Welcome to 6.200!

https://circuits.mit.edu

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STAFF

Lecturer	Prof. Jeffrey Lang
Lab Instructor	Adam Hartz
Recitation Instructor	Prof. Samantha Coday
Recitation Instructor	Prof. Farnaz Niroui
Teaching Assistant	Aklilu Aron
Teaching Assistant	Jade Sund
Lab Assistants	Too Many To List
Demo Wizard	David Otten

TODAY

- Basic information concerning 6.200 “mechanics”
- What is 6.200 about?
- Why take 6.200?
- Lumped-element modeling
- One-port electronic devices and *i*-*v* characteristics
- Network/circuit assembly and analysis overview
- Electronic circuit analogies

SCHEDULED EVENTS

- Lectures: TR at 11-12 in 3-270
- Recitations: W at 11-12, 12-1 and 1-2 in 26-210
- Labs: F at 10-1 and 2-5 in 38-530 (southwest corner)
- TA Office Hours: MT at 7:00-10:00 PM inside 38-530
- Instructor Office Hours: TBA
- Evening Quizzes: 7:30-9:30 PM on Wednesdays 3/13 and 4/24 in 50-340 (Walker)
- Final Exam: scheduled by the Registrar

ASSIGNMENTS

- Homework:
  - out Wednesdays via the 6.200 website
  - due the following Wednesday
  - answered and graded via the 6.200 website
- Prelabs:
  - out every week along with homework via the 6.200 website
  - due before the Friday lab two days later
- Labs: 3 hours every Friday
- Evening Quizzes: 7:30-9:30 PM on 3/13 and 4/24 in 50-340 (Walker)
- Final Exam: scheduled by the Registrar
- Grading details, lateness policy and collaboration policy are on the 6.002 website

RESOURCES

- Textbook: *Foundations of Analog and Digital Circuits*, Agarwal and Lang, Elsevier
- Textbook on reserve in Barker Library
- HKN tutoring program via https://hkn.mit.edu
- TA office hours Monday and Tuesday evenings 7:00-10:00 PM
- 6.200 staff
- Staff emails: 6.200-help@mit.edu and 6.200-personal@mit.edu

PLEASE DO SOON

- Before the first lab, take EHS Electrical Safety Awareness – Course EHS00509 at https://web.mit.edu/training/my_training.html

- Sign the undergrad lab safety sheet acknowledgement form at https://eecs-ug.scripts.mit.edu:444/safety/index.py/6.200

- To change or select a recitation, see the 6.200 website

- To select a lab time, see the 6.200 website

6.002 IS ALL ABOUT …

- Electronic devices and circuits:

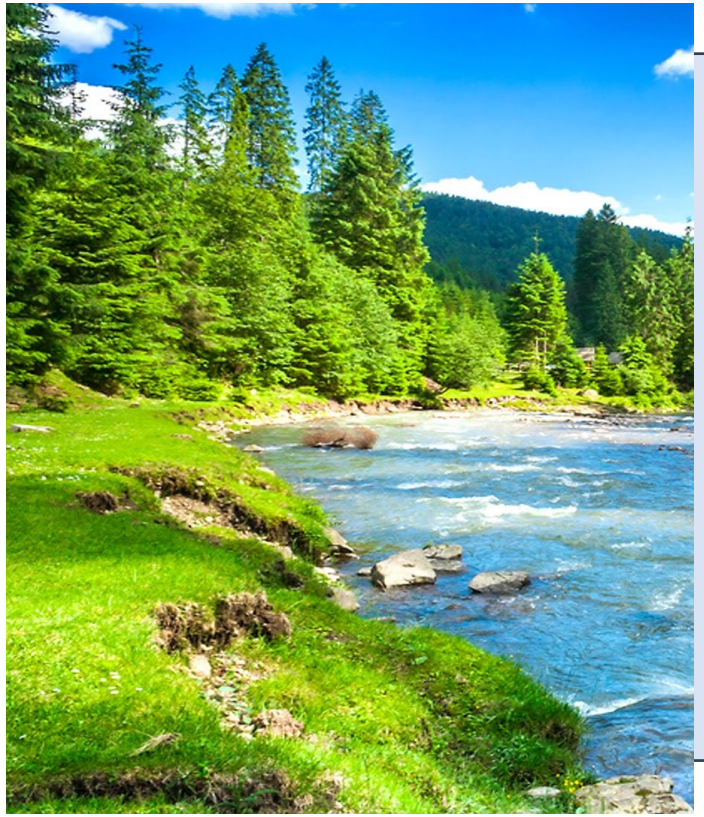
  Modeling → What makes a good model? How does abstraction fit in?
  Analysis → What does "it" do and how/why does "it" work?
  Design → What is a good design and how is one found?
  Applications → (Analog) Signal processing and signal electronics
  Energy processing and power electronics
  Interfacing to the "real (analog) world"
  Lab Experience → Making electronics real … and learning by doing

