PHYS 121 March 8, 2024

- ✓ Complete Prairie Learn HW by today @ 23:59
- ✓ Complete Pre-Lab #6 before the start of Lab #6
- ✓ Quiz #2 will be on Wednesday, March 20

  ⇒ See course website for details.

Last Time:

$$I = env_d A$$

$$J = \frac{I}{A} = env_d$$

Ohmic materials obey $\vec{J} = \sigma \vec{E}$

$$\Downarrow$$

$$\Delta V = IR$$

where $R = \frac{1}{\sigma}\frac{L}{A} = \rho \frac{L}{A}$

Today: When is ΔV across a resistor positive & when is it negative?

Rule of Thumb:

- If you cross a resistor in the dir'n of the current I, the voltage change is negative

- If you cross a resistor in opposite dir'n of current I, the voltage change is positive.

CASE 1

cross resistor in dir'n of I →

Track changes in voltage.

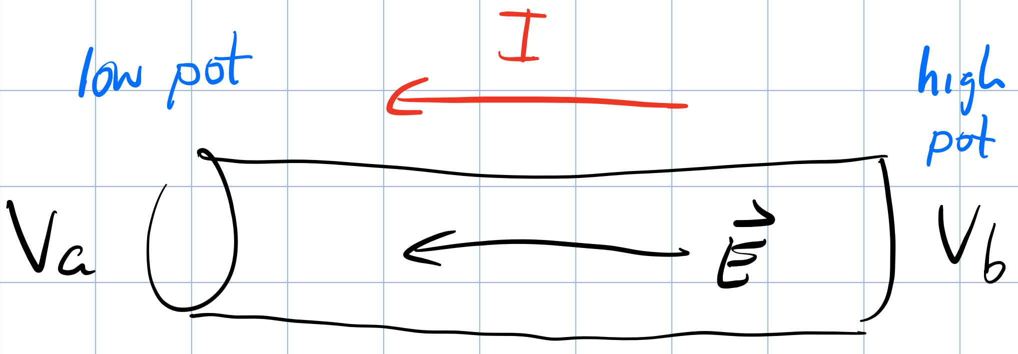
$$V_a + \underbrace{\Delta V_R}_{} = V_b$$

Voltage diff.
across resistor

$$\therefore \Delta V_R = \underset{\substack{\nearrow \\ \text{low}}}{V_b} - \underset{\substack{\uparrow \\ \text{high}}}{V_a} < 0 \quad (\text{neg.})$$

$$\boxed{\therefore \Delta V_R = -IR \text{ when cross resistor in dir'n of } I.}$$

CASE 2 : Cross R antiparallel to current I



cross R in opp. dir'n of I ⟶

$$V_a + \Delta V_R = V_b$$

$$\therefore \Delta V_R = \underset{\substack{\nearrow \\ \text{high}}}{V_b} - \underset{\substack{\uparrow \\ \text{low}}}{V_a} > 0 \quad (\text{pos.})$$

When cross R in dir'n opp. of the current:

$$\boxed{\Delta V_R = +IR}$$

Power Dissipated by a Resistor

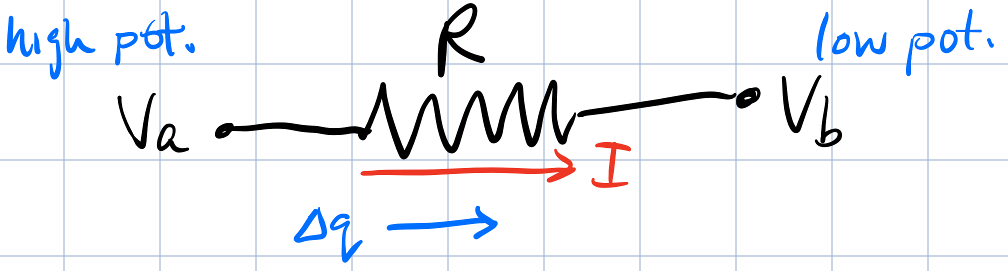
(OSUPv2 Sec. 9.5)

Recall that power is defined as:

$$P = \frac{\text{change in energy}}{\text{time interval}}$$

$$[P] = \frac{J}{s} = W \quad (1 \text{ Watt})$$

Consider an amount of charge $\Delta q > 0$ that crosses a resistor R in time Δt.



