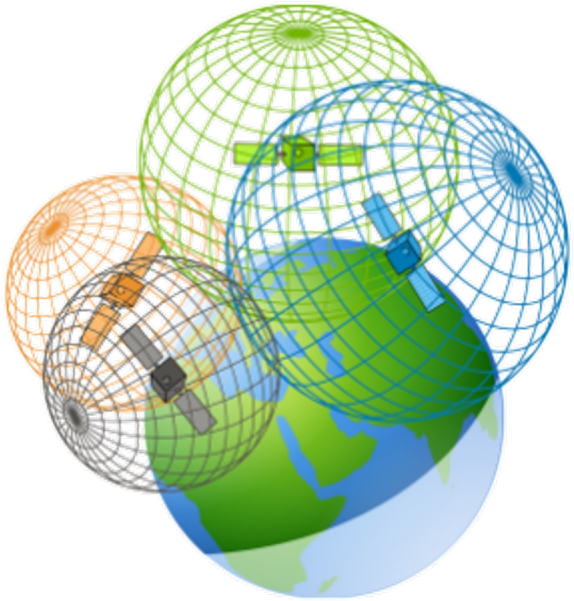
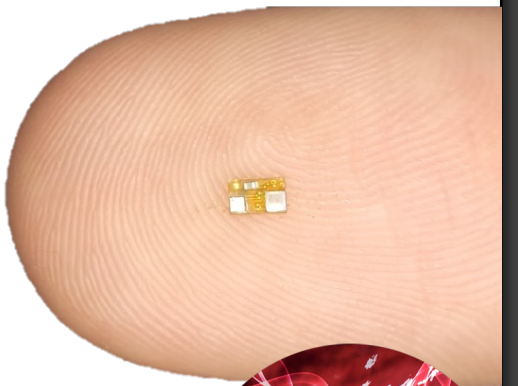
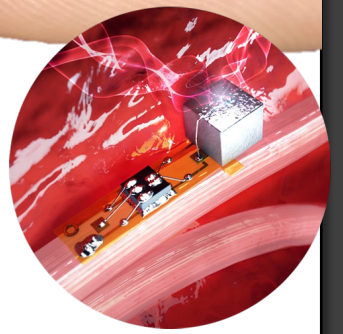






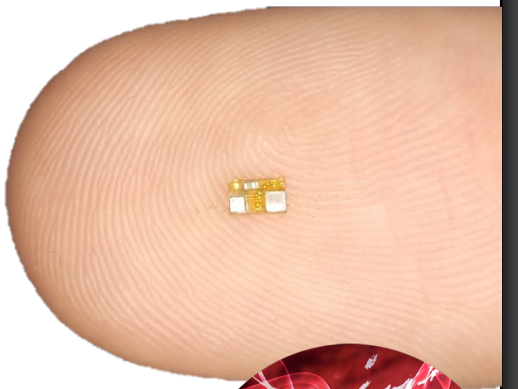
Welcome to EECS 16A!

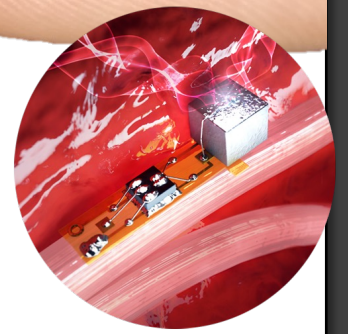
Designing Information Devices and Systems I

Prof. Laura Waller

Prof. Rikky Muller

Spring 2023





all of these extract information from the real world and interact with it;

we will learn how to design and analyze such devices and systems

Instructors

Prof. Laura Waller
waller@berkeley.edu

Prof. Rikky Muller
rikky@berkeley.edu

Office Hours: 11am Wednesdays, Cory Hall room 504
(starts next week)

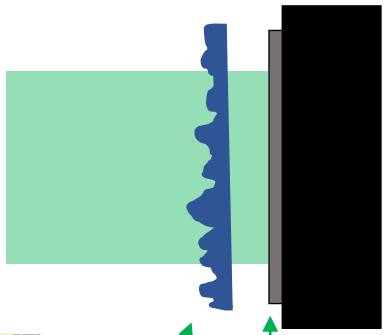
- Other contributors to 16: Vladimir Stojanovic, Anant Sahai, Gireeja Ranade, Ali Niknejad, Claire Tomlin, Michel Maharbiz, Miki Lustig, Vivek Subramanian, Thomas Courtade, Babak Ayazifar, Ana Arias

Laura: About me

- PhD 2010, M.Eng 2005, BS 2004 EECS, MIT
- Lecturer in Physics, Postdoc in EE, Princeton 2010-2012
- Professor, UC Berkeley 2012-2050?

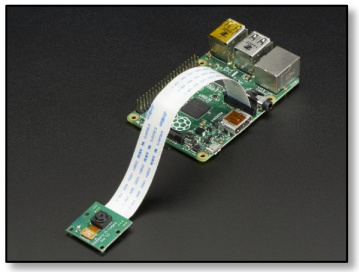
Laura: Research in Computational Imaging

