CLASS 12 PHYSICS — FORMULA SHEET

Chapter 2 : Electrostatic Potential and Capacitance (NCERT)

2.1 Electric Potential

Concept	Formula
Electric potential	$V = W \div q_0$ (work done per unit charge from infinity)
SI unit	Volt (V) = J/C ; scalar quantity
Potential due to point charge	$V = (1/4\pi\varepsilon_0) \times (q \div r)$
Potential difference	$V_B - V_A = W_{AB} \div q$
Potential from superposition	$V_{net} = V_1 + V_2 + \ldots$ (algebraic sum, with signs)
Relation E and V	$E = -dV/dr$; $V = -\int E \cdot dr$
Potential due to dipole (axial)	$V = (1/4\pi\varepsilon_0) \times (p \div r^2)$; equatorial $V = 0$

2.2 Equipotential Surfaces & Potential Energy

Concept	Detail / Formula
Equipotential surface	Surface where V is constant ; no work done in moving a charge on it
E is perpendicular to it	Field lines are always normal to equipotential surfaces
PE of two charges	$U = (1/4\pi\varepsilon_0) \times (q_1 q_2 \div r)$
PE of charge in external field	$U = qV$
PE of dipole in field	$U = -pE \cos\theta = -p \cdot E$
Work done	$W = q(V_B - V_A) = \Delta U$

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2.3 Conductors & Dielectrics

Concept	Detail
Field inside a conductor	$E = 0$ (electrostatic conditions)
Potential inside conductor	Constant throughout (equal to surface value)
Charge on conductor	Resides entirely on the outer surface
Field just outside surface	$E = \sigma \div \varepsilon_0$ (perpendicular to surface)
Dielectric	Insulator that reduces field by polarisation
Dielectric constant K	$K = E_0 \div E = C_{with} \div C_{without}$
Electrostatic shielding	Field inside a cavity of a conductor is zero

2.4 Capacitance

Concept	Formula
Capacitance	$C = Q \div V$; SI unit Farad (F) = C/V
Parallel plate (vacuum)	$C = \varepsilon_0 A \div d$

Concept	Formula
With dielectric (fills gap)	$C = K \varepsilon_0 A \div d$
Spherical capacitor	$C = 4\pi\varepsilon_0 (ab)/(b - a)$
Isolated sphere	$C = 4\pi\varepsilon_0 R$
Effect of dielectric slab (thickness t)	$C = \varepsilon_0 A \div [d - t(1 - 1/K)]$

2.5 Combination of Capacitors

Arrangement	Formula
Series	$1/C_{eq} = 1/C_1 + 1/C_2 + \ldots$ (charge Q same on each)
Two in series	$C_{eq} = (C_1C_2) \div (C_1 + C_2)$
Parallel	$C_{eq} = C_1 + C_2 + \ldots$ (voltage V same across each)
Series voltage	V splits in inverse ratio of capacitance
Parallel charge	Q splits in direct ratio of capacitance

2.6 Energy Stored in a Capacitor

Concept	Formula
Energy stored	$U = \frac{1}{2} QV = \frac{1}{2} CV^2 = Q^2 \div (2C)$
Energy density	$u = \frac{1}{2} \varepsilon_0 E^2$ (energy per unit volume)
Energy on connecting capacitors	Common $V = (C_1V_1 + C_2V_2)/(C_1 + C_2)$
Energy loss on connection	$\Delta U = \frac{1}{2} [(C_1C_2)/(C_1+C_2)](V_1 - V_2)^2$ (always lost as heat)
Effect of dielectric (battery on)	Q increases, V constant, energy increases
Effect of dielectric (battery off)	Q constant, V decreases, energy decreases

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V from point charge	$V = kq/r$ (scalar — add with signs). $E = kq/r^2$ (vector).
E and V link	$E = -dV/dr$. Field points toward decreasing potential.
Equipotential	No work to move a charge along it ; E is always perpendicular to it.
Capacitor formula	$C = \varepsilon_0 A/d$; add dielectric → multiply by K.
Series vs parallel	Series: add reciprocals (like resistors in parallel). Parallel: just add.
Energy stored	$U = \frac{1}{2}CV^2 = \frac{1}{2}QV = Q^2/2C$ — three equivalent forms.
Dielectric (battery)	Battery ON → V fixed, Q & U rise. Battery OFF → Q fixed, V & U fall.
Energy density	$u = \frac{1}{2}\varepsilon_0 E^2$ (energy stored per unit volume of the field).