

6.200 Circuits and Electronics

Week 0 Recitation: The Lumped-element Abstraction

Grab handout on table on the side of the room by the doors
(participation sheet and, optionally, an STS advert)
Sit anywhere with a circuit/meter!

Course web site: <https://circuits.mit.edu>

Please sign up for recitation/lab sections **by 8pm today!**

Course Staff

Instructors:

- Adam Hartz
- Harry Lee

TAs:

- Timmy Bui
- Ed Chen
- Kat Jander
- Fatema Zaman

and lots of LAs!

Classroom Expectations

No laptops in recitation or lecture.

Take notes and review them later.

Try to ask (and answer) questions.

Participation: bring a pen/pencil!

First-week Logistics

Week 0 problem set will be out later today through the web site.

Due Monday night at 10pm, **except** for “pre-lab” assignment due before lab this Friday.

Please review course information and schedule at <https://circuits.mit.edu>
(please plan travel, interviews, etc., around exams)

First lab (and nanoquiz!) tomorrow/Friday.

We'll make section assignments either tonight or early tomorrow.

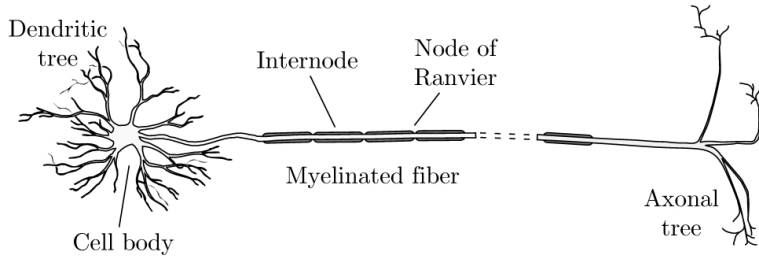
The Power of Circuits

Circuits are useful and important for (at least) two very different reasons:

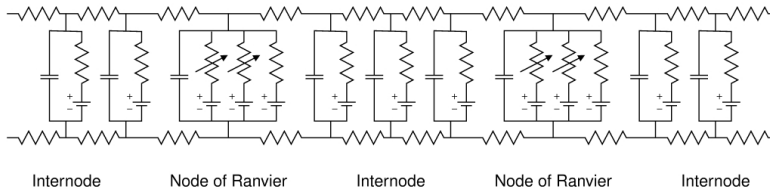
- as **models** of complex systems, e.g.,
 - biological models
 - thermodynamic models
 - fluid models
- as **physical systems**, e.g.,
 - power (generation, transmission, conversion, etc)
 - electronics (computers, etc)
 - communication and filtering (cell phones, audio processing, etc)
 - sensors (sonars, glucose sensors, etc)

Also, they're fun :)

The Power of Circuits

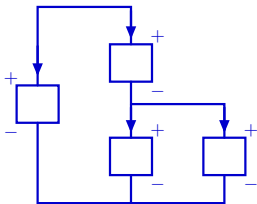


Model of myelinated nerve fiber



The Lumped-element Abstraction

In 6.200, we will model systems as networks of interconnected idealized components connected by ideal conductors. Each component has a *current* flowing through it and a *voltage* that develops across it. Our idealized components are described by the constraints they impose on their respective currents and voltages.

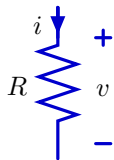


Terminology:

- Node: a set of points connected only by wires
- Branch: a connection between nodes (by way of a component)
- Loop: a closed path through branches

Primitive Components

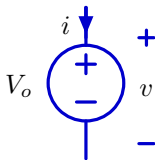
For the first few weeks of 6.200, we'll focus on a small number of types of components:



Resistor

Parameter: R (Ω)

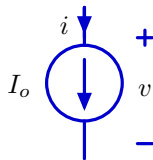
$$v = iR$$



Voltage Source

Parameter: V_o (Volts, V)

$$v = V_o$$



Current Source

Parameter: I_o (Amps, A)

$$i = I_o$$

Combining Components

The constitutive equations describe how each component individually constrains its current and voltage, but when combining them, we have some additional constraints:

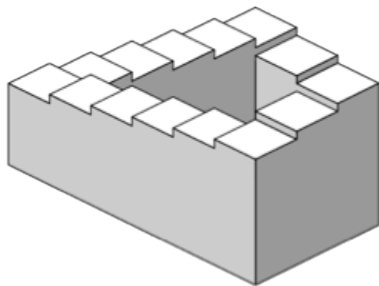
- Kirchhoff's Voltage Law
- Kirchhoff's Current Law

These are idealized rules in the lumped-element model!

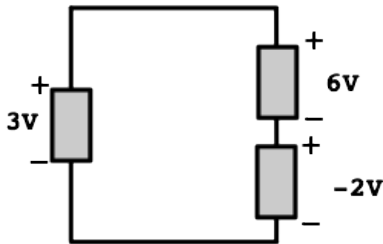
Combining Components: KVL

KVL: The sum of the voltages around any closed loop in a circuit is 0.

Impossible Things



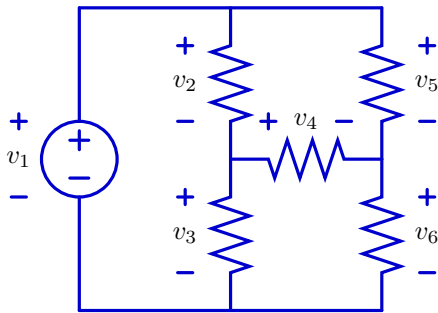
Penrose Staircase



$$3V - 6V - -2V \neq 0V$$

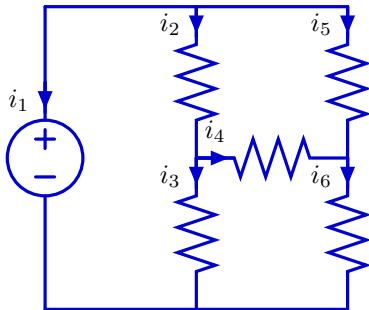
Combining Components: KVL

KVL: The sum of the voltages around any closed loop in a circuit is 0.



Combining Components: KCL

KCL: The total current flowing into any node must equal the total current flowing out of that node.



Check yourself: What Are We Losing?

What kinds of assumptions are we making when moving from Maxwell's equations to the lumped-element model?

What kinds of details are we ignoring?

Putting It Together: “Brute-force” Method

1. Assign each branch a voltage and current variable (arbitrarily but following associated signs convention)
2. Write equations:
 - B constitutive equations
 - $N - 1$ KCL equations
 - $B - N + 1$ KVL equations
3. Solve

