Electrical Engineering
Week 2

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EECE–2210
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Week 2 Agenda

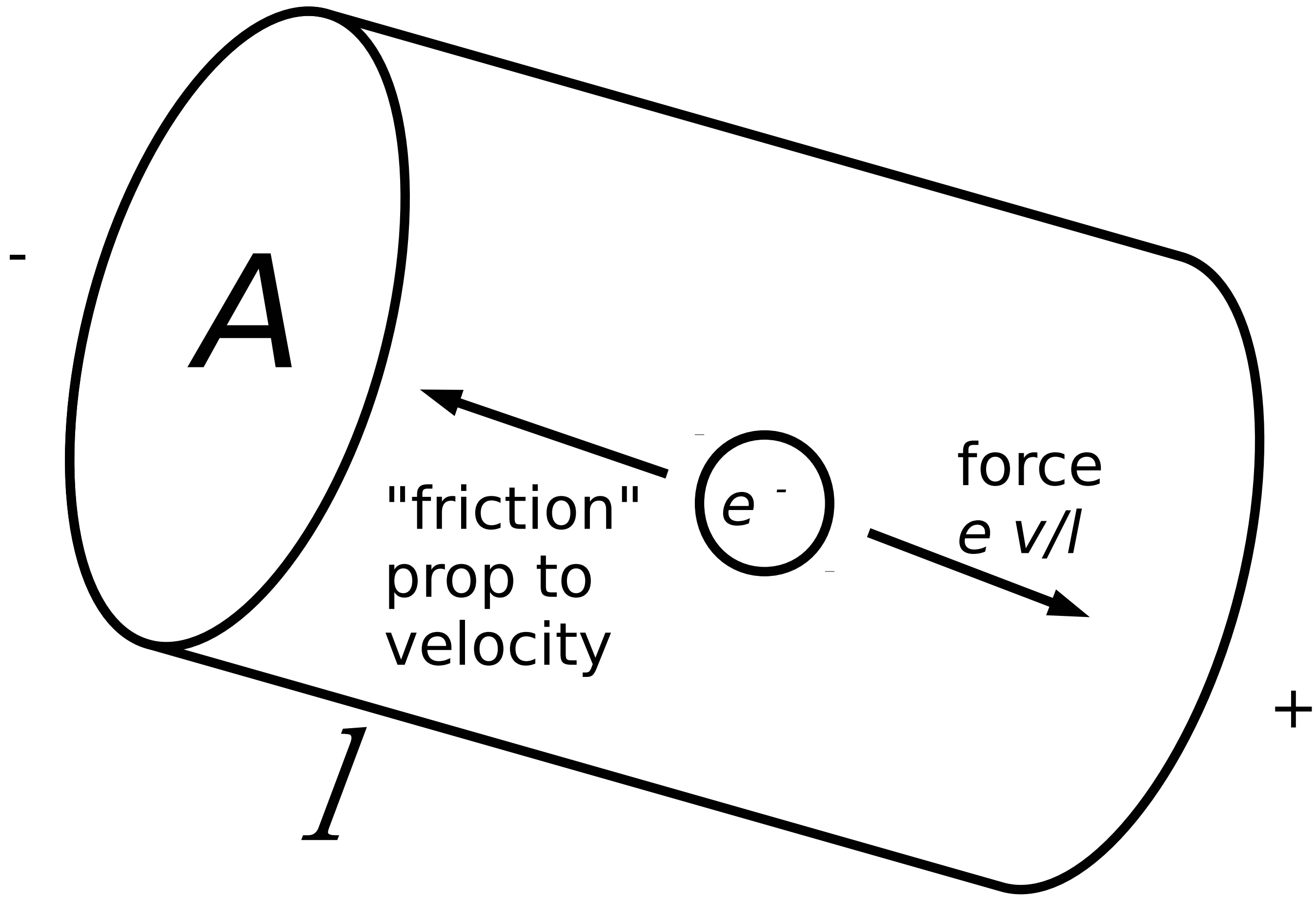
- Conductors
- Resistors
- Power in Resistors
- Insulators
- Sources (Voltage and Current, Independent and Dependent)
- Kirchoff's Current Law
- Kirchoff's Voltage Law
- AC Power (Zero–to–Peak, Peak–to–Peak, RMS)

Conductors

- Typically Copper
- Low Resistivity
- Sufficient Diameter
- Usual Approximation: $R = 0$.
- Validity?

Resistance: Ohm's Law

$v = iR$ Ohm's Law



$R = \frac{\rho \ell}{A}$

Copper Wire

$$A = \pi \times (1\text{mm}/2)^2$$

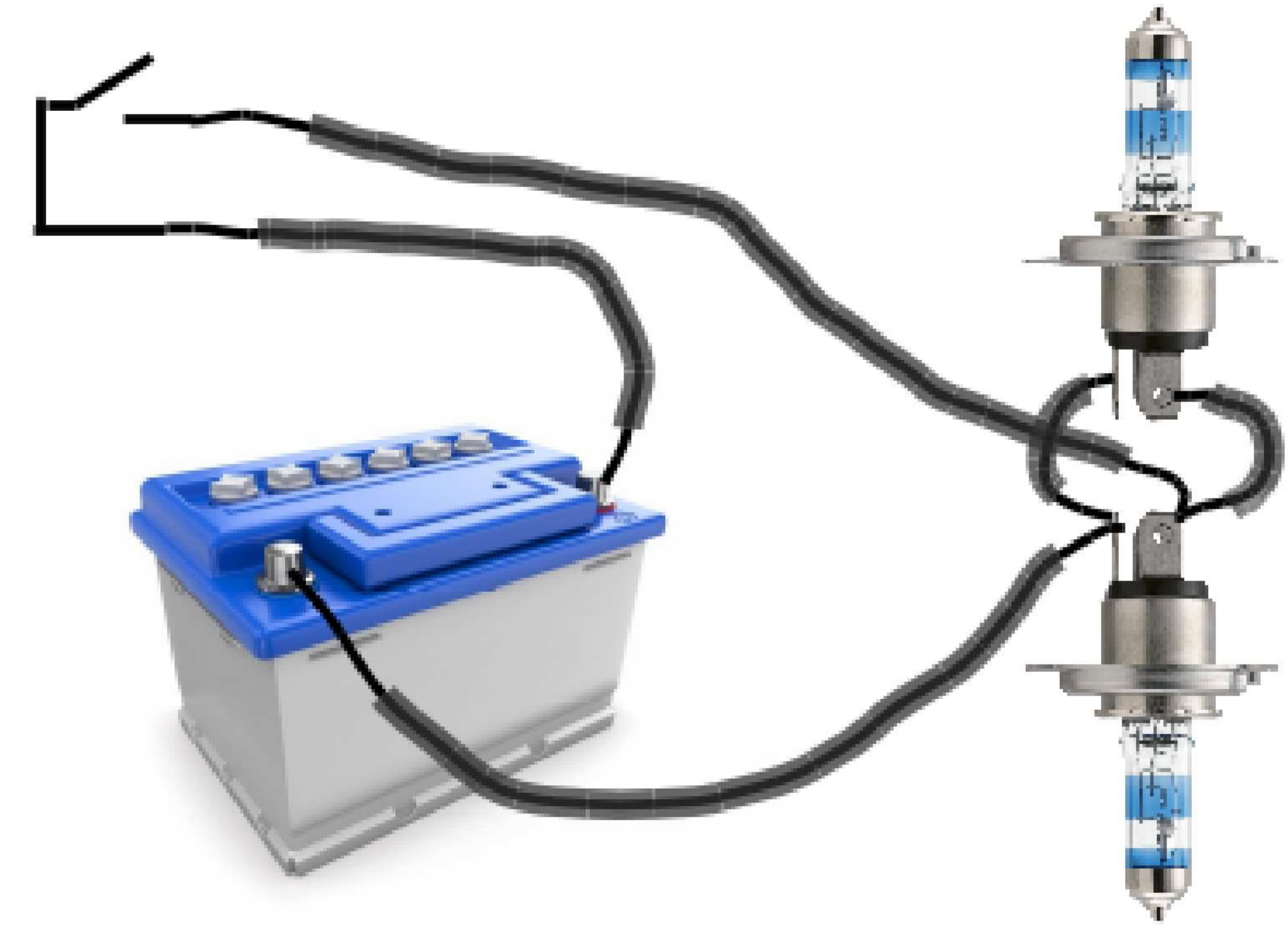
$$\ell = 1\text{m}$$

$$\rho = 1.72 \times 10^{-8}\Omega m$$

$$R = \frac{\rho\ell}{A} = 0.02\Omega$$

Is that a lot?

Wires = Conductors?