- Managing complexity:

  Physical complexity … individual complexity
  Dimensional complexity … group complexity

- A purposeful use of math
- A powerful language for lumped-parameter analysis and design
- Practical (theoretical and experimental) skills for UROP, internships, education, research …

6.200

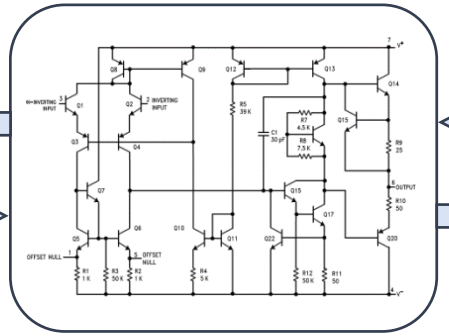


Continuous Values
Continuous Time
- Analog -

Transducers

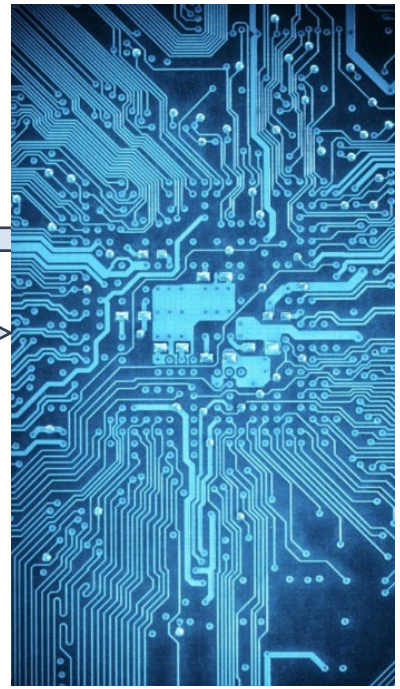
Actuators

Sensors



Analog
Electronics

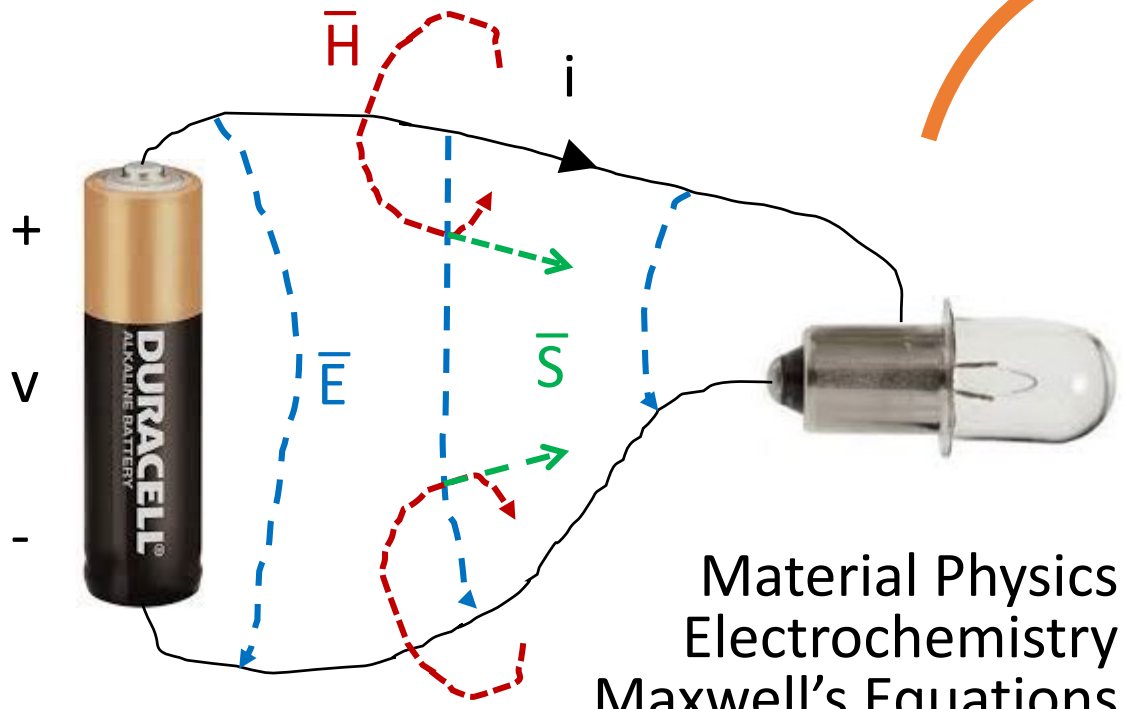
Digital
Electronics



Discrete Values
Discrete Time
- Digital -

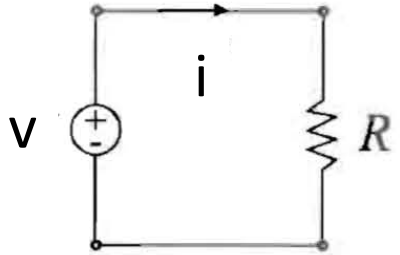
HOW TO ANALYZE A FLASHLIGHT?