Hardware design



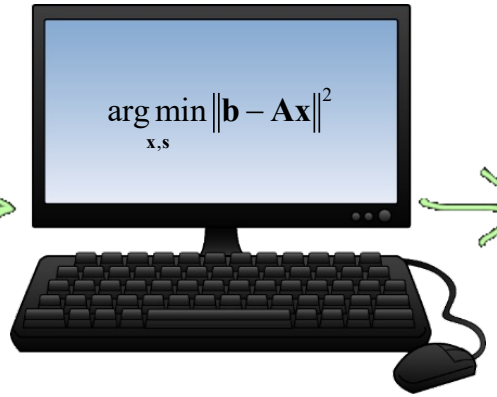
diffuser

sensor



Take picture

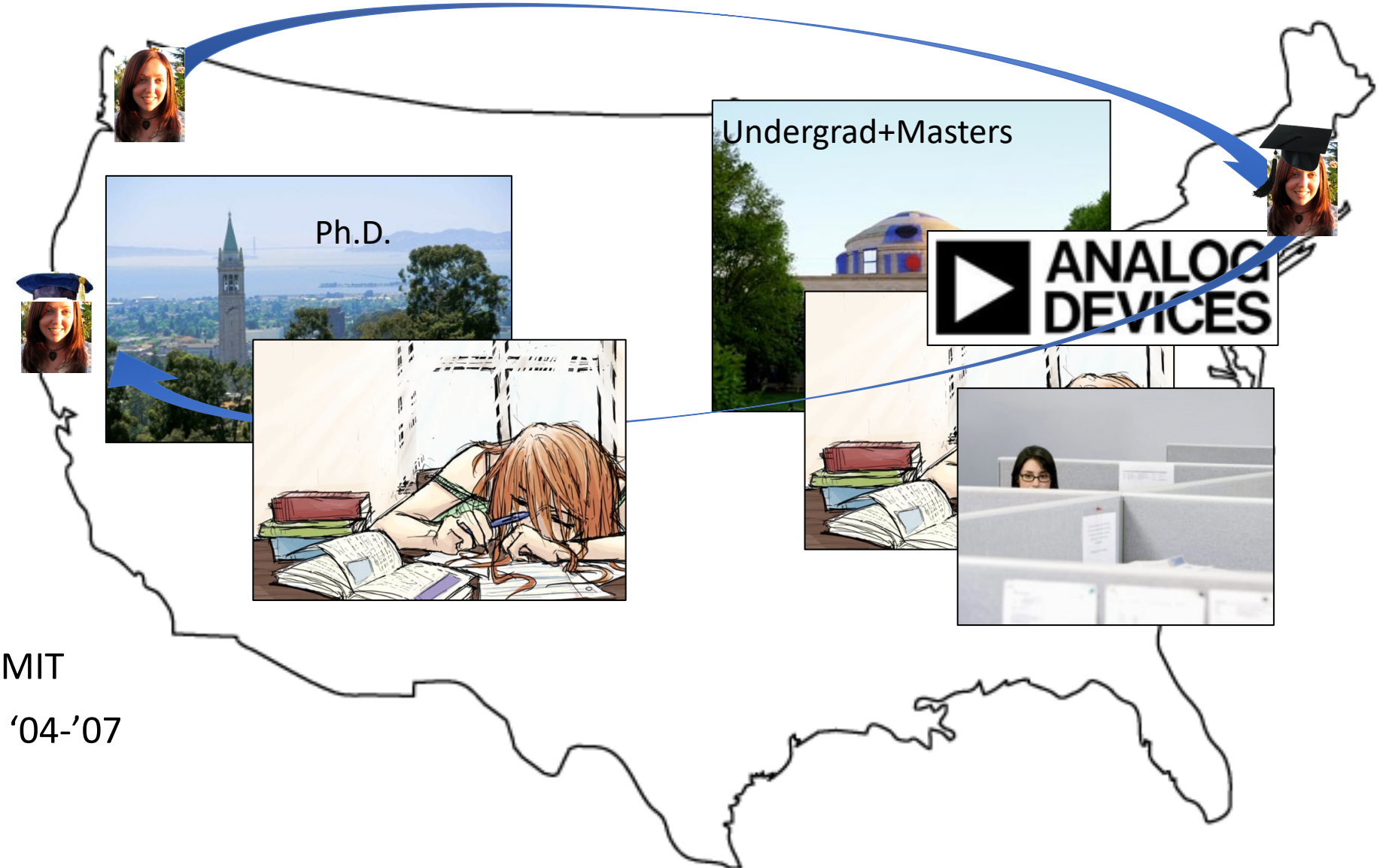
Crunch Data



Reconstruction

https://waller-lab.github.io/DiffuserCam/tutorial.html

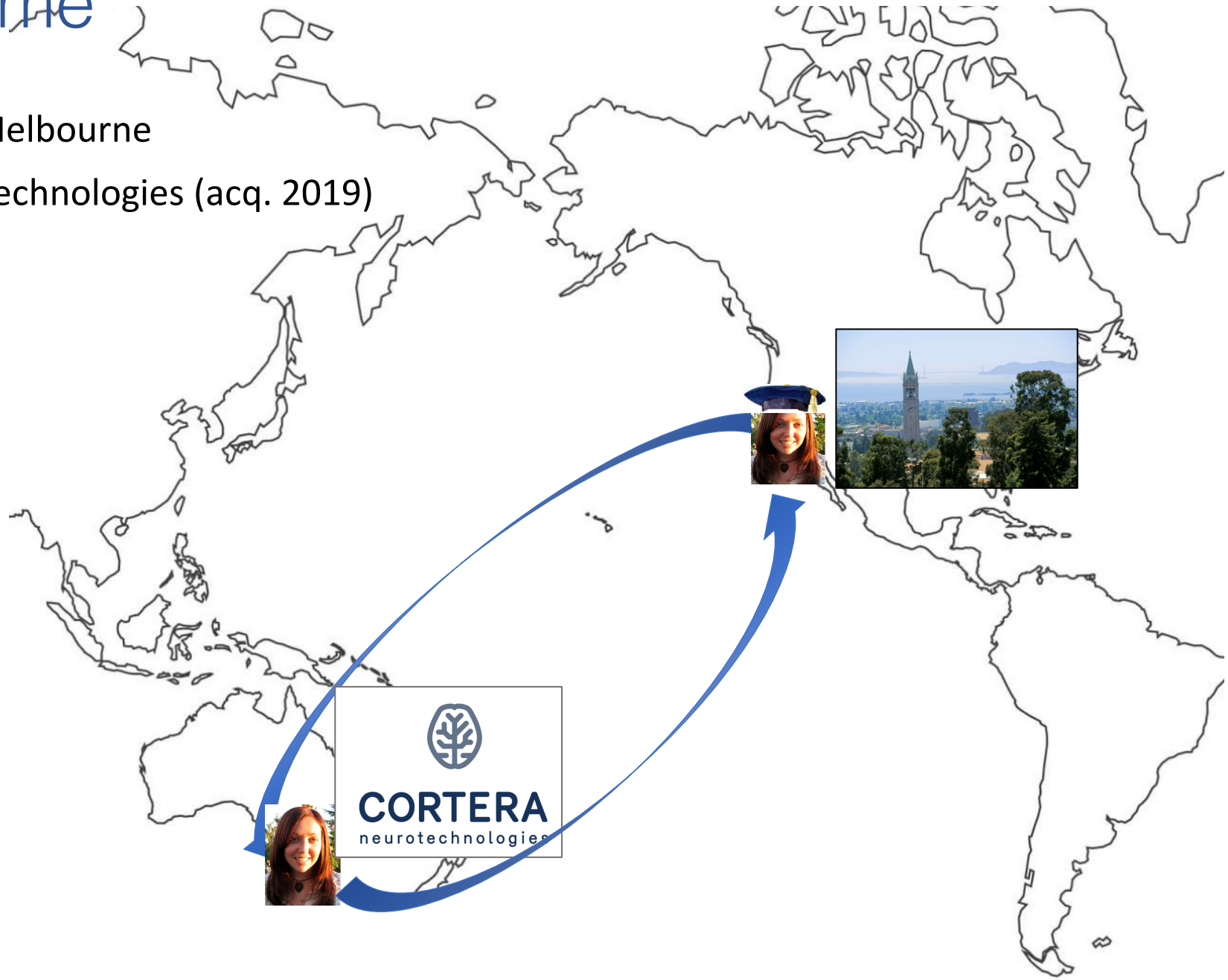
Rikky: About me



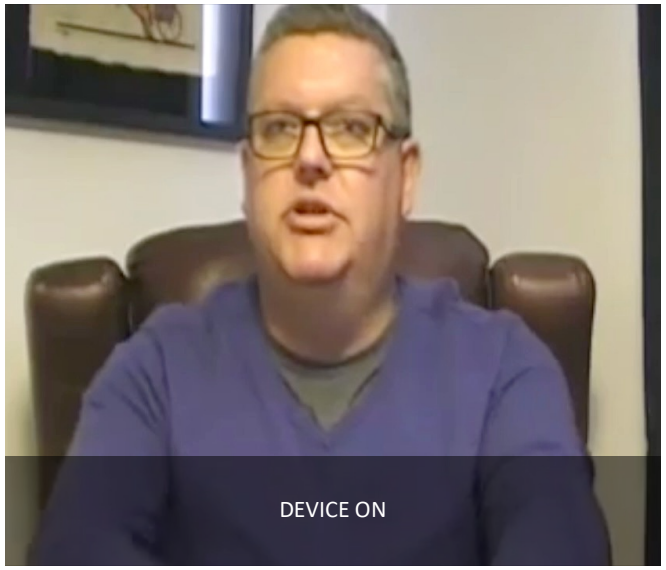
- M.Eng 2004, BS 2003 EECS, MIT
- IC Designer Analog Devices, ‘04-’07
- PhD 2013, UC Berkeley!

