# *Formula Sheet: Electricity and Magnetism*

***Coulomb's law***

$$F = k\frac{Q_1 Q_2}{r^2}$$

***Electric Field***

$$\vec{E} = \frac{\vec{F}}{q}$$

Field of a point charge

$$E = k\frac{Q}{r^2}$$

Principle of superposition

$$\vec{E}_{net} = \sum_{i=1}^{N} \vec{E}_i$$

***Electric potential***

$$V = \frac{U}{q}$$

$$V(r) = -\int_{\infty}^{r} \vec{E} \cdot d\vec{l}$$

$$V_{ba} = V_b - V_a = -\int_{a}^{b} \vec{E} \cdot d\vec{l}$$

For a point charge $V(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

***Potential Energy***

q moving through $V_{ba}$

$$\Delta U = qV_{ba}$$

***Capacitors***

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

Parallel-plate $C = \varepsilon_0 \frac{A}{d}$

***Capacitors connected in parallel***

$$C_{eq} = C_1 + C_2 + \cdots$$

***Capacitors connected in series***

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

***Energy stored in a capacitor*** $U = \frac{Q^2}{2C}$

***Ohm's law***

$$V = IR$$

$$R = \rho\frac{l}{A}$$

***Power***

$$P = IV$$

***Resistors connected in series***

$$R_{eq} = R_1 + R_2 + R_3 + \cdots$$

***Resistors connected in parallel***

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

***The potential difference across a charging capacitor in RC circuit***

$$V(t) = \varepsilon(1 - e^{-t/RC})$$

***A magnetic field exerts a force***

$$\overrightarrow{dF} = I\overrightarrow{dl} \times \vec{B}$$

$$\vec{F} = I\vec{l} \times \vec{B}$$

$$\vec{F} = q\vec{v} \times \vec{B}$$

***The torque on a current loop***

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$\vec{\mu} = NI\vec{A}$$

***The Biot-Savart Law***

$$d\vec{B} = \frac{\mu_0 I d\vec{l} \times \hat{r}}{4\pi r^2}$$

***The magnetic field of:***

***A straight line wire***

$$B = \frac{\mu_0 I}{2\pi r}$$

***A solenoid***

$$B = \mu_0 n I$$

***Magnetic flux***

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

***Mutual inductance***

$$M = \frac{N_2 \Phi_{21}}{I_1}$$

$$\varepsilon = -M \frac{dI_1}{dt}$$

***Self-inductance***

$$L = N \frac{\Phi_B}{I}$$

$$\varepsilon = -L \frac{dI}{dt}$$

***Energy stored in an inductor***

$$U = L \frac{I^2}{2}$$

***Charged LR circuit***

$$I = \frac{V_0}{R}\left(1 - e^{-t/\tau}\right);\ \tau = L/R$$

***Maxwell's equations***

$$\oint \vec{\boldsymbol{E}} \cdot \overrightarrow{\boldsymbol{dA}} = \frac{\boldsymbol{Q}}{\boldsymbol{\varepsilon_0}}$$

$$\oint \vec{\boldsymbol{B}} \cdot \overrightarrow{\boldsymbol{dA}} = \boldsymbol{0}$$

$$\oint \vec{\boldsymbol{E}} \cdot \overrightarrow{\boldsymbol{dl}} = -\frac{\boldsymbol{d\Phi_B}}{\boldsymbol{dt}}$$

$$\oint \vec{\boldsymbol{B}} \cdot \overrightarrow{\boldsymbol{dl}} = \boldsymbol{\mu_0 I} + \boldsymbol{\mu_0 \varepsilon_0} \frac{\boldsymbol{d\Phi_E}}{\boldsymbol{dt}}$$

***Constants***

Charge on electron

$e = 1.60 \cdot 10^{-19}\ C$

Electron mass $m = 9.11 \cdot 10^{-31}\ kg$

Permittivity of free space

$$\varepsilon_0 = 8.85 \cdot 10^{-12}\ C^2/Nm^2$$

Permeability of free space

$$\mu_0 = 4\pi \cdot 10^{-7}\ Tm/A$$

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \cdot 10^9\ Nm^2/C^2$$

***Kinematic eq-ns with const. Acc.:***

$v(t) = v_{0x} + at$

$x(t) = x_0 + v_{0x}t + (1/2)\,at^2$

$v^2 = v_{0x}^2 + 2a(x - x_0)$

**Centripetal acceleration** $a_R = v^2/r$