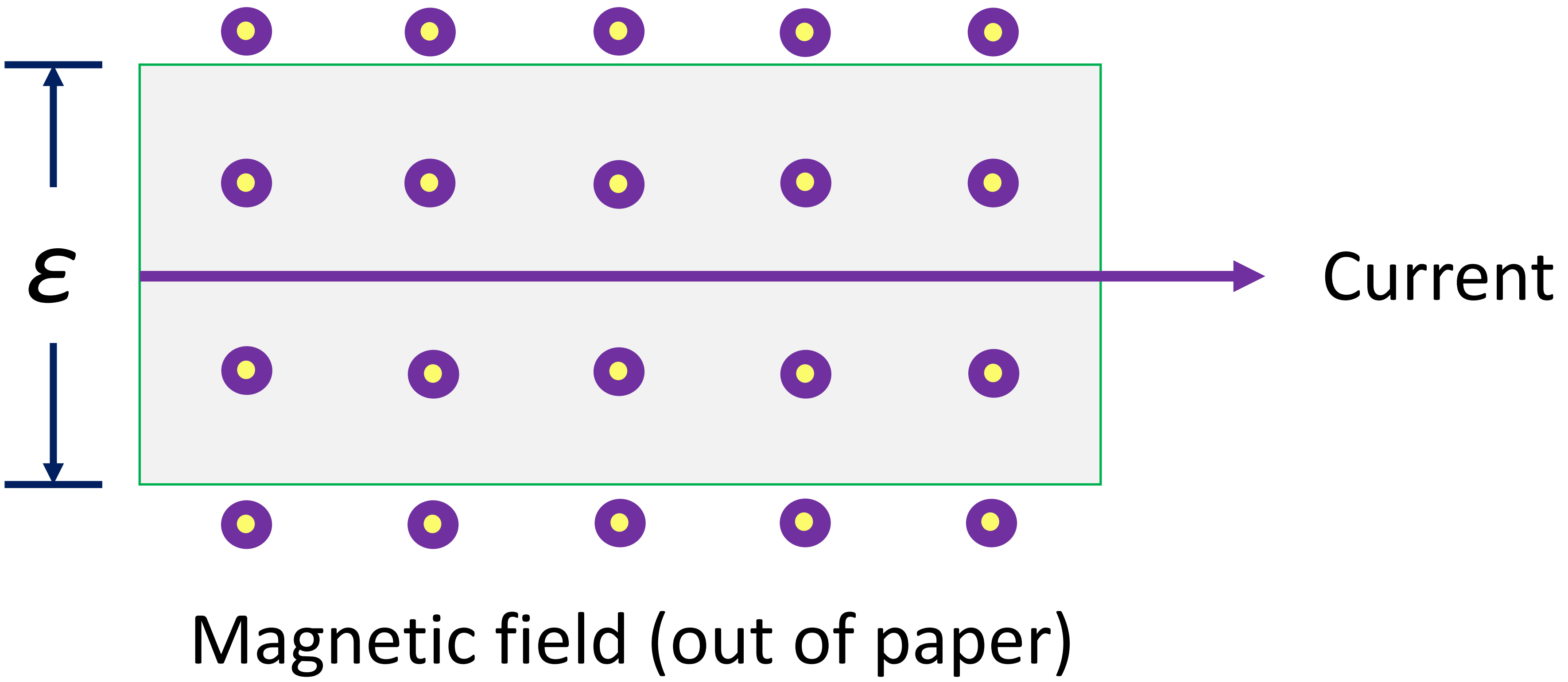
Hall effect

$$V_H = -\left(\frac{1}{nq}\right)\frac{I_x B_z}{t}$$

Dr Mohammad Abdur Rashid

Hall effect



Lets watch this video

Hall Effect - Explained and animated with 3d.

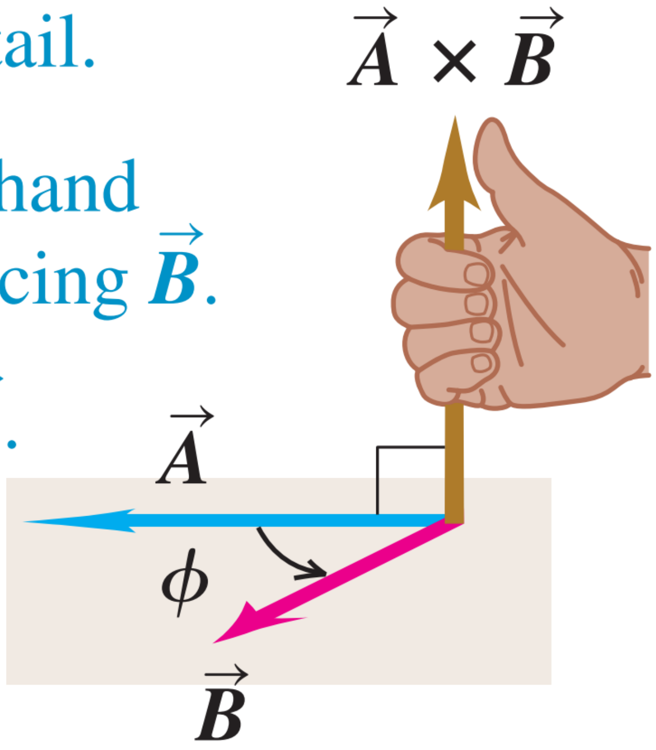
https://www.youtube.com/watch?v=Scpi91e1JKc