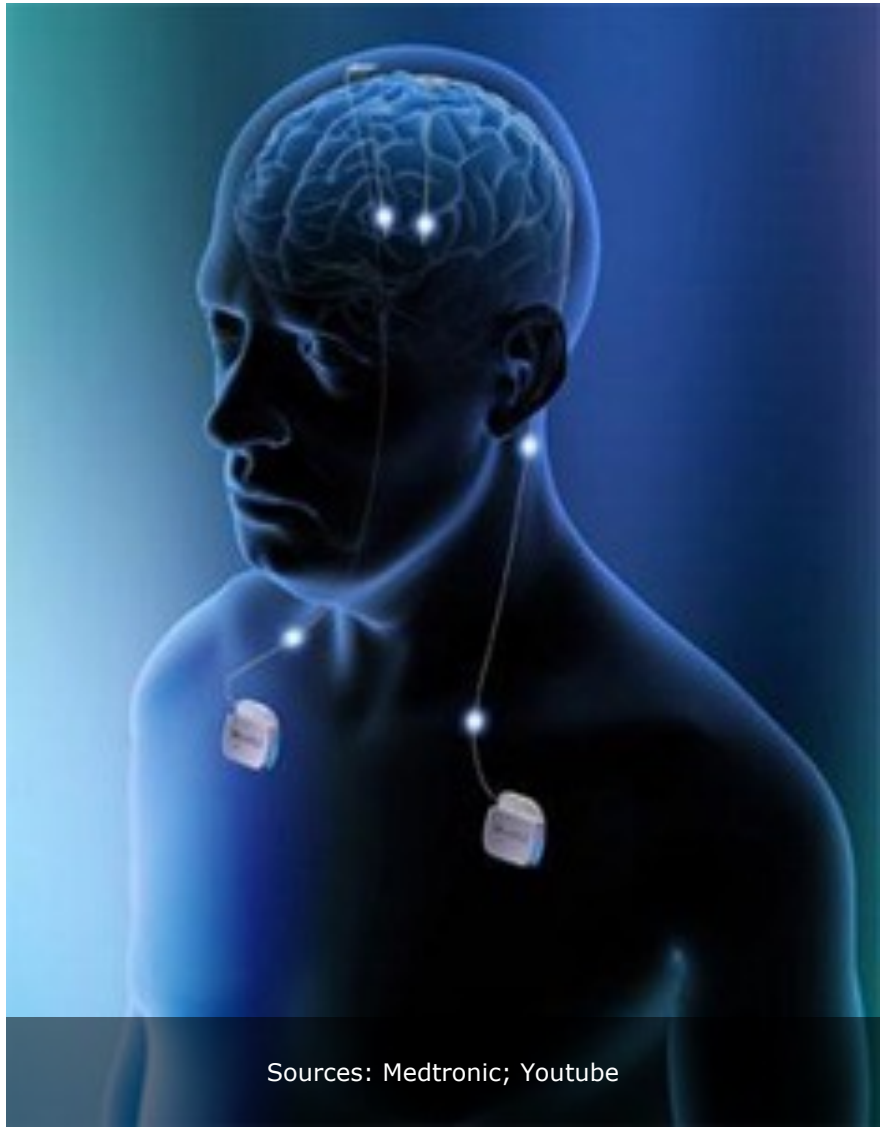
Rikky: About me

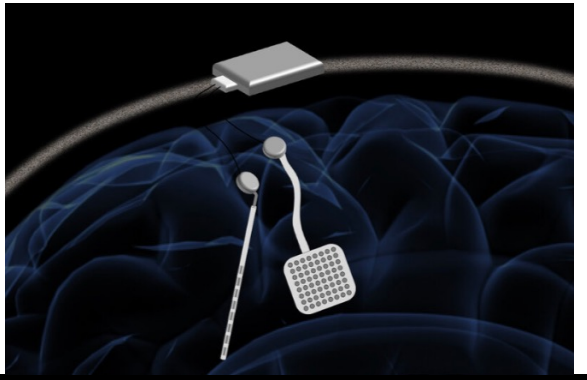
- Lecturer/Postdoc University of Melbourne
- Startup founder: Cortera Neurotechnologies (acq. 2019)
- Professor since 2016

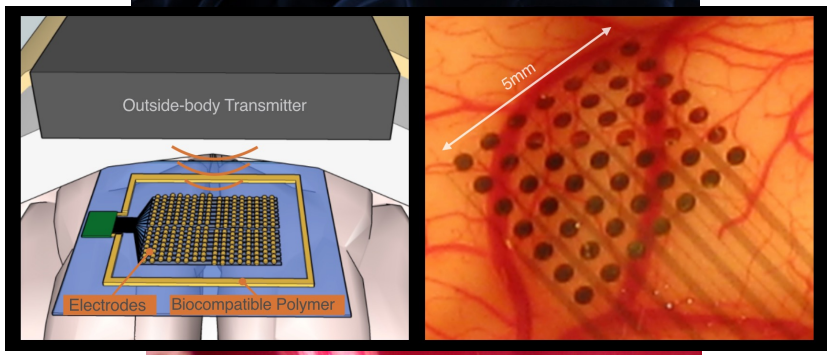


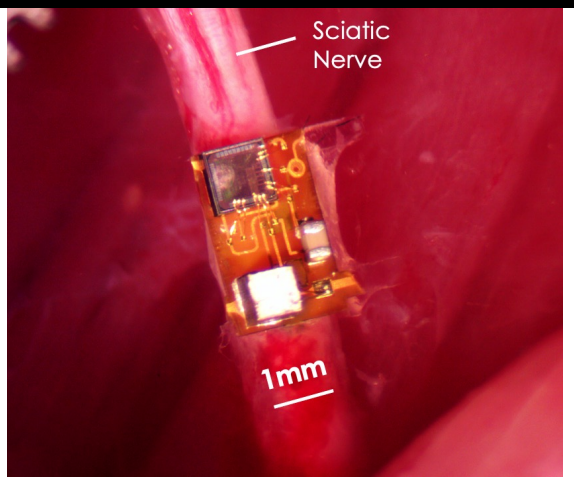
Rikky: Research in Neurotechnology











Sources: Muller Lab Publications

Course Staff

Head GSIs

Aniruddh Khanwale

Austin Patel

Head GSIs:
eecs16a@Berkeley.edu
Email with:
Questions not for Ed,
conflicts, accommodations,
emergencies,
administrative questions

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Anastasia Simonova

Shreyash Iyengar

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Email with:
Questions not for Ed,
conflicts, accommodations,
emergencies,
administrative questions

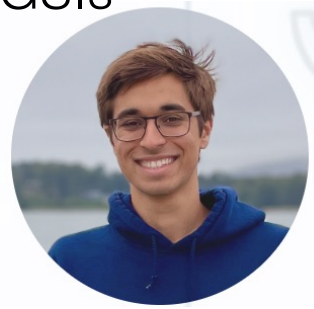
Krystle Simon

Course manager
Great resource for 1-1 concerns
Krystle@eecs.Berkeley.edu

Course Staff

Head GSIs

Aniruddh Khanwale



Austin Patel

Head Lab GSIs

Anastasia Simonova

Shreyash Iyengar

Click to Toggle Bio!
Ayah Ahmad
HW/Dis
eecs16a.homework@, ayahahmad@

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dahliasaba@

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Shuming Xu
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Carol Li
Lab
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carol.li@

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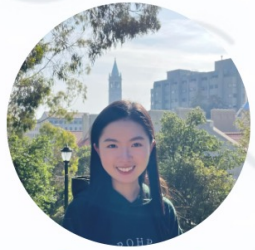
Kanav Mittal
Dis/Software
he/him/his
kanavmittal@



Click to Toggle Bio!
Vivian Wu
Dis
she/her/hers
vivianwuc25@

Click to Toggle Bio!
Anvitha Kachinthaya
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she/her/hers
anvitha@