The charge Δq losses pot. ΔV_R when it crosses R.

The corresponding loss of P.E. of the charge is :

$$\Delta U = \Delta q \, \Delta V_R$$

If time to cross R is Δt, then the dissipated power is:

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta q \, \Delta V_R}{\Delta t} = \underbrace{\frac{\Delta q}{\Delta t}}_{I} \Delta V_R$$

Power dissipated by resistor is $\boxed{P = I \Delta V_R}$

The dissipated is transformed into heat.

We know $\Delta V_R = \underline{IR}$

$$\boxed{P = I(IR) = I^2R}$$

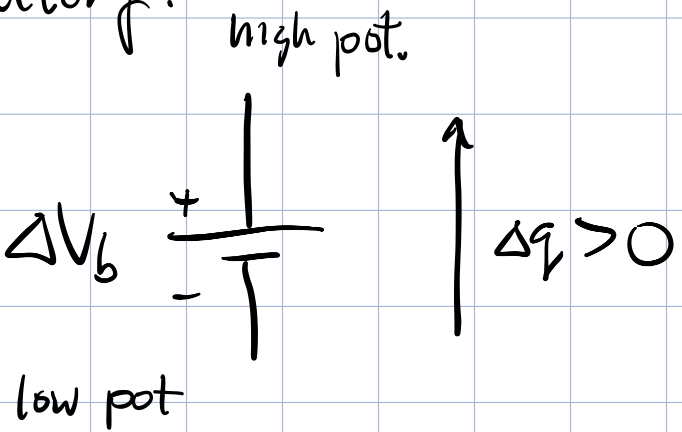
$$I = \frac{\Delta V_R}{R}$$

$$\boxed{P = \left(\frac{\Delta V_R}{R}\right)^2 R = \frac{(\Delta V_R)^2}{R}}$$

Power dissipated by a resistor:

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

In a similar way, we can determine the power supplied by a voltage source, such as a battery.



Charge $\Delta q > 0$ crosses batt. from neg. to pos. terminal in time Δt.

Δq gains pot. ΔV_b & P.E. of $\Delta U = \Delta q \Delta V_b$

$$P = \frac{\Delta U}{\Delta t} = \frac{\Delta q}{\Delta t}\Delta V_b = \boxed{I\Delta V_b}$$

↗ power supplied by battery

power supplied by battery.

Eg. The nichrome wire in a toaster has a resistance of 24 Ω. If the outlet in the wall supplies 120 V, find:

(a) resulting current in toaster

(b) The power dissipated by resistor (nichrome wire)

(c) Power supplied by outlet.

(a) $I = \frac{\Delta V}{R} = \frac{120\,V}{24\,\Omega} = 5A$

(b) $P = I^2 R = 600W$ } dissipated power

$$P = I\Delta V = 600\,W$$

$$P = \frac{(\Delta V)^2}{R} = 600W$$

(c) $P_{supplied} = I\Delta V = 600\,W.$

Energy conservation.

The dissipated power heats the nichrome wire to about 500°C. The wire heats the surrounding air to about 150° which toasts the bread.