Right-hand rule

The vector product $\vec{A} \times \vec{B}$ determined by the right-hand rule.

$$\vec{B} \times \vec{A} = -\vec{A} \times \vec{B}$$

1. Place $\vec{A}$ and $\vec{B}$ tail to tail.
2. Point fingers of right hand along $\vec{A}$, with palm facing $\vec{B}$.
3. Curl fingers toward $\vec{B}$.
4. Thumb points in direction of $\vec{A} \times \vec{B}$.

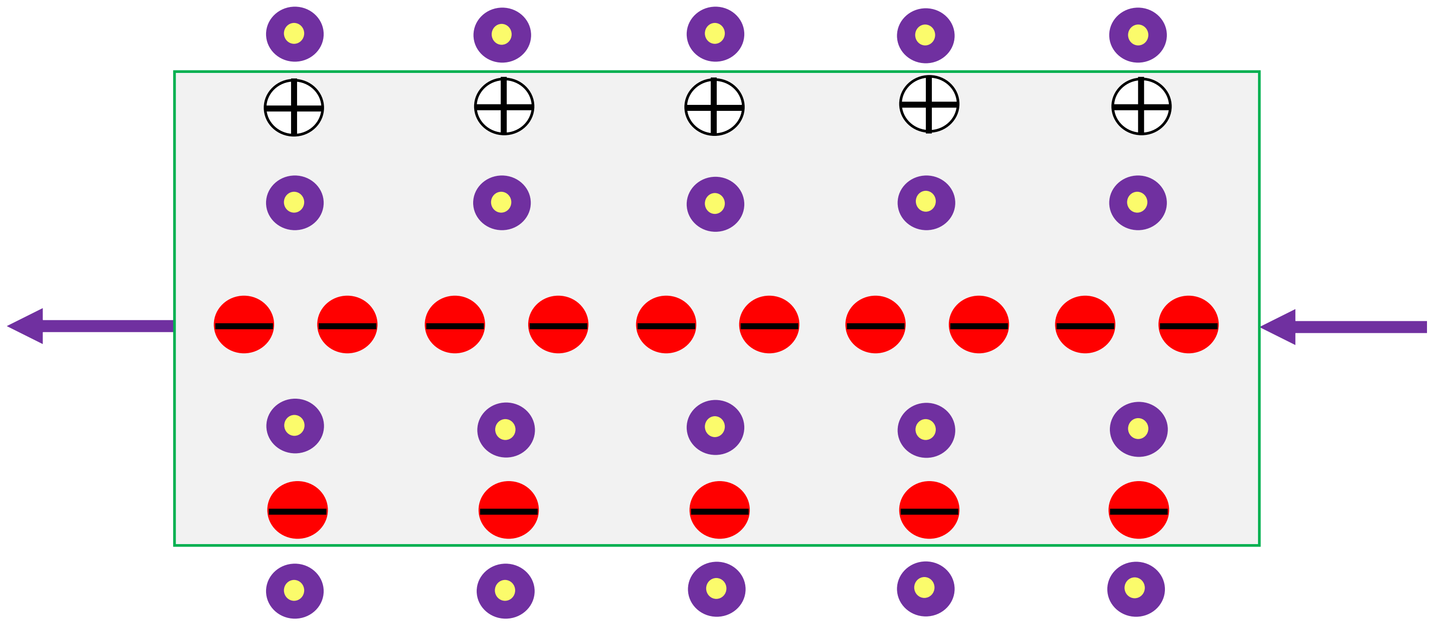


University Physics with Modern Physics – Young and Freedman

Magnetic force on moving electrons

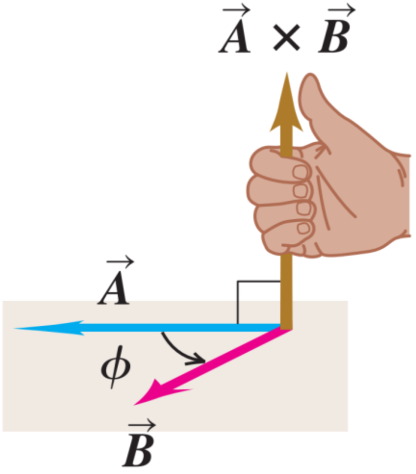
$$e = 1.6 \times 10^{-19}\ \mathrm{C}$$

$$\mathbf{F} = -e(\mathbf{v} \times \mathbf{B})$$



Motion of electrons

Magnetic field (out of paper)