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Amit Kohli
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Youbin Kim
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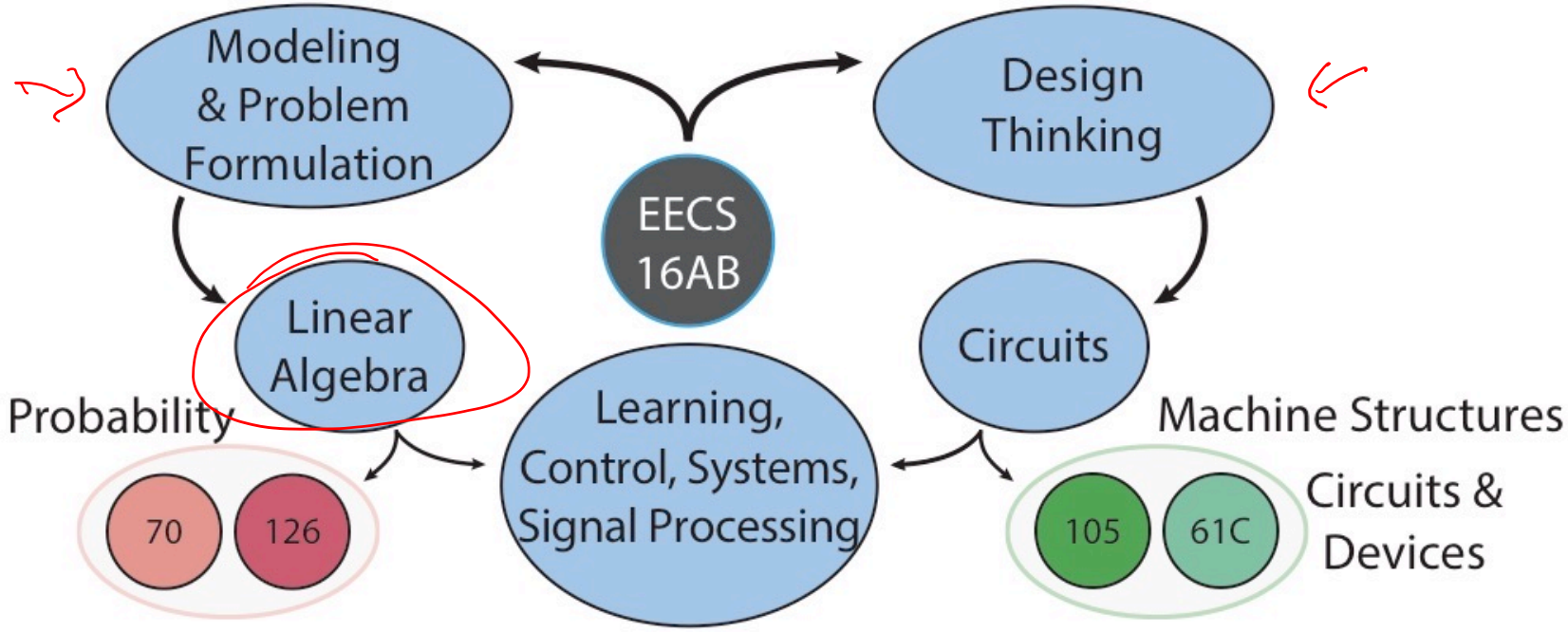
he/him/his
youbin_kim@

Click to Toggle Bio!
Nathan Brooks
Dis/Content
he/him/his
nathanbrooks@

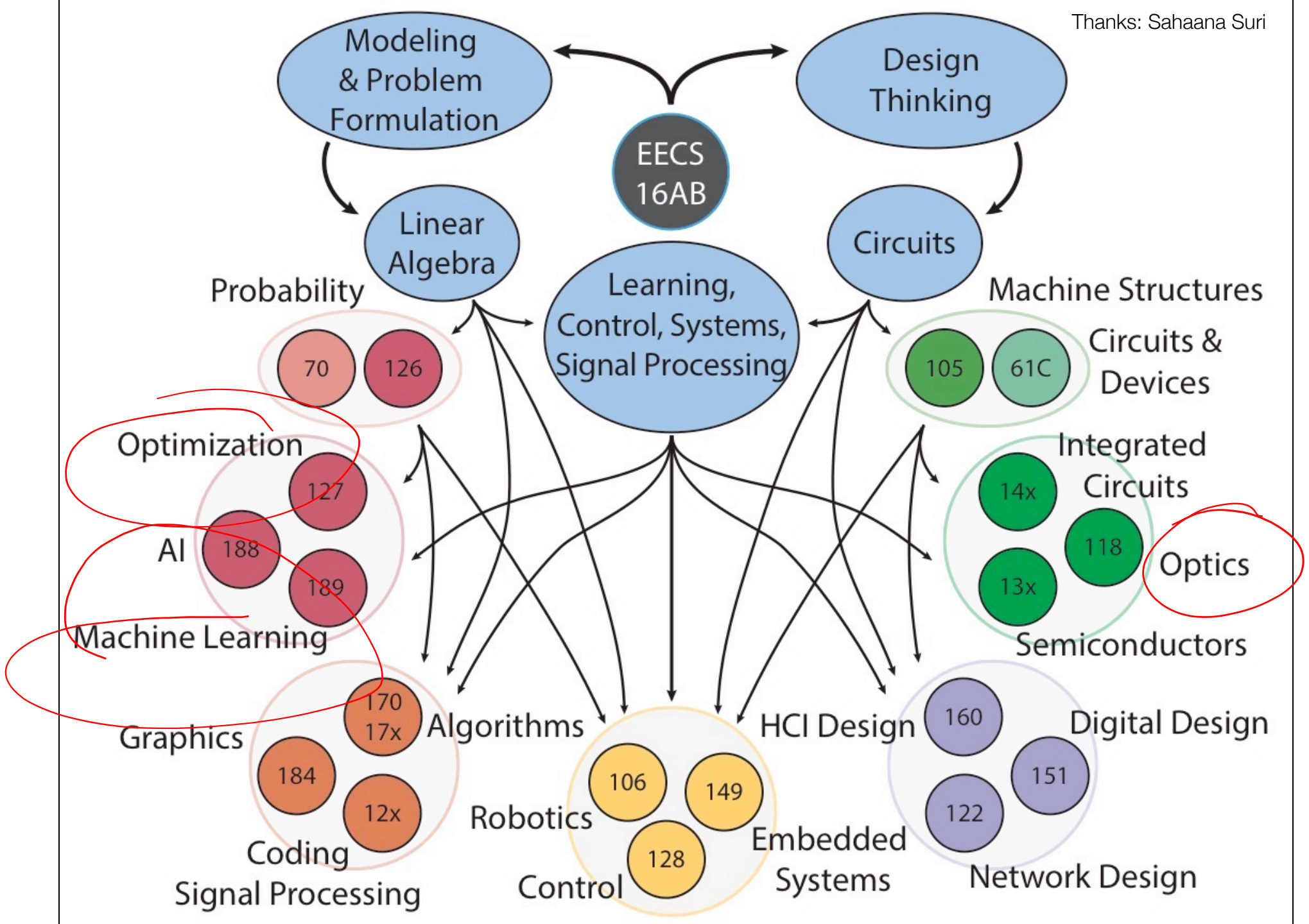
Your photo here!

Pathway to becoming like us!

- if you do well in class — you can apply to:
  - Become an ASE
    - Grade homework, assist in labs, tutor and help with office hours
  - Become a uGSI
    - Lab / Discussion / content
  - Become head TA…
  - Go to grad school, get a PhD
  - Become faculty
  - Teach 16A!


Modeling & Problem Formulation
Design Thinking
EECS 16AB
Linear Algebra
Circuits
Probability
Learning, Control, Systems, Signal Processing
Machine Structures
70
126
105
61C
Circuits & Devices

Thanks: Sahaana Suri



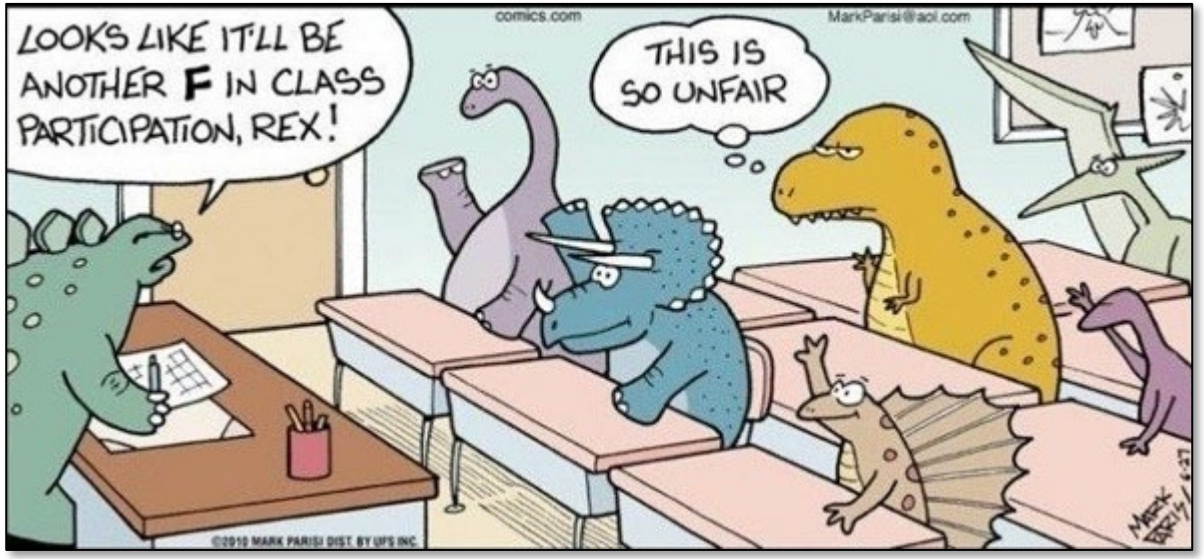
Course policies

- Syllabus is on the course website: https://eecs16a.org/
  - You are responsible for reading and following all course policies listed
- Ed: edstem.org
  - a resource for you to help each other out
- Questions? Ask eecs16a@berkeley.edu

