CLASS 12 PHYSICS — FORMULA SHEET

Chapter 8 : Electromagnetic Waves (NCERT)

8.1 Displacement Current & Maxwell's Equations

Concept	Formula / Statement
Displacement current	$I_d = \varepsilon_0 (d\Phi_E/dt)$ (due to changing electric flux)
Why introduced	Makes Ampere's law consistent for capacitor charging
Modified Ampere's law	$\oint B \cdot dl = \mu_0(I_c + I_d)$
Maxwell's key idea	A changing E-field produces a B-field, and vice versa
Source of EM waves	Accelerating (oscillating) charges

8.2 Properties of Electromagnetic Waves

Property	Detail / Formula
Speed in vacuum	$c = 1 \div \sqrt{(\mu_0\varepsilon_0)} = 3 \times 10^8$ m/s
Speed in medium	$v = 1 \div \sqrt{(\mu\varepsilon)} = c \div n$ (n = refractive index)
E and B relation	$c = E_0 \div B_0$ (ratio of amplitudes)
Nature	Transverse ; E ⊥ B ⊥ direction of propagation
E, B, c directions	E × B points along the direction of wave propagation
Carry energy & momentum	Can exert radiation pressure
No medium needed	Travel through vacuum

8.3 Energy & Intensity of EM Waves

Concept	Formula
Energy density (electric)	$u_E = ½ \varepsilon_0 E^2$
Energy density (magnetic)	$u_B = B^2 \div (2\mu_0)$
Average energy density	$u_{avg} = ½ \varepsilon_0 E_0^2 = B_0^2 \div (2\mu_0)$
u_E = u_B	Electric & magnetic energy densities are equal
Intensity	$I = u_{avg} \times c = ½ \varepsilon_0 E_0^2 c$
Radiation pressure (absorbed)	$P = I \div c$
Radiation pressure (reflected)	$P = 2I \div c$

8.4 Electromagnetic Spectrum (Increasing Frequency)

Wave	Wavelength / Use
Radio waves	> 0.1 m ; radio, TV, mobile communication
Microwaves	0.1 m – 1 mm ; radar, microwave oven, satellite
Infrared (IR)	1 mm – 700 nm ; heat, remote controls, night vision

Wave	Wavelength / Use
Visible light	700 nm – 400 nm ; human vision (VIBGYOR)
Ultraviolet (UV)	400 nm – 1 nm ; sterilisation, vitamin D
X-rays	1 nm – 10^{-3} nm ; medical imaging, crystallography
Gamma rays	< 10^{-3} nm ; nuclear reactions, cancer therapy

8.5 Production & Detection

Wave	Production / Detection
Radio waves	Oscillating circuits (LC) ; detected by antennas
Microwaves	Klystron / magnetron ; detected by point-contact diodes
Infrared	Hot bodies & molecules ; thermopiles, bolometers
Visible	Atoms & molecules in excitation ; eye, photocells
Ultraviolet	Special lamps, very hot bodies ; photocells, photographic film
X-rays	X-ray tubes (high-energy electrons hitting metal) ; photographic plates
Gamma rays	Radioactive nuclei ; Geiger tubes, scintillators

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Speed of light	$c = 1/\sqrt{(\mu_0\varepsilon_0)} = 3 \times 10^8$ m/s. Also $c = E_0/B_0$.
Transverse & perpendicular	E ⊥ B ⊥ propagation. E × B gives the travel direction.
Energy densities equal	u_E = u_B in an EM wave — energy is split evenly.
Radiation pressure	Absorbed: P = I/c ; Reflected: P = 2I/c (twice).
Spectrum order	'Radio Micro Infra Visible Ultra X Gamma' — frequency increases left to right.
VIBGYOR	Visible spectrum: Violet (high f) to Red (low f).
Displacement current	$I_d = \varepsilon_0 d\Phi_E/dt$ — completes Ampere's law for capacitors.
Source	Only ACCELERATING charges radiate EM waves.