Lumped-Parameter Abstraction



Material Physics
Electrochemistry
Maxwell's Equations

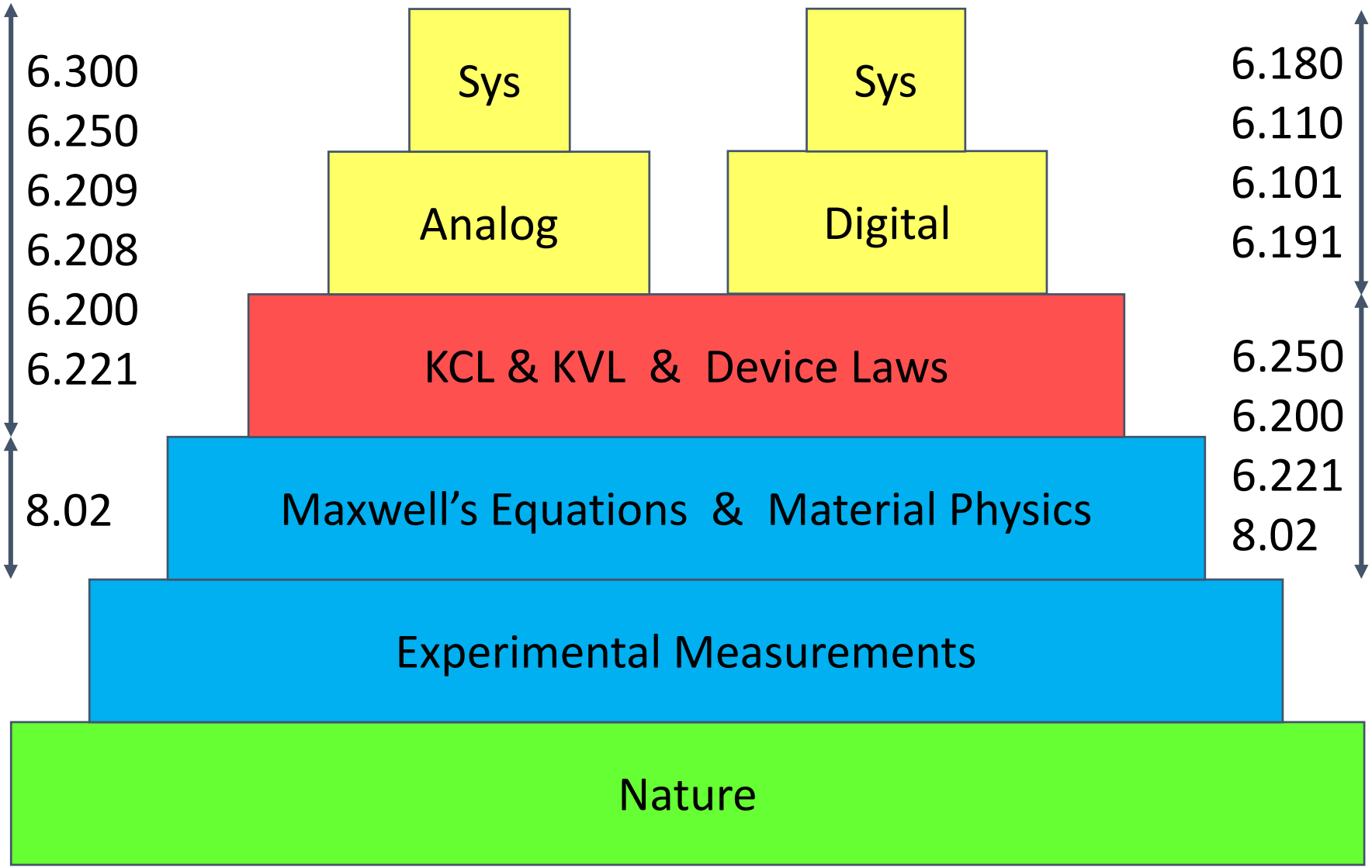
Lumped-Parameter Analysis



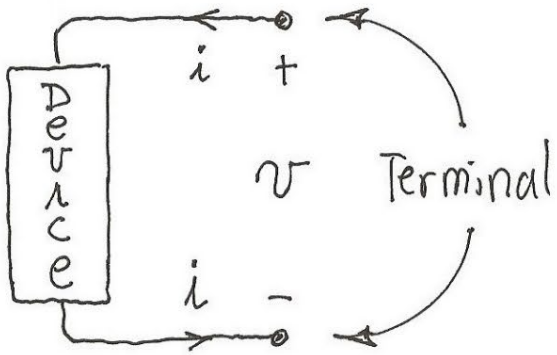
$v = i R$

$p = v i$

SCIENCE/ENGINEERING (CIRCUITS) HIERARCHY



ELECTRONIC DEVICES

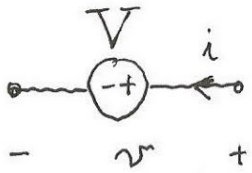


$$i = f_i(v)$$

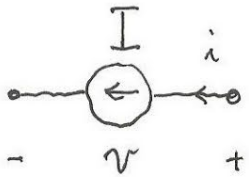
$$v = f_v(i)$$

Power In $= vi$

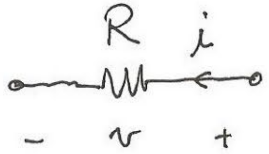
Voltage Source

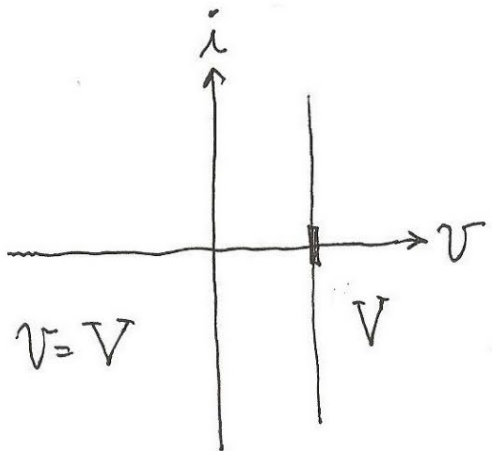