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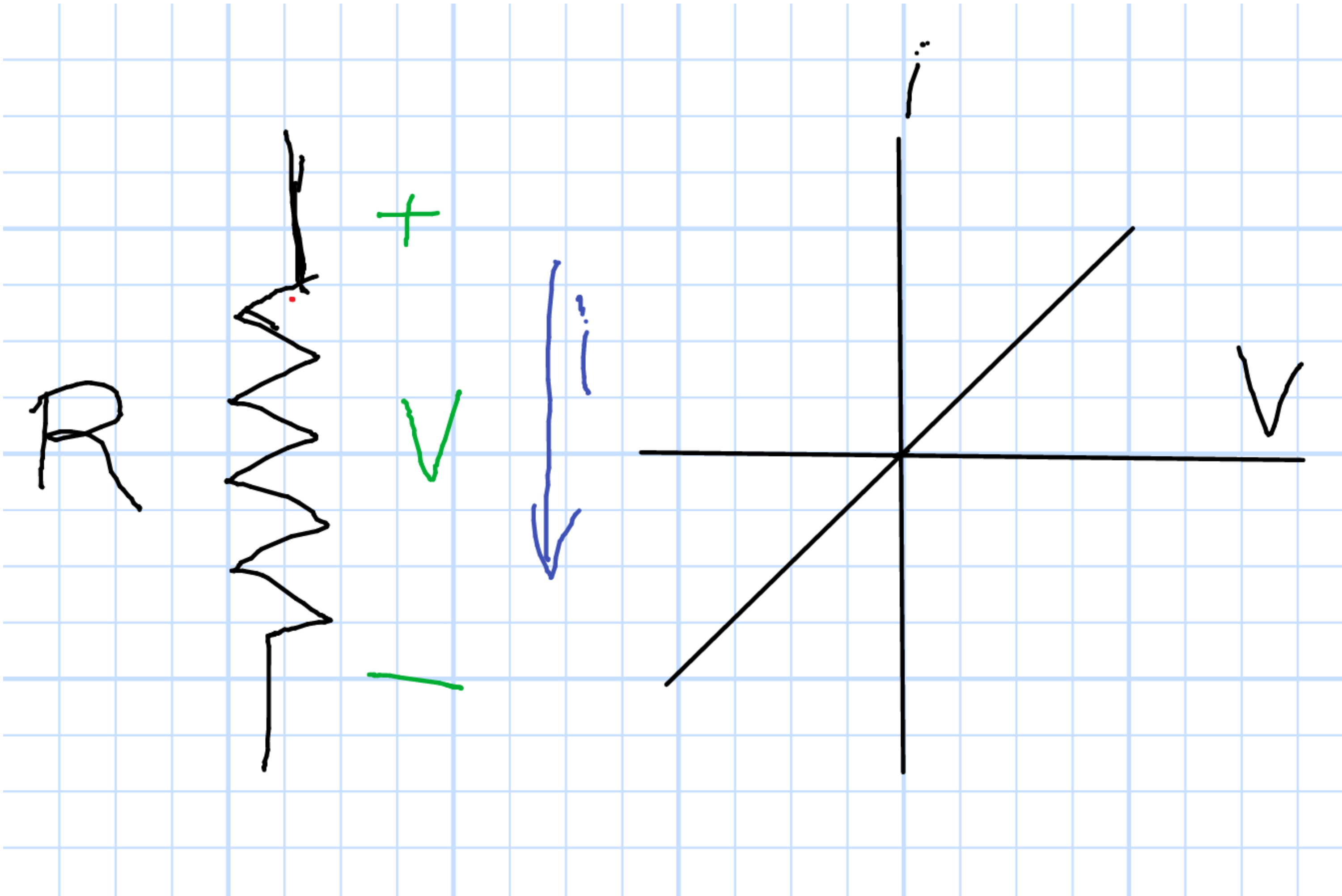
Is that a lot?

$$P_{lights} = 200\text{W} \qquad V = 12\text{V} \qquad i = \frac{p}{v} = 16.7\text{A}$$

$$P_{wire} = i^2 R = 5.6\text{W} \qquad V_{wire} = 0.33\text{V}$$

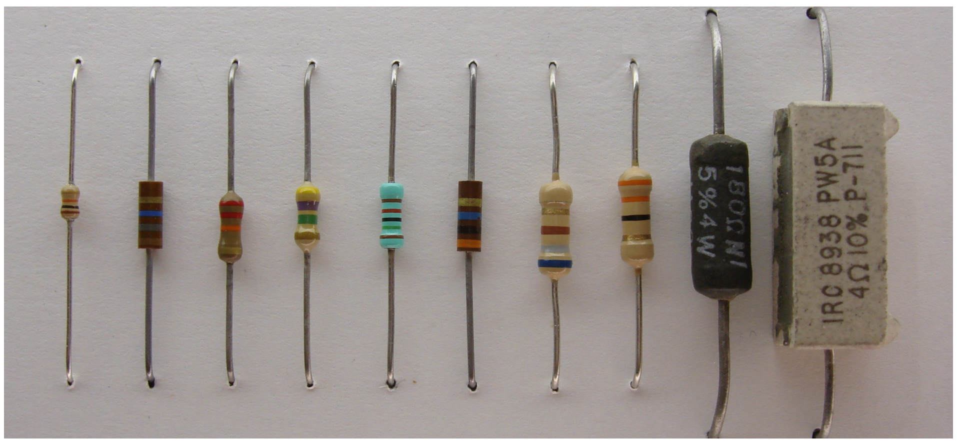
The Resistor



Resistors

Power Ratings Low to High from Left to Right

Typical in Our Lab



http://ecee.colorado.edu/ mathys/ecen1400/labs/resistors.html

Dynamic Braking

trainweb.org

Parameters

- Resistance
- Tolerance
- Power Rating (Maximum)

Power in Resistors

- $p = iv$, Always
- $v = iR$
- $p = \frac{v^2}{R}$, for Resistors
- $p = i^2 R$, for Resistors
- Resistors always absorb power

Power Ratings

$p = v^2/R$

A typical resistor we might use in the lab has a power rating of 1/4 Watt. Is this ok?

- 1 Volt on a 1kOhm Resistor?

-

- 12 Volts on a 100 Ohm Resistor?

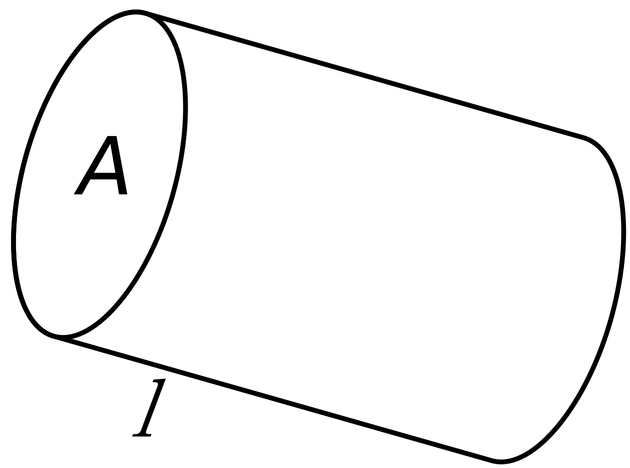
-

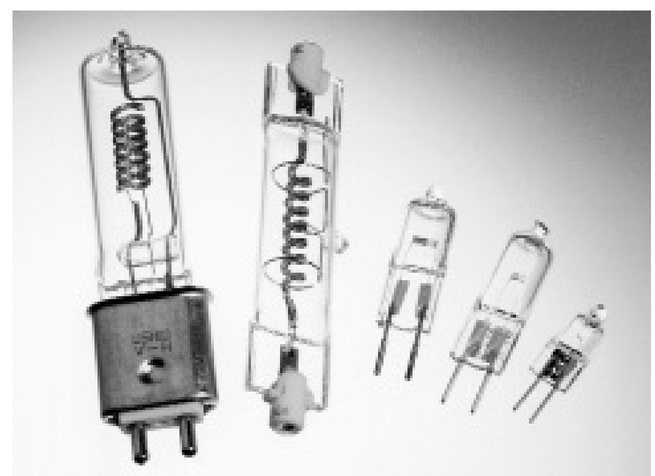
Quartz–Halogen Lamp

$$R = \frac{\rho \ell}{A}$$

$$P = \frac{v^2}{R}$$

- Tungsten Light
  - 3000 K
  - Glass Bulb
  - Failure: Evaporation and Condensation
- Quartz–Halogen
  - 3500 K
  - Halogen Catalyst Prevents Condensation
  - Large Diameter Tungsten Filament ($R \downarrow$ so $V \downarrow$)
  - Lower Voltage for Low Power
  - Quartz Bulb