Grading Policies

- Midterm 1, Midterm 2 (55 points each)
- Final (100 points)
- Lab – mandatory (55 points)*
- Homework (35 points)

- Exam second-chance policy based on optional Midterm Redo



*signup instructions coming tomorrow on Ed

Homework (HW)

- Due Fridays at 11:59pm
- HW Party: Fri 9-11am in ‘the Woz’
- Office Hours: see course calendar
- HW0 due Friday
- You grade, we check!
  - Self-grades due the next Friday
  - 2 HW drops, 6 ‘slip days’

Note: Self-grading is not *just* about us being lazy!!
(it is also to help you learn)

Academic Honesty

We treat all our students with utmost trust and respect and expect students to return the same trust and respect. We will have ***zero-tolerance*** for academic dishonesty. ***No excuses or special circumstances will be considered***.

Always seek help, never cheat.

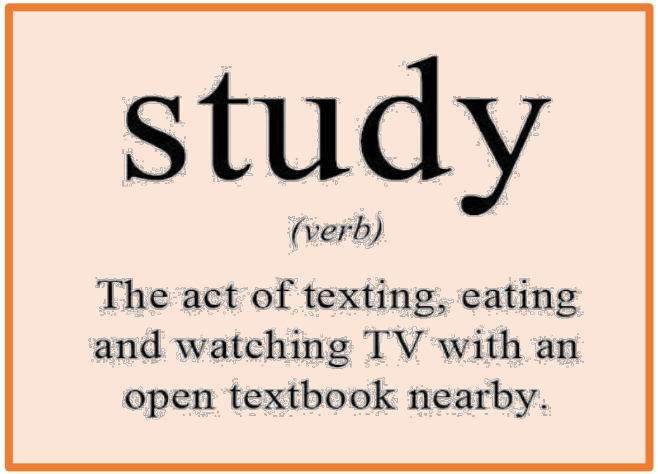
You are here to learn!

- Learning can be hard and fun
- Collaborate and build community on Ed/HW Party/Study Groups
- Encourage different perspectives – this is Berkeley!

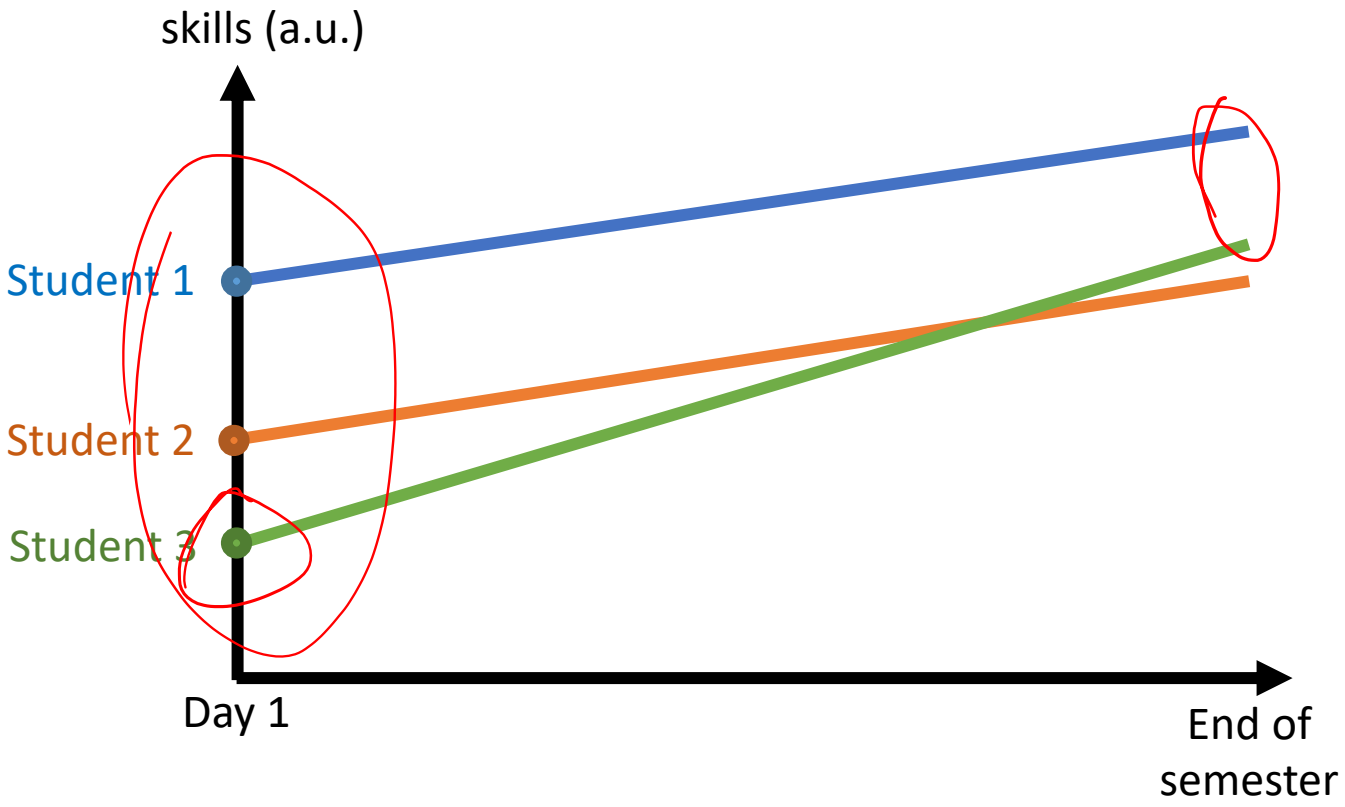
- Everyone here is smart
  - Students have different backgrounds
  - (some) Professors make mistakes – feedback helps
  - If you are struggling, ask for help!

