Electrical Engineering
Week 1

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EECE–2210
Northeastern University

Sep 2021

Week 1 Agenda

- Administrivia
  - Introduction
  - Overview of the Course
  - Review of Syllabus
  - Is your Eastern US Timezone (GMT-5+1)?
  - Intro to Mastering Engineering (not for grade)
- Introduction
  - Circuits
  - Current
  - Voltage
  - Kirchoff's Current Law
  - Kirchoff's Voltage Law
  - Sine Waves

Course Components

- Lectures (Synchronously and Recorded)
- Slides (Available on the Website)
- Quizzes
- In–Class Exercises
- Homework (Mastering Engineering)
- Take–Home Exams
- Participation
- EECE2211 to be Taken Concurrently
- Office Hours on Zoom or in 302ST

Me

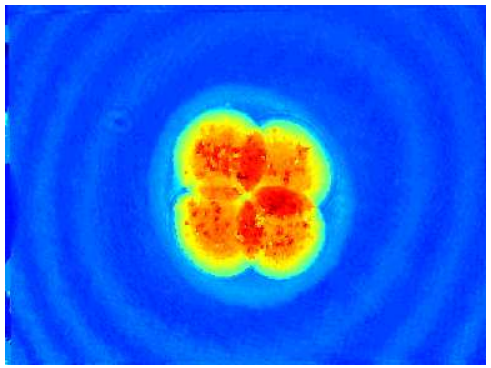
- Education
  - 1969: BS in Engineering Physics, University of Maine
  - 1973: MS in Physics, WPI
  - 1996: Ph.D. in Electrical Engineering, Northeastern
- Employment
  - 1973 — 1987: Raytheon Company (Laser Radar)
  - 1983 — 1987: Northeastern (Part–Time Lecturer)
  - 1987 — 2000: Northeastern (Research Scientist)
  - 2000 — Present: Northeastern ECE Faculty (MIE/BioE)
  - 2014 — 2020: Topical Editor for *Optics Letters*
  - 2014 — 2016: Associate Chair of ECE
- Home: Cambridge, with my Wife, Sheila
- Family: 2 Children, 3 Grandchildren
- Home Ski Area: Killington, Vermont

Personal History

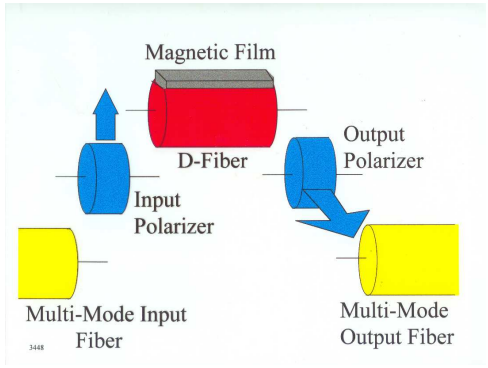
- Raytheon (Jelalian)
  - Aircraft Wake LIDAR
  - Airborne LIDAR
- Northeastern University
  - LIDAR
  - MOKE Sensors
  - Landmine Detection
  - Hyperspectral Imaging (Biomed)
  - Light and Sound
  - Optical Quadrature
  - Multi-Modal Microscopy

Severe Storms

Coal–Dust Lidar



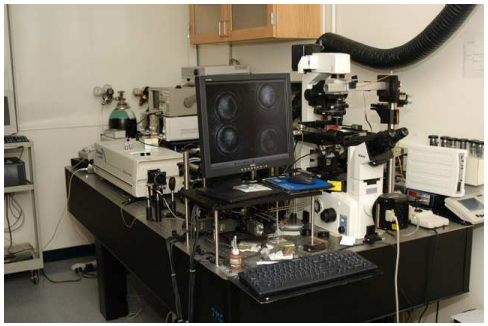
Cell Counting



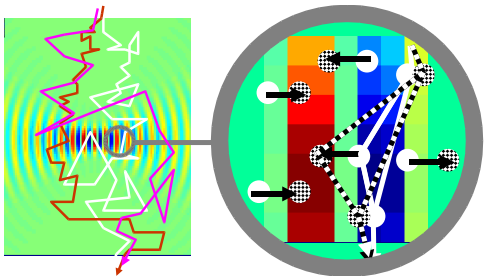
Magnetic Sensor

Our Current Research

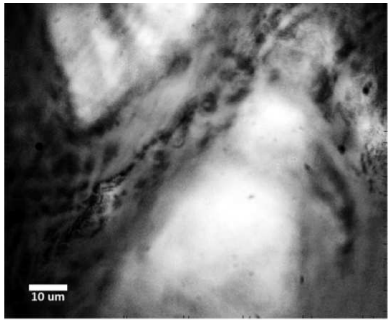
- Multi–Modal Microscopy
- Light and Sound
- Structured Illumination
- Collagen Orientation
- Stepwise 3–Photon Fluorescence in Melanin
- Lidar (Laser Radar)



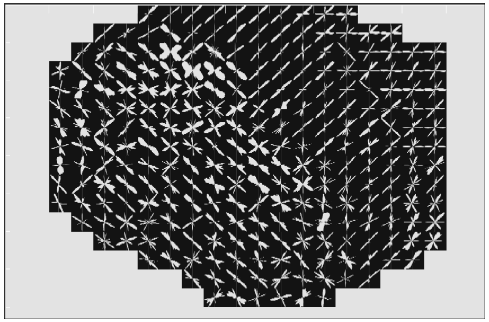
Multi–Modal



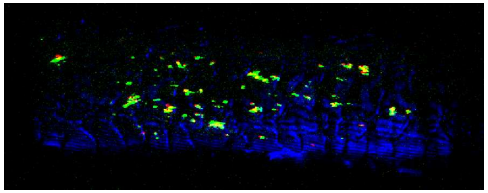
Light and Sound



SIM



Collagen



Melanin

Lidar

Engineers at Play

Teaching Team

- Prof. DiMarzio
- Course Assistant
  - Susmitha Bumadi
- Lab Teaching Assistants
  - Gabriel Giribaldi
  - Mahsa Azizi
  - Antea Risso

What is Electrical Engineering

- Moving Electrons
  - Moving Energy
  - Moving Information
- Sub–Disciplines
  - Power
  - Communication
  - Control (Sensor and Actuators and All in Between)
  - Computers (Including Embedded Ones)
  - Circuits and Electronics (RLC, Diodes, Transistors, Chips, more)
  - Electromagnetics, Optics (Photonics)

Why Electrical Engineering?