https://www.azom.com/images/Article_Images/

Glass Resistor

$$A = (1\text{cm})^2 \qquad \ell = 1\text{mm} \qquad \rho = 10^{12}\Omega m$$

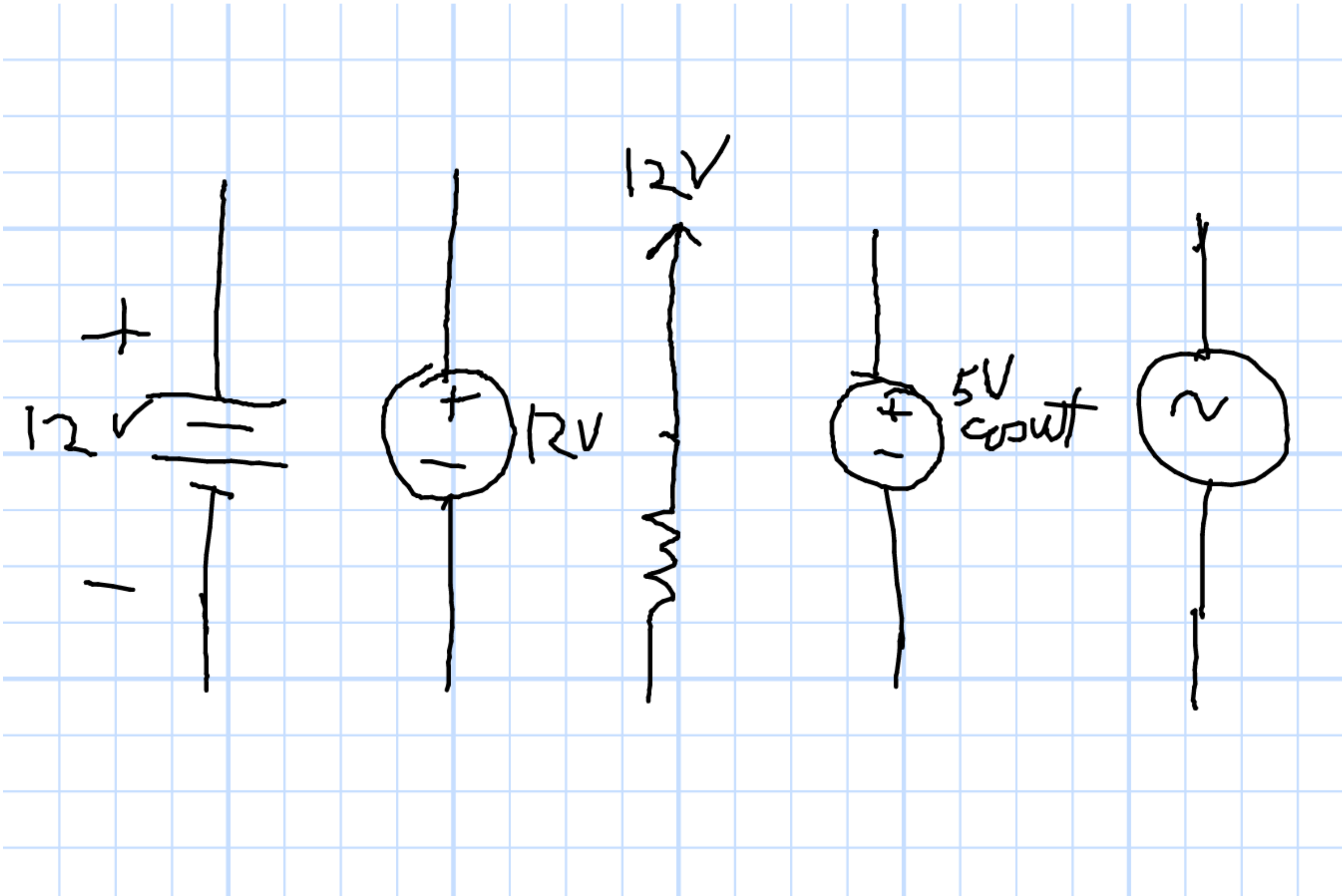
How Long to Heat the Glass 1K at 1V?

$$\text{Volume} = 0.1\text{cm} \times (1\text{cm})^2 = 0.1\text{cc}$$

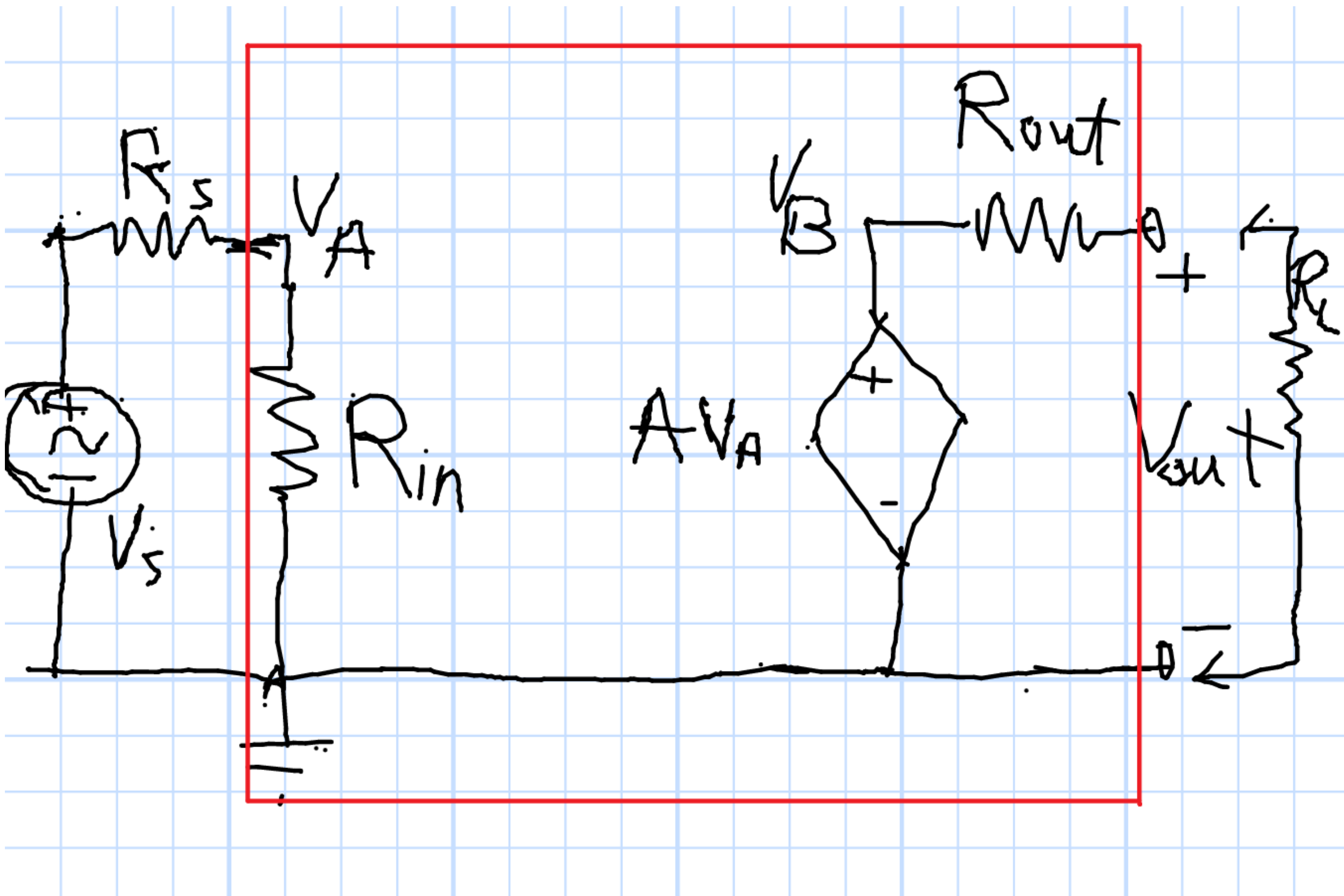
$$0.2\frac{J}{gm\ K} \times 2\frac{gm}{cc} \times \text{Volume} = 0.04\text{Joules}$$

