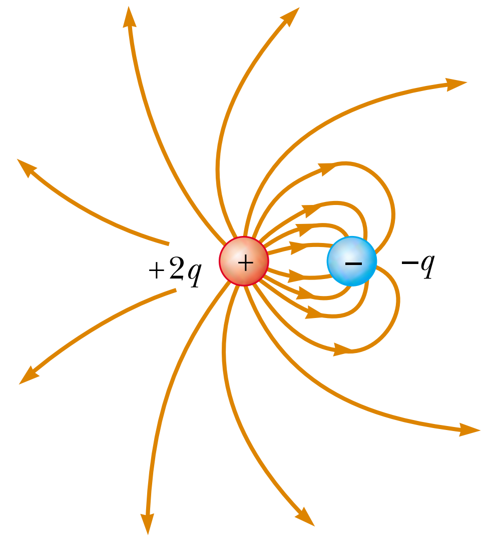
Point charges	Continuous charge distribution	Line charge distribution	Surface charge distribution	Volume charge distribution

$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}_E}{q_0} = k_e \sum_i \frac{q_i}{r_i^2}\hat{\mathbf{r}}_i = k_e \int \frac{dq}{r^2}\hat{\mathbf{r}} = k_e \int \frac{\lambda dl}{r^2}\hat{\mathbf{r}} = k_e \int \frac{\sigma dA}{r^2}\hat{\mathbf{r}} = k_e \int \frac{\rho dV}{r^2}\hat{\mathbf{r}}$$

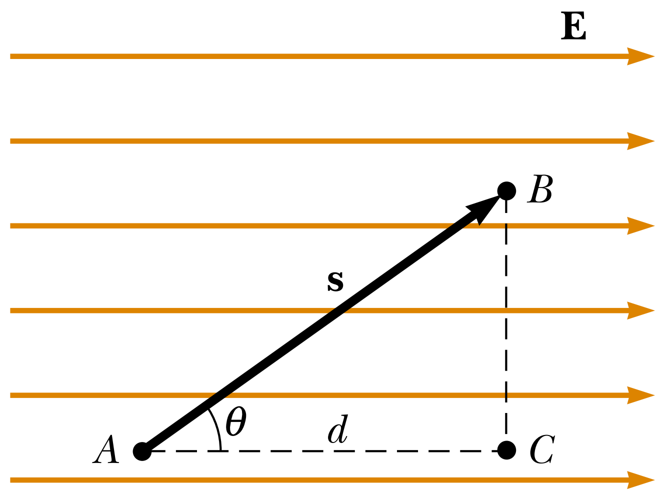


$$V_B - V_A = \Delta V = \frac{\Delta U}{q_0} = -\int_A^B \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}} = Es\cos\theta = Ed$$

$$V = k_e \sum_i \frac{q_i}{r_i}$$

Assuming $V \to 0$ when $r \to \infty$

$$U = k_e\left(\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}} + \dots\right)$$



$$\vec{\mathbf{F}}_E = q\vec{\mathbf{E}} = m\vec{\mathbf{a}} \Rightarrow \vec{\mathbf{a}} = \frac{q\vec{\mathbf{E}}}{m}$$

$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

$$v_f = v_i + at$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$KE = \frac{1}{2}mv^2$$

$$\oint \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{q_{in}}{\epsilon_0} \Rightarrow$$

$E = k_e\frac{q}{r^2}$	Outside: point charge, insulated sphere, shell
$E = k_e\frac{q}{a^3}r$	Inside: insulated sphere
$E = 0$	Inside: shell, conducting sphere
$E = 2k_e\frac{\lambda}{r}$	Charged wire
$E = \frac{\sigma}{2\epsilon_0}$	Charged sheet
$E = \frac{\sigma}{\epsilon_0}$	Charged conducting sheet

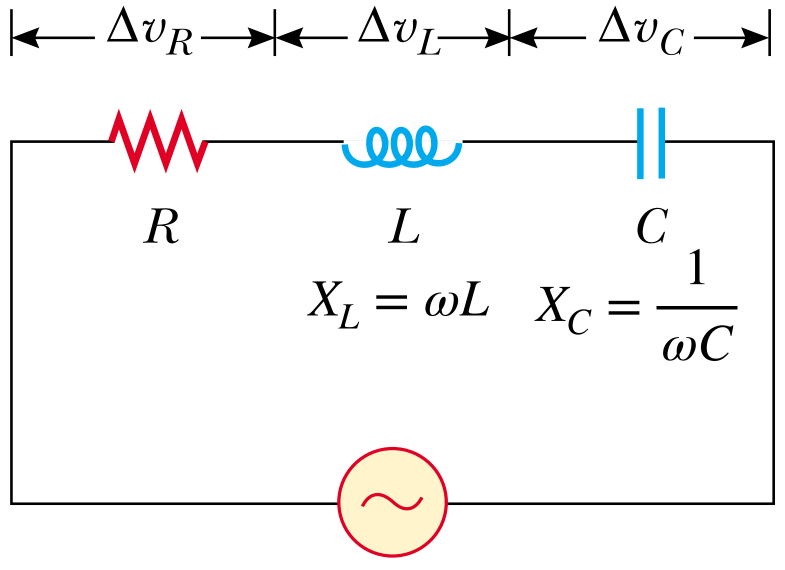
$$\Phi_E = \int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = EA\cos\theta$$