- Sensors (Position, Speed, Pressure, Strain, more)
- Actuators (Translation, Rotation, etc.)
- Control Systems and Computers

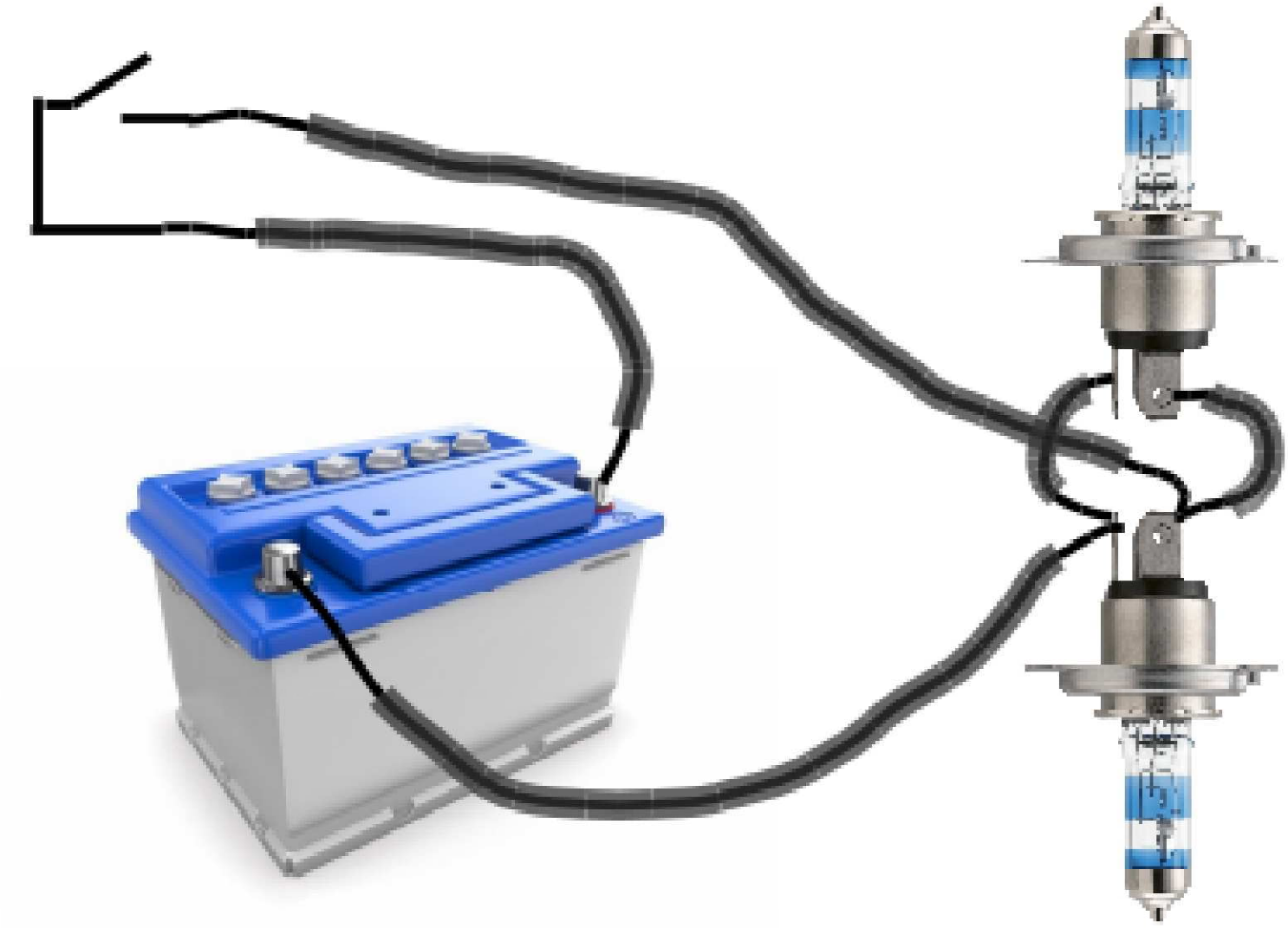
The Syllabus

See Website

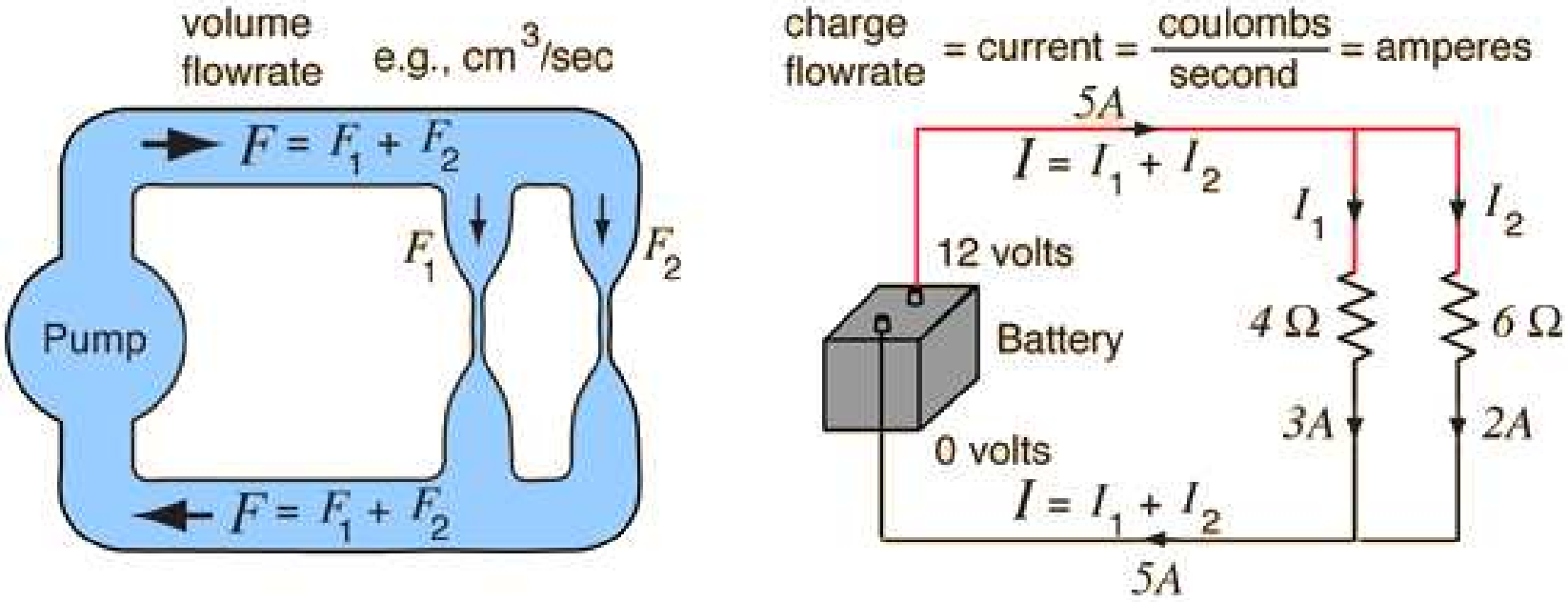
Circuits

- Wires
- Insulators
- Components
  - Power Sources
  - Switches
  - Resistors
  - Capacitors
  - Inductors
  - Other

Circuit Example



Fluid–Flow Analogy



http://hyperphysics.phy-astr.gsu.edu/hbase/electric/imgele/curlaw3.gif

Current

Current is moving charge