$$t =$$

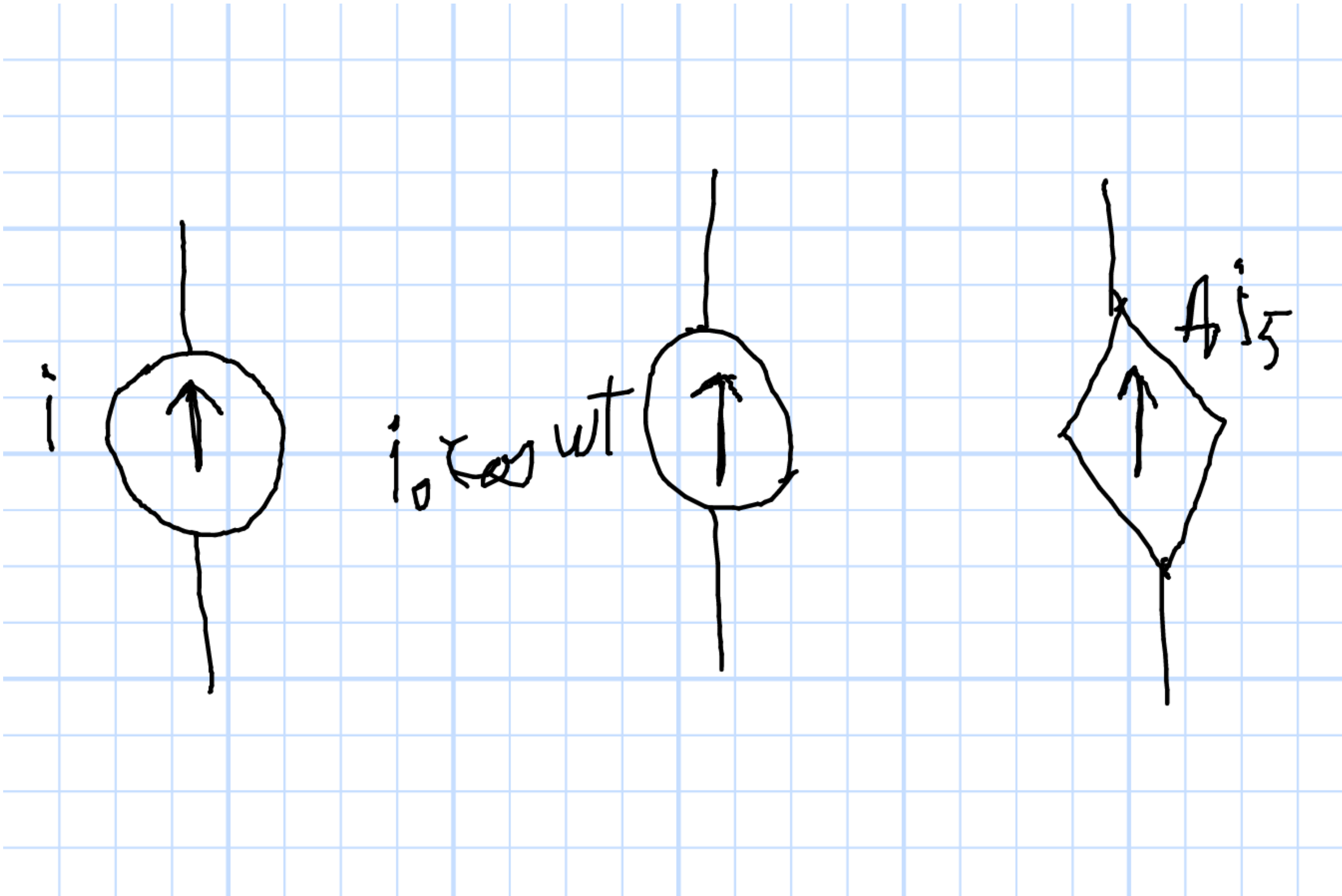
Voltage Sources



Example Dependent Voltage Source



Current Sources



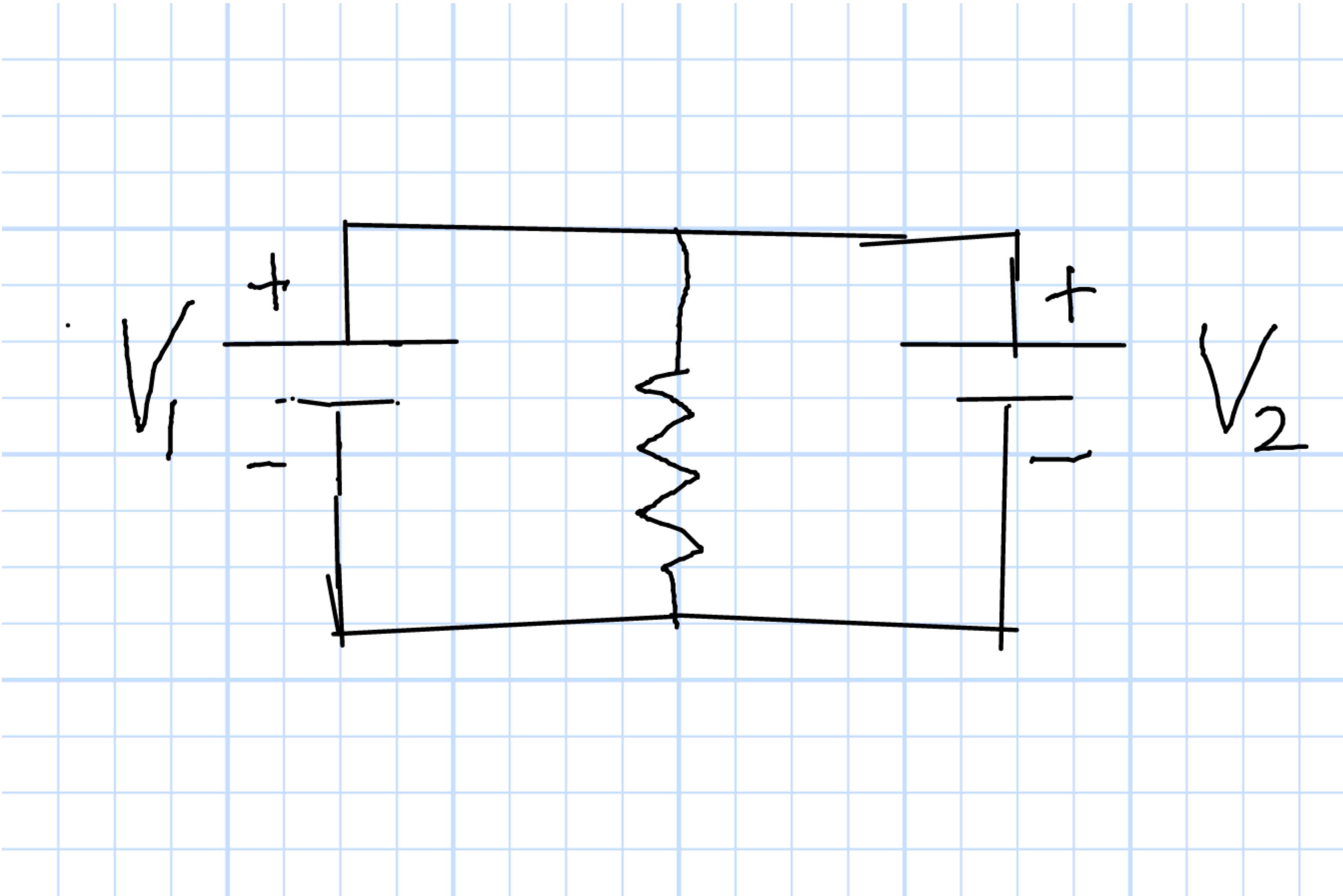
Models

All Models Are Approximations

- The Earth is Flat
- The Earth is a Sphere
- The Earth is Very Complicated
- Sources: Perfect Voltage or Current Sources
- Conductors: $R = 0$

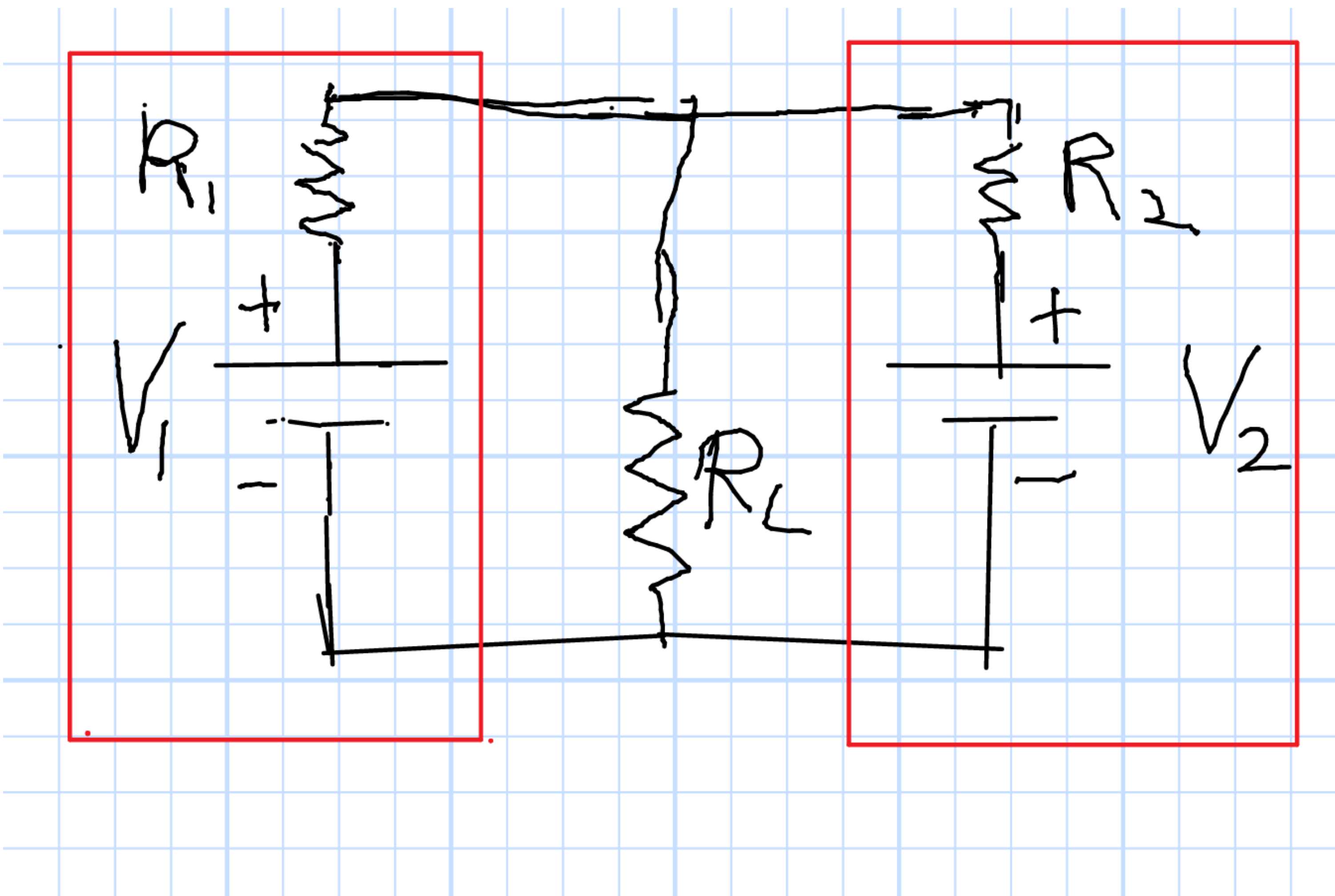
What if a 5–amp source is connected to an infinite resistance?