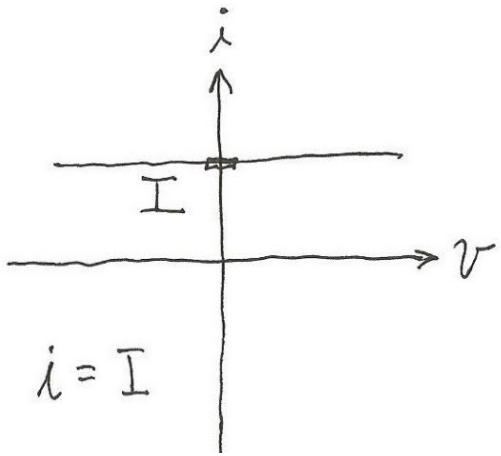
Current Source

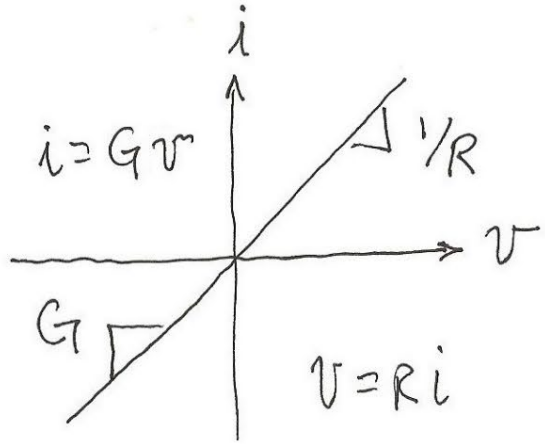


(Linear) Resistor

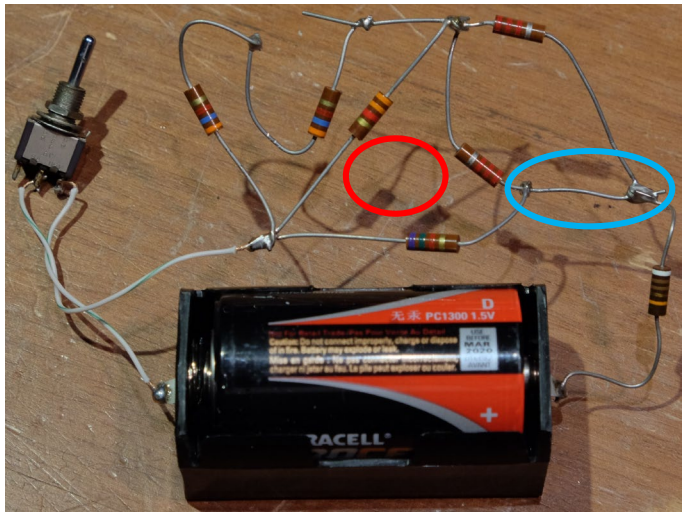


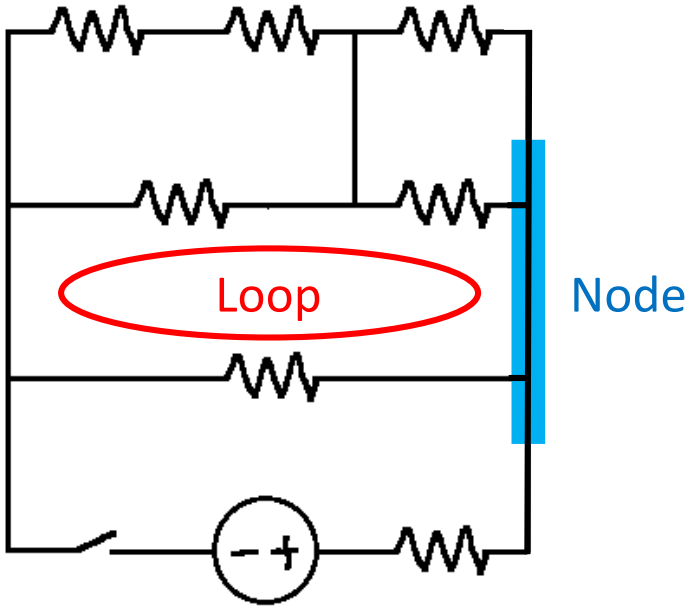






ASEMBLING & ANALYZING ELECTRONIC NETWORKS/CIRCUITS





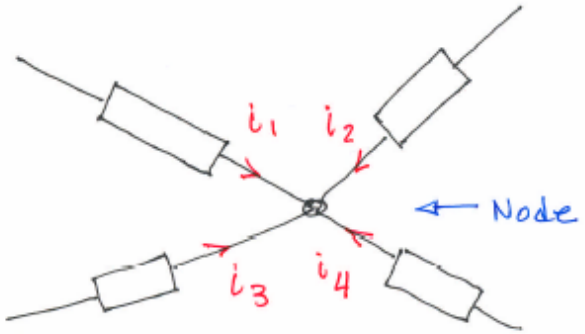
- Circuit assembly → connecting devices together at their terminals (soldering, twisting, protoboarding).
- Circuit assembly creates nodes and loops.
- Circuit assembly constrains device operation via Kirchhoff's current (KCL) and voltage (KVL) laws.
