Ohm's Law

$\Delta V = IR$

Kirchoff's Laws

The sum of changes in voltage around a circuit in any given loop is always zero:
$\Delta V_{loop} = \Sigma(\Delta V)_i = 0$

Power

Power dissipated by an element with some resistance (or just resistor): $P_R = I\Delta V_R = I^2 R = \frac{(\Delta V_R)^2}{R}$

Equivalent Resistance

Series

$R_{eq} = R_1 + R_2 + \cdots + R_N$

Parallel

$R_{eq} = (\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N})^{-1}$

RC Circuits

Properties

- Capacitors in series always have the same amount of charge.

Energy of Capacitor

$E = \frac{1}{2}CV^2$

Capacitor Relationship

$Q = CV$

Time Constant

$\tau = RC$

Constants

$\mu_0 = 4\pi \times 10^{-7} T\ m/a$

Capacitor Equations

Discharging

Charge After Time

$Q = Q_0 e^{-t/\tau}$

Current After Time

$I = -\frac{dQ}{dt} = \frac{Q_0}{\tau} e^{-t/\tau} = I_0 e^{-t/\tau}$

Voltage After Time

$V_C = V_0 e^{-t/\tau}$

Charging

Charge After Time

$Q = CV_b[1 - e^{\frac{-t}{\tau}}]$

Charging Current

$I = \frac{V_b}{R} e^{\frac{-t}{\tau}}$

Point Charge

$\vec{B}_{point\ charge} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$

Or sometimes easier:

$\vec{B}_{point\ charge} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \vec{r}}{r^3}$

Notice the second one does not involve finding the ˆ (unit vector) of r.

Current Segment

$\vec{B}_{current\ segment} = \frac{\mu_0}{4\pi} \frac{Idl \times \hat{r}}{r^2}$

Notice a current segment is an equation representing point charges.

Infinite Wire

$B = \frac{\mu_0}{2\pi} \frac{I}{r}$

A current loop

With N turns:

$B_{center} = \frac{\mu_0}{2} \frac{NI}{R}$

Dipole Moment of Ring

$\vec{B}_{dipole} = \frac{\mu_0}{4\pi} \frac{2\vec{\mu}}{z^3}$

or

$\vec{\mu} = (AI$, from South Pole to North Pole)

A is the area of the loop, I is current.

Solenoid

With coil density $n = N/L$

$B = \mu_0 n I = \frac{\mu_0 N I}{L}$

Loop off of the X-Y Plane

$B_{loop} = \frac{\mu_0}{2} \frac{IR^2}{(z^2+R^2)^{3/2}}$

Where R is the ring radius, Z is the distance from the center.

Ampère's Law

$\int_{surface} \vec{B} \cdot d\vec{s} = \mu_0 I_{through}$

If you curl your right fingers around the closed path in the direction in which you are going to integrate, then any current passing through the bounded area in the direction of your thumb is a positive current. Any direction opposite is a negative current.

Field of Wire With Thickness

Inside

$B = \frac{\mu_0 I}{2\pi r} r$

Where r is the inner radius.

Outside

Reuse Ampère's law:

$B = \frac{\mu_0 I}{2\pi R}$

Where R is distance outside.

Cross Product

2 Dimensions

$$||A \times B|| = ||\vec{A}||\ ||\vec{B}|| \sin(\theta)$$

$$\text{Or} = A_1 B_2 - A_2 B_1$$

3 Dimensions

$$\vec{u} \times \vec{v} = \begin{bmatrix} \vec{i} & \vec{j} & \vec{k} \\ u_x & u_y & u_z \\ v_x & v_y & v_z \end{bmatrix} = \begin{bmatrix} u_y & u_z \\ v_y & v_z \end{bmatrix} \vec{i} - \begin{bmatrix} u_x & u_z \\ v_x & v_z \end{bmatrix} \vec{j} + \begin{bmatrix} u_x & u_y \\ v_x & v_y \end{bmatrix} \vec{k}$$