Contradictory Circuits



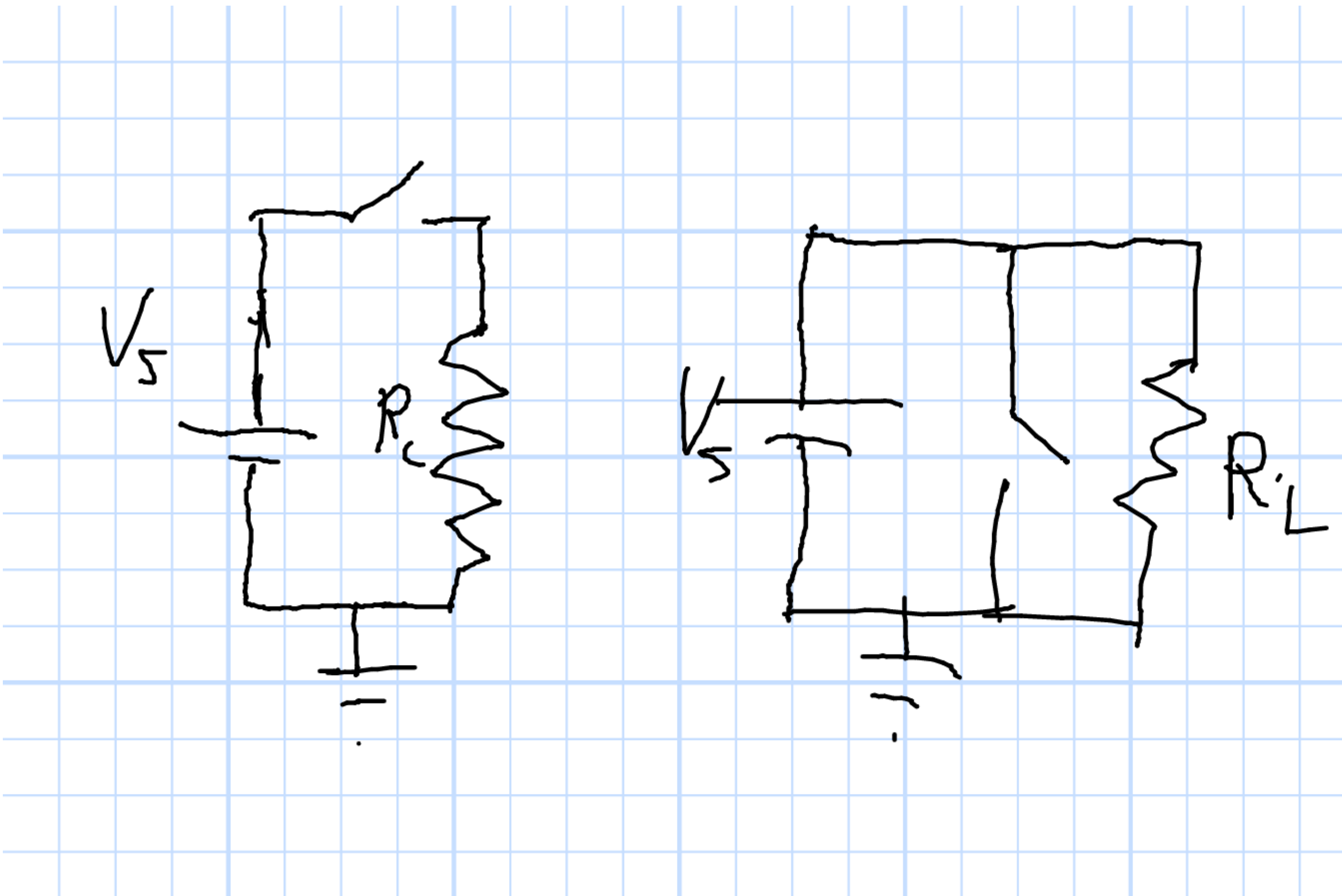
Need a Better Model

Source Resistance



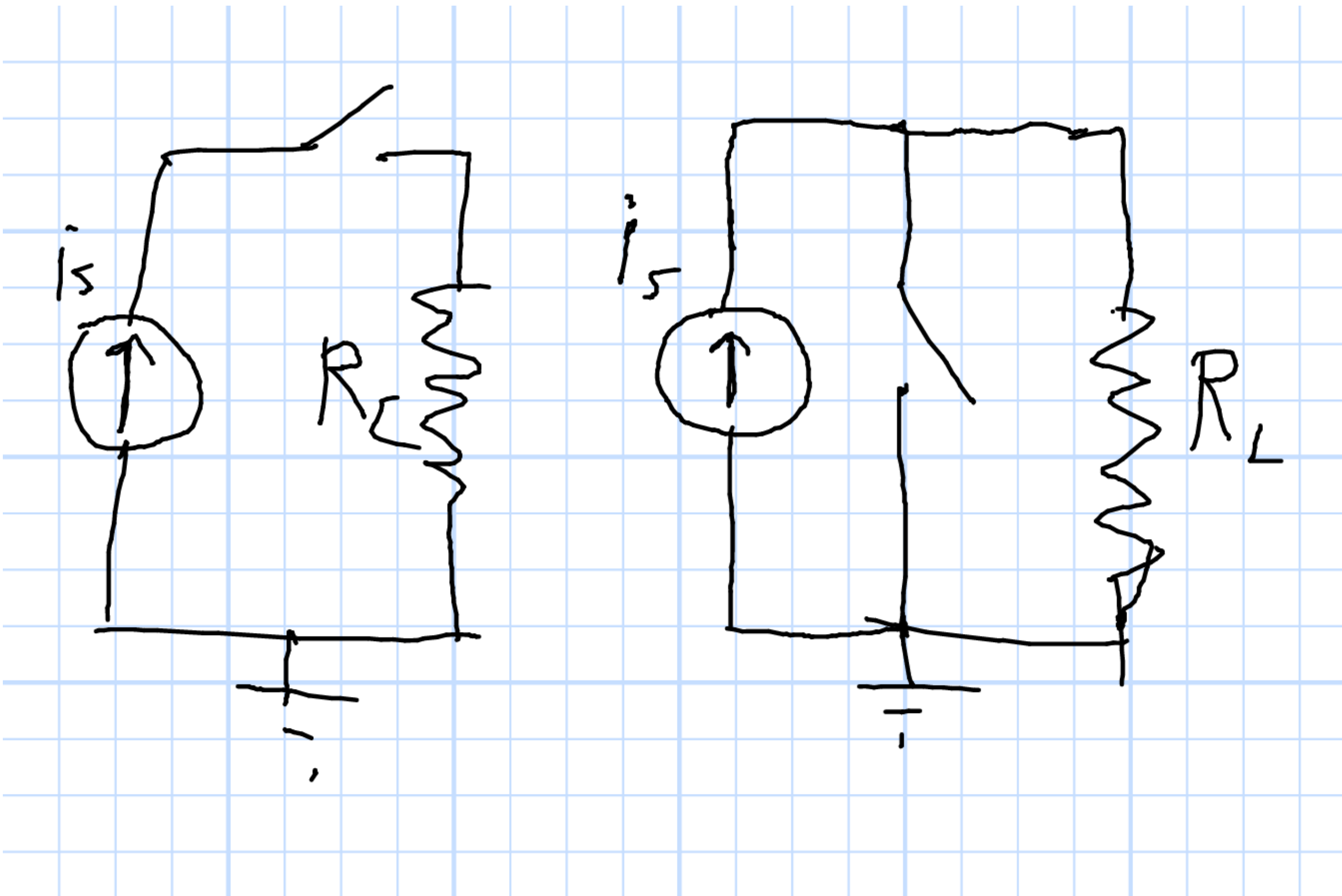
Switching Voltage

Which is Better?