- Circuit analysis → determining all device voltages and currents, and then interpreting the voltages and currents in terms of functionality.
- Circuit voltages and currents are important; they are associated with information and power.

KIRCHHOFF'S CURRENT LAW (KCL)

$$\sum \left[\text{Branch Currents Into A Node} \right] = 0$$

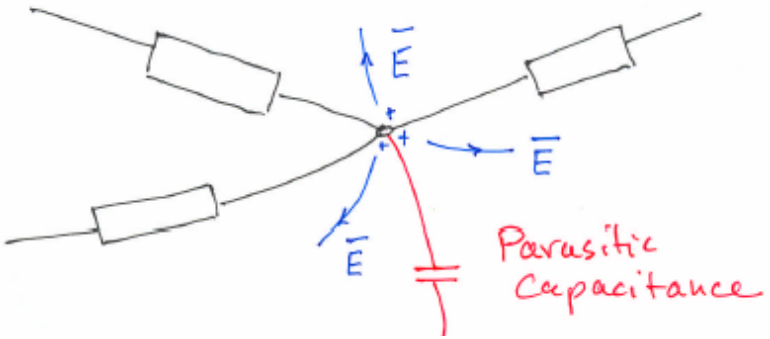
Charge Conservation

Branches At A Node



KCL

$$i_1 + i_2 + i_3 + i_4 = 0$$

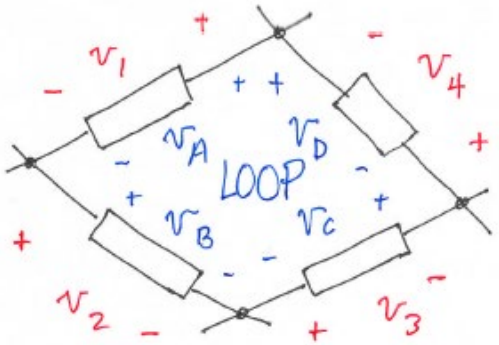


KIRCHHOFF'S VOLTAGE LAW (KVL)