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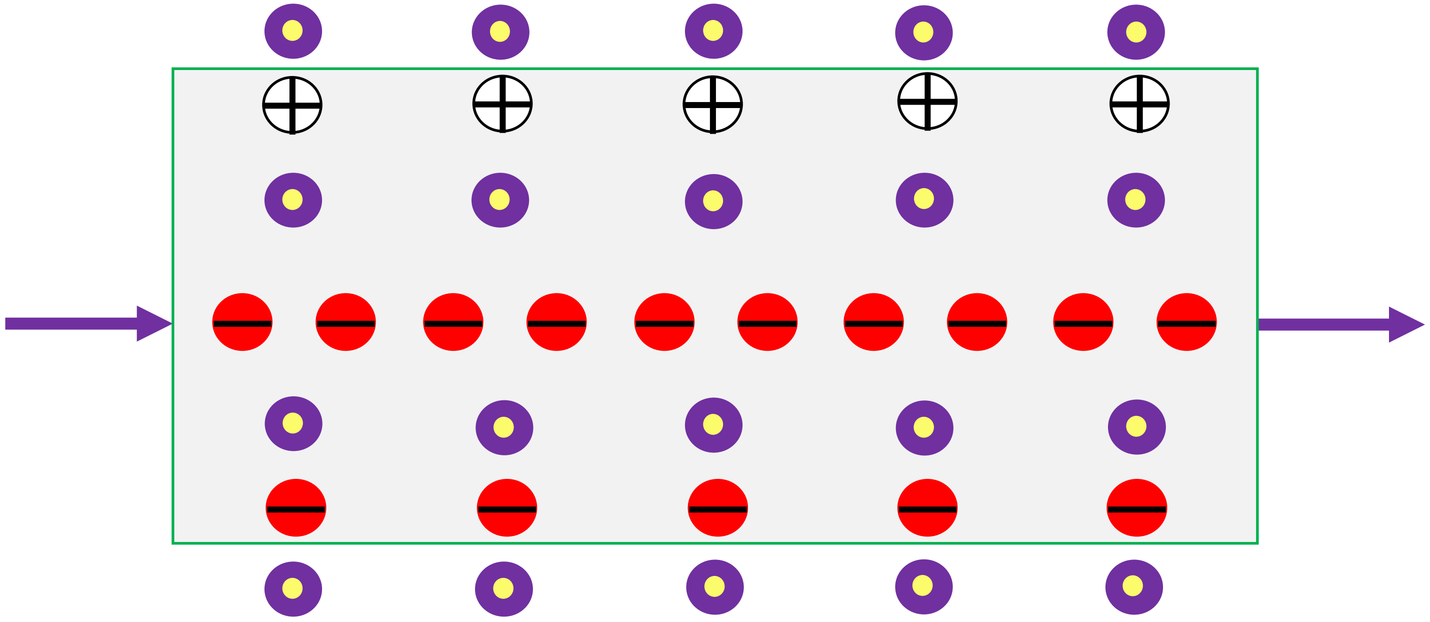
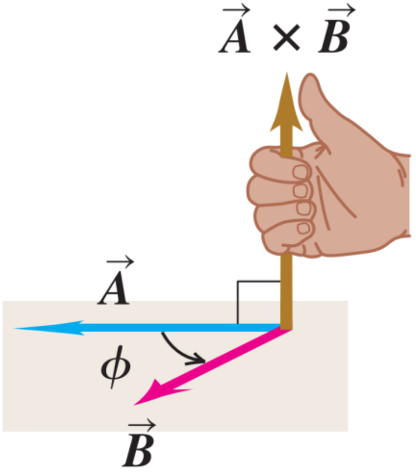


Direction of current

Magnetic field (out of paper)



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Magnetic force on moving holes

