Constants

Magnitude of electron charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
Coulomb's constant	$k = 8.99 \times 10^{9}\,\mathrm{N.m^2C^{-2}}$
Permittivity of free space	$\epsilon_0 = \frac{1}{4\pi k}$
	$\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2N^{-1}m^{-2}}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H.m^{-1}}$
Mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$

Equations from 121

Kinematics (1-dim)	$x = x_0 + v_0 t + at^2/2$
	$v = v_0 x + at$
	$v^2 = v_0^2 + 2a\Delta x$
Kinetic energy	$K = \frac{1}{2}mv^2$
Newton's 2nd law	$\vec{F}_{net} = m\vec{a}$
Newton's 3rd law	$\vec{F}_{12} = -\vec{F}_{21}$

Electrostatics

Coulomb's Law	$\vec{F}_{12} = \frac{kq_1q_2}{r_{12}^2}\hat{r}_{12}$
Electric field	$\vec{E} = \vec{F}/q$
Dipole moment	$\vec{p} = q\vec{L}$
Torque on a dipole	$\vec{\tau} = \vec{p} \times \vec{E}$
Potential energy of a dipole	$U = -\vec{p} \cdot \vec{E}$
Electric flux	$\phi = \int \vec{E} \cdot d\vec{A}$
Electric flux for uniform field	$\phi = \lvert\vec{E}\rvert A \cos\theta$
Gauss's law	$\phi_{net} = \oint \vec{E} \cdot d\vec{A} = Q_{enc}/\epsilon_0$
Potential difference	$\Delta V = \frac{\Delta U}{q_0} = -\int_a^b \vec{E} \cdot d\vec{L}$
Electric field from potential	$\vec{E} = -\vec{\nabla}V$ (magnitude = slope)
Pot. energy of point charges	$U = \sum_{\mathrm{pairs}} kq_iq_j/r_{ij}$
E from point charge	$\vec{E} = \frac{kq}{r^2}\hat{r}$
E from system of charges	$\vec{E} = \sum_i \vec{E}_i$
E from infinite line of charge	$E_R = 2k\lambda/R$
E from infinite plane of charge	$E = \sigma/2\epsilon_0$
E from thin spherical shell	$E_r = \begin{cases} \frac{Q}{4\pi\epsilon_0 r^2}, & \text{if } r > R \\ 0, & \text{if } r < R \end{cases}$
E outside conductor	$E = \sigma/\epsilon_0$ (perp. to surface)
E inside conductor	$E = 0$
V from point charge	$V = \frac{kq}{r}$
V from system of point charges	$V = \sum_i \frac{kq_i}{r_i}$
V from thin spherical shell	$V = \begin{cases} \frac{kQ}{r}, & \text{if } r > R \\ \frac{kQ}{R}, & \text{if } r < R \end{cases}$

Capacitance

Capacitance	$C = Q/V$
Parallel plate capacitor	$C = \epsilon_0 A/d$
Cylindrical capacitor	$C = \frac{2\pi\epsilon_0 L}{\ln\left(R_2/R_1\right)}$
Energy stored in a capacitor	$U = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$
Energy density of an E field	$u_e = \frac{1}{2}\epsilon_0 E^2$
Parallel capacitors	$C_{eq} = C_1 + C_2 + ...$
Series capacitors	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + ...$
Electric field inside dielectric	$E = \frac{E_0}{\kappa}$
Capacitance with dielectric	$C = \kappa C_0$

Resistance and current

Electric current	$I = dQ/dt$
Current density	$J = I/A$
Current microscopic view	$I = qn_eAv_d$
Resistance	$R = V/I$
Resistivity, ρ	$R = \rho L/A$
Power loss in resistor	$P = IV = \frac{V^2}{R} = I^2R$
Series resistors	$R_{eq} = R_1 + R_2 + ...$
Parallel resistors	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$

Power output of battery	$P = IV$
Discharging a capacitor	$Q(t) = Q_0 e^{-t/\tau}$
Charging a capacitor	$Q(t) = C\mathcal{E}(1 - e^{-t/\tau})$
Time constant	$\tau = RC$
Current in a capacitor	$I(t) = I_0 e^{-t/\tau}$