$$\sum \left[\text{Branch Voltages} \right] = 0$$

Energy Conservation

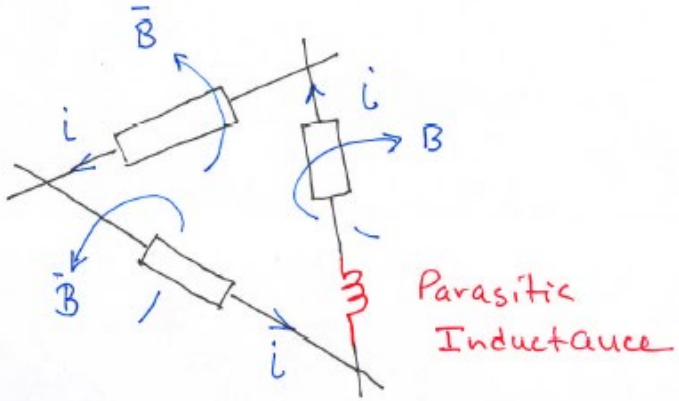
Branches Around A Loop



KVL

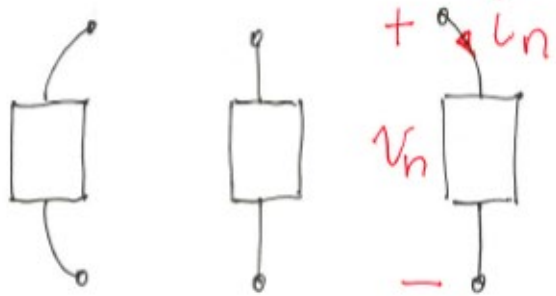
$$v_1 + v_2 + v_3 + v_4 = 0$$

$$v_A + v_B = v_C + v_D$$



CIRCUIT ANALYSIS

Circuit analysis involves the combination of device laws and connection laws.

