

Chapter 8 · Electromagnetic Waves

CBSE Class 12 Physics (042) · Unit V · Unit V + VI = 18 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Only a basic idea of displacement current is required, and the transverse nature is qualitative. The heavy marks here sit in the **electromagnetic spectrum** and the elementary facts about each band's uses — that is where to spend your time.

60-SECOND RECALL

Displacement current	$I_d = \epsilon_0 d\phi_E/dt$ — exists wherever the electric field changes
Speed in vacuum	$c = 1/\sqrt{\mu_0\epsilon_0} = 3 \times 10^8 \text{ m s}^{-1}$
In a medium	$v = 1/\sqrt{\mu\epsilon}$ · always less than c
E and B	Perpendicular to each other AND to the direction of travel — transverse
Ratio	$E_0/B_0 = c$
Order (increasing frequency)	Radio → Microwave → Infrared → Visible → Ultraviolet → X-rays → Gamma

1. Displacement Current

THE IDEA — why Maxwell needed it During the charging of a capacitor, **no conduction current flows between the plates**, yet a magnetic field is observed there. Ampere's law gave two different answers depending on the surface chosen. Maxwell resolved it by proposing that a **changing electric field** also produces a magnetic field. The equivalent current is the **displacement current**.

FORMULAS

$$I_d = \epsilon_0 d\phi_E/dt$$

$$\text{Ampere-Maxwell law: } \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0(I_c + I_d)$$

Inside a charging capacitor $I_d = I_c$, so the total current is continuous through the circuit.

2. Properties of Electromagnetic Waves

THE PROPERTIES ASKED 1. Produced by an **accelerated charge**.

2. **Transverse** — E and B are mutually perpendicular and both perpendicular to the direction of propagation.
3. They travel in **vacuum**, needing **no material medium**.
4. E and B oscillate **in phase**, with $E_0/B_0 = c$.
5. They carry **energy and momentum**; the energy is shared equally between the electric and magnetic fields.
6. They are **not deflected** by electric or magnetic fields (they are uncharged).

FORMULAS

$$c = 1/\sqrt{(\mu_0 \epsilon_0)} \cdot c = v\lambda$$

$$\text{Energy density: } u = \frac{1}{2}\epsilon_0 E^2 + \frac{B^2}{2\mu_0}$$

$$\text{Momentum delivered: } p = U/c \text{ (total absorption)}$$

3. The Electromagnetic Spectrum

THE TABLE THAT CARRIES THE MARKS

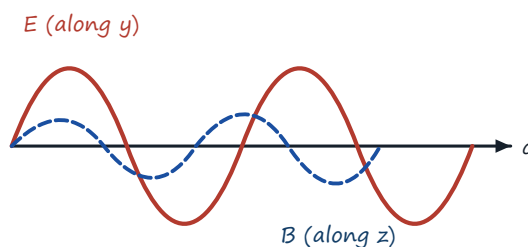
Band	Wavelength	How it is produced	Uses
Radio waves	> 0.1 m	Accelerated charge in aerials	Radio, TV, cellular communication
Microwaves	0.1 m – 1 mm	Klystron , magnetron, Gunn diode	RADAR , microwave ovens, satellite links
Infrared	1 mm – 700 nm	Vibrating molecules of hot bodies	Remote controls, night vision, physiotherapy, greenhouse effect
Visible	700 – 400 nm	Electron transitions in atoms	The only band the eye detects ; photosynthesis
Ultraviolet	400 – 1 nm	Sun, arcs, mercury lamps	Sterilising water, LASIK; absorbed by the ozone layer
X-rays	1 nm – 10^{-3} nm	Fast electrons hitting a metal target	Medical imaging, cancer treatment, crystallography
Gamma rays	< 10^{-3} nm	Radioactive nuclei , nuclear reactions	Treating cancer, sterilising equipment

TRAP All electromagnetic waves travel at the same speed c in vacuum — only frequency and wavelength differ.

Higher frequency → higher energy ($E = h\nu$) and shorter wavelength.

Know these three by heart: **microwaves** → **RADAR**, **infrared** → **greenhouse effect**, **ultraviolet** → **ozone absorbs it**. One-markers come straight from this list.

EM waves are TRANSVERSE: $E \perp B \perp c$



E and B are **in phase**, peak together, and $E_0/B_0 = c$. Direction of travel is along $E \times B$.

Syllabus: transverse nature is **QUALITATIVE** only.

Displacement current $i_d = \epsilon_0 d\Phi_E/dt$ is what Maxwell added, and it is why the field between capacitor plates is continuous with the wire current.

Spectrum

frequency increasing ↓↑

Radio — broadcasting

Microwave — radar, oven

Infrared — heat, remotes

Visible — 400–700 nm

Ultraviolet — ozone absorbs

X-rays — imaging

Gamma — nuclear origin

Order is worth a mark on its own.

All travel at c in vacuum.

4. Question Triggers name the radiation

If the question describes...	The answer is...
"used in RADAR and satellite communication"	Microwaves
"responsible for the greenhouse effect"	Infrared
"absorbed by the ozone layer"	Ultraviolet
"produced by fast electrons striking a metal target"	X-rays
"emitted by radioactive nuclei"	Gamma rays
"used in remote controls / night vision"	Infrared
"highest frequency / shortest wavelength"	Gamma rays
"changing electric field produces this"	Displacement current

MOST-ASKED BOARD QUESTIONS

1. [3M] Arrange the electromagnetic spectrum in order of **increasing frequency** and give one use of each band.
2. [2M] What is **displacement current**? Write the Ampere–Maxwell law.
3. [2M] List four **properties** of electromagnetic waves.
4. [2M] Identify the radiation from a described use (very common as an assertion–reason or MCQ).
5. [1M] Which EM wave is used to **sterilise surgical instruments**? → **Gamma rays** (UV for water)
6. [1M] What is the relation between E_0 and B_0 ? → $E_0/B_0 = c$

THE HABIT THAT SCORES — This is the cheapest chapter in the paper: almost all of it is recall. Learn the spectrum table in the order **radio** → **gamma**, with one production method and one use each, and you have covered nearly every question that has ever been set on it.