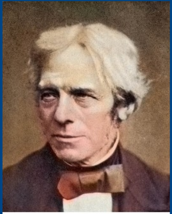
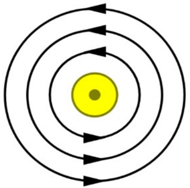
DC Electric Motors & Wire Coils



M Faraday
1791 – 1867

By 1820, scientists noticed that a compass needle aligned circumferentially around a direct current (DC) in a conductor. Current flow direction sets the compass "North" orientation.

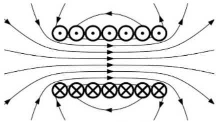


B-Field @ Wire

Michael Faraday envisioned magnetic (B-field) lines surrounding a DC wire. In Maxwell's Equations, a magnetostatic 4th Law gives a circular B-field. If a wire with DC current (I) is wrapped around an iron core (n_c) times, a bar magnet exists.

4th Law: $\oint(\mathbf{B} \cdot d\ell) = n_c\, \mu_0 \iint(\mathbf{J} \cdot \hat{\mathbf{n}}_s)\, ds$ **&** $I = \iint(\mathbf{J} \cdot \hat{\mathbf{n}}_s)\, ds$

$\oint(\mathbf{B} \cdot d\ell) = B\,(2\pi r) = n_c\, \mu_0\, I \;\Rightarrow\; B = (n_c\, \mu_0\, I)\,/\,(2\pi r)$



B-Field @ Coils

The 3rd Law gives impeding Voltage (V) from change in applied magnetic flux ($\Delta\Phi_B$) through magnet coils. The flux increases due to bar magnet alignment.

3rd Law: $\oint(\mathbf{E} \cdot d\ell) = -d/dt \iint(\mathbf{B} \cdot \hat{\mathbf{n}}_s)\, ds$

$V = n_c \oint(\mathbf{E} \cdot d\ell)$ **&** $\Phi_B \equiv \iint(\mathbf{B} \cdot \hat{\mathbf{n}}_s)\, ds \;\Rightarrow\; V = -n_c\, \Delta\Phi_B/\Delta t$

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