Equations of Electricity and Magnetism

(R is radius, r is distance)	Finite	Infinite
Point/sphere(ext)	$E = Kq/r^2$	-
Linear	$E = KQ/r\sqrt{(r^2 + L^2/2)}$	$2K\lambda/r$
Ring	$E = KrQ/(r^2+R^2)^{3/2}$	-
Dipole	$E = F/q = K2p/r^3 = Ksq/r^3$	$\tau = \sin\theta\ sqE = \sin\theta\ pE$
Disk	$E = (\eta/2\varepsilon_0)(1-(r/\sqrt{(r^2+R^2)})$	$\eta/2\varepsilon_0$
Planes, 2, between	$E = Q/A\varepsilon_0 = \eta/\varepsilon_0$	
$E = \frac{V}{s}$	$E_c = Q_c/(A_c\varepsilon_0)$	
$E_{solenoid\_inside} = r/2 \mid \frac{\delta B}{\delta t} \mid$	$E_{solenoid\_outside} = R^2/2r \mid \frac{\delta B}{\delta t} \mid$	

Electrical Potential

$V \equiv Es = U_{q'}/q' = KQ/r = -L\ dI/dt$ $V_c = Q\Delta x/(\varepsilon_0 A)$ *Units: (1 volt = 1 V $\equiv$ 1 J/C)* *(1 N/C = 1V/m) (F = C/V)*

$\varepsilon = \Delta\Phi_m/\Delta t = \oint E\ ds = -\frac{\delta}{\delta t}\int_A \vec{B}\,d\vec{A} = -L\ dI/dt$

Force

$\vec{F} = q\vec{v}X\vec{B} = qv B\sin\theta = I\vec{l}_{wire}X\vec{B} = IlB = vl^2B^2/R$

$\vec{F}_{parallelWires} = Il_1B_2 = \mu_0 lI_1I_2/2\pi d$

Energy

Energy= $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 = \frac{1}{2}CV_c^2 = \frac{1}{2}LI^2 = q\Delta V$(J) *Energy density* $u = U_c/Ad = \frac{1}{2}\kappa\varepsilon_0 E^2 = B/2\mu_0$ (J/m^3)

$\Delta U_E = qEs_f - qEs_i = -W_{elec} = U_0 + qEs$ $U_E = q\Delta V = -\int F_{1on2}\,dx$

$U = -Kq_1q_2/r = -\int Kq_1q_2/x^2\,dx = Kq_1q_2/x_f - Kq_1q_2/x_i$

$U_{cap} = Q^2/2C = \frac{1}{2}CV_c^2 = \kappa\varepsilon_0\frac{A}{2}\bullet E^2 d$ $P = U/t = I^2R = V^2/R = I\Delta V = \frac{1}{2}LI^2/t = v^2l^2B^2/R$

$U_{dipole} = -pE\cos\phi = -\vec{p}\bullet\vec{E}$ $\Delta U_{elec} = -W_{elec}$ if $U_{elec} = K\ q_1q_2/r$

Electrical

$C = \kappa\varepsilon_0\frac{A}{d} = \frac{Q}{V}$	$V = \frac{Q}{C} = IR = vlB = L\frac{\delta I}{\delta t}$	$L_{solonoid} = \mu_0 N^2 A/l = \Phi_m/l$
$Q = C\Delta V_c = \kappa\varepsilon_0\frac{A}{d}\bullet\Delta V_c = eN_e$	$I = Q/t = vlB/R$	$E = V/L_{wire}$
$N_e = i_e t = n_e Ax = n_e Av_d t$	$v_d = eE\tau/m$	$\tau = v_d m/eE = m/n_e e^2\rho$
$R = \rho L/A = V/I$	$\rho = RA/L = \sigma^{-1} = m/n_e e^2\tau$	$J = I/A = n_e e v_d = \sigma E$
$P = U/t = I^2R = V^2/R = I\Delta V = \frac{1}{2}LI^2/t$	$\varepsilon = \Delta\Phi_m/\Delta t = \oint E\ ds = -\frac{\delta}{\delta t}\int_A \vec{B}\,d\vec{A} = -L\ dI/dt$	
RC Cap discharge $I = I_o e^{-\Delta t/RC}$	$\Delta V_C = (\Delta V_C)_o e^{-\Delta t/RC}$	$Q = Q_0(e^{-\Delta t/RC})$ $\tau = RC = L/R$
RC Cap charge $I = I_o e^{-\Delta t/RC}$	$\Delta V_C = V_{battery}(1-e^{-\Delta t/RC})$	$Q = Q_0(1-e^{-\Delta t/RC})$

