6.200 Circuits and Electronics

Week 0 Lecture A:
The Lumped-element Abstraction

Course web site: `https://circuits.mit.edu`
Please sign up for recitation/lab sections **by 5pm today**!

Grab handout by the door (participation sheet).

Course Staff

Instructors:

- Sam Coday
- Adam Hartz
- Jeff Lang

TAs:

- Mozi Guobadia
- Sruthi Parthasarathi
- Lydia Patterson

and lots of LAs!

Classroom Expectations

No laptops.

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.

Some problem sets have a hardware component (including problem set 0).
Please pick up a kit (and multimeter) at recitation tomorrow **and don't lose it!**

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

First lab (and nanoquiz!) on Friday.
We'll do section assignments tomorrow afternoon and let you know sometime that evening.

The Power of Circuits

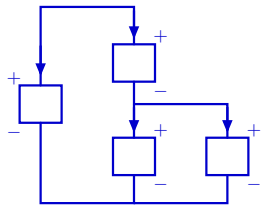
Circuits are useful and important for (at least) two very different reasons:

- 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 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.

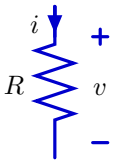


Terminology:

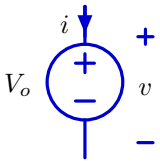
- Node: a set of points connected only by wires
- Branch: a connection between nodes (by way of a component)
- Loop: a closed path through branches

Primitive Components

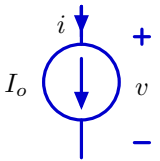
For the first few weeks of 6.200, we'll focus on a small number of types of components:



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

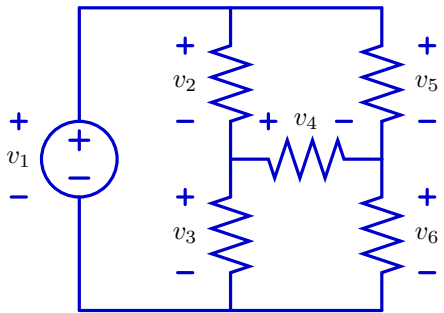
The constitutive equations describe how each component individually constrains its current and voltage, but when combining them, we have some additional constraints:

- Kirchoff's Voltage Law
- Kirchoff's Current Law

These are idealized rules in the lumped-element model!

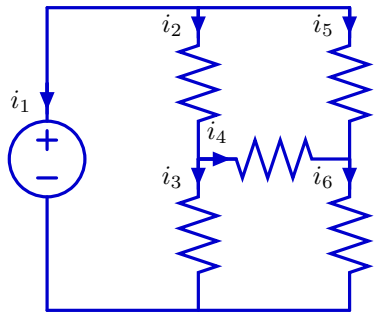
Combining Components: KVL

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



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