$$q(t) = \int_{t0}^{t} i(t)\, dt + q(t_0)$$

$$i(t) = \frac{dq(t)}{dt}$$

Electrons have negative charge

$$q_e = -1.6 \times 10^{-19}$$

Direction of electron motion is opposite current direction. This is an unfortunate decision made by Benjamin Franklin.

Voltage

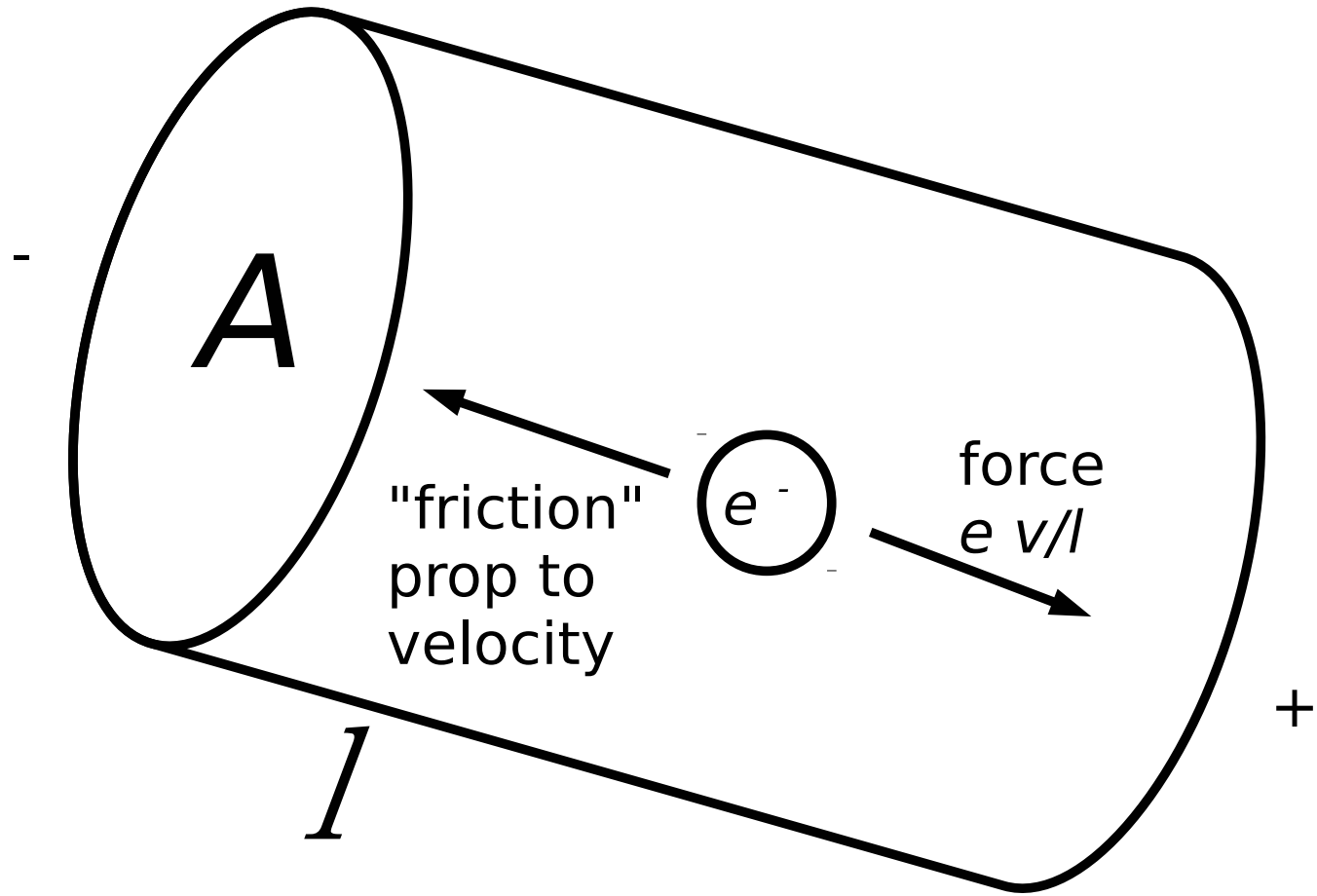
High Voltage, High Energy

Energy Difference $\Delta w = e\Delta v$ where
$e = 1.6 \times 10^{-19}$ Coulombs
Charge times Voltage = Energy
Alternative Energy Unit: Electron Volt
$1\text{eV} = 1.6 \times 10^{-19}$Joules