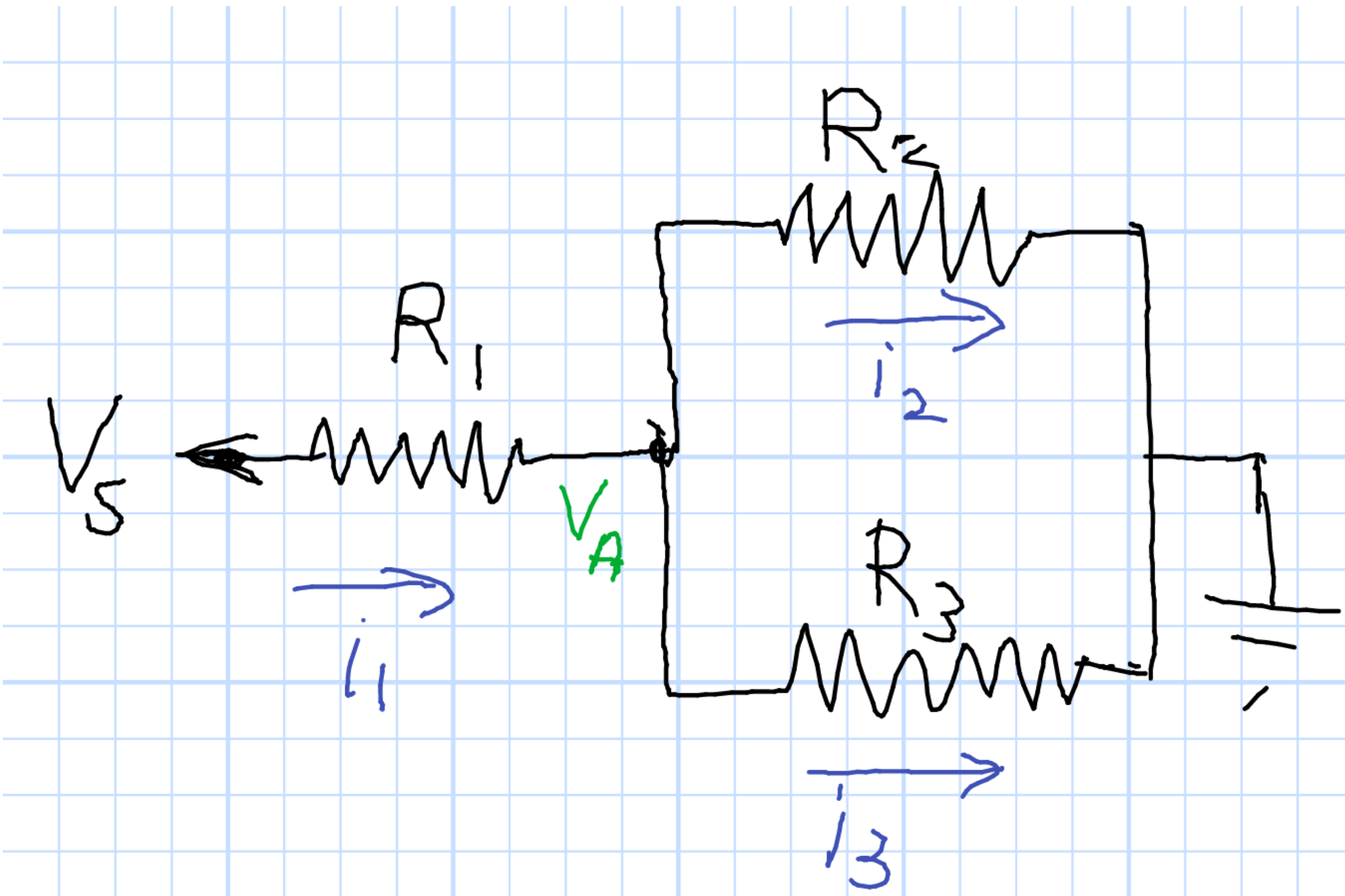
Switching Current

Which is Better?