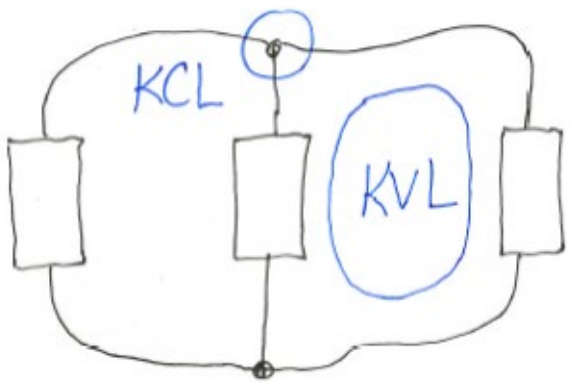


Device Laws

$i_n = f_{i_n}(v_n)$

$v_n = f_{v_n}(i_n)$

Assembly ⇓

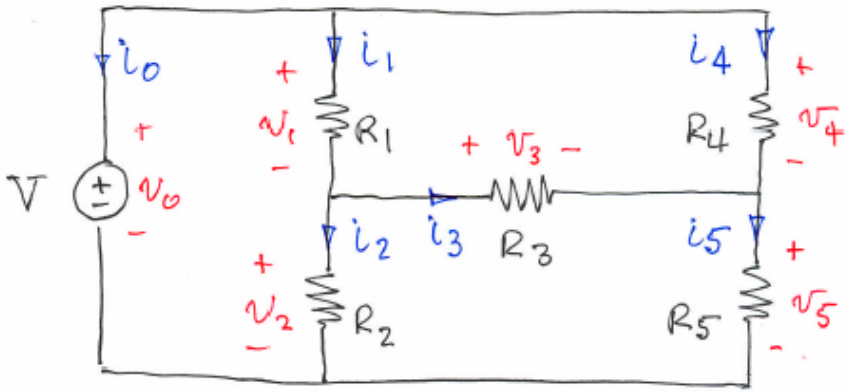


Connection Laws

KCL

KVL

CIRCUIT ANALYSIS EXAMPLE



Device Laws

$v_0 = V$

$v_1 = R_1 i_1$

$v_2 = R_2 i_2$

$v_3 = R_3 i_3$

$v_4 = R_4 i_4$

$v_5 = R_5 i_5$

KCL

$i_0 + i_1 + i_4 = 0$

$-i_1 + i_2 + i_3 = 0$

$-i_3 - i_4 + i_5 = 0$

$-i_0 - i_2 - i_5 = 0$ Redundant

KVL

$v_0 = v_1 + v_2$

$v_1 + v_3 = v_4$

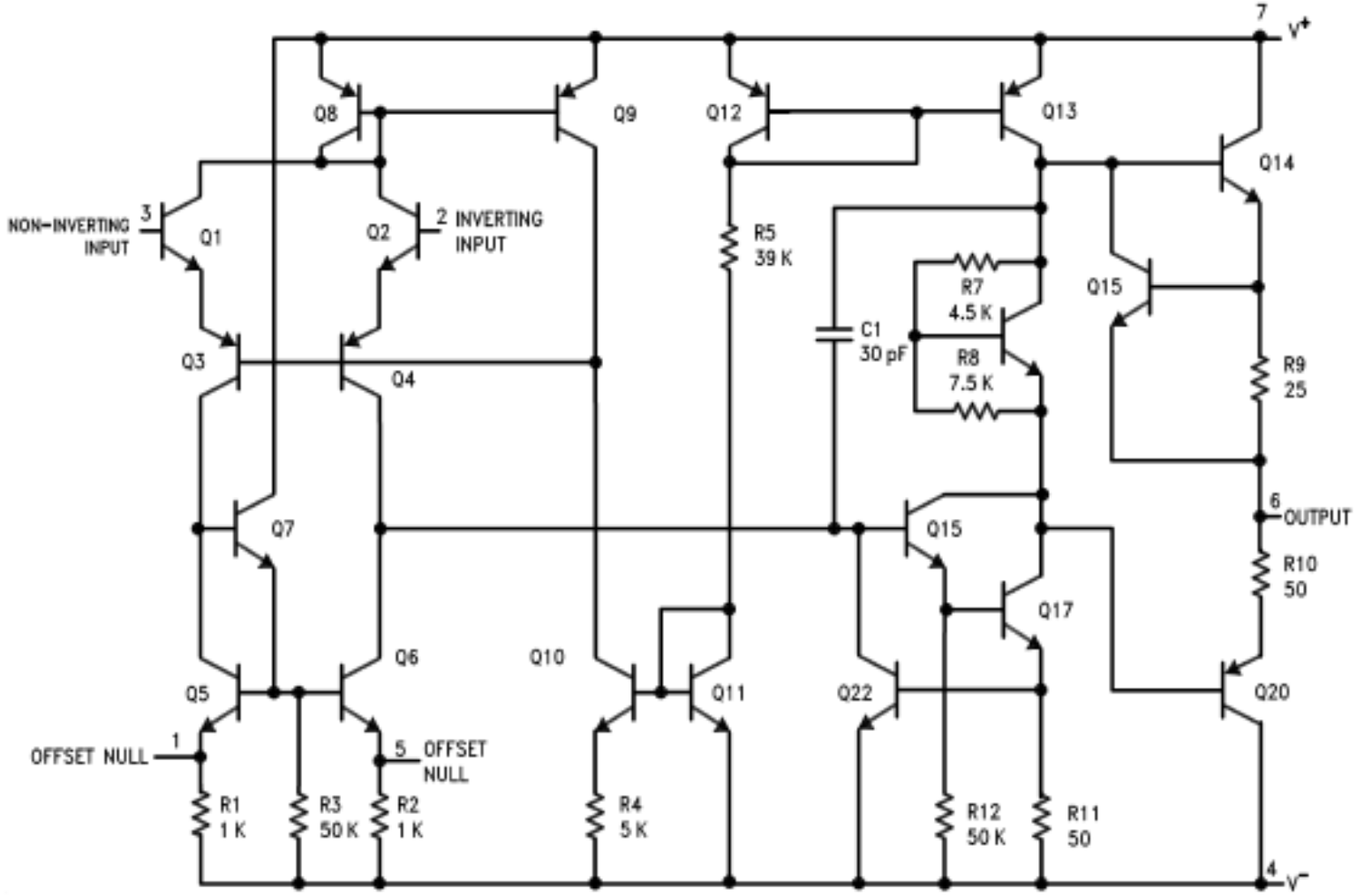
$v_3 + v_5 = v_2$

$v_0 = v_4 + v_5$ Redundant

12 Equations → Algebra → 12 Unknowns

HOW DO WE ANALYZE CIRCUITS CONTAINING MANY ELEMENTS?