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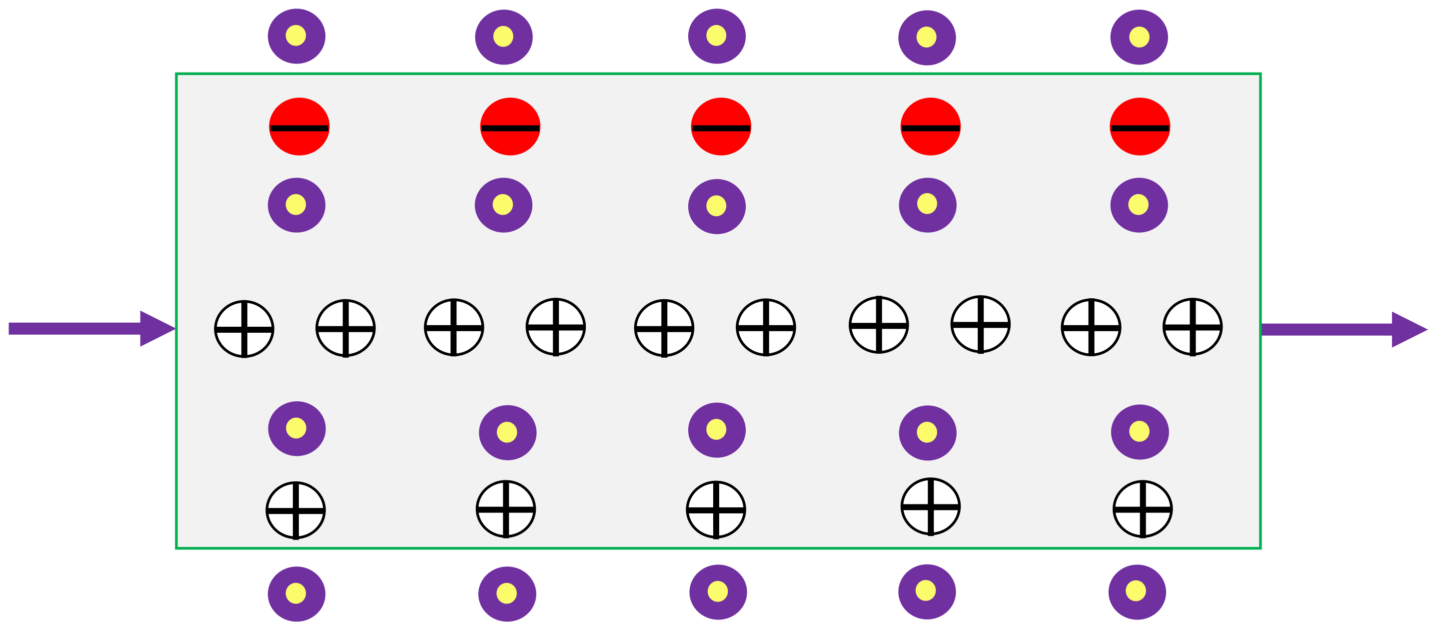
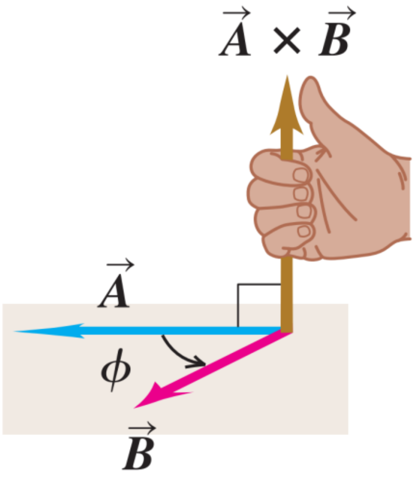


Direction of current

Magnetic field (out of paper)