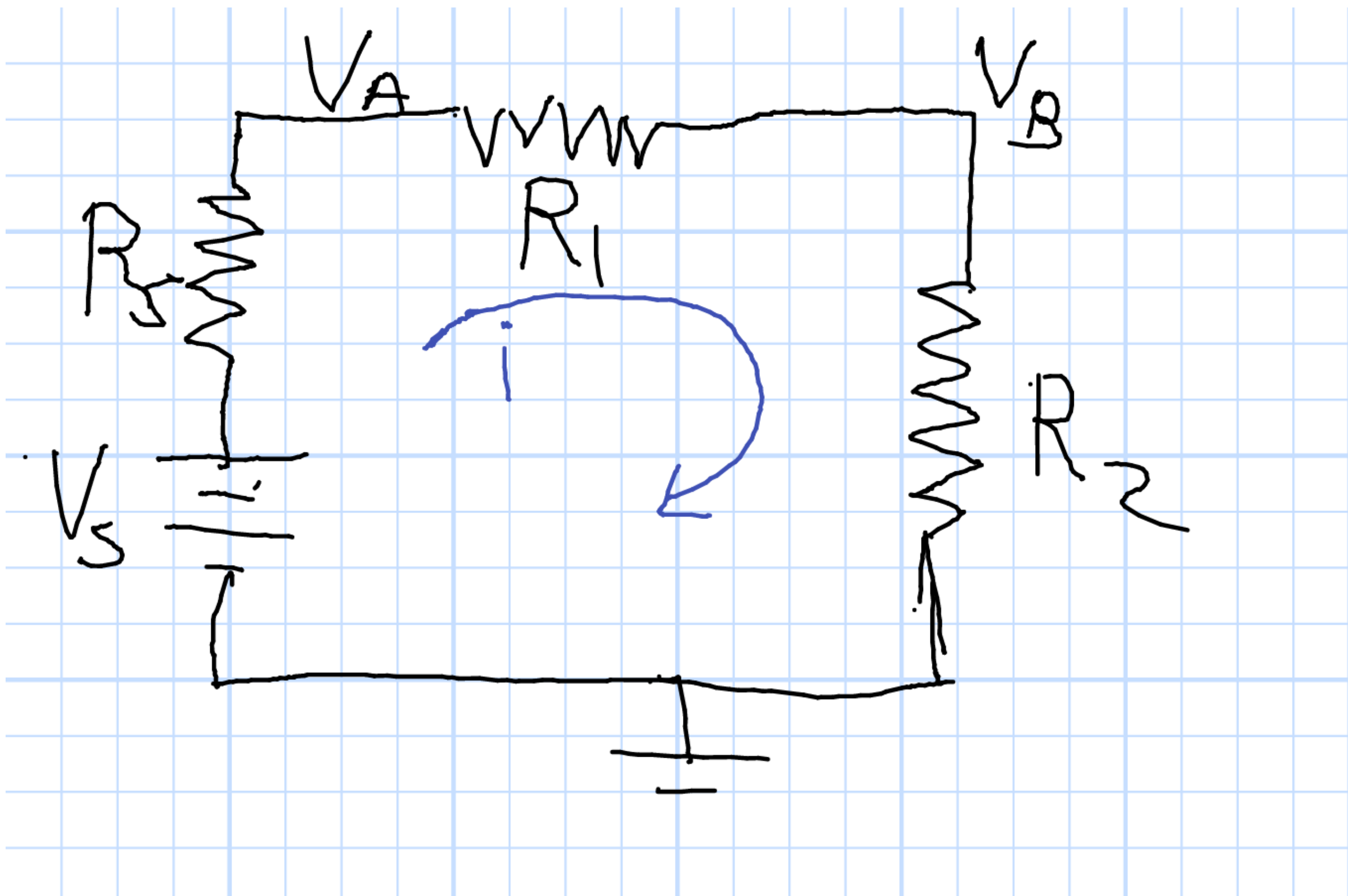
Kirchoff's Current Law

Conservation of Charge



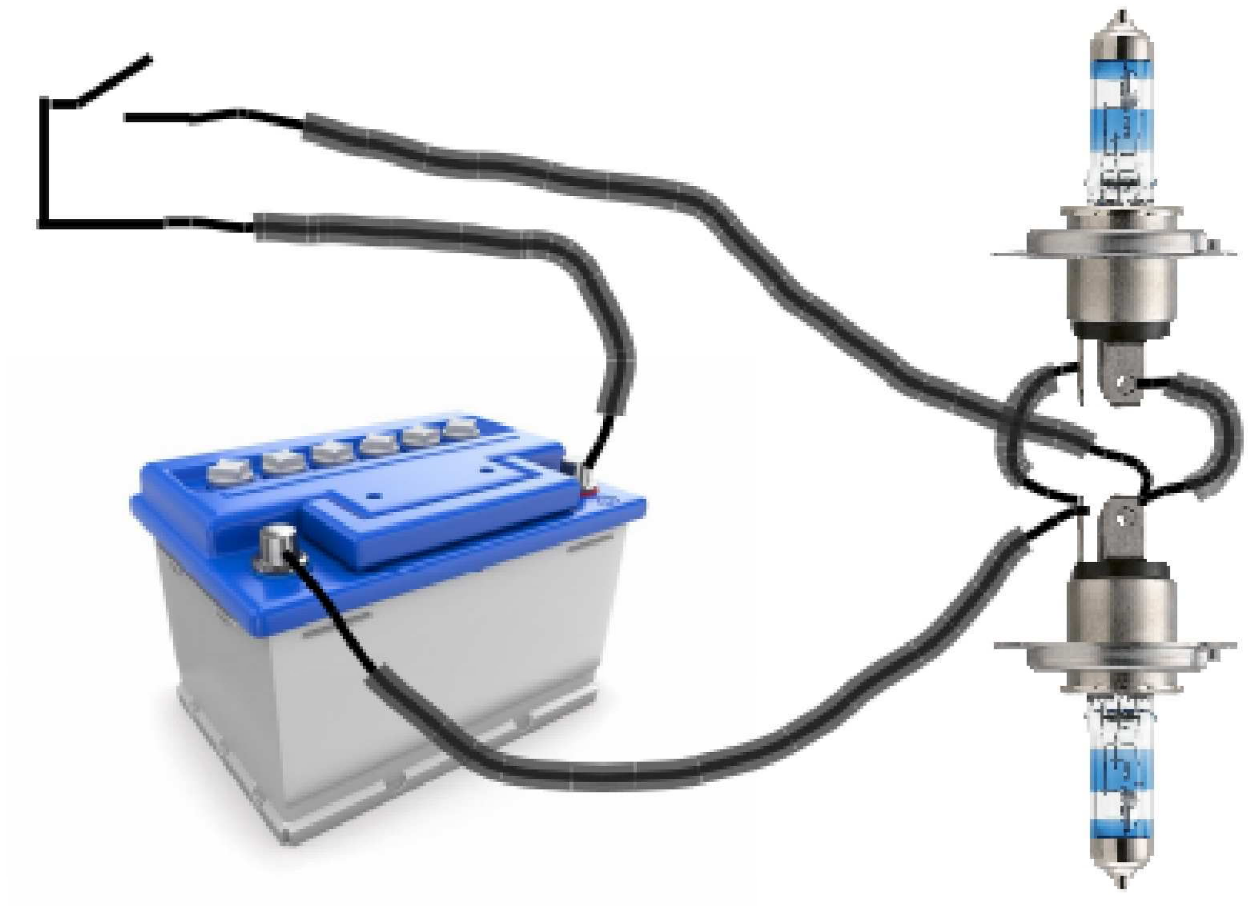
Kirchoff's Voltage Law

Conservation of Energy

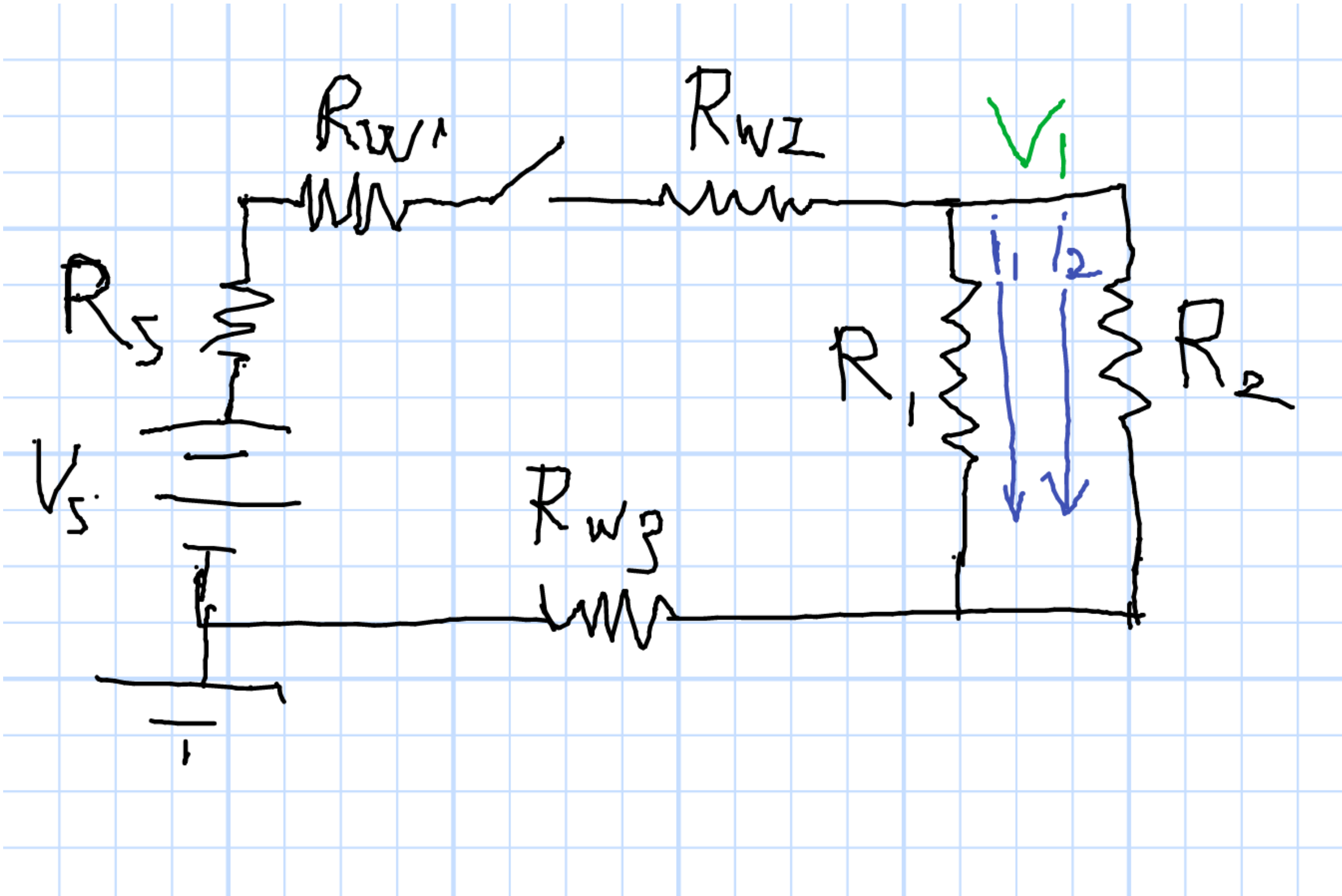


Use KCL and KVL

Draw the Circuit Using Symbols

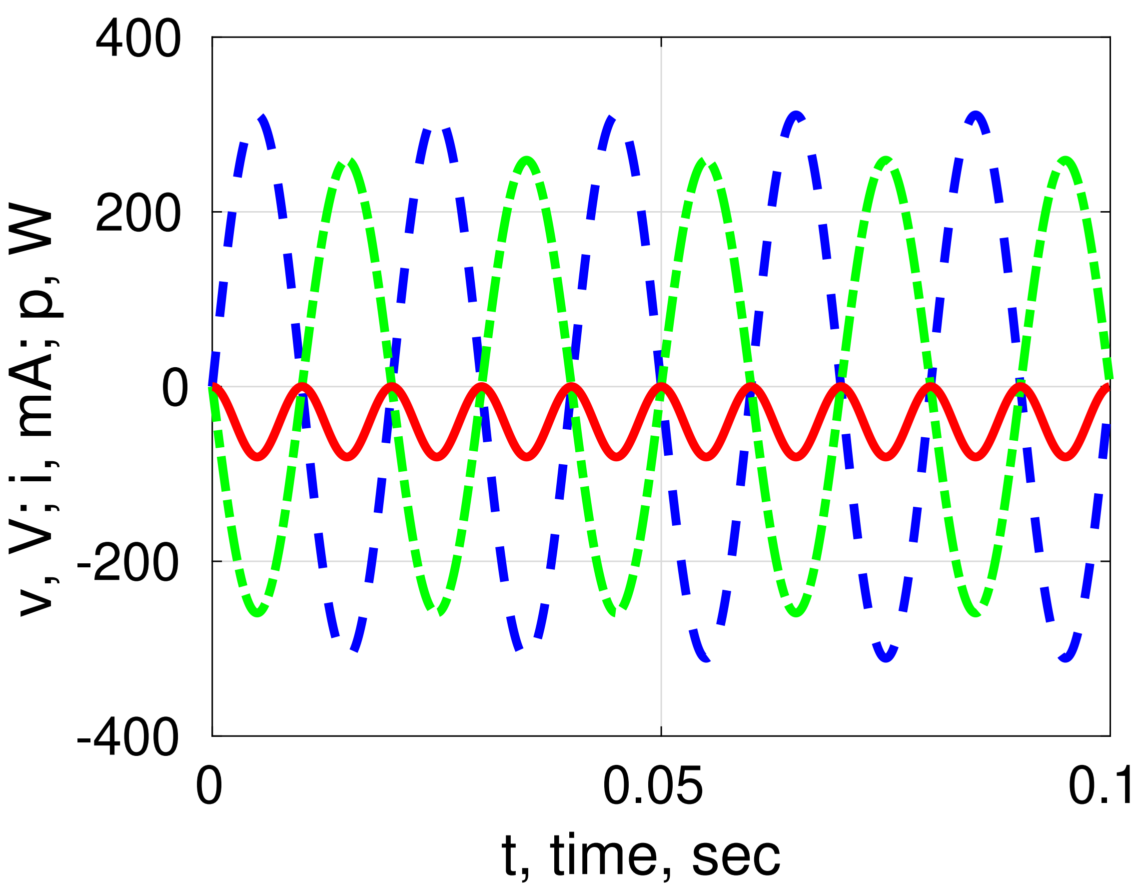


Car Headlights Circuit



Sine Waves Again

$p = iv$, Voltage in Blue, Current in Green, Power in Red
Power at Twice the Operating Frequency