Low Voltage, Low Energy

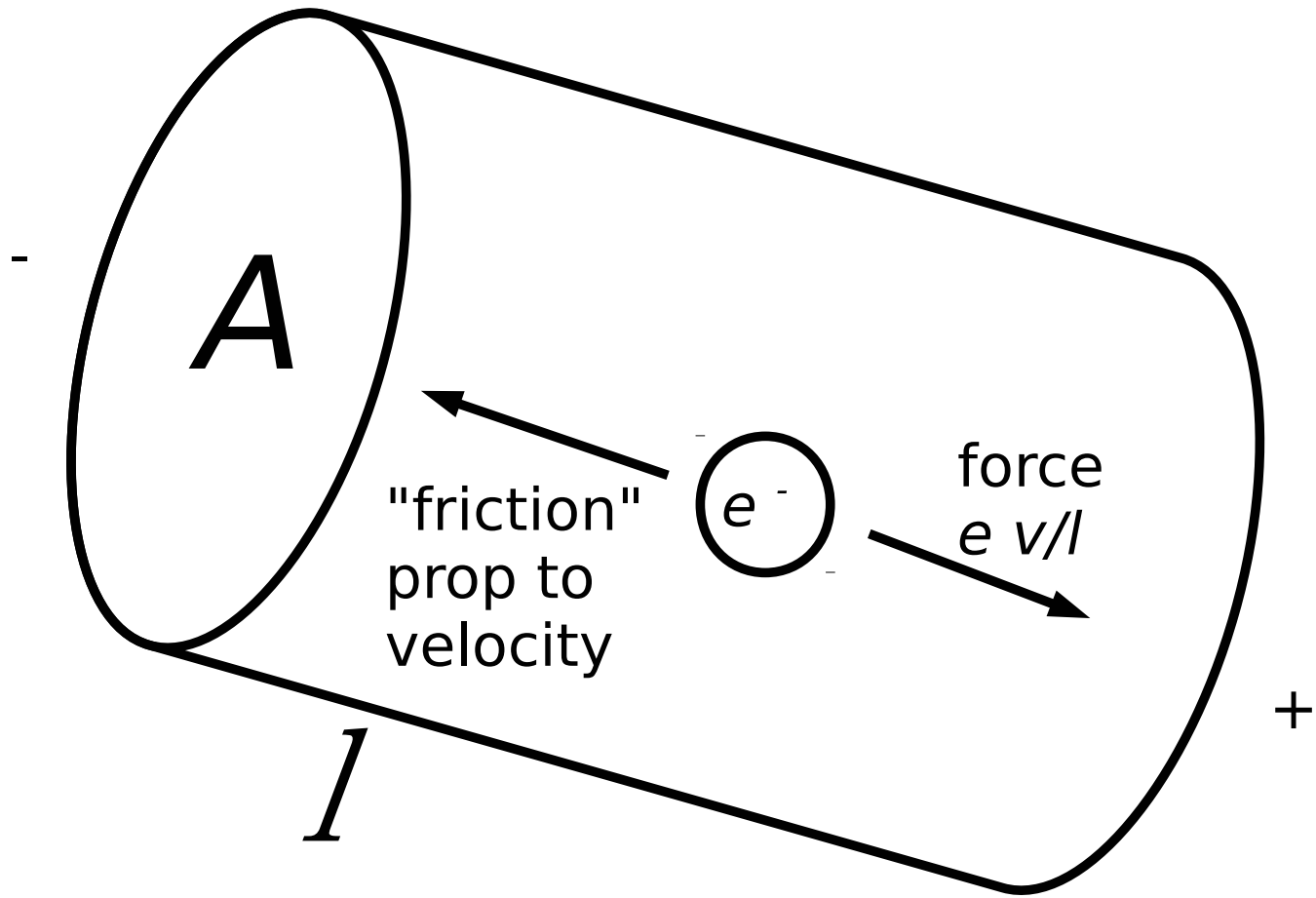
Electron Motion and Resistance

$f = \frac{v}{l}e$, Collisions cause "friction," $\frac{i}{A} = \frac{v}{l}\mu_n n e$



Voltage Measures Energy

$$\text{Energy Change} = -\left(v_+ - v_-\right) e$$



Electrons as Quanta of Charge

- $N = \frac{it}{e}$: Why do we care about the number of electrons?

