Physics 102 – Formula Sheet

Coulomb's Law: $\vec{F}_{12} = k\dfrac{|Q_1Q_2|}{r^2}\hat{r}_{12} = \dfrac{1}{4\pi\varepsilon_o}\dfrac{|Q_1Q_2|}{r^2}\hat{r}_{12}$

The Electric Field: $\vec{E} = \dfrac{1}{4\pi\varepsilon_o}\int_Q \dfrac{dq}{r^2}\hat{r}$

Force on a charged particle in an electric field: $\vec{F} = q\vec{E}$

Gauss' Law: $\phi = \oint_S \vec{E}.d\vec{A} = \dfrac{q_{encl}}{\varepsilon_0}$

Electric Field Calculations:

Charge Distribution	Electric Field
Point Charge	$\dfrac{1}{4\pi\varepsilon_o}\dfrac{Q}{r^2}$
Charged Ring (along the axis taken to be the x-axis)	$\dfrac{1}{4\pi\varepsilon_o}\dfrac{Q\text{x}}{(\text{x}^2+R^2)^{3/2}}$
Charged Disk (along the axis taken to be the x-axis)	$\dfrac{\sigma}{2\varepsilon_o}\left[1-\dfrac{\text{x}}{\sqrt{\text{x}^2+R^2}}\right]$
Infinite Sheet (nonconducting)	$\dfrac{\sigma}{2\varepsilon_o}$
Uniform spherical charge distribution of radius R	$\dfrac{1}{4\pi\varepsilon_o}\dfrac{Q}{r^2}$ $r > R$ $\dfrac{1}{4\pi\varepsilon_o}\dfrac{Qr}{R^3}$ $r < R$
Infinite linear distribution	$\dfrac{\lambda}{2\pi\varepsilon_o r} = \dfrac{2k\lambda}{r}$

$$\Delta V = V_f - V_i = -\int_{r_i}^{r_f} \vec{E}.d\vec{l} = -\frac{W_{i\to f}}{q}$$

Electric Potential: $V = \dfrac{1}{4\pi\varepsilon_o}\int\dfrac{dq}{r}$, *relative to* ∞

$$E_i = -\frac{\partial V}{\partial \text{x}_i}$$

Potential Energy of a point charge: $\Delta U = q\Delta V$

Potential energy of a system of charges: $U = \dfrac{1}{4\pi\varepsilon_0}\sum_{i<j}\dfrac{q_iq_j}{r_{ij}}$

Potential Relative to Infinity:

Distribution	Potential form
Point charge	$\frac{1}{4\pi\varepsilon_o}\frac{Q}{r}$
Charged Ring (along the axis taken to be the x-axis)	$\frac{1}{4\pi\varepsilon_o}\frac{Q}{\sqrt{x^2+R^2}}$
Charged Disk (along the axis taken to be the x-axis)	$\frac{\sigma}{2\varepsilon_o}\left[\sqrt{x^2+R^2}-x\right]$
Uniform spherical charge distribution of radius R.	$\frac{1}{4\pi\varepsilon_o}\frac{Q}{r}$ $\quad r \geq R$ $\frac{1}{8\pi\varepsilon_o}\frac{Q}{R}\left(3-\frac{r^2}{R^2}\right)$ $\quad r \leq R$

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

System	Capacitance
Parallel Plates	$\varepsilon_o\frac{A}{d}$
Spherical capacitor of radii *a* and *b*.	$\varepsilon_o\frac{4\pi ab}{b-a}$
Isolated Sphere of radius *R*	$\varepsilon_o 4\pi R$
Cylindrical capacitor of radii *a* and *b* and height *L*	$\varepsilon_o\frac{2\pi L}{\ln(b/a)}$

Capacitor Combinations:

Series Connection : $\frac{1}{C_{eq}}=\sum_{i=1}^{N}\frac{1}{C_i}$

Parallel Connection : $C_{eq}=\sum_{i=1}^{N}C_i$

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

Energy Density: $u=\frac{1}{2}\varepsilon_o E^2$

Dielectric: In the presence of a dielectric material, **replace** (ε_o) **by** $(\kappa\varepsilon_o)$**.**

Electric Current & D.C.

$$I=\frac{dQ}{dt}=\int\vec{J}.d\vec{A} \qquad \vec{J}=ne\vec{v}_d$$

$R = \rho \frac{L}{A}$, $\rho = \rho_o(1 + \alpha \Delta T)$

$V = IR$ $P = V\,I = I^2 R = \frac{V^2}{R}$

$R_{eq} = \sum_{i=1}^{N} R_i$ (*Series*) $\frac{1}{R_{eq}} = \sum_{i=1}^{N} \frac{1}{R_i}$ (*Parallel*)

R-C Circuits:

$Q(t) = C\varepsilon(1 - e^{-t/\tau})$ (Charging)

$Q(t) = Q_o e^{-t/\tau}$ (Discharging)

Charged particle in a magnetic field:

$F = q\vec{v} \times \vec{B}$ $\omega = \frac{qB}{m} = \frac{v}{r}$

Force on a current carrying conductor: $\vec{F} = I\vec{L} \times \vec{B}$

Magnetic Field:

Moving charge: $\vec{B} = \frac{\mu_o}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$

Biot – Savart Law: $d\vec{B} = \frac{\mu_o I}{4\pi} \frac{d\vec{l} \times \hat{r}}{r^2}$

Ampere's Law: $\oint \vec{B}.d\vec{l} = \mu_o I_{encl}$

Magnetic Field Calculations:

Shape	Field
Long Straight Wire	$\frac{\mu_o I}{2\pi\, r}$
Circular loop (along the axis)	$B_x = \frac{\mu_0 I a^2}{2(x^2 + a^2)^{3/2}}$
Circular loops (at the centre)	$B_x = \frac{\mu_o N\, I}{2a}$
Solenoid	$\mu_o n I$

Force between two long straight wires: $F = \frac{\mu_o I_1 I_2 L}{2\pi\, d}$

Faraday's Law: $\varepsilon = -N \frac{\Delta \phi_B}{\Delta t}$, $\phi_B = BA\cos\theta$

Motional EMF: $\varepsilon = BLv$

Induced Electric Field: $\oint \vec{E}.d\vec{l} = -\frac{d\phi_B}{dt}$