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
\[ k = 1/4\pi\varepsilon_0 = 8.988 \text{ GN-m}^2/\text{C}^2 \text{ (Coulomb's Law)} \]
\[ e = 1.602 \times 10^{-19} \text{ C} \text{ (proton charge)} \]
\[ m_e = 9.11 \times 10^{-31} \text{ kg} \text{ (electron mass)} \]
\[ m_p = 1.67 \times 10^{-27} \text{ kg} \text{ (proton mass)} \]

Units and Conversions
\[ N_A = 6.02 \times 10^{23}/\text{mole} \text{ (Avogadro’s #)} \]
\[ 1.0 \text{ eV} = 1.602 \times 10^{-19} \text{ J} \text{ (electron-volt)} \]
\[ 1 \text{ F} = 1 \text{ C/V} = 1 \text{ farad} = 1 \text{ C}^2/\text{J} \]
\[ 1 \text{ A} = 1 \text{ C/s} = 1 \text{ ampere} = 1 \text{ coulomb/second} \]
\[ 1 \Omega = 1 \text{ V/A} = 1 \text{ ohm} = 1 \text{ J} \cdot \text{s}/\text{C}^2 \]

Vectors
Written \(\vec{V}\) or \(\vec{V}\), described by magnitude=\(V\), direction=\(\theta\) or by components \((V_x, V_y)\).
\[ V_x = V \cos \theta, \quad V_y = V \sin \theta, \]
\[ V = \sqrt{V_x^2 + V_y^2}, \quad \tan \theta = \frac{V_y}{V_x}. \]
\(\theta\) is the angle from \(\vec{V}\) to +x-axis.

Addition: \(\vec{A} + \vec{B}\), head to tail. Subtraction: \(\vec{A} - \vec{B}\) is \(\vec{A} + (-\vec{B})\), \(-\vec{B}\) is \(\vec{B}\) reversed.

Trig summary
\[ \sin \theta = \frac{\text{(opp)}}{\text{(hyp)}}, \quad \cos \theta = \frac{\text{(adj)}}{\text{(hyp)}}, \quad \tan \theta = \frac{\text{(opp)}}{\text{(adj)}}, \quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2. \]
\[ \sin \theta = \sin(180^\circ - \theta), \quad \cos \theta = \cos(-\theta), \quad \tan \theta = \tan(180^\circ + \theta), \quad \sin^2 \theta + \cos^2 \theta = 1. \]

Chapter 16 Equations

Charges:
\[ Q = \pm Ne, \quad \Delta Q_1 + \Delta Q_2 = 0, \quad e = 1.602 \times 10^{-19} \text{ C}. \]

Electric Force:
\[ F = k \frac{Q_1 Q_2}{r^2}, \quad k = 8.988 \times 10^9 \text{ N-m}^2/\text{C}^2, \quad F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}, \quad \varepsilon_0 = \frac{1}{4\pi k} = 8.854 \text{ pF/m}. \]
\[ \vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \ldots \quad \text{superposition of many forces}. \]
\[ F_x = F_{1x} + F_{2x} + F_{3x} + \ldots \quad \text{superposition of } x\text{-components of many forces}. \]
\[ F_y = F_{1y} + F_{2y} + F_{3y} + \ldots \quad \text{superposition of } y\text{-components of many forces}. \]

Electric Field:
\[ \vec{E} = \frac{\vec{F}}{q}, \quad q= \text{ test charge}. \quad \text{Or: } \vec{E} = q\vec{E}. \]
\[ |\vec{E}| = E = k \frac{Q}{r^2}, \quad \text{due to point charge. Negative } Q \text{ makes inward } \vec{E}, \quad \text{positive } Q \text{ makes outward } \vec{E}. \]
\[ \vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \ldots \quad \text{superposition of many electric fields}. \]
\[ E_x = E_{1x} + E_{2x} + E_{3x} + \ldots \quad \text{superposition of } x\text{-components of many electric fields}. \]
\[ E_y = E_{1y} + E_{2y} + E_{3y} + \ldots \quad \text{superposition of } y\text{-components of many electric fields}. \]
\[ E = k \frac{Q}{r^2} = \text{electric field around a point charge or } \text{outside a spherical charge distribution}. \]
Chapter 17 Equations

Potential Energy and Work:
\[ W_{ba} = F_E d \cos \theta = \text{work done by electric force } F_E \text{ on test charge, in displacement } d \text{ from } a \text{ to } b. \]
\[ W_{ba} = -q \Delta V = -q(V_b - V_a) = \text{work done by electric force on a test charge, moved from } a \text{ to } b. \]
\[ \Delta PE = q \Delta V = q(V_b - V_a) = \text{change in electric potential energy of the system. Also: } \Delta PE = -W_{ba}. \]
\[ \Delta KE + \Delta PE = 0, \text{ or, } \Delta KE = -\Delta PE = -q \Delta V, \text{ principle of conservation of mechanical energy.} \]

Potential:
\[ \Delta V = \frac{\Delta PE}{q} = \text{definition of change in electric potential.} \]
\[ \Delta V = Ed = \text{potential change in a uniform electric field.} \]
\[ V = k\frac{Q}{r} = \text{potential produced by a point charge or outside a spherical charge distribution.} \]
\[ PE = qV = \text{potential energy for a test charge at a point in a field.} \]
\[ PE = k\frac{Q_1Q_2}{r_{12}} = \text{potential energy of a pair of charges.} \]

Capacitance:
\[ Q = CV, \quad C = K\epsilon_0 \frac{A}{d} = \text{capacitor equations.} \]
\[ U = \frac{1}{2}qV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \text{stored energy.} \]
\[ E = \frac{Q}{\epsilon_0 A} = \text{electric field strength very near a charged conductor.} \]

Chapter 18 Equations

Electric current:
\[ I = \frac{\Delta Q}{\Delta t}, \text{ or } \Delta Q = I \Delta t, \text{ definition of current.} \]
\[ V = IR, \text{ or } I = V/R, \text{ Ohm’s law.} \]
\[ R = \rho \frac{L}{A} = \text{calculation of resistance.} \]
\[ \rho_T = \rho_0 [1 + \alpha(T - T_0)] = \text{temperature-dependent resistivity.} \]

Electric power:
\[ P = IV, \quad P = I^2R, \quad P = \frac{V^2}{R}, \quad P = \text{instantaneous energy/time.} \]

Alternating current:
\[ V = V_0 \sin 2\pi ft = \text{time-dependent AC voltage.} \]
\[ I = I_0 \sin 2\pi ft = \text{time-dependent AC current.} \]
\[ V_{\text{rms}} = \sqrt{\frac{V^2}{2}} = V_0/\sqrt{2} = \text{root-mean-square voltage.} \]
\[ I_{\text{rms}} = \sqrt{\frac{I^2}{2}} = I_0/\sqrt{2} = \text{root-mean-square current.} \]

AC power in resistors:
\[ P = \frac{1}{2}I_0^2R = \frac{1}{2}V_0^2/R = \frac{1}{2}I_0V_0 = \text{average power.} \]
\[ P = I_{\text{rms}}^2R = V_{\text{rms}}^2/R = I_{\text{rms}}V_{\text{rms}} = \text{average power.} \]