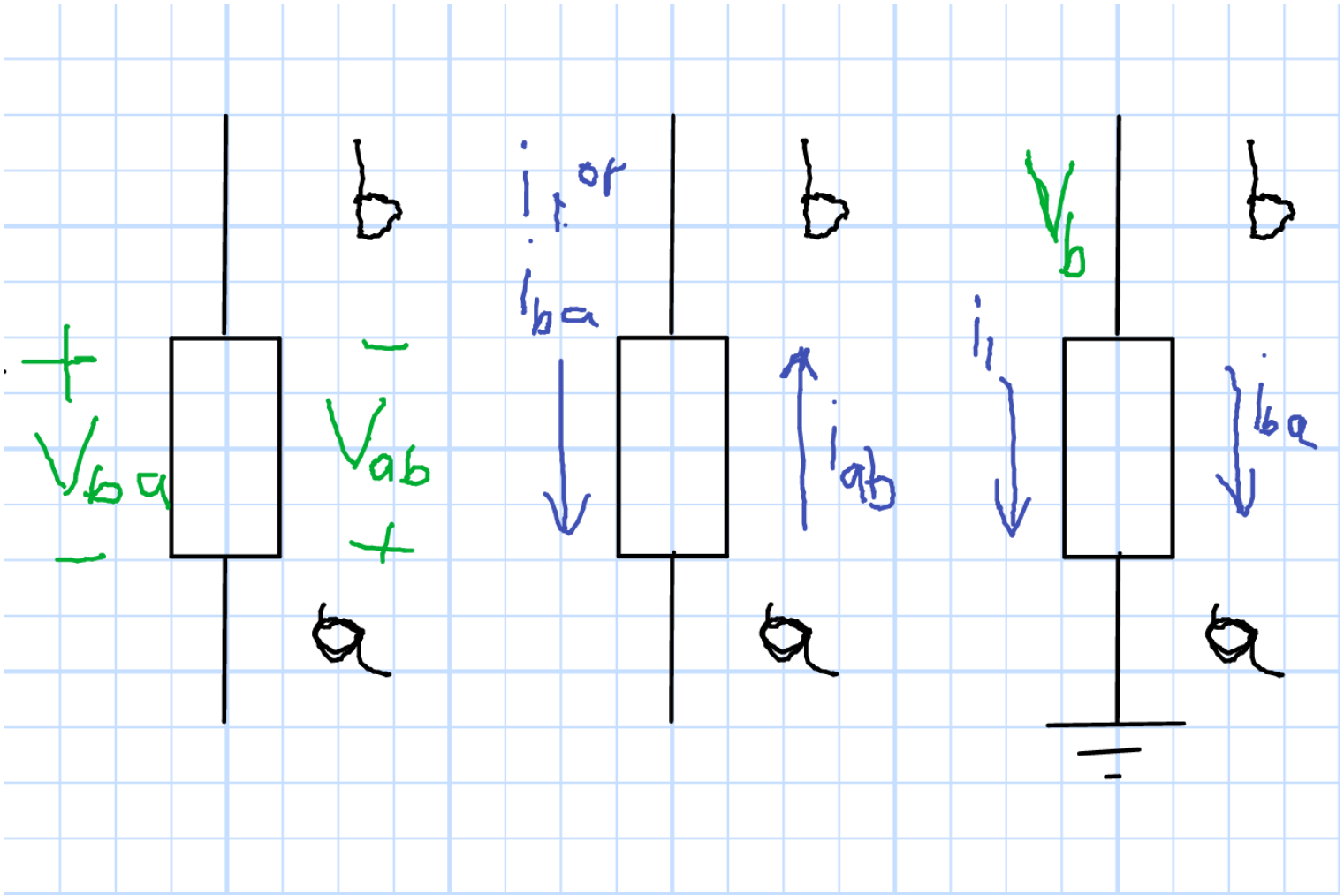
- Noise!
  - Number: $N = \frac{it}{e}$
  - Poisson Distribution: $\sigma_N = \sqrt{N}$
  - $\sigma_i = \frac{e\sigma_N}{t}$

$$\sigma_i = \frac{e}{t}\sqrt{\frac{it}{e}} = \sqrt{i\frac{e}{t}}$$

Proximity Sensor (e.g. Lidar)

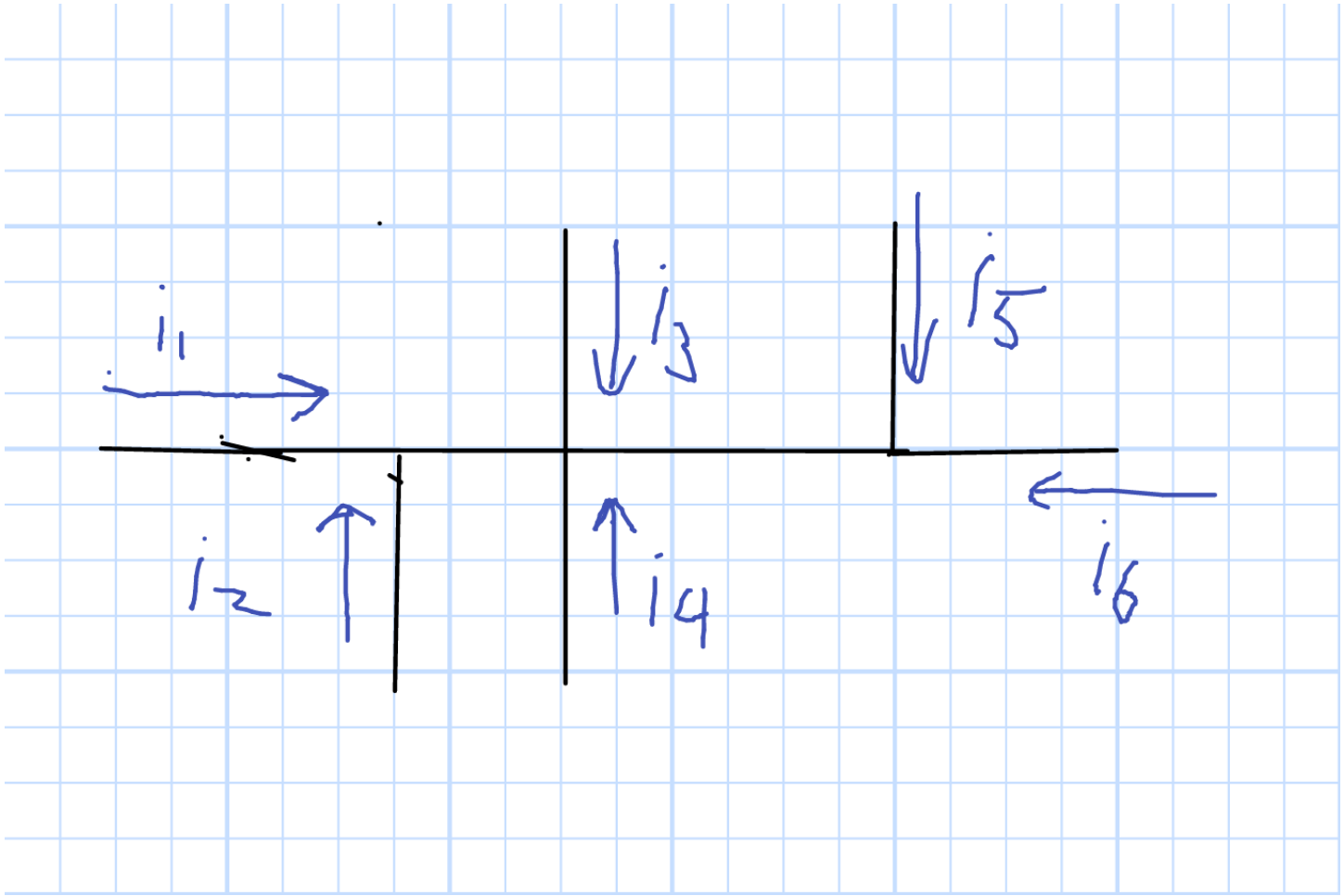
An optical proximity sensor generates a current of 1 nanoampere at a distance of 1 meter. At this distance, what is the signal–to–noise ratio at this distance? At 10 meters?

