A copper wire with square cross section carries a conventional current I in the +x direction. There is a magnetic field B in the -z direction. Draw a diagram illustrating the situation, to help you answer the following questions.

What is the direction of $E_{parallel}$, the electric field that causes the current to flow?

---Select---

What is the direction of the drift velocity of the mobile electrons?

---Select---

What is the direction of the magnetic force on the moving electrons?

---Select---

What is the direction of $E_{transverse}$, the electric field due to the Hall effect, inside the wire?

---Select---

If the mobile charges had been positive (holes) instead of negative, what would have been the direction of the magnetic force on the moving positive charges?

---Select---

If the mobile charges had been positive instead of negative, what would have been the direction of the transverse electric field?

---Select---

Part One +x

Part Two -x

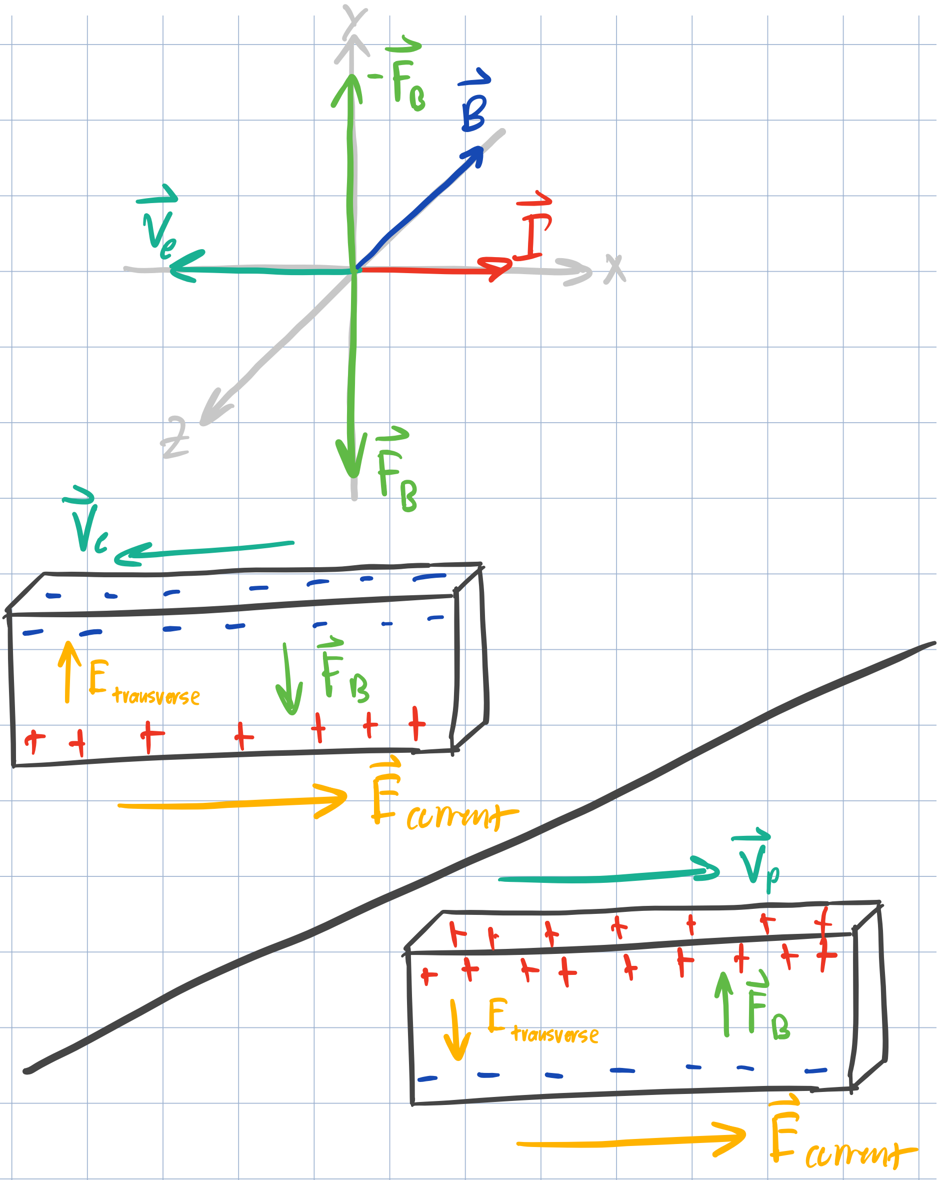
Part Three +y

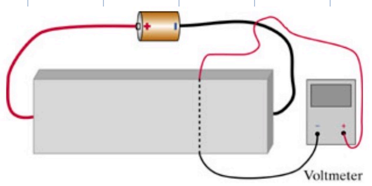
Part Four +y

Part Five +y

Part Six +y

Part Seven -y





The Hall effect can be used to determine the sign of the mobile charges in a particular conducting material.

