ISP 209
Equations of Physics – Part 2

Electrostatics

Coulomb's Law. The magnitude of the electrostatic force between two charged particles is equal to the Coulomb constant K times the product of the charges Q_1 Q_2 divided by the square of the distance r between the centers;

$$F = \frac{KQ_1Q_2}{r^2} \ .$$

($K = 8.99 \times 10^9$ $\mathrm{Nm^2/C^2}$)

• The electric field **E(x)** is a physical entity which is created by electric charges and which exerts a force on electric charges. Quantitatively, **E(x)** is equal to the force per unit charge **F**/q on a small test charge *q* placed at **x**;

$$\mathbf{E(x)} = \mathbf{F}/q \ .$$

• The electric potential *V(***x***)* is the electrostatic potential energy per unit charge *U(***x***)/q* if a small test charge *q* is placed at **x**;

$$V(\mathbf{x}) = U(\mathbf{x})/q \ .$$

• The voltage drop across a capacitor, i.e., the difference in electrostatic potential between the conductors, is Q/C where +Q and –Q are the charges on the conductors and C = capacitance;

$$V = Q/C \ .$$

Or, if the potential drop is known, e.g., from the emf of a battery, then the charge on the capacitor plates is $Q = CV$.
The energy stored in a capacitor is

$$U = \tfrac{1}{2}QV \ .$$

Electric current

The definition of the electric current I in a wire is

$$I = \Delta Q / \Delta t \ .$$

Ohm's Law. The voltage drop *V* across a resistor is equal to the current *I* flowing through the resistor times the electrical resistance *R*;

$$V = IR \ .$$

Or, if the potential drop is known, e.g., from the emf of a battery, the current is $I = V/R$.

Joule's Law. The power dissipated as heat in a resistor is I^2R, where I = current and R = resistance;

$$P = I^2R \ .$$

The power supplied to a DC current is $P = IV$ where I = current and V = voltage.

The average power supplied to an AC current is $P = IV$ where I = RMS current and V = RMS voltage.

Magnetic Force

If a charged particle with charge *q* moves with velocity **v** through a magnetic field **B,** the magnetic force on the particle is

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}.$$

The direction of the force is perpendicular to both **v** and **B**, in the direction determined by the right-hand rule for the cross product.

If the velocity vector **v** is orthogonal to the magnetic field vector **B**, then the magnitude of the force is

$$F = qvB \ .$$

The force on a current carrying wire is

$$\mathbf{F} = I\,\mathbf{L} \times \mathbf{B} \ .$$