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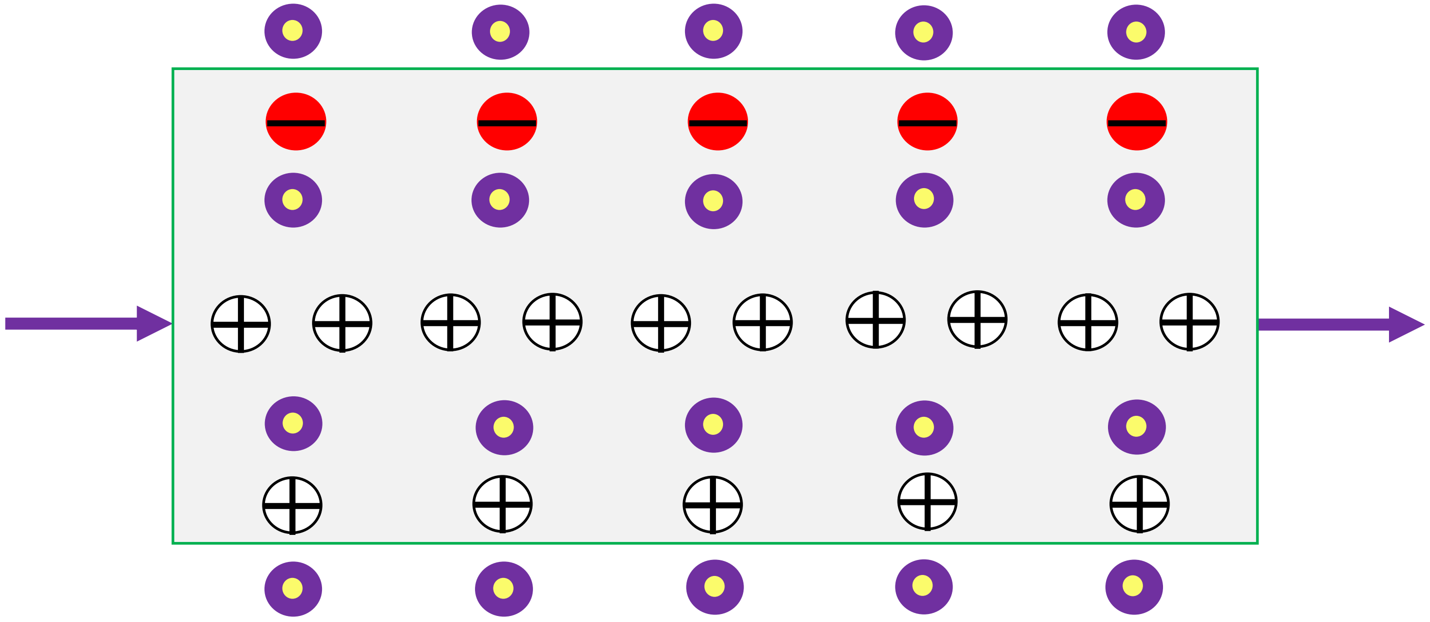
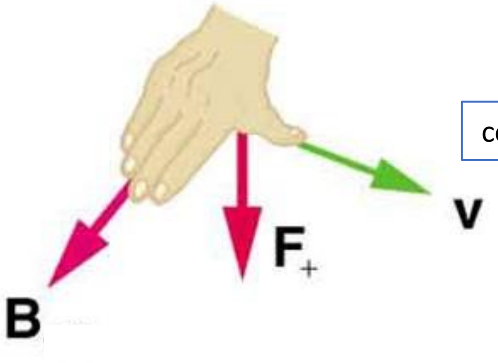


Direction of current

Magnetic field (out of paper)



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Magnetic force on moving electrons

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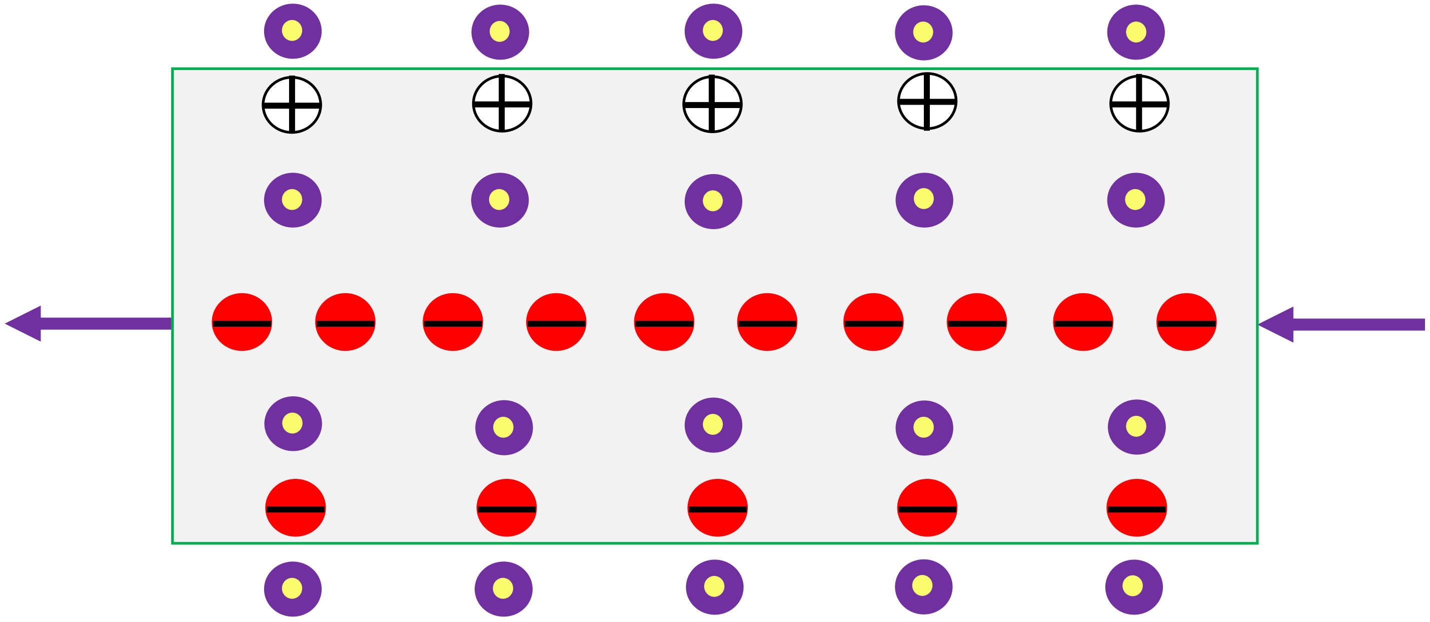