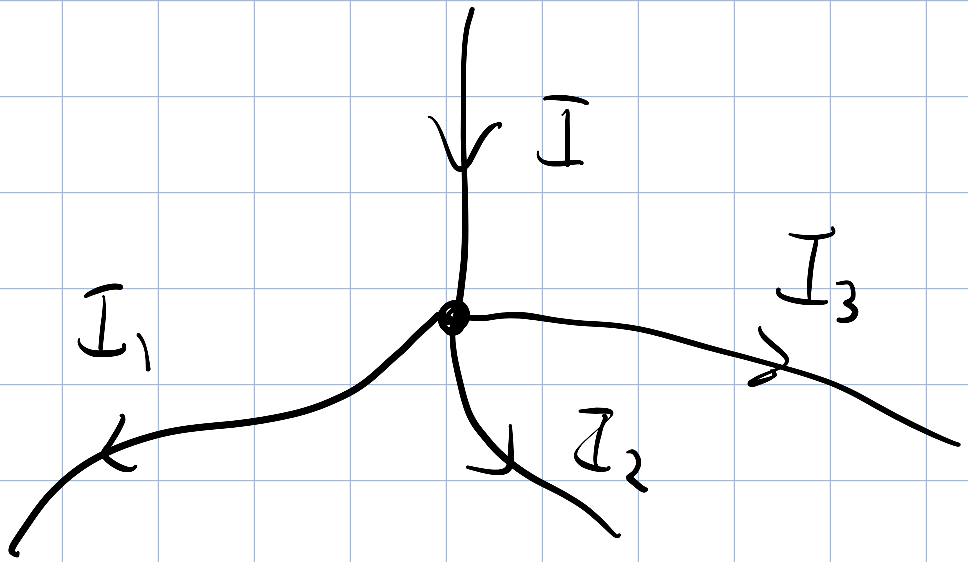
Recall Kirchhoff Voltage Loop Rule

sum of voltage changes around a closed loop

$$\sum_i \Delta V_i = 0$$

$\Rightarrow$ Conservation of energy.

Kirchhoff Junction Rule.



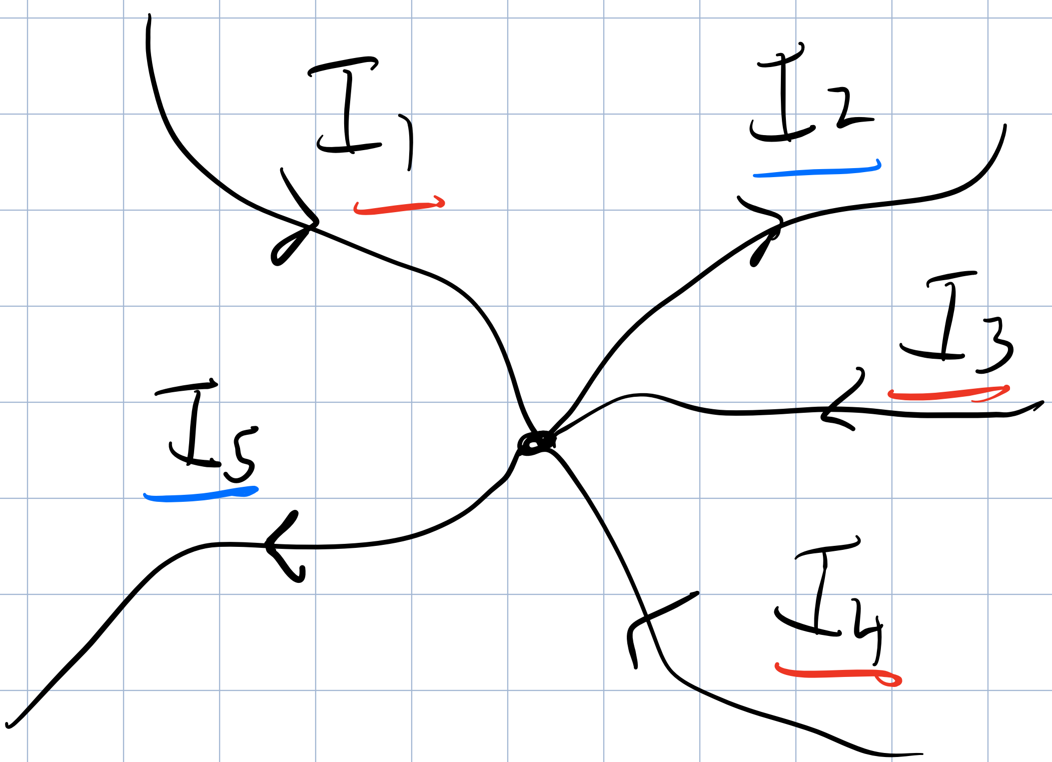
When a current encounters a jcn, some takes path 1, some takes path 2, & some takes path 3. However, the net current into the junction must equal net current leaving the jcn. There can be no charge created or destroyed at jcn.

$\Rightarrow$ Conservation of charge.

Junction Rule: $\boxed{\text{current in} = \text{current out}}$

In our example: $I = I_1 + I_2 + I_3$

Eg.



$$\underbrace{I_1 + I_3 + I_4}_{\text{current in}} = \underbrace{I_2 + I_5}_{\text{current out.}}$$