Formula Sheet

Perimeter of a circle

$$L = 2\pi r \tag{1}$$

Area of a sphere

$$A = 4\pi r^2 \tag{2}$$

Volume of a sphere

$$V = \frac{4}{3}\pi r^3 \tag{3}$$

Electric Field by a point charge:

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r} \quad \left(\text{alternative } \vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^3}\vec{r}\right) \tag{4}$$

Coulomb's Law (Electric Force):

$$\vec{F}_E = Q\vec{E} \tag{5}$$

Gauss's Law:

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{\text{enc}}}{\varepsilon_0} \tag{6}$$

Voltage or Potential difference - Electric Field relation between points a and b:

$$\Delta\phi = -\int_a^b \vec{E}\cdot d\vec{\ell} \tag{7}$$

Electrostatic Energy - Electric Field relation :

$$\Delta U = Q\int_a^b \vec{E}\cdot d\vec{\ell} \tag{8}$$

Time Constant RC Circuit:

$$\tau = RC \tag{9}$$

Voltage Across Capacitor in charging RC Circuit:

$$V_C = V_0\left(1 - e^{-t/\tau}\right) \tag{10}$$

Voltage Across Capacitor in discharging RC Circuit:

$$V_C = V_0\left(e^{-t/\tau}\right) \tag{11}$$

Ohm's Law:

$$I = \frac{V}{R} \tag{12}$$

Lorentz Force:

$$\vec{F} = q\vec{v}\times\vec{B} + q\vec{E} \tag{13}$$

Ampere's Law:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enc}} + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} \tag{14}$$

Biot-Savart law: Magnetic field created by a piece of wire ds with current i flowing through it.

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{s} \times \hat{r}}{r^2} \tag{15}$$

Magnetic Flux

$$\Phi_B = -\oint \vec{B} \cdot d\vec{A} \tag{16}$$

Induced Electromotive Force:

$$\varepsilon = -\frac{d\Phi_B}{dt} \tag{17}$$

Electric Field Inside a parallel plate Capacitor:

$$E = \frac{\sigma}{\varepsilon_0} \tag{18}$$

Scalar or dot product(θ is the angle between $\vec{A}$ and $\vec{B}$):

$$\vec{A} \cdot \vec{B} = A\,B \cos\theta \tag{19}$$

Vector or cross product (θ is the angle between $\vec{A}$ and $\vec{B}$):

$$\left|\vec{A} \times \vec{B}\right| = AB \sin\theta \tag{20}$$

Series Behavior Resistor:

$$R_{eq} = R_1 + R_2 \tag{21}$$

Capacitance

$$C = \frac{Q}{V} \tag{22}$$

Energy Stored in a Capacitor

$$U = \frac{1}{2} \frac{Q^2}{C} \tag{23}$$

Capacitor filled with a dielectric:

$$C_\kappa = \kappa C_0 \tag{24}$$

Series Behavior Capacitor:

$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} \right)^{-1} \tag{25}$$

Parallel Behavior Resistor:

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} \right)^{-1} \tag{26}$$

Parallel Behavior Capacitor:

$$C_{eq} = C_1 + C_2 \tag{27}$$

Relation between Polarization Vector and E in Linear and Isotropic Dielectrics

$$\vec{P} = \chi\varepsilon_0\vec{E} \tag{28}$$

Bound charge

$$Q_B = -\oint \hat{n} \cdot \vec{P}\, da \tag{29}$$

Total charge: See Gauss Law

Bound charge density

$$\sigma_B = \hat{n} \cdot (\vec{P}_{in} - \vec{P}_{out}) \tag{30}$$

Total charge density

$$\sigma_T = -\varepsilon_0\hat{n} \cdot (\vec{E}_{in} - \vec{E}_{out}) \tag{31}$$