cooked.
   (b) Ionisation: Organic molecules absorb energy to break molecular bonds to form ions which can react with neighbouring molecules. This results in destruction or changes to the tissue.

3. Mobile phones emit radiation in the form of electromagnetic waves which can heat up the brain.

4. Too much sun-tanning can lead to an overdose of ultraviolet radiation which can cause skin cancer (i.e. melanoma).