Useful Constants:
Acceleration due to gravity: $g = 9.80$ m/s^2
Basic unit of charge: $e = 1.6 \times 10^{-19}$ C
Mass of electron: $m_e = 9.11 \times 10^{-31}$ kg
Mass of proton/neutron: $m_p = 1.67 \times 10^{-27}$ kg
Coulomb constant: $k = 8.99 \times 10^9$ Nm^2/C^2
Permittivity of free space: $\epsilon_0 = 1/(4\pi k) = 8.85 \times 10^{-12}$ C^2/Nm^2
Permeability of free space: $\mu_0 = 4\pi \times 10^{-7}$ Tm/A
Speed of light in a vacuum: $c = 3 \times 10^8$ m/s
Planck's Constant: $h = 6.626 \times 10^{-34}$ Js
eV to joule conversion: 1 eV $= 1.6 \times 10^{-19}$ J
kilowatt-hour to joule conversion: 1 kW·hr=3.6×10^6 J
Atomic Mass Unit: 1 u $= 1.66054 \times 10^{-27}$ kg $= 931.5$ MeV/c^2

Vector Concepts:
Unit Vector: $\hat{r} = \frac{\vec{r}}{r}$
Gradient: $\vec{\nabla} = \frac{\partial}{\partial x}\hat{x} + \frac{\partial}{\partial y}\hat{y} + \frac{\partial}{\partial z}\hat{z}$
Dot Product: $\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}|\cos\theta$
Dot Product: $\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$
Cross Product:

$$\begin{aligned} |\vec{A} \times \vec{B}| =& |\vec{A}||\vec{B}|\sin\theta \\ \vec{A} \times \vec{B} =& (A_y B_z - A_z B_y)\hat{x} - (A_x B_z - A_z B_x)\hat{y} \\ &+ (A_x B_y - A_y B_x)\hat{z} \end{aligned}$$

Sample Indefinite Integrals:

$$\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \ln(x + \sqrt{x^2 \pm a^2}) + c$$
$$\int \frac{xdx}{(x^2 + a^2)^{3/2}} = -\frac{1}{\sqrt{x^2 + a^2}} + c$$
$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2 + a^2}} + c$$
$$\int x^n dx = \frac{x^{n+1}}{n+1} + c (n \neq -1)$$
$$\int \frac{dx}{x} = \ln(x) + c$$
$$\int \frac{dx}{x^2 + a^2} = \frac{1}{a}\arctan\frac{1}{x} + c$$
$$\int \frac{dx}{\sqrt{a^2 - x^2}} = \arcsin\frac{x}{a} + c$$

SI Prefixes:
T=$\times 10^{12}$, G=$\times 10^9$, M=$\times 10^6$, k=$\times 10^3$
c=$\times 10^{-2}$, m=$\times 10^{-3}$
μ=$\times 10^{-6}$, n=$\times 10^{-9}$, p=$\times 10^{-12}$, f=$\times 10^{-15}$

Useful integral relationships:
Spherical: $\mathrm{d}V = 4\pi r^2 \mathrm{d}r$
Cylindrical (with constant r): $dV = \pi r^2 \mathrm{d}z$
Cylindrical (with constant z): $dV = z 2\pi r \mathrm{d}r$
Cylindrical (with constant r): $dA = 2\pi r \mathrm{d}z$
Cylindrical (with constant z): $dA = 2\pi r \mathrm{d}r$

Geometry:
Surface Area of a Sphere: $A = 4\pi r^2$
Volume of a Sphere: $V = \frac{4}{3}\pi r^3$
Area of curved region of a cylinder: $A = 2\pi r h$
Volume of a cylinder: $V = \pi r^2 h$

Physics 1 Concepts:
Work: $W = \int \vec{F} \cdot d\vec{\ell}$
Potential Energy of conservative force:
$W_{cons} = -\Delta U$
Kinetic Energy: $K = \frac{1}{2}mv^2$
Momentum: $\vec{p} = m\vec{v}$

Chapter 21:

Coulomb's Law [N]: $\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}$

Force due to an electric field [N]: $\vec{F} = q\vec{E}$

E Field due to a pt. charge [N/C]: $\vec{E} = \frac{kq}{r^2}\hat{r}$

E Field due to a continuous charge dist. [N/C]:
$\vec{E} = \int \frac{kdq}{r^2}\hat{r}$

Electric dipole moment [Cm]: $\vec{p} = q\vec{d}$

Torque on an electric dipole [Nm]: $\vec{\tau} = \vec{p} \times \vec{E}$

Electric pot. energy stored in electric dipole [J]:
$U = -\vec{p} \cdot \vec{E}$

Chapter 22:

Electric Flux [Vm or Nm^2/C]: $\Phi_E = \int \vec{E} \cdot d\vec{A}$

Electric Flux when E and θ are const. on the surface: $\Phi_E = EA\cos\theta$

Gauss's Law (vacuum): $\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{encl}}}{\epsilon_0}$

Chapter 23: The below equations generally but not always assume that $V(\infty) = 0$ and/or $U(\infty) = 0$.