A bar of a new kind of conducting material is connected to a battery as shown. In this diagram, the x-axis runs to the right, the y-axis runs up, and the z-axis runs out of the screen, toward you. A voltmeter is connected across the bar as shown, with the leads placed directly opposite each other along a vertical line. In order to answer the following questions, you should draw a careful diagram of the situation, including all relevant charges, electric fields, magnetic fields, and velocities.

Initially, there is no magnetic field in the region of the bar.

Inside the bar, what is the direction of the electric field $\vec{E}_{||}$, due to the charges on the batteries and surface of the wires and the bar? This is the electric field that drives the current in the bar.
---Select---
If the mobile charges in the bar are positive, what direction do they move when current runs? ---Select---
If the mobile charges in the bar are negative, what direction do they move when current runs? ---Select---
In this situation (zero magnetic field), what is the sign of the reading on the voltmeter? ---Select---

Now large coils (not shown) are moved near the bar, and current runs through the coils, making a magnetic field in the +z direction (out of the page).

If the mobile charges in the bar are negative, what is the direction of the magnetic force on the mobile charges? ---Select---
If the mobile charges in the bar are negative, which of these things will happen?
- Negative charge will accumulate on the bottom of the bar.
- The bar will not become polarized.
- Negative charge will accumulate on the left end of the bar.
- Positive charge will accumulate on the bottom of the bar.

If the mobile charges in the bar are positive, what is the direction of the magnetic force on the mobile charges? ---Select---
If the mobile charges in the bar are positive, which of these things will happen?
- Positive charge will accumulate on the bottom of the bar.
- Positive charge will accumulate on the right end of the bar.
- Negative charge will accumulate on the bottom of the bar.
- The bar will not become polarized.

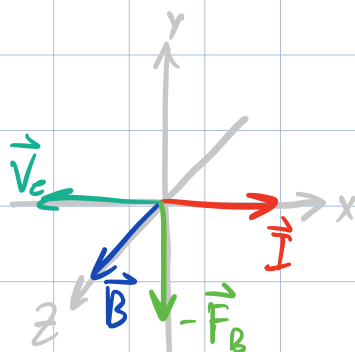
You look at the voltmeter and find that the reading on the meter is +0.0005 volts. What can you conclude from this observation? (Remember that a voltmeter gives a positive reading if the positive lead is attached to the higher potential location.)
- The mobile charges are negative.
- There is not enough information to figure out the sign of the mobile charges.
- The mobile charges are positive.

Part One + X

Part Two + X

Part Three - X

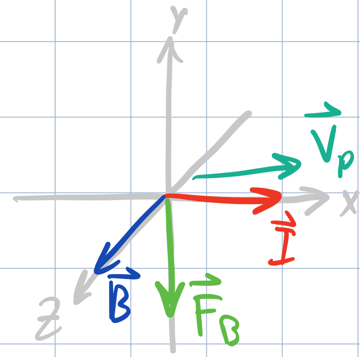
Part Four Zero



Part Five -Y

Part Six Negative charges accumlate on the bottom.

Part Seven $-y$

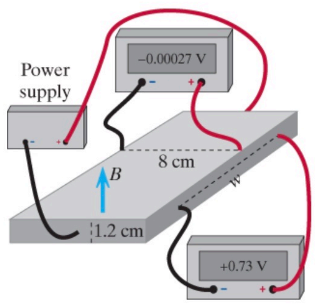


Part Eight Positive charges acumulate on the bottom.

Part Nine Mobile charges are negative

Measuring the properties of a slab of material

A slab made of unknown material is connected to a power supply as shown in the figure. There is a uniform magnetic field of 0.5 tesla pointing upward throughout this region (perpendicular to the horizontal slab). Two voltmeters are connected to the slab and read steady voltages as shown. (Remember that a voltmeter reads a positive number if its positive lead is connected to the higher potential location.) The connections across the slab are carefully placed directly across from each other. The distance w = 0.14 m. Assume that there is only one kind of mobile charges in this material, but we don't know whether they are positive or negative.