741 Operational Amplifier



20 Transistors
(2 Branches Each)
10 Resistors
1 Capacitor
2 Input Voltage Sources
2 Power Supplies

55 Branches or “Devices”
110 Unknowns

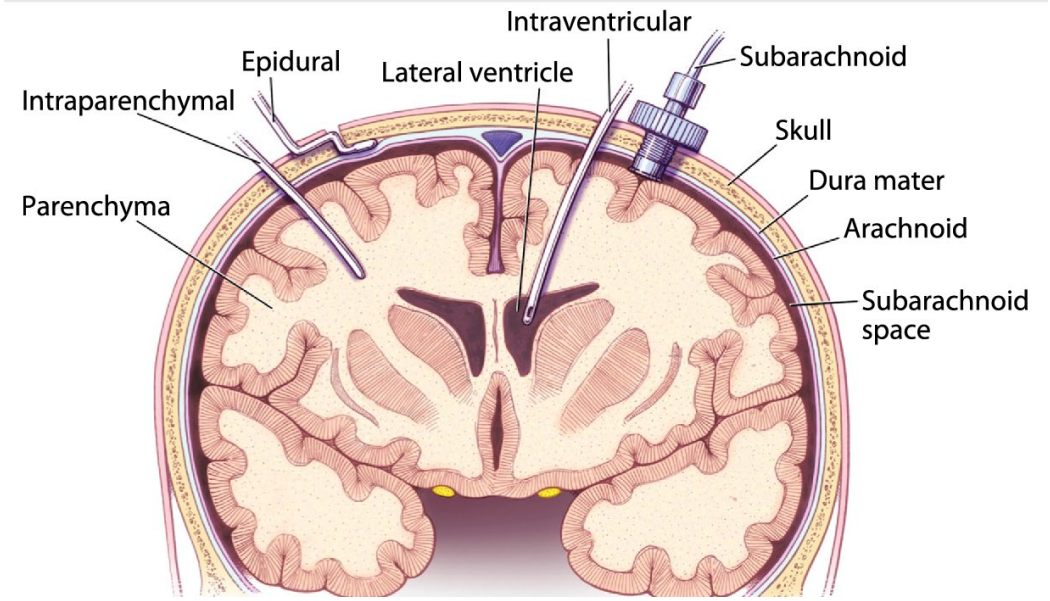
THE LANGUAGE OF ELECTRONIC CIRCUITS

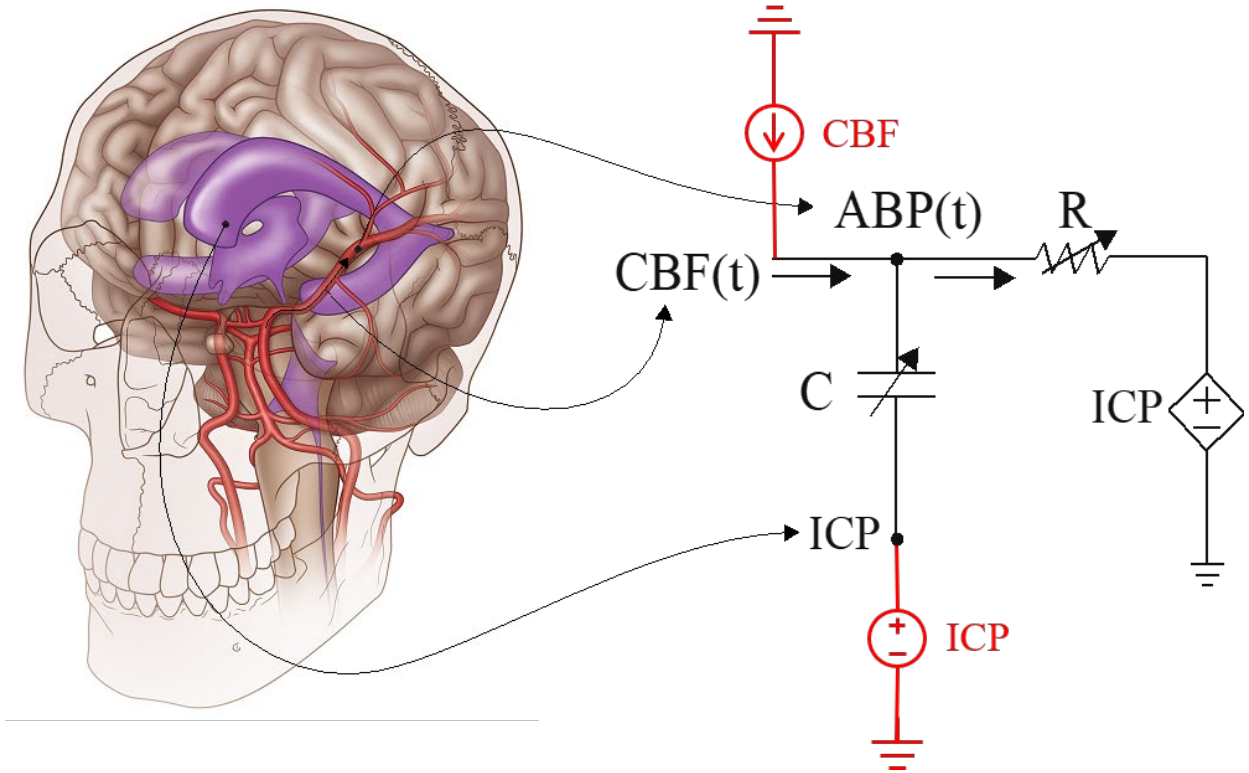
A way to model electrical systems …

… and acoustic, biomedical, fluidic, magnetic, thermal, mechanical, etc systems

A way to model/describe and analyze systems described by ODEs

ELECTRICAL ↔ BIOMEDICAL ANALOGS





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