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Short Notes :- ELECTROSTATICS

- Comprehensive compilation of high-yield formulas.
- Organized by subtopic for efficient revision.
- Includes concise definitions and context

- Electric Potential is a scalar quantity capable of describing the nature of the electric field in 3D space.

- When a charge +q is moved from point A to B in a region of electric field under the action of an external force, the potential energy change is given by:

$$U_B - U_A = W_{ext} \text{(provided } \Delta KE = 0)$$

The change in electric potential is defined as the change in potential energy per unit charge:

$$V_B - V_A = (U_B - U_A) / q$$

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SL	Quantities	Formula (Relations)	Electrostatics
1	Quantification of Electric Charges (q) on a body	$Q = n \cdot e$	n is an integral number, e is charge on electron = 1.6×10^{-19} C
2	Electrostatic Force Constant	$1/(4\pi\varepsilon_0)$	Value: 9×10^9 Nm^2/C^2
3	Permittivity	ε_0	8.85×10^{-12} $C^2/N \cdot m^2$
4	Coulomb's Law	$F = q_1 q_2 / (4\pi\varepsilon_0 r^2)$	q_1 and q_2 are two charges placed at distance r
5	Forces on two charges	$F_{12} = -F_{21}$	Direction of F is along r
6	Dielectric Constant	$K = \varepsilon/\varepsilon_0 = \varepsilon_r$	ε is absolute permittivity of medium, ε_0 is permittivity of free space, ε_r is relative permittivity
7	Electric Field at a point	$E = F/q$	F is force experienced by the test charge q at a point. E is called field intensity at that point
8	Force with respect to field	$F = q \cdot E$	—
9	Electric Field due to source charge Q at distance r	$E = Q / (4\pi\varepsilon_0 r^2)$	Direction of E is along r
10	Electric Field due to dipole on a point on axial line	$E = 2P / (4\pi\varepsilon_0 r^3)$	P is dipole moment, r is distance from centre of dipole on axial line
11	Electric Field due to dipole on a point on territorial line	$E = P / (4\pi\varepsilon_0 r^3)$	P is dipole moment, r is distance from centre of dipole on equatorial line
12	Electric Field due to dipole at any general point, at distance r making angle θ with P	$E = P\sqrt{(1 + 3\cos^2\theta)} / (4\pi\varepsilon_0 r^3)$	r is distance of point from midpoint of dipole, θ is angle between direction of r and dipole moment P
13	E makes angle α with r then	$\tan\alpha = (1/2) \cdot \tan\theta$	α is angle between resultant field and direction of r, θ is angle between r and P
14	E at any point on the axis of a uniformly charged ring at distance x	$(q \cdot x) / [4\pi\varepsilon_0 (r^2 + x^2)^{(3/2)}]$	—

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Electric charges are a fundamental property of matter that cause objects to attract or repel each other. There are two types of charges: positive and negative. Objects with the same type of charge repel each other, while those with opposite charges attract. These interactions are central to the study of electrostatics. Charges can move from one object to another, especially through contact or induction, but the total charge in a closed system remains constant.

An electric field is the region around a charged object where other charges feel a force. It describes how a charge can influence its surroundings without physical contact. The electric field has both strength and direction, and it always points away from positive charges and toward negative charges. It becomes weaker as you move farther from the source charge. Electric fields help explain how forces act between charges over a distance, and they play a crucial role in many physical phenomena and technologies.

SL	Quantity/Concept	Formula	Explanation
15	Potential Energy of a Dipole in Equilibrium Condition When *P* is Along *E*	$U = -P \cdot E$	*P* is the dipole moment, *E* is the electric field
16	Potential Energy of a Dipole at 90° to *E*	Zero	—
17	Potential Energy of a Dipole at 180° to *E*	$U = +P \cdot E$	*P* is the dipole moment, *E* is the electric field
18	Electric Flux (φ_e)	$\varphi_e = E \cdot S = \int E \cdot ds$	—
19	Gauss's Theorem	$\varphi_e = \oint (E \cdot ds) = q / \varepsilon_0$	The flux linked to a closed surface is q/ε_0 times the charge enclosed in it
20	Field Due to an Infinite Long Straight Charged Conductor	$\lambda / 2\pi\varepsilon_0 r$	λ is the linear charge density in the conductor, *r* is the perpendicular distance
21	Electric Field Due to an Infinite Plane Sheet of Charge	$\sigma / 2\varepsilon_0$	σ is the areal charge density. The field is independent of distance
22	Field Between Two Parallel Sheets of Charge	σ / ε_0	Outside, the field is zero