(a) Determine the (previously unknown) sign of the mobile charges, and state which way these charges move inside the slab. Which of the following are true?

- ○ The mobile charges are positive and move out of the page.
- ○ The mobile charges are positive and move into the page.
- ○ The mobile charges are negative and move into the page.
- ○ The mobile charges are negative and move out of the page.

(b) In the steady state, the current moves straight along the bar, so the net sideways force on a moving charge must be zero. Use this fact to determine the drift speed $\bar{v}$ of the mobile charges.

[ ] m/s

(c) Knowing the drift speed, determine the mobility u of the mobile charges. (Note that there are two contributions to the electric field in the bar. Think about which one drives the current.)

[ ] (m/s)/(volts/m)

(d) The current running through the slab was measured to be 0.3 ampere. If each mobile charge is singly charged ($|q| = e$), how many mobile charges are there in 1 m^3 of this material?

[ ] carriers/m^3

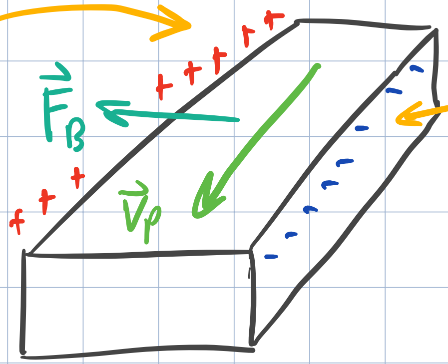
(e) What is the resistance in ohms of a 0.14 m length of this slab?

[ ] ohms

Part One

Positive and moving out of the page because this is the only possible case.

Higher potential on left side



Higher potential at back

Part Two

$$|\vec{F}_B| = |\vec{F}_E|$$

$$\cancel{q}|\vec{v}||\vec{B}|\sin(90) = |\vec{E}|\cancel{q}$$

$$vB = E \qquad \vec{E} = -\frac{V}{\vec{r}_{ab}}$$

$$|\vec{E}| = \frac{V}{r}$$

$$vB = \frac{V}{L}$$

$$v = \frac{V}{BL}$$

$$= 0.00675 \text{ m/s}$$

Part Three

$$V = EN$$

$$V = \frac{V}{r} N$$

$$N = \frac{rv}{V}$$

Use electric field in the direction of current. $r = w$ and V is 0.73V

$$= 1.295e{-3}\ \frac{m/s}{V/m}$$

Part Four

$$I = qnAV$$

$$n = \frac{I}{qAV}$$

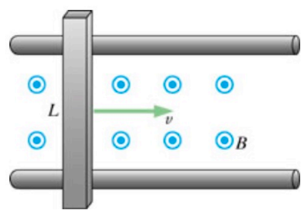
$$= 289.352e21\ \frac{\text{carriers}}{m^3}$$

Part Five

$$R = \frac{V}{I}$$

$$= 2.433\ \Omega$$

A metal rod of length L = 0.20 m slides horizontally at constant speed v = 13 m/s on frictionless *insulating* rails through a region of uniform upward magnetic field of magnitude B = 1.2 tesla.



For your own orientation, show on a diagram the polarization of the rod and the direction of the Coulomb electric field inside the rod and explain to yourself briefly.

(a) What is the magnitude E_C of the Coulomb electric field inside the rod?

E_C = ______ N/C

(b) What is the potential difference across the rod?

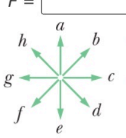
ΔV = ______ volts

(c) What is the emf across the rod?

emf = ______ volts

(d) What are the magnitude and direction of the force you have to apply to keep the rod moving at a constant speed v?

F = ______ N



⊙ j out of the page

⊗ k into the page

0 m zero magnitude

---Select---

Part One

$$|\vec{F}_B| = |\vec{F}_E|$$

$$\cancel{q}|\vec{B}||\vec{v}|\sin(90) = \cancel{q}|\vec{E}|$$

$$|\vec{E}| = |\vec{B}||\vec{v}|$$

$$= 15.6\ N/C$$

Part Two and Three

$$|\vec{V}| = |\vec{E}||\vec{r}|$$

$$= 3.12\,v$$

Part Four and Five

No force is required to keep the bar moving