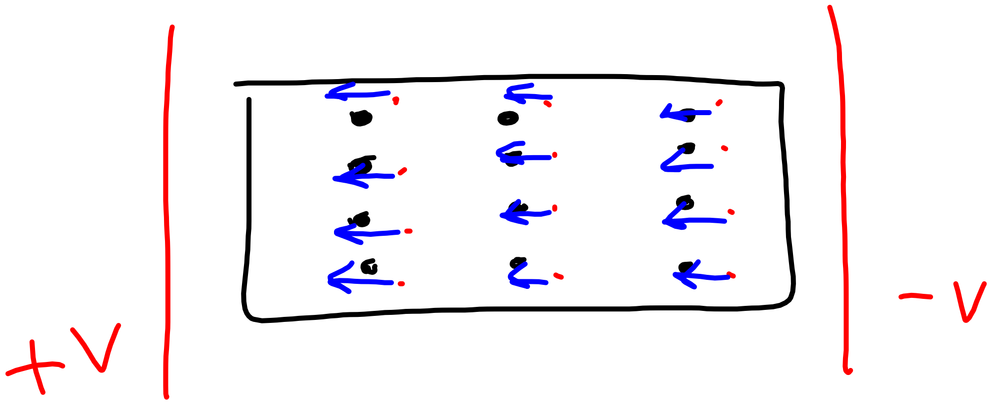
MAGNETIC FIELDS

- Produced by:
  - Permanent magnets (17.11–17.12)
  - Moving charges
- Moving charged particles produce both $\bar{E}$- and $\bar{B}$-fields

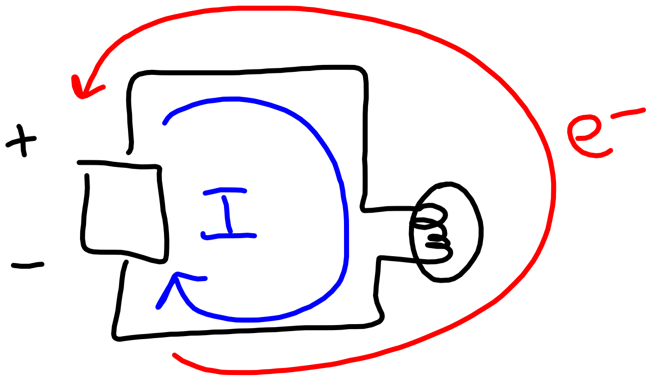
$$c = \frac{1}{\mu_0 \varepsilon_0}$$

Aside into current:



current = $\frac{\text{charge}}{\text{time}}$

$$I = \frac{dQ}{dt}$$



- Biot - Savart Law

$$\bar{B} = \underbrace{\frac{\mu_0}{4\pi}}_{\text{constant}} \frac{q\bar{v} \times \hat{r}}{|\bar{r}|^2}$$

q → charge

v → velocity

$\bar{r}$ → vector that points from source to observed location

CROSS PRODUCTS

$$\bar{A} = \langle A_x, A_y, A_z \rangle = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\bar{B} = \langle B_x, B_y, B_z \rangle = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}$$

$$\bar{A} \cdot \bar{B} = A_x B_x + A_y B_y + A_z B_z$$

SCALAR!

$$\bar{A} \cdot \bar{B} = |\bar{A}||\bar{B}| \cos\theta$$

$$\bar{A} \times \bar{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$= \langle A_y B_z - A_z B_y,\ A_z B_x - A_x B_z,\ A_x B_y - A_y B_x \rangle$$

VECTOR!

$$\bar{A} \times \bar{B} = |\bar{A}||\bar{B}| \sin\theta$$

Biot-Savart Law for short thin wire

$$d\bar{B} = \frac{\mu_0}{4\pi} \frac{I \, d\bar{l} \times \hat{r}}{r^2}$$

Magnetic field of straight wire

$$B_{wire} = \frac{\mu_0}{4\pi} \frac{L I}{r\sqrt{r^2 + \left(\frac{L}{2}\right)^2}}$$

Reduces to:

$$B = \frac{\mu_0}{4\pi} \frac{2I}{r}$$

when wire is "long"

Magnetic field of loop

$$B_{loop} = \frac{\mu_0}{4\pi} \frac{2\pi R^2 I}{(z^2 + R^2)^{3/2}}$$

Reduces to:

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

when measuring along z-axis through loop

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