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SL	Quantity/Concept	Formula	Explanation
23	Electric field between two parallel sheets of similar charges	Zero	Outside, the field is σ/ε_0
24	Electric field due to a spherical shell (outside shell)	$E = Q/(4\pi\varepsilon_0 r^2)$	*Q* is the charge on the shell, *r* is the distance from the center
25	Electric field on the surface of a spherical shell	$E = q/(4\pi\varepsilon_0 R^2)$	*R* is the radius of the shell
26	Electric field inside a spherical shell	Zero	—
27	Electric field inside the sphere of charge distributed uniformly all over the volume	$E = \rho r/3\varepsilon$	*r* is the radius of the sphere, ρ is the volumetric charge density, ε is the permittivity of the medium
28	Potential due to charge *Q* at distance *r*	$V = Q/(4\pi\varepsilon_0 r)$	Potential is characteristic of that location
29	Potential energy with charge *q* kept at a point with potential *V*	$U = qV = (Qq)/(4\pi\varepsilon_0 r)$	Potential energy is that of the system containing *Q* and *q*
30	Work done in moving a charge *q* through a potential difference of *V*	$W = q(V_2 - V_1)$	$V = (V_2 - V_1)$
31	Energy of a system of two charges	$U = q_1 q_2/(4\pi\varepsilon_0 r)$	—
32	Relation of *E* and *V*	$E = -dv/dr$	*dV* is the potential difference between two points at a distance where *r* and *E* are in the same direction
33	Relation of *E* and *V* and angle θ	$E\cdot\cos\theta = -dv/dr$	Where θ is the angle between *r* and *E*
34	Potential at infinity / on Earth	Zero	—
35	Electric potential due to a dipole on an axial line	$V = P/(4\pi\varepsilon_0 r^2)$	*P* is the dipole moment, *r* is the distance from the center of the dipole
36	Electric potential due to a dipole on an equatorial line	Zero	—

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No.	Concept/Quantity	Formula(s)	Explanation
38	Work done in moving a charge between two points on an equipotential surface	Zero	No work is done since potential difference is zero
39	Capacitance of a spherical conductor	$C = 4\pi\varepsilon_0 R$	*R* is the radius of the sphere
40	Dielectric constant	$k = C / C_0$	*C* is capacitance with dielectric, C_0 is in vacuum
41	Capacitance of a spherical capacitor	$C = 4\pi\varepsilon_0 r_1 r_2 / (r_2 - r_1)$	r_1 and r_2 are inner and outer radii
42	Equivalent capacitance for capacitors in parallel	$C = C_1 + C_2 + C_3$	Sum of individual capacitances
43	Equivalent capacitance for capacitors in series	$1/C = 1/C_1 + 1/C_2 + 1/C_3$	Reciprocal sum of individual capacitances
44	Charge, capacitance, potential difference	$C = q / V$	*q* is charge, *V* is potential difference
45	Energy stored in a capacitor	$\frac{1}{2}CV^2$, $\frac{1}{2}q^2/C$, $\frac{1}{2}qV$	Different forms based on known values

Capacitors are essential electrical components that store and release electrical energy in a circuit. They are made of two conductive plates separated by an insulating material called a dielectric. When a voltage is applied, one plate stores positive charge and the other stores an equal amount of negative charge, creating an electric field between them.The amount of charge a capacitor can store depends on its capacitance, which is determined by the size of the plates, the distance between them, and the type of dielectric used.

Capacitors are important in both basic and advanced electronics. They are widely used to smooth out voltage fluctuations in power supplies, filter signals in communication systems, and store energy in devices like flash cameras. In timing circuits, capacitors help control how long a device stays on or off. They are also used in motors, fans, and air conditioners to help with startup and running efficiency. Capacitors play a crucial role in modern electronics due to their ability to charge and discharge quickly, making them vital for both energy storage and signal processing.

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SL	Concept	Formula	Explanation
46	Common potential	$V = (C_1V_1 + C_2V_2) / (C_1 + C_2)$	—
47	Energy loss in connecting	$\frac{1}{2}(C_1C_2 / (C_1 + C_2)) \times (V_1 - V_2)^2$	C_1 at V_1 is connected to C_2 at V_2
48	Capacitor with dielectric slab inserted	$\varepsilon_0 K^*A / (d - t + t/K)$	*t* is the thickness of the dielectric slab of constant *K*
49	Capacitor with metal plate inserted	$\varepsilon_0 KA / (d - t)$	*t* is the thickness of the metal plate inserted
50	Force of attraction between plates	$(q^2 / 2\varepsilon_0 A)$, $\frac{1}{2}\varepsilon_0 AE^2$, $q^2 / 2C$	*q* is charge on plate, *A* is area, *E* is electric field