Current and Voltage Notation



Kirchoff's Current Law (KCL)

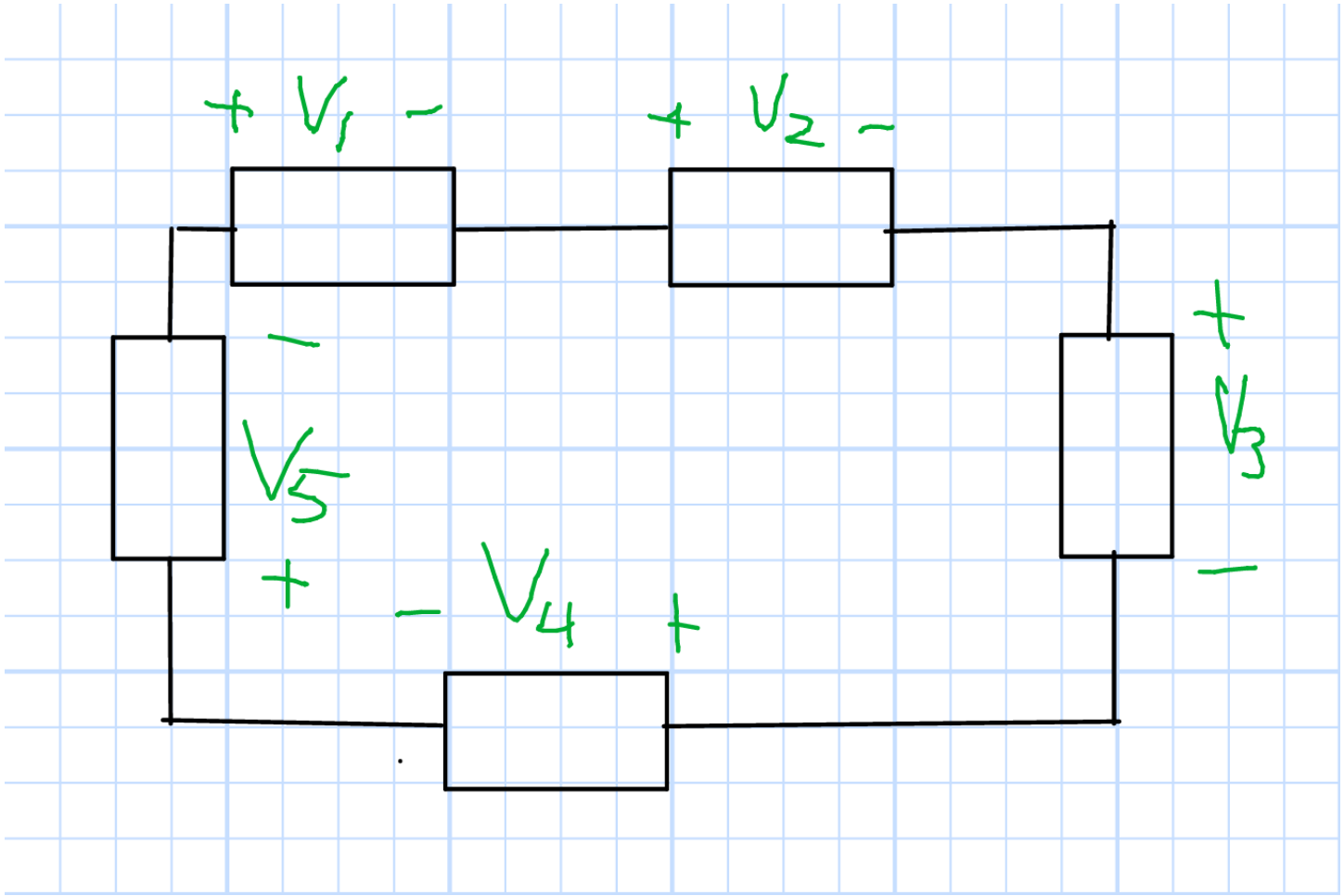
Conservation of Electrons $\sum i_n = 0$



Kirchoff's Voltage Law (KVL)