How to succeed in 16A

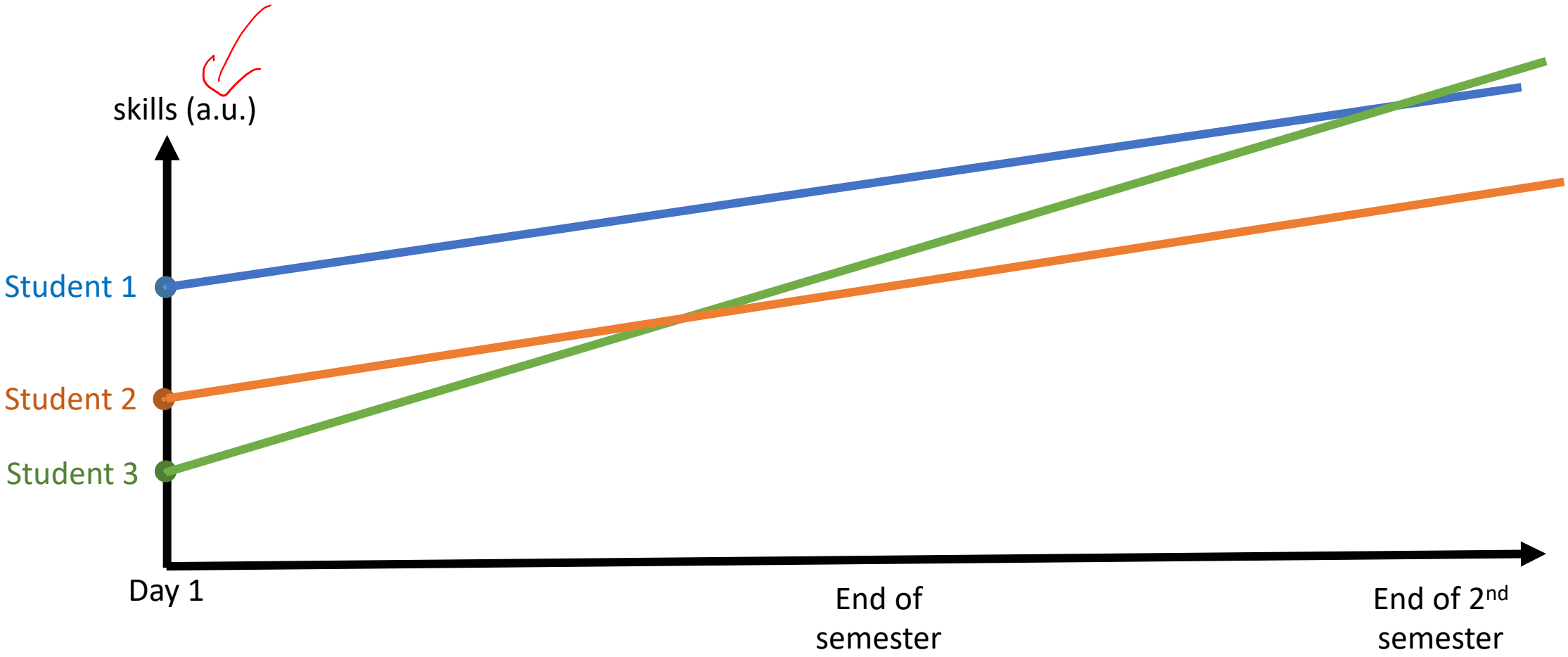
- Get enough sleep
- Attend lecture and discussion
- Do not do the above two at same time
- Actively read notes
- Try HW on your own, early
- Discuss problems with study group and/or at HW Party
- Study with others as well as alone
- Seek and offer help

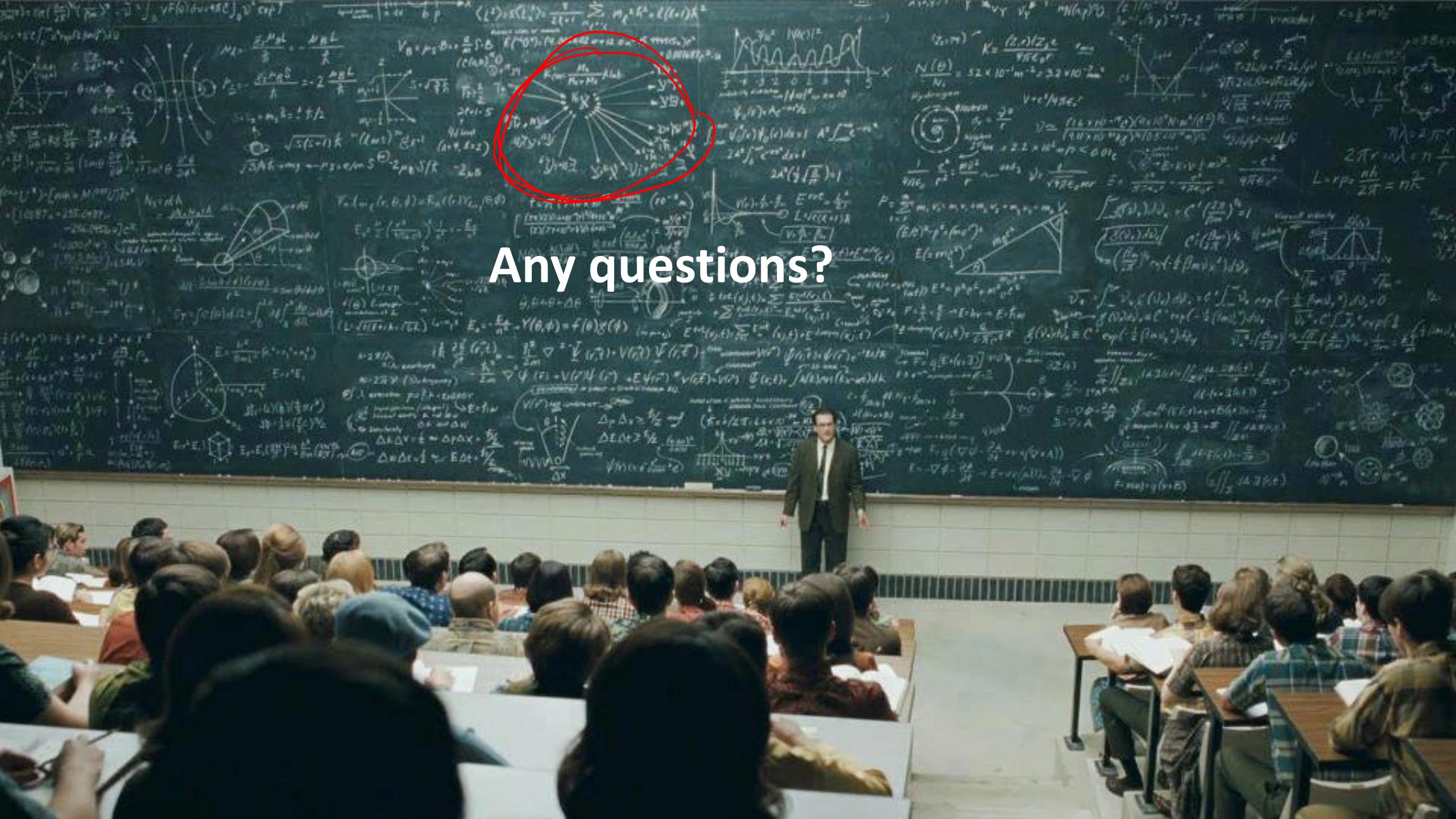


Slope is more important than intercept



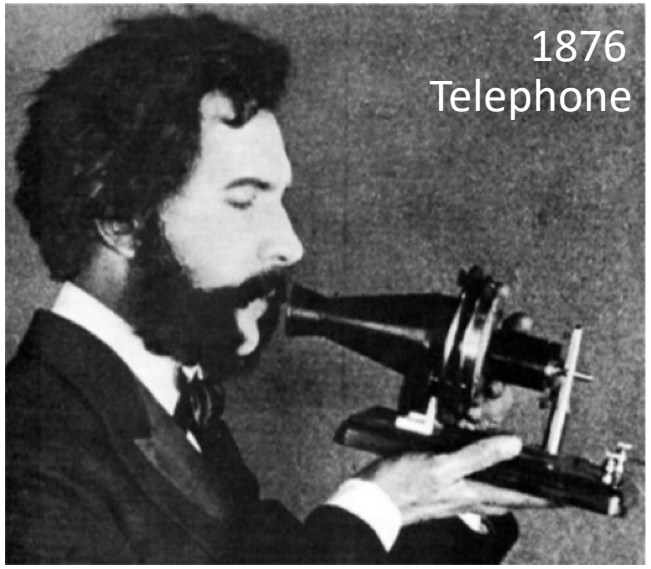
Slope is more important than intercept




Any questions?

