# CLASS 12 PHYSICS — FORMULA SHEET

Chapter 1 : Electric Charges and Fields (NCERT)

## 1.1 Electric Charge — Basic Properties

| Concept | Detail / Formula |
|---|---|
| **Quantisation of charge** | $q = \pm n e$ ($n$ = integer) ; $e = 1.6 \times 10^{-19}$ C |
| **Conservation of charge** | Total charge of an isolated system stays constant |
| **Additivity** | Total charge = algebraic sum of individual charges |
| **Like / unlike charges** | Like charges repel ; unlike charges attract |
| **1 coulomb** | Charge of about $6.25 \times 10^{18}$ electrons |
| **Charging methods** | Friction, conduction, and induction |

## 1.2 Coulomb's Law

| Concept | Formula |
|---|---|
| **Coulomb's law (force)** | $F = (1/4\pi\varepsilon_0) \times (q_1q_2 \div r^2)$ |
| **Coulomb constant** | $k = 1/4\pi\varepsilon_0 = 9 \times 10^9$ N m$^2$ C$^{-2}$ |
| **Permittivity of free space** | $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$ N$^{-1}$ m$^{-2}$ |
| **In a medium** | $F_{medium} = F_{vacuum} \div K$ ($K$ = dielectric constant) |
| **Vector form** | $F_{12} = k(q_1q_2/r^2)\,\hat{r}_{12}$ (along line joining charges) |
| **Superposition principle** | Net force = vector sum of forces due to each charge |

## 1.3 Electric Field (E)

| Concept | Formula |
|---|---|
| **Electric field** | $E = F \div q_0$ (force per unit positive test charge) |
| **Field due to point charge** | $E = (1/4\pi\varepsilon_0) \times (q \div r^2)$ |
| **SI unit** | N/C or V/m |
| **Direction** | Away from +ve charge, toward −ve charge |
| **Field from superposition** | $E_{net} = E_1 + E_2 + \ldots$ (vector sum) |
| **Force on a charge in field** | $F = qE$ |

## 1.4 Electric Dipole

| Concept | Formula |
|---|---|
| **Dipole moment** | $p = q \times 2a$ (vector, from $-q$ to $+q$) ; unit C·m |
| **Field on axial line** | $E = (1/4\pi\varepsilon_0) \times (2p \div r^3)$ (for $r >> a$) |
| **Field on equatorial line** | $E = (1/4\pi\varepsilon_0) \times (p \div r^3)$ (for $r >> a$) |
| **Axial : equatorial ratio** | $E_{axial} = 2 \times E_{equatorial}$ (same distance) |

| Concept | Formula |
|---|---|
| **Torque on dipole** | $\tau = p \times E$ ; $\|\tau\| = pE \sin\theta$ |
| **Potential energy of dipole** | $U = -p\cdot E = -pE \cos\theta$ |
| **Stable / unstable equilibrium** | $\theta = 0°$ stable (U min) ; $\theta = 180°$ unstable (U max) |

## 1.5 Electric Flux & Gauss's Law

| Concept | Formula |
|---|---|
| **Electric flux** | $\Phi = E\cdot A = EA \cos\theta$ ; unit N $m^2/C$ |
| **Gauss's law** | $\Phi = \oint E\cdot dA = q_{enclosed} \div \varepsilon_0$ |
| **Key point** | Flux depends only on enclosed charge, not its position |
| **Field of infinite line charge** | $E = \lambda \div (2\pi\varepsilon_0 r)$ ($\lambda$ = linear charge density) |
| **Field of infinite sheet** | $E = \sigma \div (2\varepsilon_0)$ ($\sigma$ = surface charge density) |
| **Field between two sheets** | $E = \sigma \div \varepsilon_0$ (opposite charges) |
| **Field of charged shell (outside)** | $E = (1/4\pi\varepsilon_0)(q \div r^2)$ (acts as point charge) |
| **Field inside shell** | $E = 0$ (no charge enclosed) |

## 1.6 Charge Densities

| Type | Definition |
|---|---|
| **Linear charge density (λ)** | $\lambda$ = charge ÷ length (C/m) |
| **Surface charge density (σ)** | $\sigma$ = charge ÷ area ($C/m^2$) |
| **Volume charge density (ρ)** | $\rho$ = charge ÷ volume ($C/m^3$) |

## ★ QUICK MEMORY AIDS & TRICKS

| | |
|---|---|
| **Coulomb constant** | $k = 1/4\pi\varepsilon_0 = 9 \times 10^9\ N\cdot m^2/C^2$. Memorise this value. |
| **Charge is quantised** | $q = ne$ ; $e = 1.6 \times 10^{-19}$ C. Charge always comes in whole multiples. |
| **E from a point charge** | $E = kq/r^2$ ; force on a charge $F = qE$. |
| **Dipole fields** | Axial = $2kp/r^3$ ; Equatorial = $kp/r^3$. Axial is TWICE the equatorial. |
| **Dipole energy** | $U = -pE \cos\theta$. Minimum (stable) at $\theta = 0°$, maximum at 180°. |
| **Gauss's law** | $\Phi = q\_enclosed/\varepsilon_0$. Pick a symmetric Gaussian surface. |
| **Sheet vs shell** | Infinite sheet: $\sigma/2\varepsilon_0$ (independent of distance). Shell inside: $E = 0$. |
| **Torque on dipole** | $\tau = pE \sin\theta$ ; maximum at $\theta = 90°$, zero at 0° and 180°. |