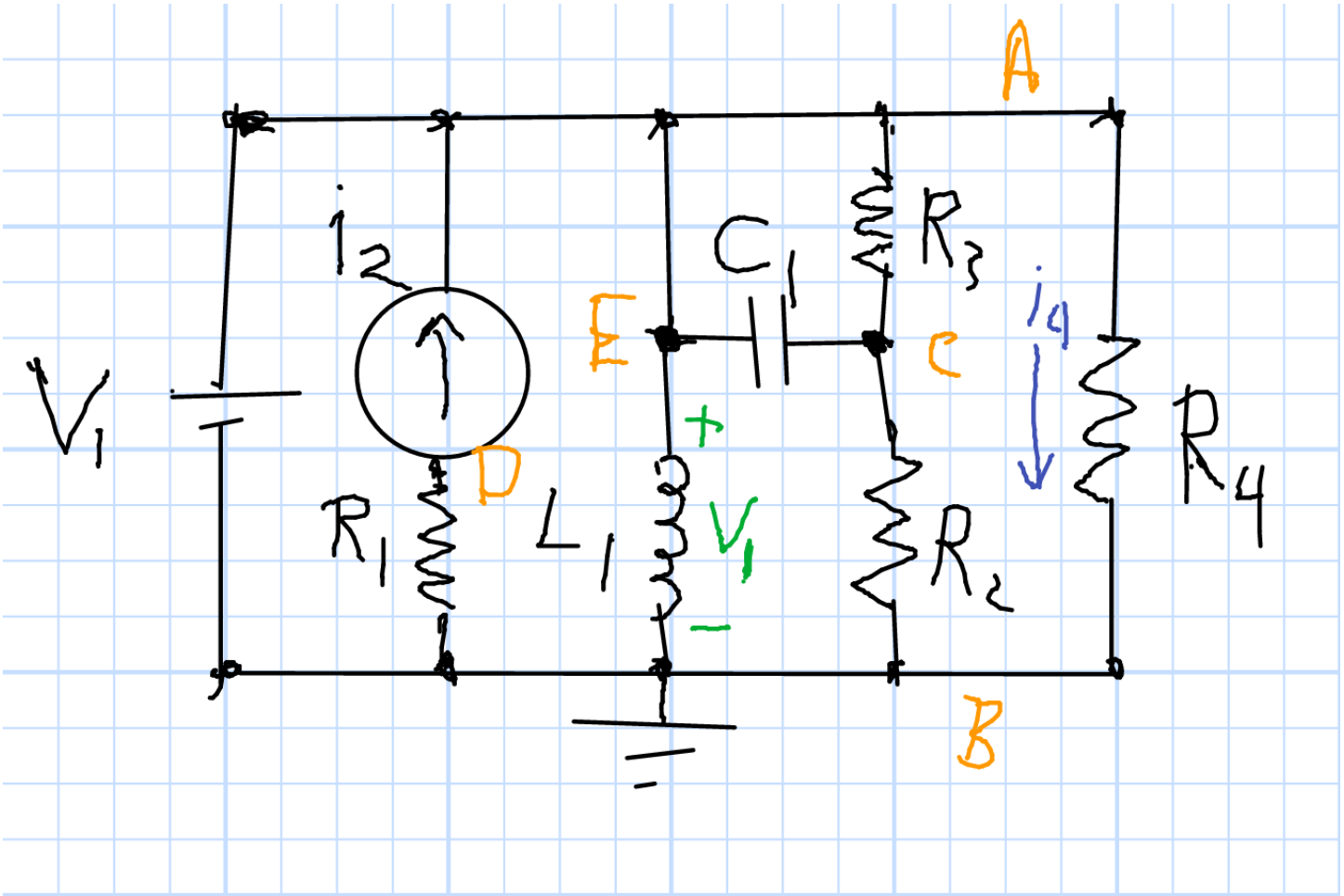
Conservation of Energy

$$\sum v_n = 0$$

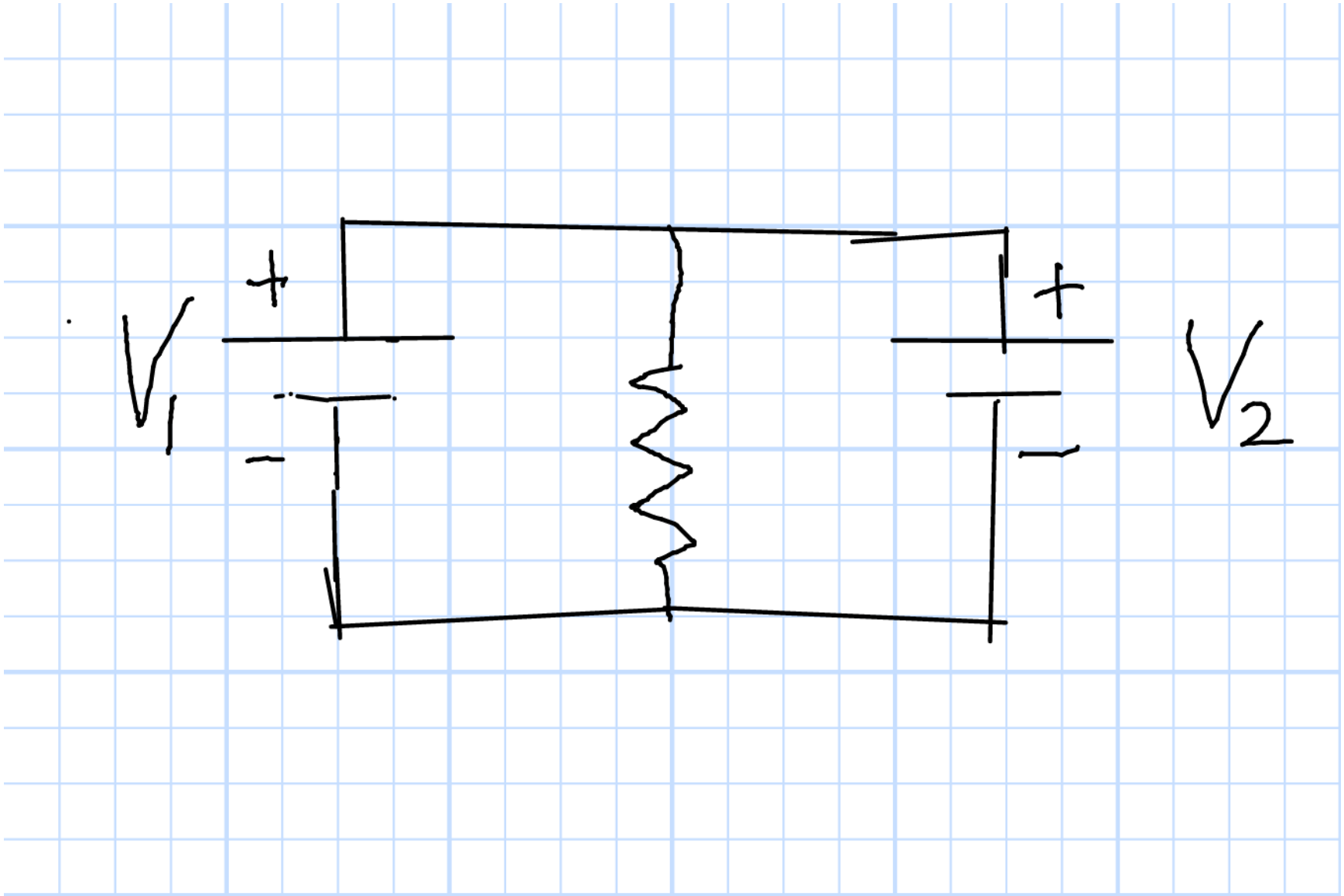


Nodes and Loops

Where are the Nodes and Loops?

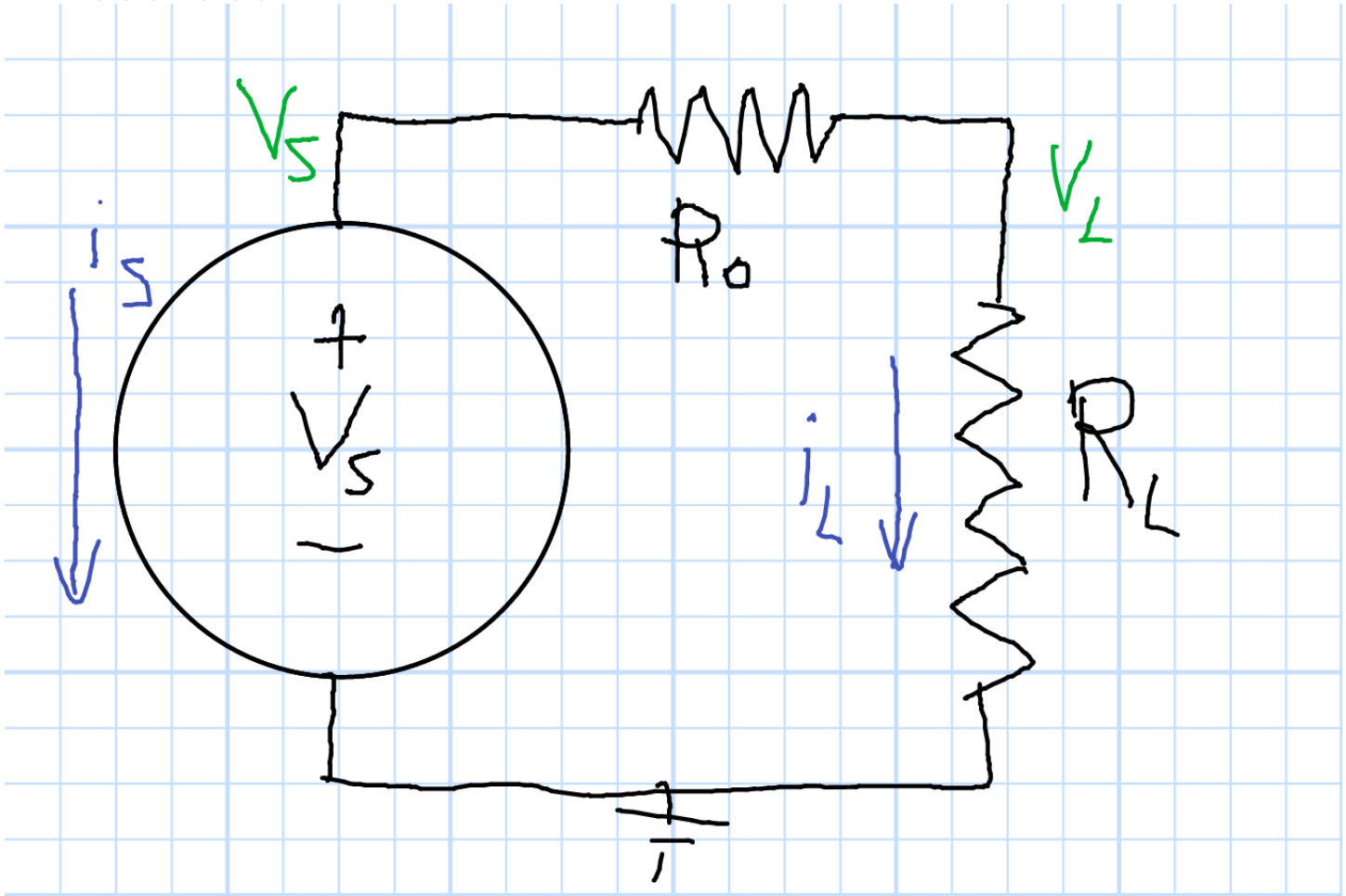


Contradictory Circuits



Sign Conventions

Power Absorbed $P = iv$



A Cup of Coffee

- Energy: Pt (1000 Watts $\times$?Sec $=$ Joules)

- Heat a Cup of Water $T_0 = 20$C to $T_1 = 60$C (250mℓ)

Time–Variation

- DC = Direct Current: No Time Variation (Only Conceptual)
- Steady State
- Transients
- Pulses
- Pulse Trains
- Sinusiods
- More Complicated Time Variation

Sine Waves

$p = iv$, Voltage in Blue, Current in Green, Power in Red
Questions: What is the average power in each case?
Hint: The first one is really easy.