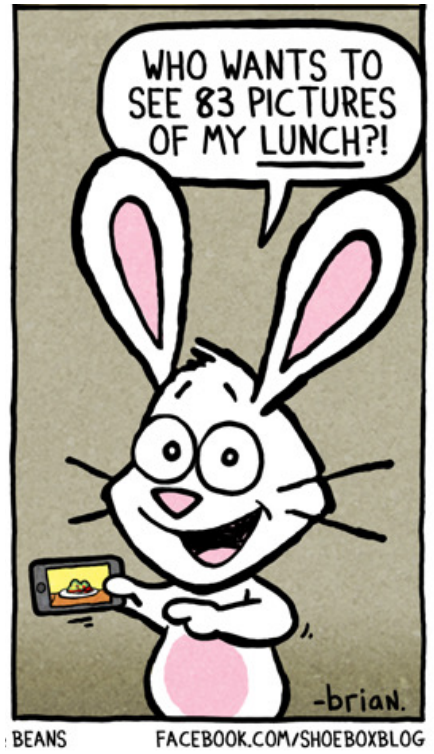

START

How did we get from this…

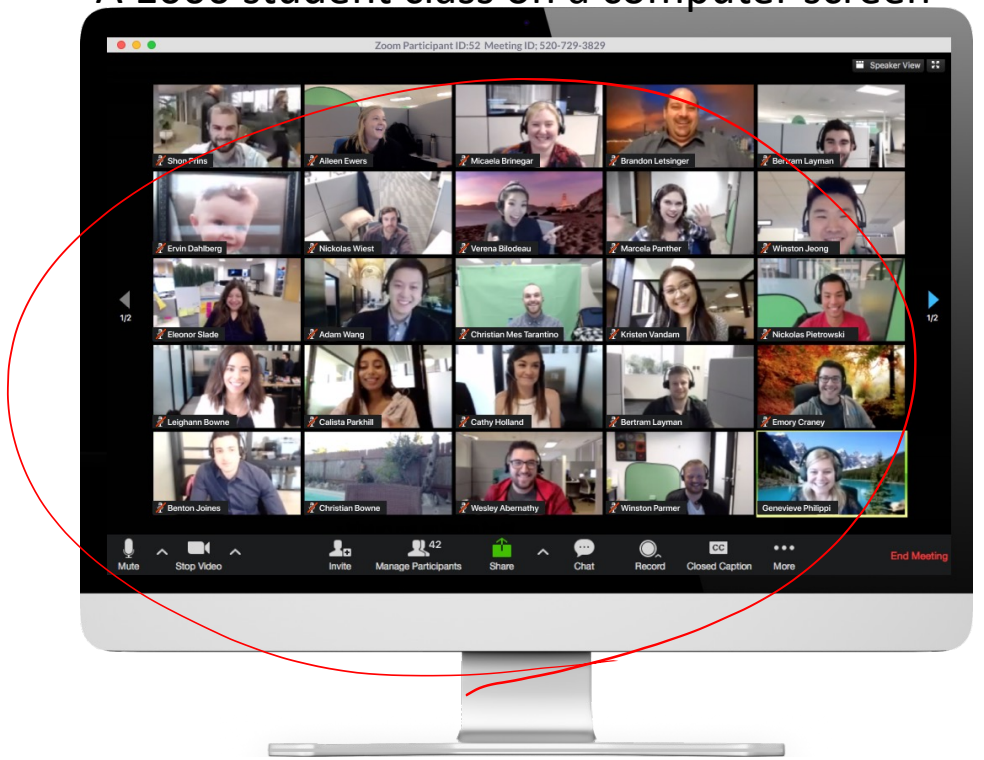


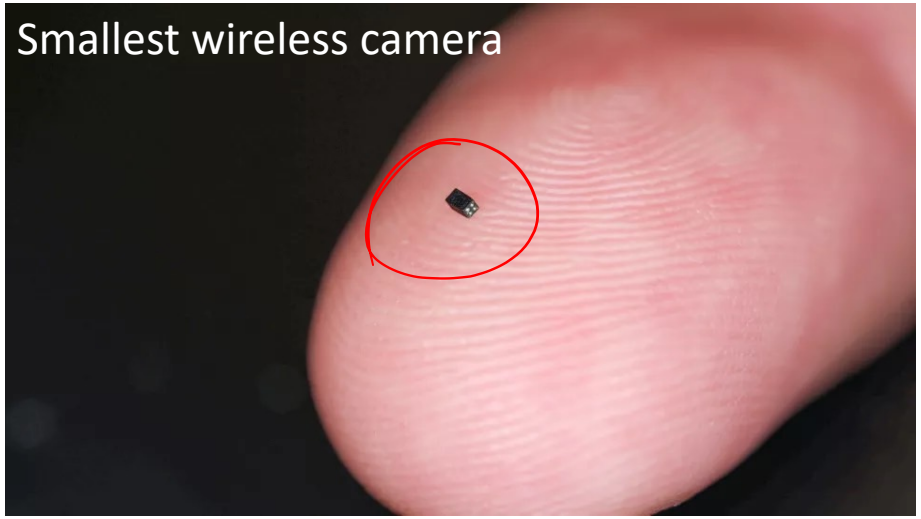
Flight of the Conchords S01E03 (HBO)

To this…



A 1000 student class on a computer screen





Learning Goals

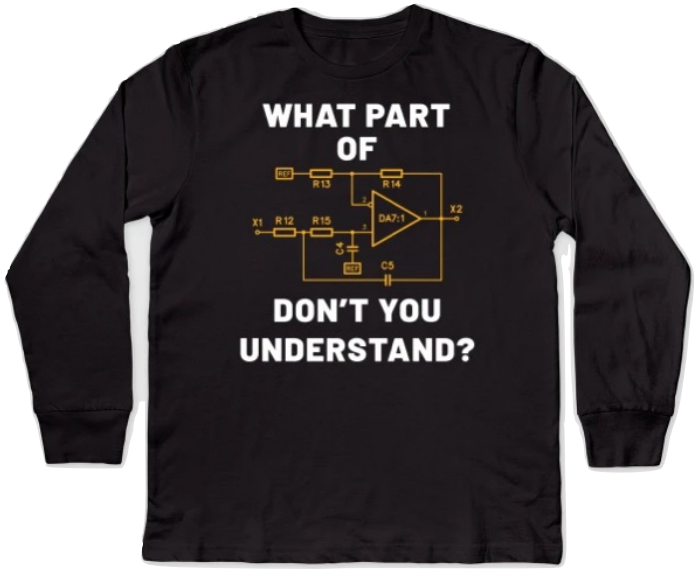
To help you understand many nerd jokes:

EECS 16A

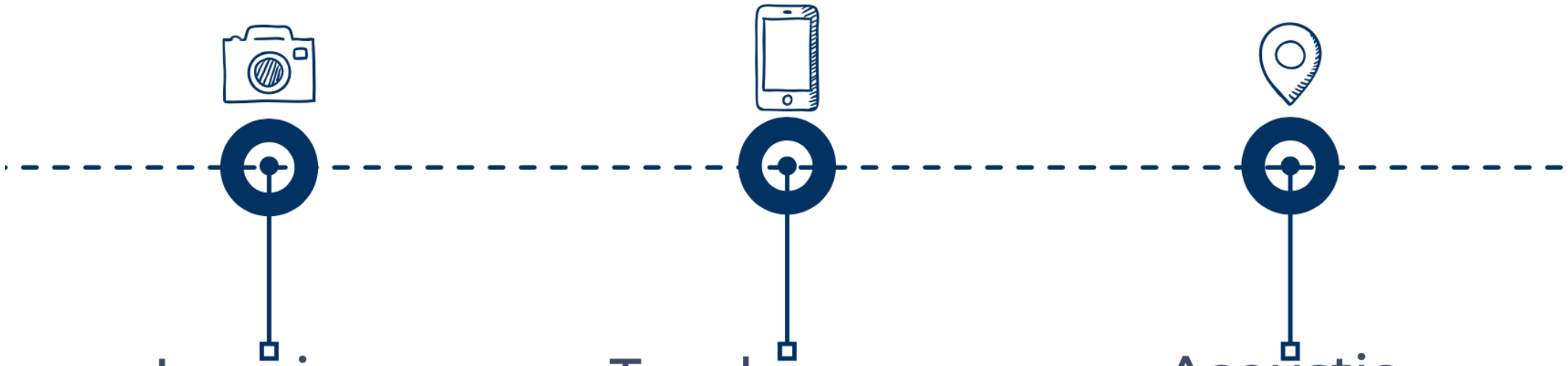
- Module 1: Introduction to linear systems
- Module 2: Introduction to circuits and design
- Module 3: Introduction Signal Processing and Machine Learning

