Electric potential and capacitors

🔢 Important Formulas

1. Electric Potential

- Due to point charge:

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r}$$

- Due to dipole (for $r \gg a$):

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{p} \cdot \hat{r}}{r^2}$$

2. Potential Energy

- Of two point charges:

$$U = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r}$$

- Of dipole in external field:

$$U = -\vec{p} \cdot \vec{E}$$

3. Electric Field and Potential Relation

$$E = -\frac{dV}{dr}$$

4. Capacitance

- Basic definition:

$$C = \frac{Q}{V}$$

- Parallel plate capacitor (vacuum):

$$C = \varepsilon_0 \cdot \frac{A}{d}$$

- With dielectric:

$$C = K\varepsilon_0 \cdot \frac{A}{d}$$

5. Combination of Capacitors

- Series:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

- Parallel:

$$C = C_1 + C_2 + \cdots$$

6. Energy Stored in a Capacitor

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{1}{2}QV$$

7. Energy Density in Electric Field

$$u = \frac{1}{2}\varepsilon_0 E^2$$

8. Electric Field near a Charged Conductor

$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{n}$$

📏 Important Constants and Units

Quantity	Symbol	SI Unit	Value / Dimension
Permittivity of free space	ε_0	F·m⁻¹ (farad/meter)	8.854×10^{-12} F·m⁻¹
Electric potential	V	Volt (V)	$[M^1L^2T^{-3}A^{-1}]$
Capacitance	C	Farad (F)	$[M^{-1}L^{-2}T^4A^2]$
Polarisation	P	C·m⁻²	Dipole moment per unit volume
Dielectric constant	K	Dimensionless	$K = \frac{\varepsilon}{\varepsilon_0}$
Energy stored	U	Joule (J)	—
Electric field	E	V·m⁻¹	—
Energy density	u	J·m⁻³	—