$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = 0$$

$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{s}} = \mu_0 I \Rightarrow$$

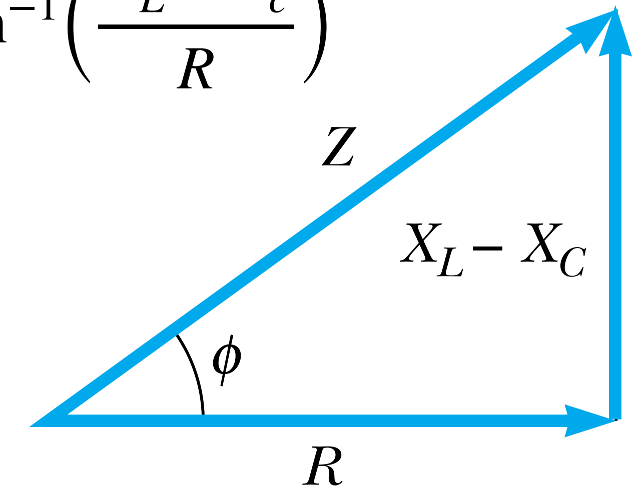
$B = \frac{\mu_0 I}{2\pi r}$	Outside: wire
$B = \frac{\mu_0 I}{2\pi R^2}r$	Inside: wire
$B = \mu_0\frac{N}{l}I = \mu_0 nI$	Inside: Solenoid

$$\Phi_B = \int \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = BA\cos\theta;\quad \vec{\mathbf{B}}(\vec{\mathbf{r}}) = \frac{\mu_0 I}{4\pi}\int\frac{d\vec{\mathbf{s}} \times \hat{\mathbf{r}}}{r^2}$$



$X_L = \omega L \qquad X_C = \frac{1}{\omega C}$

$$\phi = \tan^{-1}\left(\frac{X_L - X_c}{R}\right)$$



$$\Delta v = \Delta V_{\max}\sin(\omega t);\quad \Delta i = I_{\max}\sin(\omega t - \phi);\quad I_{\max} = \frac{\Delta V_{\max}}{Z}$$

$$\omega = 2\pi f = \frac{2\pi}{T};\quad I_{\text{rms}} = \frac{I_{\max}}{\sqrt{2}};\quad P_{\text{avg}} = I_{\text{rms}}^2 R = I_{\text{rms}}\Delta V_{\text{rms}}\cos(\phi)$$

$$\text{when } X_L = X_C \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

$$\vec{\mathbf{F}}_B = q\vec{\mathbf{v}} \times \vec{\mathbf{B}} = qvB\sin\theta\hat{\mathbf{n}} = \begin{vmatrix} \hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}} \\ v_x & v_y & v_z \\ B_x & B_y & B_z \end{vmatrix}$$

$\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \qquad \hat{\mathbf{j}} \times \hat{\mathbf{i}} = -\hat{\mathbf{k}}$

$\hat{\mathbf{j}} \times \hat{\mathbf{k}} = \hat{\mathbf{i}} \qquad \hat{\mathbf{k}} \times \hat{\mathbf{j}} = -\hat{\mathbf{i}}$

$\hat{\mathbf{k}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \qquad \hat{\mathbf{i}} \times \hat{\mathbf{k}} = -\hat{\mathbf{j}}$

$\hat{\mathbf{i}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0$

Charged particle in a uniform magnetic field

$$\vec{\mathbf{F}}_B = m\vec{\mathbf{a}}_c \Rightarrow qv_\perp B = m\frac{v_\perp^2}{r}$$

$$r = \frac{mv_\perp}{qB};\quad \omega = \frac{v_\perp}{r} = \frac{qB}{m}$$

$$T = \frac{2\pi}{\omega};\quad v = \sqrt{\frac{2q\Delta V}{m}}$$

Magnetic force on a wire

$$\vec{\mathbf{F}}_B = I\vec{\mathbf{L}} \times \vec{\mathbf{B}} = I\int d\vec{\mathbf{s}} \times \vec{\mathbf{B}};$$

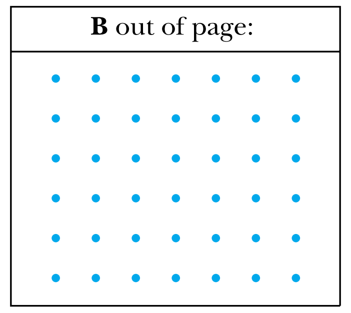
Magnetic force between 2 wires

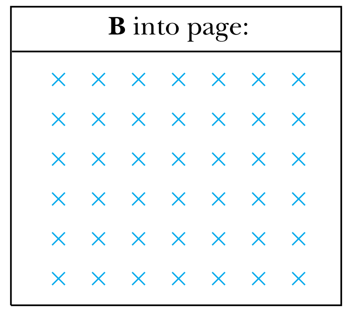
$$f = \frac{F_b}{l} = \frac{\mu_0 I_1 I_2}{2\pi a};$$