Kirchhoff's laws for circuits

Loop rule	$\sum_i \Delta V_i = 0$
Junction rule	$\sum I_{\text{in}} = \sum I_{\text{out}}$

Magnetic Fields

Force on moving charge	$\vec{F} = q\vec{v} \times \vec{B}$
Force on current element	$d\vec{F} = I d\vec{l} \times \vec{B}$
Force on current in wire	$\vec{F} = I\vec{L} \times \vec{B}$
Circular motion	$R = \frac{mv}{qB}$
Circular motion period	$T = \frac{2\pi m}{qB}$
Magnetic dipole moment	$\vec{\mu} = NI\vec{A}$
Torque on magnetic dipole	$\vec{\tau} = \vec{\mu} \times \vec{B}$
Mag. dipole potential energy	$U = -\vec{\mu} \cdot \vec{B}$
Hall effect	$V_H = E_H w = v_d B w = \frac{IB}{nte}$
Biot-Savart law	$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{s} \times \hat{r}}{r^2}$
B inside long solenoid	$B = \mu_0 n I$
B from long straight wire	$B = \frac{\mu_0}{2\pi} \frac{I}{R}$
Magnetic flux	$\phi_m = \int \vec{B} \cdot d\vec{A}$
Magnetic flux, for uniform field	$\phi_m = NBA\cos\theta$
Gauss's law for magnetism	$\phi_{m\,net} = \oint \vec{B} \cdot d\vec{A} = 0$
Ampere's law	$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$
Faraday's law	$\mathcal{E} = -\frac{d\phi_m}{dt}$
Rod moving in B field EMF	$\|\mathcal{E}\| = Blv$
Self inductance	$L = \frac{\phi_m}{I}$
Self inductance of solenoid	$L = \mu_0 n^2 A l$
Inductors in series	$L_{\text{eq}} = L_1 + L_2$
Mutual inductance	$M = \phi_{m21}/I_1 = \phi_{m12}/I_2$
Energy stored in inductor	$U = \frac{1}{2} L I^2$
Magnetic field energy density	$u_m = \frac{B^2}{2\mu_0}$
EMF across inductor	$\mathcal{E} = -L\frac{dI}{dt}$
Energizing an inductor	$I(t) = I_f(1 - e^{-t/\tau})$
De-energizing an inductor	$I(t) = I_0 e^{-t/\tau}$
Time constant	$\tau = L/R$

AC circuits

Generated EMF	$\mathcal{E} = \mathcal{E}_{\text{peak}} \cos\omega t$
RMS voltage	$V_{RMS} = V_{\text{peak}}/\sqrt{2}$
Inductor (V leads I by $90°$)	$V_{L,\text{peak}} = I_{\text{peak}} X_L$
Capacitor (V lags I by $90°$)	$V_{C,\text{peak}} = I_{\text{peak}} X_C$
Inductive reactance	$X_L = \omega L$
Capacitive reactance	$X_C = 1/(\omega C)$
LC circuit natural frequency	$\omega_0 = 1/\sqrt{LC}$
LC charge	$Q = Q_m \cos(\omega_0 t + \phi)$
Impedance	$Z = \sqrt{R^2 + (X_L - X_C)^2}$
Phase angle	$\tan(\delta) = (X_L - X_C)/R$
Q factor	$Q = \frac{\omega_0 L}{R} = \sqrt{\frac{L}{CR^2}} \approx \frac{\omega_0}{\Delta\omega}$

Electromagnetism

Displacement current	$I_d = \epsilon_0 \frac{d\phi_e}{dt}$
Generalized Ampere's law	$\oint \vec{B} \cdot d\vec{L} = \mu_0(I_{enc} + I_d)$
EM wave in z-direction	$E_x = E_0 \cos(kz - \omega t)$
	$B_y = B_0 \cos(kz - \omega t),\ E_0 = cB_0$
EM wave propagation direction	$\vec{E} \times \vec{B}$
Wavelength and frequency	$\lambda = 2\pi/k,\ f = \omega/(2\pi)$
EM wave speed	$c = \frac{\omega}{k} = \lambda f = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$
	$c = 3.0 \times 10^8$ m/s