Motion of electrons

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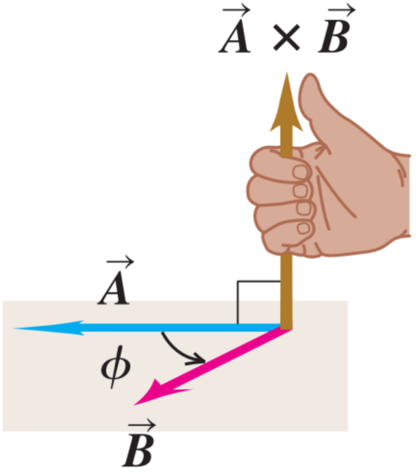

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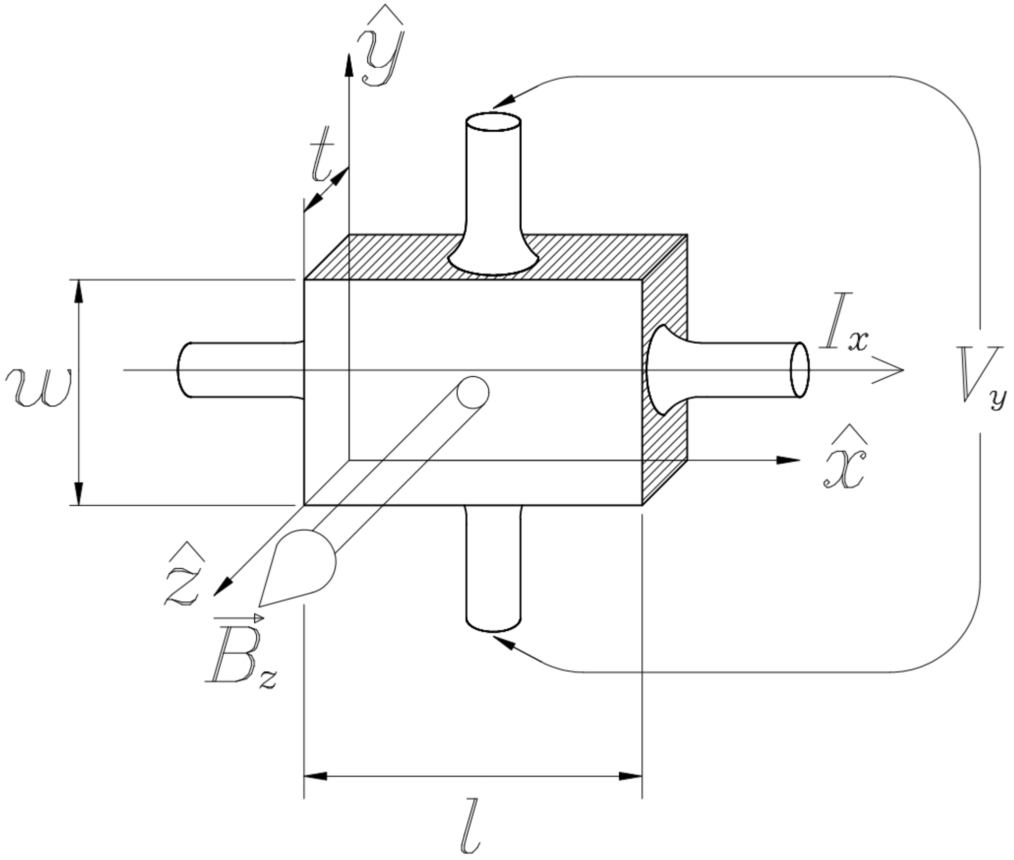
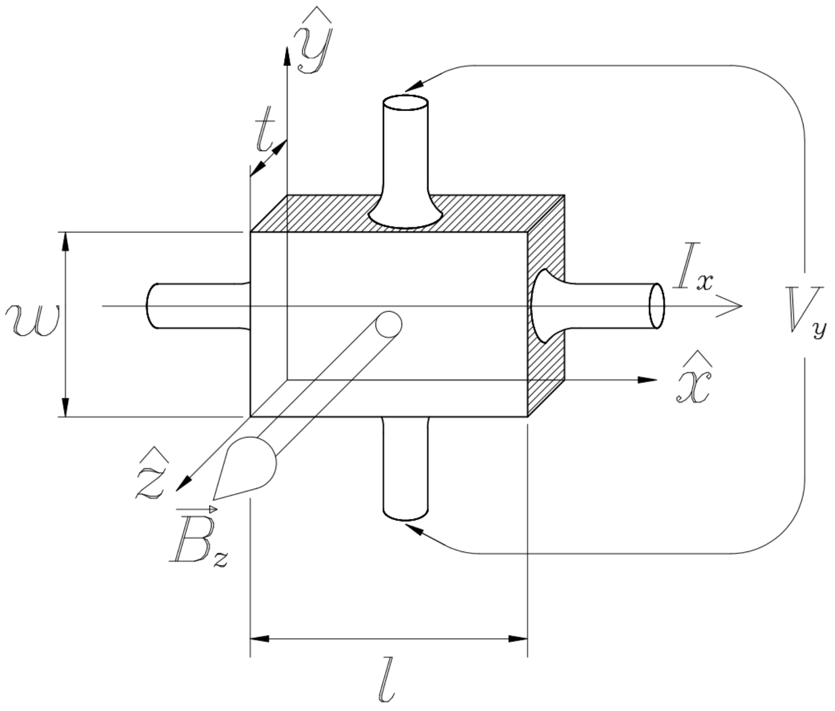
Hall voltage