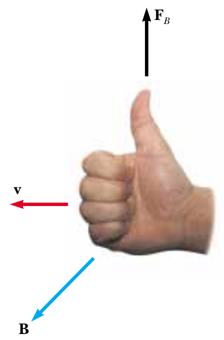
$$\vec{\mathbf{F}} = q[\vec{\mathbf{E}} + (\vec{\mathbf{v}} \times \vec{\mathbf{B}})]$$

Velocity selector

$$qE = qvB \Rightarrow v = \frac{E}{B}$$





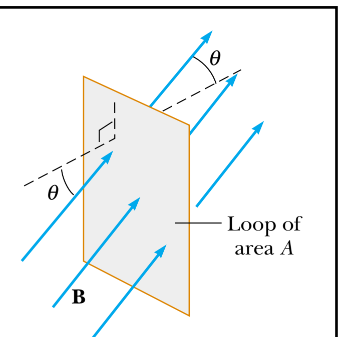


$$I = \frac{dQ}{dt};\quad I_{avg} = \frac{\Delta Q}{\Delta t} = nqv_d A;\quad J = \frac{I}{A} = \sigma E;\quad \rho = \frac{1}{\sigma};\quad \frac{\Delta\rho}{\rho_0} = \alpha\Delta T = \frac{\Delta R}{R_0}$$

$$\varepsilon = -N\frac{d\Phi_B}{dt}$$

Sliding Conducting Bar

$$\varepsilon = -Blv$$

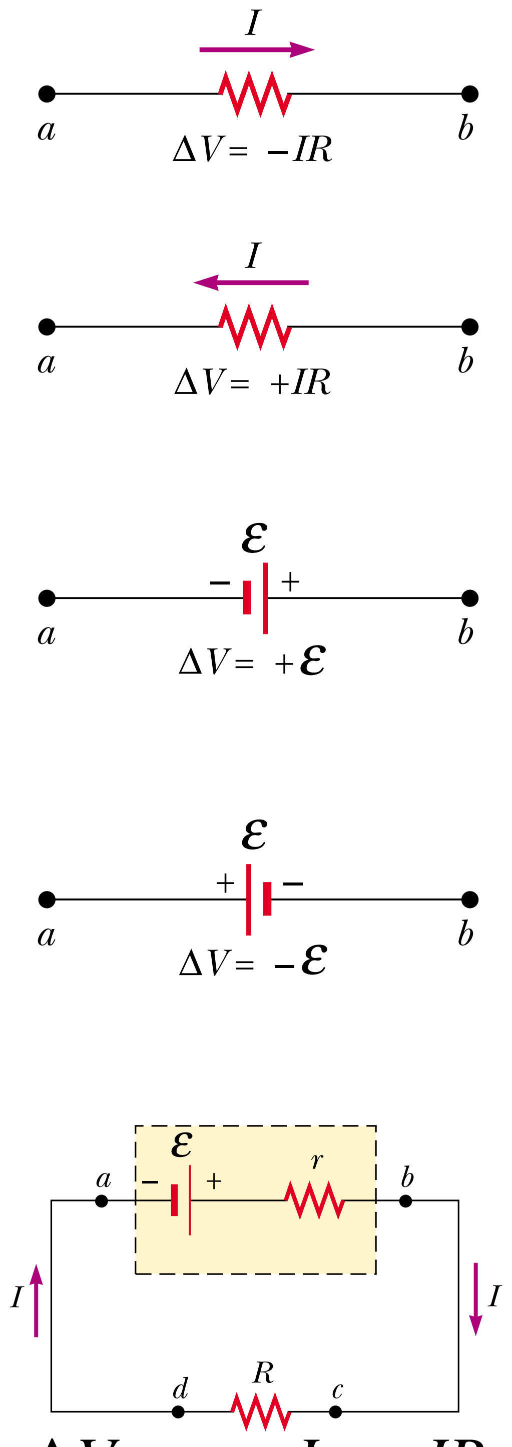


$$\sum I = 0$$

Junction

$$\sum \Delta V = 0$$

closed loop



$$\Delta V = \varepsilon - Ir = IR$$

	Series	Parallel
	$\Delta V = \Delta V_1 + \Delta V_2 + \dots$	$\Delta V = \Delta V_1 = \Delta V_2 = \dots$
$R = \frac{\Delta V}{I} = \frac{\rho l}{A}$	$R_{\text{eq}} = R_1 + R_2 + \dots$	$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$C = \frac{Q}{\Delta V} = \kappa\frac{\epsilon_0 A}{d}$	$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$	$C_{\text{eq}} = C_1 + C_2 + \dots$

$$P = I\Delta V = I^2 R = \frac{(\Delta V)^2}{R}$$

$$U = \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}\frac{Q^2}{C};\quad u_E = \frac{1}{2}\epsilon_0 E^2$$

$$L = \frac{-\varepsilon_L}{\frac{dI}{dt}} = \frac{N\Phi_B}{I} = \mu_0 n^2 Al$$

$$u_B = \frac{1}{2\mu_0}B^2;\quad U = \frac{1}{2}LI^2$$