Another Cup of Coffee: RMS Voltage (or Current)

$$p(t) = i(t)\,v(t) \qquad\qquad p(t) = \frac{v^2(t)}{R}$$

$$v(t) = v_0 \cos(2\pi f t) \qquad v_0 = 311\text{Volts} \qquad f = 50\text{Hz}$$

$$v^2(t) = [v_0 \cos(2\pi f t)]^2 \qquad \frac{v^2(t)}{R} = \frac{v_0^2\left[\frac{1}{2} + \frac{1}{2}\cos(4\pi f t)\right]}{R}$$

$$\bar{P} = \frac{\overline{v_0^2}}{2R} = \frac{v_{RMS}^2}{R} = 970\text{ Watts} \qquad t = 43\text{ s}$$

Comparable to the Previous Cup (1kW): See Next Slide

RMS Voltage Defined:

$$v_{RMS} = \frac{v_0}{\sqrt{2}} = \frac{v_{pp}}{2\sqrt{2}}$$

This problem was based on power in Europe or South America. How would it be different in North America?

The First Cup of Coffee

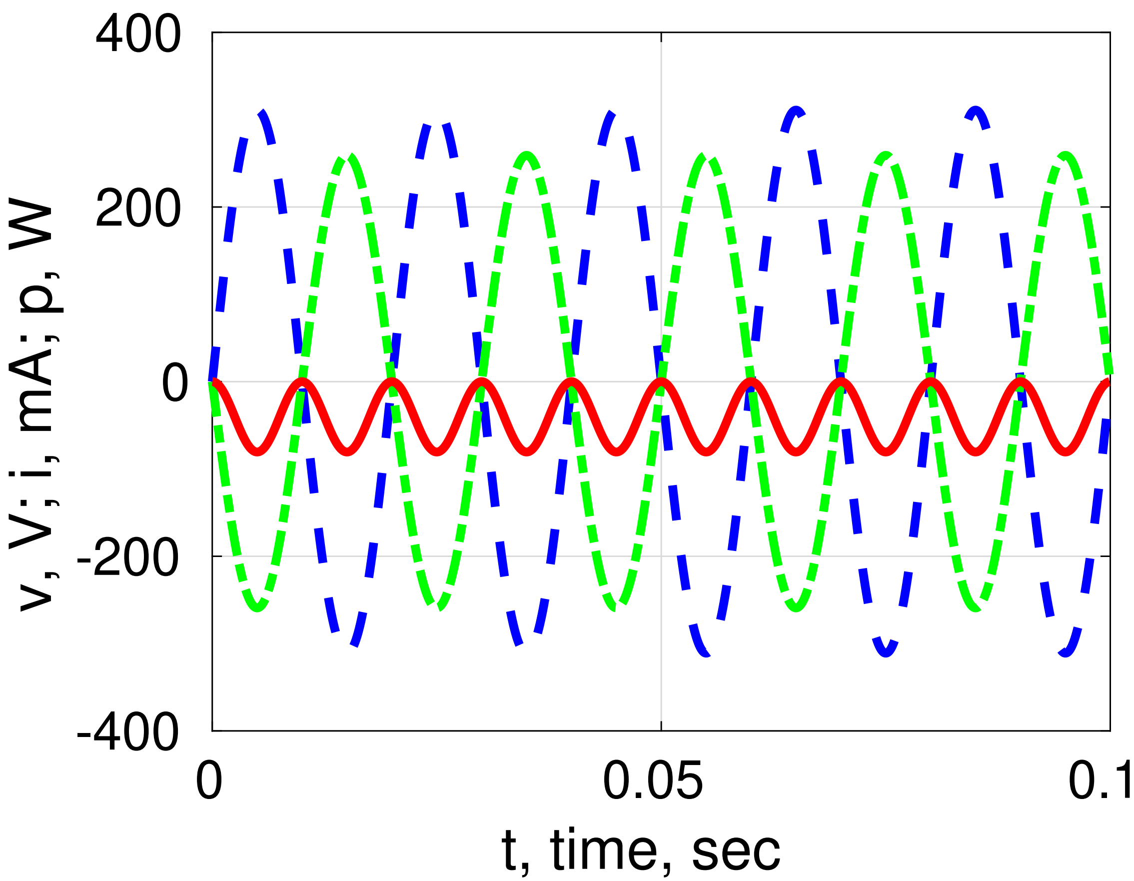
- Energy: Pt (Watts $\times$ Sec = Joules)
- Heat a Cup of Water $T_0 = 20$C to $T_1 = 60$C (250mℓ)
- Energy Required 4.18J/K/mℓ
- 1kW Heater

$$Pt = 4.18\text{J/K/m}\ell \times 250\text{m}\ell \times \Delta T$$

$$t = 42\text{s}$$

RMS Voltage

What Is the Peak–to–Peak Voltage, Zero–to–Peak, RMS



Frequency Question

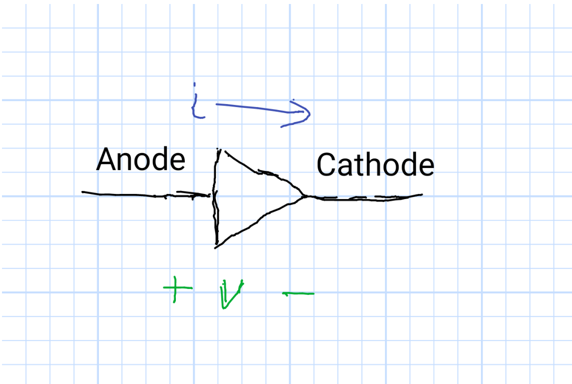
In the lab, you will build a remote control using an infrared light source and detector.

Ambient light will affect the performance of your device because it will be detected by the receiver.

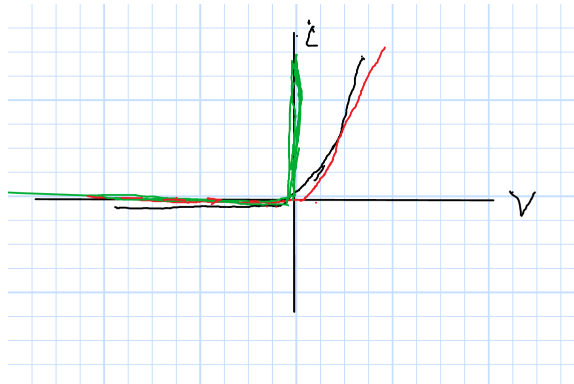
What will be the frequency of the ambient light . . .

- Outdoors?
- Indoors in the US?
- Indoors in Chile?

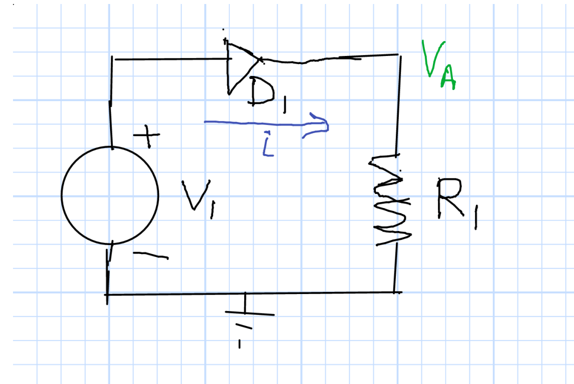
Diodes, Briefly



Diode Symbol



I–V Curves



Circuit

- Diodes are Pretty Good Conductors One Way
- Diodes are Pretty Good Insulators the Other Way
- Light Emitting Diodes Emit Light When they Conduct
- They are Nonlinear
- There are Several Piecewise–Linear Approximations
- The Details Can Get Messy