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TN CLASS 12

FORMULA SHEET

ELECTROSTATICS

BY

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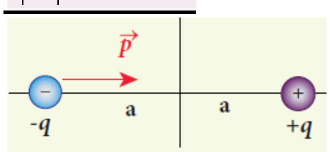
FORMULA	EXPLANATION OF TERMS INVOLVED	UNITS
Quantization of charges **Q=ne**	• Q=charge • n= no of electrons • e=fundamental unit charge *For electron, e= -1.6×10^{-19} C *For proton, e= $+1.6 \times 10^{-19}$ C • (note: n is always a whole number)	Q=coulomb (C) e=coulomb (C)
Coulomb's law $\vec{F}_{21} = k\frac{q_1 q_2}{r^2}\hat{r}_{12}$	• F=electrostatic force $k = \frac{1}{4\pi\epsilon_o}$ *Value of k= $9\times 10^9\, \text{N m}^2\,\text{C}^{-2}$ • r=distance b/w to charges • q1,q2 = charges	Force= newton (N) k=Nm^2C^{-2}
Electric field $\vec{E} = \frac{\vec{F}}{q_0} = \frac{kq}{r^2}\hat{r} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$	• q=charge • r=distance • electric field → vector quantity	SI unit: newton per coulomb NC^{-1}
Electric dipole moment $\vec{p} = qa\hat{i} - qa(-\hat{i}) = 2qa\hat{i}$ $\|\vec{p}\| = 2qa$ 	⇨ p=dipole moment • a=distance of the charge from centre of dipole • q=magnitude of the charge Note: direction of dipole vector is from – q to +q.	**SI unit** coulomb metre (Cm).

Electrostatic potential $V_p = -\int_{\infty}^{p} \vec{E} \cdot d\vec{r}$	• V=Potential • E=electric field • dr=distance • p=point of interest to bring the charge from infinity	Joule per coulomb J/C or Volts
Electric field due to an electric dipole at point on the axial line $\vec{E}_{tot} = \frac{1}{4\pi\epsilon_0} \frac{2\vec{p}}{r^3}$	• E=electric field • p=dipole moment • r=distance of the chosen point from centre of dipole	newton per coulomb NC^{-1}
Electric field due to an electric dipole at a point on the equatorial plane $\vec{E}_{tot} = -\frac{1}{4\pi\epsilon_\circ} \frac{\vec{p}}{r^3}$	• E=electric field • p=dipole moment • r=distance of the chosen point from centre of dipole	newton per coulomb NC^{-1}
Torque experienced by an electric dipole in the uniform electric field $\vec{\tau} = \vec{p} \times \vec{E}$ or $\tau = qE \cdot 2a\sin\theta$ or $\tau = pE\sin\theta$	• τ=torque • p=dipole moment • E=electric field	SI UNIT: Newton metre
Electric potential due to a point charge **1)If the source charge is positive:** $V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$	• V=Potential • q=magnitude of the charge • r=distance 2)If the source charge is negative: $V = -\frac{1}{4\pi\epsilon_0} \frac{q}{r}$	Joule per coulomb J/C or Volts

Electrostatic potential at a point due to an electric dipole $V = \frac{1}{4\pi\epsilon_\circ}\frac{p}{r^2}$	• p=dipole moment • r=distance • V=Potential	Joule per coulomb J/C or Volts
Relation between electric field and potential $dW = dV.$ $dV = -E\,dx$ $E = -\frac{dV}{dx}$	W=work done V=potential E=electric field	Work done= **joule** Potential= Joule per coulomb **J/C** or **Volts**
Electrostatic potential energy of a dipole in a uniform electric field $U = -pE\cos\theta = -\vec{p}\cdot\vec{E}$	U=potential energy p=dipole moment E=electric field	Unit of electrostatic potential energy= volt
Electric Flux $\Phi_E = \vec{E}\cdot\vec{A} = EA\cos\theta$ **For uniform electric field,** $\Phi_E = \int \vec{E}\cdot d\vec{A}$	Φ=flux E=electric field A=area Note: flux is scalar quantity **For closed surfaces,** $\Phi_E = \oint \vec{E}\cdot d\vec{A}$	Nm^2C^{-1}
Gauss law $\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_\circ}$	Φ=flux E=electric field A=area Q=charge inside closed space. $\epsilon_\circ = \frac{1}{4\pi k} = 8.85\times10^{-12}C^2N^{-1}m^{-2}$	Volt metres

Electric field due to an infinitely long charged wire $E = \frac{1}{2\pi\epsilon_o}\frac{\lambda}{r}$	E=electric field r=radius of the imaginary cylindrical area. λ=linear charge density = charge per unit length= λ=Q/L	newton per coulomb NC^{-1}
Electric field due to charged infinite plane sheet $\vec{E} = \frac{\sigma}{2\epsilon_o}\hat{n}$	σ =charge present per unit area=Q/A $\epsilon_o = \frac{1}{4\pi k} = 8.85\times10^{-12}C^2N^{-1}m^{-2}$ E=electric field	newton per coulomb NC^{-1}
Electric field due to two parallel charged infinite sheets $E_{inside} = \frac{\sigma}{2\epsilon_o} + \frac{\sigma}{2\epsilon_o} = \frac{\sigma}{\epsilon_o}$	σ =charge present per unit area=Q/A $\epsilon_o = \frac{1}{4\pi k} = 8.85\times10^{-12}C^2N^{-1}m^{-2}$ E=electric field	newton per coulomb NC^{-1}
Electric field due to a uniformly charged spherical shell **(a) At a point outside the shell ($r > R$)** $\vec{E} = \frac{1}{4\pi\epsilon_o}\frac{Q}{r^2}\hat{r}$	Q=charge r,R = Radius of the spheres **(b)At a point on the surface of the spherical shell ($r = R$)** $\vec{E} = \frac{Q}{4\pi\epsilon_o R^2}\hat{r}$	newton per coulomb NC^{-1} **(c)At a point inside the spherical shell ($r < R$)** $E = 0$
Polarisation $\vec{P} = \chi_e \vec{E}_{ext}$	X= electric susceptibility P=polarisation	Coulomb per metre square Cm^{-2}
Capacitance **Q=CV** ⇨ **C=Q/V**	Q=Charge C=capacitance V=potential	Coulomb per volt or farad (F)

Capacitance of a parallel plate capacitor $C = \frac{\epsilon_0 A}{d}$	C=capacitance $\epsilon_o = \frac{1}{4\pi k} = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$ A=area of the plates d=distance between the plates	Coulomb per volt or farad (F)
Energy stored in the capacitor $U_E = \frac{Q^2}{2C} = \frac{1}{2} CV^2$	Q=Charge C=capacitance V=potential U=energy stored in the capacitor	farad (F) or joules
Energy density $u_E = \frac{U}{Volume}$	u=energy density U=energy stored	Joule per metre cube Jm^{-3}
Capacitors in series $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	C_S=Effective capacitance in series	Coulomb per volt or farad (F)
Capacitors in parallel $C_P = C_1 + C_2 + C_3$	C_p=effective capacitance in parallel	Coulomb per volt or farad (F)
Distribution of charges in a conductor $\frac{q_1}{r_1} = \frac{q_2}{r_2}$ $\sigma_1 r_1 = \sigma_2 r_2$	σ= charge density on the surface r1,r2= radius of the spheres $\sigma r = \text{constant}$	