Electricity & Magnetism Equation Sheet

Think about how to set up the problem first, then apply the needed principles and formulas.

Electric Field & Force

$F = \frac{kq_0 q}{r^2}$

$E = \frac{F}{q} = \frac{kq_0}{r^2}$

$E_{ring} = \frac{kQx}{(x^2+a^2)^{3/2}}$

$E_{line} = \frac{\lambda}{2\pi\epsilon_0 r}$

$E_{disk} = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{z}{R^2+z^2}\right]$

$E_{sheet} = \frac{\sigma}{2\epsilon_0}$

$E_{para.\,plates} = \frac{\sigma}{\epsilon_0}$

$p = qd$ (dipole moment)

$\vec{\tau}_{dipole} = \vec{p} \times \vec{E}$

$\tau_{dipole} = pE\sin\phi$

$U = -pE\cos\phi$

$\Phi_E = EA\cos\phi$

$\Phi_E = \int \vec{E}\cdot d\vec{A}$

$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$

Electric Potential

$W = \int \vec{F}\cdot d\vec{l} = -\Delta U$

$U = \frac{kq_0 q}{r}$

$V = \frac{U}{q} = \frac{kq_0}{r}$

$\Delta V = -\int \vec{E}\cdot d\vec{l}$

$V_{cyl} = \frac{\lambda}{2\pi\epsilon_0}\ln\left(\frac{R}{r}\right)$

$V_{ring} = \frac{kQ}{x^2+a^2}$

$\vec{E} = -\vec{\nabla}V$

Capacitance

$C = \epsilon_0\frac{A}{d} = \frac{Q}{V}$

$E = \frac{\sigma}{\epsilon_0} = \frac{Q}{\epsilon_0 A}$

$V = Ed = \frac{Qd}{\epsilon_0 A}$

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

$u = \frac{1}{2}\epsilon_0 E^2$

$C_{new} = \kappa C_{old}$

$E_{new} = \frac{E_{old}}{\kappa}$

$\varepsilon = \kappa\epsilon_0$

$C_{eq} = C_1 + C_2 + \cdots$ (parallel)

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

Circuits

$I = \frac{dQ}{dt} = nqv_d A$

$J = \frac{I}{A}$

$\rho = \frac{E}{J}$

$\sigma = \rho^{-1}$

$\rho(T) = \rho_0[1 + \alpha(T - T_0)]$

$V = IR$

$V_{term.} = \varepsilon - Ir$

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

$R_{eq} = R_1 + R_2 + \cdots$ (series)

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ (parallel)

$\sum I_{junction} = 0$

$\sum V_{closed\,loop} = 0$

$\tau = RC$

$Q(t) = Q(1 - e^{-t/\tau})$ (charging)

$Q(t) = Qe^{-t/\tau}$ (discharging)

$I(t) = I_0 e^{-t/\tau}$ (charging)

$I(t) = -I_0 e^{-t/\tau}$ (discharging)

$I_0 = -\frac{Q_0}{\tau}$

Magnetism

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

$\Phi_B = BA\cos\phi$

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

$\oint \vec{B}\cdot d\vec{A} = 0$

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

$\vec{\tau}_{mag.\,dipole} = \vec{\mu} \times \vec{B}$

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

$U = -\mu B\cos\phi$

$nq = -\frac{J_z B_y}{E_z}$

$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$

$B_{wire} = \frac{\mu_0 I}{2\pi r}$

$F = \frac{\mu_0 I_1 I_2 L}{2\pi r}$

$B_{loop} = \frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}$

$B_{solenoid} = \mu_0 n I$

$B_{toroid} = \frac{\mu_0 N I}{2\pi r}$

$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$

Induction

$\varepsilon = -\frac{d\Phi}{dt}$

$\varepsilon = vBL$

$\varepsilon = \oint(\vec{v} \times \vec{B})\cdot d\vec{l}$

$\oint \vec{E}\cdot d\vec{l} = -\frac{d\Phi_B}{dt}$

$i_D = \varepsilon_0\frac{d\Phi_E}{dt}$

$\oint \vec{B}\cdot d\vec{l} = \mu_0(I + \epsilon_0\frac{d\Phi_E}{dt})$

$M = \frac{N_1\Phi_{B_1}}{i_2}$

$\varepsilon_1 = -M\frac{di_2}{dt}$

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

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

$U = \frac{1}{2}LI^2$

$u_0 = \frac{B^2}{2\mu_0}$

$u = \frac{B^2}{2\mu}$

$\tau = \frac{L}{R}$

$i = I_0 e^{-t/\tau}$

$\varepsilon i = i^2R + Li\frac{di}{dt}$

$\omega = \sqrt{\frac{1}{LC}}$

$\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$

AC Circuits

$i = I\cos(\omega t)$

$I_{rms} = \frac{I}{\sqrt{2}}$

$v_{rms} = \frac{v}{\sqrt{2}}$

$X_C = \frac{1}{\omega C}$

$X_L = \omega L$

$V_C = IX_C$

$V_L = IX_L$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$\tan\phi = \frac{X_L - X_C}{R}$

$P_{av} = \frac{1}{2}IV\cos\phi$

$\omega_0 = \frac{1}{\sqrt{LC}}$

$\frac{V_2}{V_1} = \frac{N_2}{N_1}$

$I_1V_1 = I_2V_2$

EM Waves

$E = cB$

$B = \epsilon_0 \mu_0 c E$

$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$

$\vec{E}(x,t) = E_{max} \cos(kx \pm \omega t)\, \hat{j}$

$\vec{B}(x,t) = B_{max} \cos(kx \pm \omega t)\, \hat{k}$

$v = \frac{1}{\sqrt{\varepsilon \mu}} = \frac{c}{\sqrt{\kappa \kappa_m}}$

$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$

$I = S_{av} = \frac{1}{2} \epsilon_0 c E_{max}^2$

$\frac{1}{A} \frac{dp}{dt} = \frac{S}{c} = \frac{EB}{\mu_0 c}$

Constants

$\epsilon_0 = 8.854 \times 10^{-12}\ \frac{C^2}{N \cdot m^2}$

$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^{9}\ \frac{N \cdot m^2}{C^2}$

$m_p = 1.67 \times 10^{-27}\, kg$

$m_e = 9.11 \times 10^{-31}\, kg$

$e = 1.602 \times 10^{-19}\, C$

$1eV = 1.602 \times 10^{-19}\, J$

$\mu_0 = 4\pi \times 10^{-7}\ \frac{Wb}{A \cdot m}$

$c = 2.998 \times 10^{8}\ \frac{m}{s}$

$1u = 1.66 \times 10^{-27}\, kg$

Miscellaneous

$\vec{A} \cdot \vec{B} = AB \cos\theta$

$$\vec{A} \cdot \vec{B} = (A_y B_z - A_z B_y)\hat{i} + (A_z B_x - A_x B_z)\hat{j} + (A_x B_y - A_y B_x)\hat{k}$$

$A_{sphere} = 4\pi r^2$

$V_{sphere} = \frac{4}{3}\pi r^3$

$Circum.\ of\ circle = 2\pi r$

$A_{circle} = \pi r^2$

Scientific Notation Prefixes		
Factor	Prefix	Symbol
10^{-12}	pico-	p
10^{-9}	nano-	n
10^{-6}	micro-	μ
10^{-3}	milli-	m
10^{-2}	centi-	c
10^{3}	kilo-	k
10^{6}	mega-	M
10^{9}	giga-	G