Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}

Physical Constants

$k = 1/4\pi\epsilon_0 = 8.988$ GNm^2/C^2 (Coulomb's Law)
$e = 1.602 \times 10^{-19}$ C (proton charge)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$\epsilon_0 = 1/4\pi k = 8.854$ pF/m (permittivity of space)
$\mu_0 = 4\pi \times 10^{-7}$ T·m/A (permeability of space)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units

$N_A = 6.02 \times 10^{23}$/mole (Avogadro's #)
1.0 eV = 1.602×10^{-19} J (electron-volt)
1 F = 1 C/V = 1 farad = 1 C^2/J
1 A = 1 C/s = 1 ampere = 1 coulomb/second
1 T = 1 N/A·m = 1 tesla = 1 newton/ampere·meter
1 u = 1 g/N_A = 1.6605×10^{-27} kg (mass unit)
1 V = 1 J/C = 1 volt = 1 joule/coulomb
1 H = 1 V·s/A = 1 henry = 1 J/A^2
1 Ω = 1 V/A = 1 ohm = 1 J·s/C^2
1 G = 10^{-4} T = 1 gauss = 10^{-4} tesla

OpenStax Chapter 18 Equations

Charges:

$Q = \pm Ne, \quad \Delta Q_1 + \Delta Q_2 = 0, \quad e = 1.602 \times 10^{-19}$ C.

Electric Force:

$F = k\frac{Q_1 Q_2}{r^2}, \quad k = 8.988 \times 10^9$ N·m^2/C^2, $\quad F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}, \quad \epsilon_0 = \frac{1}{4\pi k} = 8.854$ pF/m.

$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + ...$ superposition of forces.

Electric Field:

$\vec{E} = \frac{\vec{F}}{q}$, q= test charge. Or: $\vec{F} = q\vec{E}$.

$|\vec{E}| = E = k\frac{Q}{r^2} = \frac{Q}{4\pi\epsilon_0 r^2}$, due to point charge. Negative Q makes inward $\vec{E}$, positive Q makes outward $\vec{E}$.

$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ...$ superposition of many electric fields.

$E = k\frac{Q}{r^2}$ = electric field around a point charge or *outside* a spherical charge distribution.

OpenStax Chapter 19 Equations

Potential Energy and Work:

$W_{ba} = F_E d\cos\theta$ = work done by electric force F_E on test charge, in displacement d from a to b.

$W_{ba} = -q\Delta V = -q(V_b - V_a)$ = work done by electric force on a test charge, moved from a to b.

$\Delta\text{PE} = q\Delta V = q(V_b - V_a)$ = change in electric potential energy of the system. Also: $\Delta\text{PE} = -W_{ba}$.

Potential:

$\Delta V = \frac{\Delta\text{PE}}{q}$ = definition of change in electric potential.

$\Delta V = Ed$ = potential change in a uniform electric field.

$V = k\frac{Q}{r}$ = potential produced by a point charge or *outside* a spherical charge distribution.

$\text{PE} = qV$ = potential energy for a test charge at a point in a field.

$\text{PE} = k\frac{Q_1 Q_2}{r_{12}}$ = potential energy of a pair of charges.

Capacitance:

$Q = CV, \quad C = K\epsilon_0\frac{A}{d}$ = capacitor equations.

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

$E = \frac{Q/A}{\epsilon_0}$ = electric field strength very near a charged conductor.

OpenStax Chapter 20 Equations

Electric current and power:

$I = \frac{\Delta Q}{\Delta t}, \quad \Delta Q = I\Delta t$ current definition.

$V = IR, \quad I = V/R$ Ohm's law.

$R = \rho L/A$ calculation of resistance.

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

$P = IV, \quad P = I^2 R, \quad P = V^2/R.$

$P =$ instantaneous work/time.

Alternating current:

$V = V_0 \sin(2\pi f t) =$ time-dependent AC voltage.

$I = I_0 \sin(2\pi f t) =$ time-dependent AC current.