Elec. pot. energy between 2 pt charges [J]:
$U = \frac{kq_1q_2}{r}$

Elec. pot. difference btw. two locations [V or J/C]:
$\Delta V = \frac{\Delta U}{q}$ (or often) $V = \frac{U}{q}$

Electric potential due to a point charge [V]:
$V = \frac{kq}{r}$

Electric potential due to a charge dist. [V]:
$V = \int \frac{kdq}{r}$

Relating $\vec{E}$ and V: $\vec{E} = -\vec{\nabla}V$

$\Delta V = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{\ell}$

Chapter 24:

Capacitance [F]: $Q = CV$

Capacitance for Parallel Plates [F]: $C = \frac{\kappa\epsilon_0 A}{d}$

Energy stored in a capacitor [J]: $U = \frac{1}{2}CV^2$

E field energy density [J/m^3]: $u_E = \frac{1}{2}\kappa\epsilon_0 E^2$

Definition of Dielectric Constant: $C = \kappa C_0$

Eff. Cap. (series) [F]: $\frac{1}{C_{eff}} = \sum_i \frac{1}{C_i}$

Eff. Cap. (parallel) [F]: $C_{eff} = \sum_i C_i$

Chapters 25 and 26:

Electric Current [A]: $I = \frac{dq}{dt}$

I from current density [A]: $I = \int \vec{j} \cdot d\vec{A}$

j of uniform current [A/m^2]: $|\vec{j}| = \frac{I}{A}$

j for charges in motion [A/m^2]: $\vec{j} = nq\vec{v}_d$

Ohm's Law: $\vec{E} = \rho\vec{j}$

Ohm's Law: $\Delta V = IR$ (or often just) $V = IR$

Resistivity and conductivity: $\rho = \frac{1}{\sigma}$

Resistance of a wire [Ω]: $R = \frac{\rho\ell}{A}$

Resistance of an object [Ω]: $R = \int \frac{\rho(x)dx}{A(x)}$

Power in a circuit element [W]:
$P = I\Delta V$ (or often) $P = IV$

Eff. Res. (series) [Ω]: $R_{eff} = \sum_i R_i$

Eff. Res. (parallel) [Ω]: $\frac{1}{R_{eff}} = \sum_i \frac{1}{R_i}$

Time constant for an RC-circuit [s]: $\tau = RC$

Charge on a charging capacitor [C]:
$q(t) = q_{\max}(1 - e^{-t/\tau})$

Charge on a discharging capacitor [C]:
$q(t) = q_0 e^{-t/\tau}$

Current in an RC-circuit [A]: $I(t) = I_0 e^{-t/\tau}$

Chapter 27:

Mag. Force on a moving q [N]: $\vec{F} = q\vec{v} \times \vec{B}$
Mag. Force on a current-carrying conductor [N]:
$\vec{F} = I \int d\vec{\ell} \times \vec{B}$

R of q's path in a B field [m]: $R = \dfrac{mv}{|q|B}$

Magnetic Dipole Moment [Am^2]: $\vec{\mu} = I\vec{A}$

Torque on current loops [Nm]: $\vec{\tau} = N\vec{\mu} \times \vec{B}$

Mag. pot. energy in a magnetic dipole [J]:
$U = -N\vec{\mu} \cdot \vec{B}$

Chapter 28:

Biot-Savart Law (2 forms):

B made by a moving charge [T]: $\vec{B} = \dfrac{\mu_0}{4\pi} \dfrac{q\vec{v} \times \hat{r}}{r^2}$

B made by any current [T]: $\vec{B} = \int \dfrac{\mu_0}{4\pi} \dfrac{Id\vec{\ell} \times \hat{r}}{r^2}$

B made by a long straight wire in a vacuum [T]:
$B = \dfrac{\mu_0 I}{2\pi r}$

B made by N loops, w/ radius R, on the axis,
z from the center (vacuum) [T]: $B = \dfrac{N\mu_0 I R^2}{2(z^2 + R^2)^{3/2}}$

B made inside a solenoid: $B = \mu_0 K_m \dfrac{N}{\ell} I$

Chapter 29:

Magnetic Flux [Wb]: $\Phi_B = \int \vec{B} \cdot d\vec{A}$

Magnetic Flux when B and θ are const.
on the surface: $\Phi_B = BA\cos\theta$

Faraday's Law [V]: $\mathcal{E} = -N\dfrac{d\Phi_B}{dt}$

Motional emf [V]: $\mathcal{E} = \int (\vec{v} \times \vec{B}) \cdot d\vec{\ell}$

Induced E Fields: $\oint \vec{E} \cdot d\vec{\ell} = -\dfrac{d\Phi_B}{dt}$

Displacement current [A]: $i_d = \epsilon_0 \dfrac{d\Phi_E}{dt}$

General Ampere's Law: $\oint \vec{B} \cdot d\vec{\ell} = \mu_0(I_{\text{encl}} + i_d)$

Chapter 30:

emf and Mutual Inductance:
$\mathcal{E}_1 = -M\dfrac{di_2}{dt}$, $\mathcal{E}_2 = -M\dfrac{di_1}{dt}$

Mut. Inductance [H]: $M = \dfrac{N_2\Phi_{B,2}}{i_1} = \dfrac{N_1\Phi_{B,1}}{i_2}$

emf and Self Inductance: $\mathcal{E} = -L\dfrac{di}{dt}$

Self Inductance [H]: $L = \dfrac{N\Phi_B}{i}$

Inductance of a Solenoid [H]: $L = \dfrac{\mu_0 N^2 A}{\ell}$

Magnetic energy stored in an inductor [J]:
$U = \dfrac{1}{2}LI^2$

B field energy density [J/m^3]: $u_B = \dfrac{1}{2\mu_0}B^2$

Time Constant in an RL-Circuit [s]: $\tau = L/R$
Current growth in an RL-Circuit [A]:
$i(t) = I_{max}(1 - e^{-t/\tau})$
Current decay in an RL-Circuit [A]:
$i(t) = I_0 e^{-t/\tau}$
Angular frequency of the oscillation
in an LC-Circuit [rad/s]: $\omega = \dfrac{1}{\sqrt{LC}}$

q on a capacitor in an ideal LC-Circuit [C]:
$q(t) = q_{max}\cos(\omega t + \phi)$