Magnetic

$B_{point} = \mu_0 qv\sin\theta/4\pi r^2$ (dir RHrule)	$B_{wire} = \mu_0 I/2\pi r$ (dir RHrule)	$B_{loop} = \mu_0 NI/2R$ (N-Num loops,R-radius)
$\vec{B}_{dipole} = 2\mu_0\vec{\mu}/4\pi z^3$ (on axis of mag moment)	$B_{Solonoid} = \mu_0 NI/l = \mu_0 nI$ (n=N/l)	$\oint B\ ds = \mu_0 I$
$\tau_{loop} = NIAB\sin\theta$ (A area, θ angle to loop plane)	$\tau = \vec{\mu}X\vec{B} = \mu B\sin\theta$	$\vec{\mu} = IA = 4\pi z^3 B/2\mu_0$
$P = v^2l^2B^2/R = V^2/R = I^2R$	$\Phi_m = \vec{A}x\vec{B} = AB\cos\theta = \mu_0 I$	$\Phi_E = \frac{Q}{\epsilon_0}$

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

Maxwell's Equations

Gauss's Law	$\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}$ $\quad \vec{\nabla}\cdot\vec{G} = \hat{\imath}\,\frac{\delta G}{\delta x} + \hat{\jmath}\,\frac{\delta G}{\delta y} + \hat{k}\,\frac{\delta G}{\delta z}$	$\oint_A \vec{E}\,d\vec{A} = \frac{Q}{\epsilon_0}$
	$\vec{\nabla}\cdot\vec{B} = 0$	$\oint_A \vec{B}\,d\vec{A} = 0$
Faraday's Law	$\vec{\nabla}\,x\,\vec{E} = -\frac{\delta\vec{B}}{\delta t}$	$\oint_L \vec{E}\,d\vec{L} = -\frac{\delta}{\delta t}\int_A \vec{B}d\vec{A}$
Ampere's Law	$\vec{\nabla}\,x\,\vec{B} = \mu_0\vec{J} + \frac{1}{C^2}\frac{\delta\vec{E}}{\delta t} = \mu_0(\vec{J} + \epsilon_0\frac{\delta\vec{E}}{\delta t})$	$\oint_L \vec{B}\,d\vec{L} = \mu_0\,(I + \epsilon_0\frac{\delta}{\delta t}\int_A \vec{E}\,d\vec{A})$

Legend

s, r, d L or h = distance, radius or height(m)	θ, Φ = angle	A = area; ampere(C/s)
v = velocity	ω = angular velocity (Rad/s)	
a = acceleration	α = angular acceleration	g = acceleration of gravity
a_t = tangential acceleration	a_c = centripetal acceleration	G = gravitational constant
F = force; Farad = $C^2s^2/(kg\ m^2)$	p = dipole moment (Cm or D)	τ=torque(Nm)
Q, q = charge (C)	λ = charge/length	η = charge/area
E = electric field (N/C or V/m)	W = work (J); watts (J/s)	
U = potential energy(J)	K = Kinetic Energy (J)	P = power (W; J/s)
ρ = charge density (C/m^3); resistivity (Ωm)	u_E = elec energy density (J/m^3)	R = resistance (Ω)
n_e = conduction e^- density	N_e = # e^- pass cross-section/s	i_e = electron current (#e^-/s)
v_d = drift velocity	σ = conductivity	B = magnetic field strength (T, kg/As^2)
J = current dens(A/m^2); Joules (Nm or kg m^2/s^2)	e = charge of electron	$\vec{\mu}$ = mag dipole moment vector (Am^2)
V = voltage or elect pot. (V); volume(m^3)	C = capacitance (F);Coulomb (C)	L = Inductance (H, Wb/A, Tm^2/A)
τ=avg t bet collisions(s); time const	Φ_m=Magnetic Flux (Wb or Tm^2)	Φ_m = Electric flux (Vm;Nm^2/C)
T = tesla (kg/As^2, N/Am)	Wb = Weber (kgm^2/As^2,Nm/A,Tm^2)	

ϵ =permittivityConst ($8.85x10^{-12}C^2/Nm^2$);emf	*K = 1/2πε₀ ($8.99x10^9\ Nm^2/C^2$)*	*κ = dielectric constant*
μ_0 = permeability Const ($4\pi x10^{-7}$Tm/A)	*G=$6.67x10^{-11}$N*	
(q)e^- = $1.6x10^{-19}$C (m)=$9.11x10^{-31}$kg	*(m)p^+ = $1.67x10^{-27}$ kg*	

Other

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$