$V_{\text{rms}} = \sqrt{\overline{V^2}} = V_0/\sqrt{2} =$ root-mean-square voltage.

$I_{\text{rms}} = \sqrt{\overline{I^2}} = I_0/\sqrt{2} =$ root-mean-square current.

AC power:

$\overline{P} = \frac{1}{2} I_0 V_0 = \frac{1}{2} I_0^2 R = \frac{1}{2} V_0^2/R =$ average power.

$\overline{P} = I_{\text{rms}} V_{\text{rms}} = I_{\text{rms}}^2 R = V_{\text{rms}}^2/R =$ average power.

OpenStax Chapter 21 Equations

Resistor Combinations

$R_{\text{eq}} = R_1 + R_2 + R_3 + ...$ (series)

$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$ (parallel)

Real batteries

$V_{ab} = \mathcal{E} - Ir$ (terminal voltage)

$V_{ab} = IR$ (connected to load R)

Kirchhoff's Rules

$\sum \Delta V = 0$ (loop rule, energy conservation)

$\sum I = 0$ (node rule, charge conservation)

OpenStax Chapter 22 Equations

Magnetic forces, torque

$F = IlB \sin\theta$ (on a current)

$F = qvB \sin\theta$ (on a moving charge)

$F/l = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{d}$ (between currents)

$F = qvB = mv^2/r$ (during cyclotron motion)

$\tau = NBAI \sin\theta$ (torque on a coil)

$v = \omega r = 2\pi f r = 2\pi r/T$ (circular motion)

Magnetic Fields

$B = \frac{\mu_0}{2\pi} \frac{I}{r}$ (due to long straight wire)

$B = \mu_0 IN/l$ (inside a solenoid)

Right Hand Rules

Force (thumb) = [I (4 fingers)] $\times$ [magnetic field (palm)] (force on a current)

Force (thumb) = [qv (4 fingers)] $\times$ [magnetic field (palm)] (force on a moving charge)

Current (thumb) $\Longleftrightarrow$ [magnetic field (4 fingers)] (magnetic field around a wire)

Current (4 fingers) $\Longleftrightarrow$ [magnetic field (thumb)] (magnetic field inside a current loop)

OpenStax Chapter 23 Equations

Faraday's Induced EMF

$\Phi_B = BA \cos\theta$ (magnetic flux)

$\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t}$ (induced emf)

$\mathcal{E} = Blv$ (moving conductor)

$\mathcal{E} = NBA\omega \sin(\omega t), \ \omega = 2\pi f$ (AC generator)

$V - \mathcal{E} = IR$ (motor's back-emf)

$\mathcal{E}_1 = -M \frac{\Delta I_2}{\Delta t}$ (mutual inductance emf)

$V_S/V_P = N_S/N_P$ (transformer equation)

$I_P V_P = I_S V_S$ (power in = power out)

AC Circuits, Inductors, Capacitors, Reactance

$\mathcal{E} = -L \frac{\Delta I}{\Delta t}$ (self-inductance emf)

$U = \frac{1}{2} L I^2$ (stored magnetic energy)

$X_L = 2\pi f L = \omega L$ (inductive reactance)

$V_L = I X_L$ (inductor voltage)

$X_C = 1/(2\pi f C) = 1/(\omega C)$ (capacitive reactance)

$V_C = I X_C$ (capacitor voltage)

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

$V_{\text{gen}} = IZ = \sqrt{V_R^2 + (V_L - V_C)^2}$ (series RLC)

$\omega_0 = 1/\sqrt{LC}, \quad f_0 = \frac{\omega_0}{2\pi}$ (LC resonance)

$\tan\phi = (X_L - X_C)/R$ (series RLC phase)

$\overline{P} = I_{\text{rms}} V_{\text{rms}} \cos\phi$ (AC average power)

$\overline{P} = I_{\text{rms}} V_{\text{rms}} \cos\phi = I_{\text{rms}}^2 R$ (series RLC)