http://courses.washington.edu/phys431/hall_effect/hall_effect.pdf

Assume the conductor to have charge carrier of charge q (can be either positive or negative or both, but we take it to be of just one sign here), charge carrier number density n (i.e., number of carriers per unit volume), and charge carrier drift velocity v_x when a current I_x flows in the positive x direction.

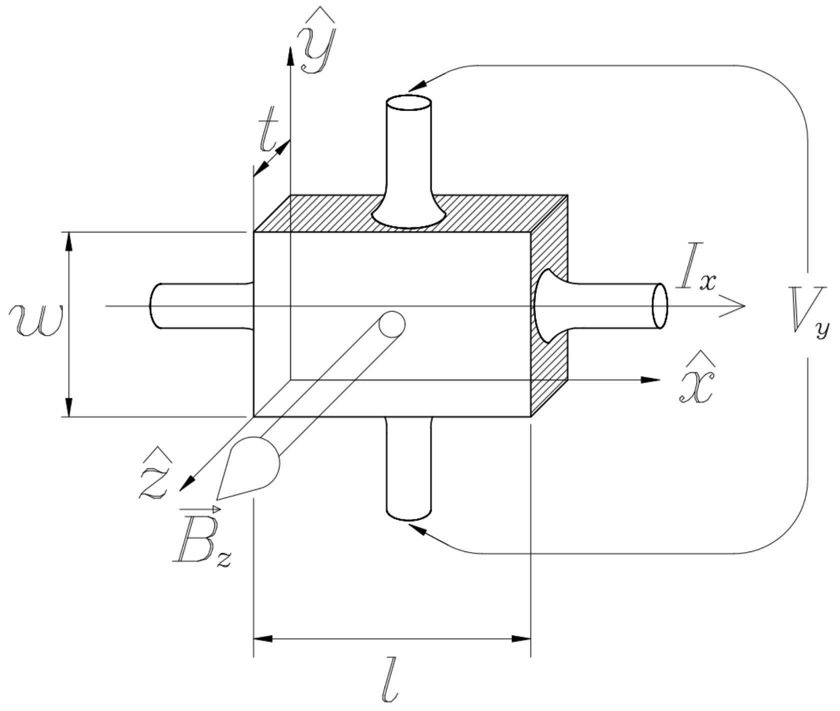
Hall voltage



The charge carriers will experience a Lorentz force $q(\mathbf{v} \times \mathbf{B})$ that will deflect them toward one side of the slab. The result of this deflection is to cause an accumulation of charges along one side of the slab which creates a transverse electric field E_y that counteracts the force of the magnetic field.

http://courses.washington.edu/phys431/hall_effect/hall_effect.pdf

Hall voltage



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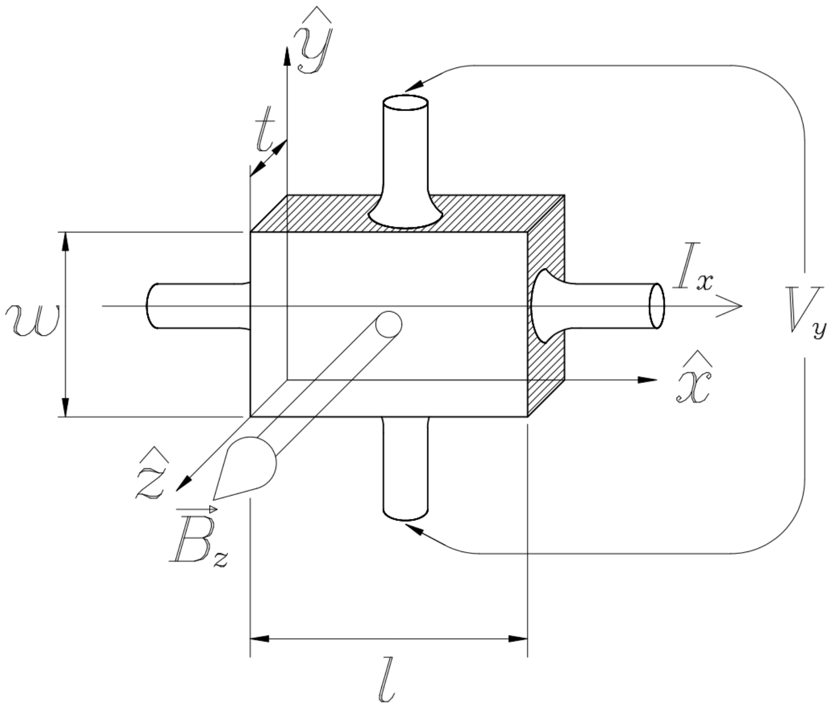
When steady state is reached, there will be no net flow of charge in the y direction, since the electrical and magnetic forces on the charge carriers in that direction must be balanced. Since the force of an electric field on a charge q is $q\mathbf{E}$, we have

$$q\mathbf{E} = q(\mathbf{v} \times \mathbf{B})$$

$$E_y = v_x B_z$$

Hall voltage



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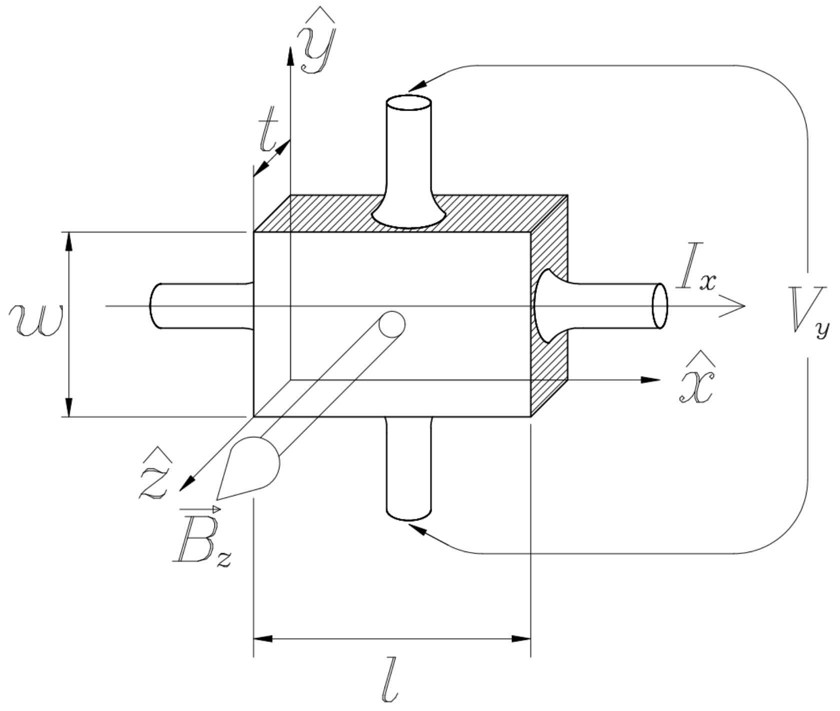
The potential difference across the sample — the Hall voltage V_H — which is related to the Hall field by

$$V_H = -E_y w$$
$$= -v_x w B_z$$

The current I_x is related to the charge density nq and the drift velocity v_x as

$$I_x = nqv_x wt$$

Hall voltage



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$$V_H = -\left(\frac{1}{nq}\right)\frac{I_x B_z}{t}$$

The Hall coefficient: $R_H = \dfrac{1}{nq}$

It is positive if the charge carriers are positive, and negative if the charge carriers are negative. In practice, the polarity of V_H determines the sign of the charge carriers.

Assignments

- Discuss how the Hall effect could be used to obtain information on free charge density in a conductor. (Hint: Consider how drift velocity and current are related.)

- Can mobility of charge carriers can be determined from Hall effect? If yes, how?