EECS 16B

- Module 4: Advanced circuit design / analysis
- Module 5: Introduction to control and robotics
- Module 6: Introduction to data analysis and signal processing



In the Lab



Imaging Module

- photodiodes
- systems of linear equations
- matrix analysis

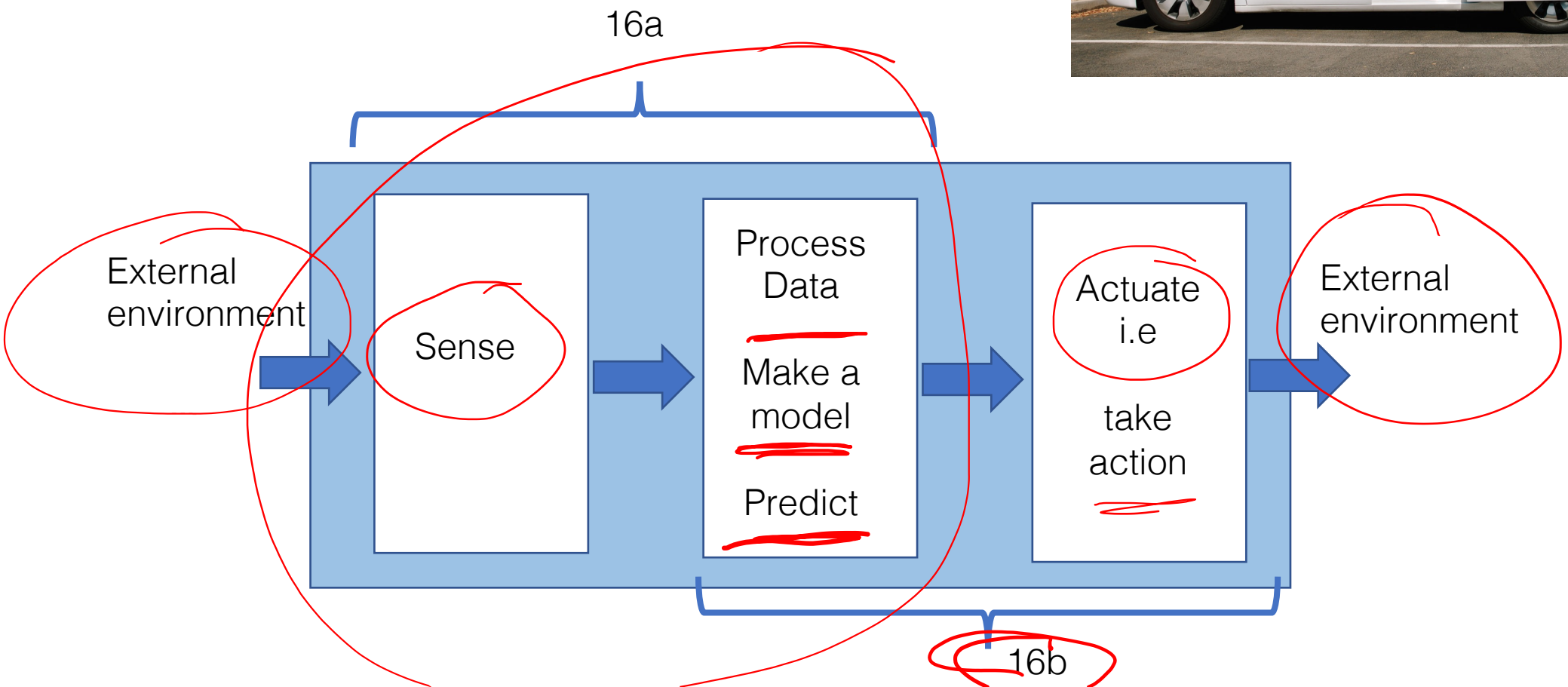
Touchscreen Module

- resistance
- capacitance
- circuit analysis

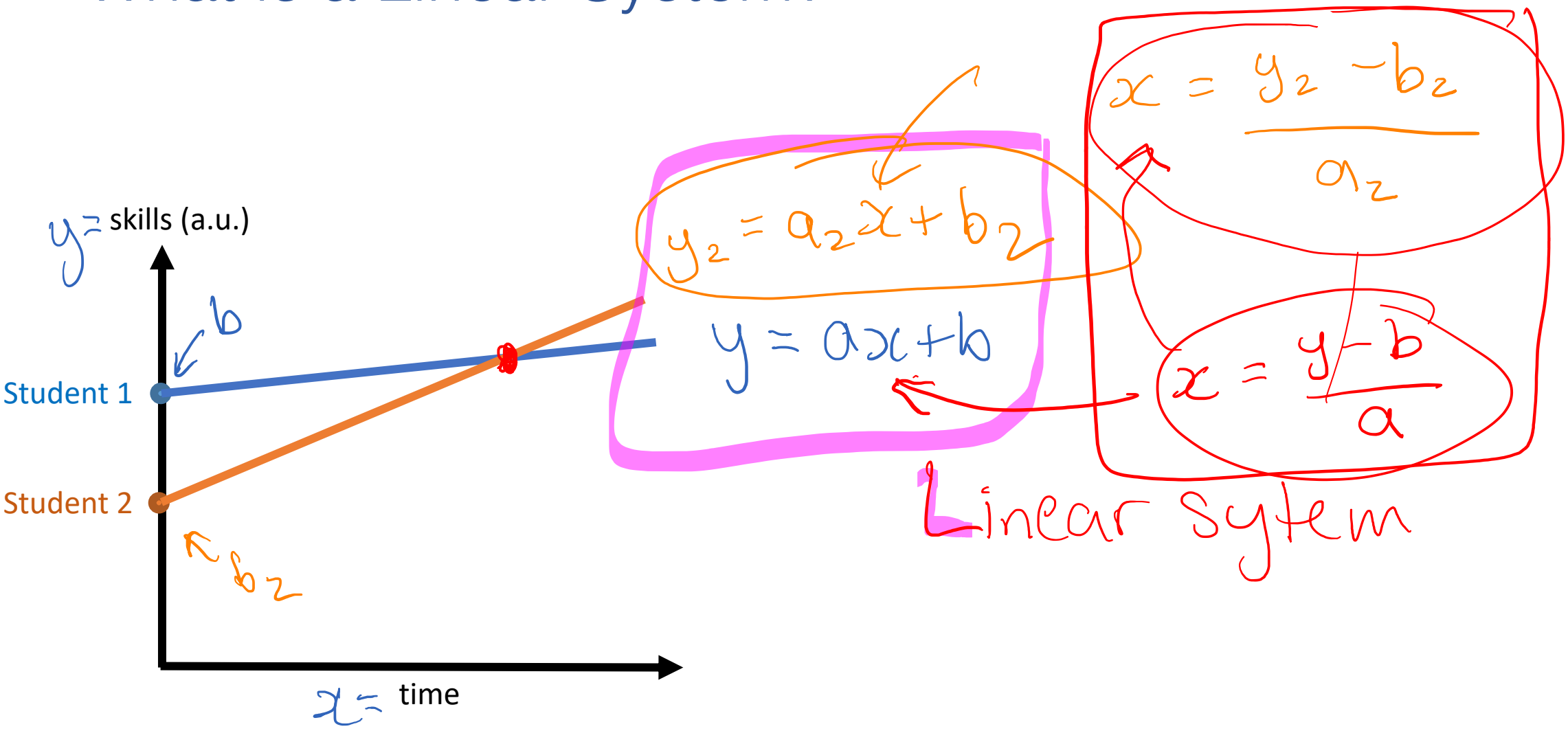
Acoustic Positioning Module

- cross-correlation
- optimization

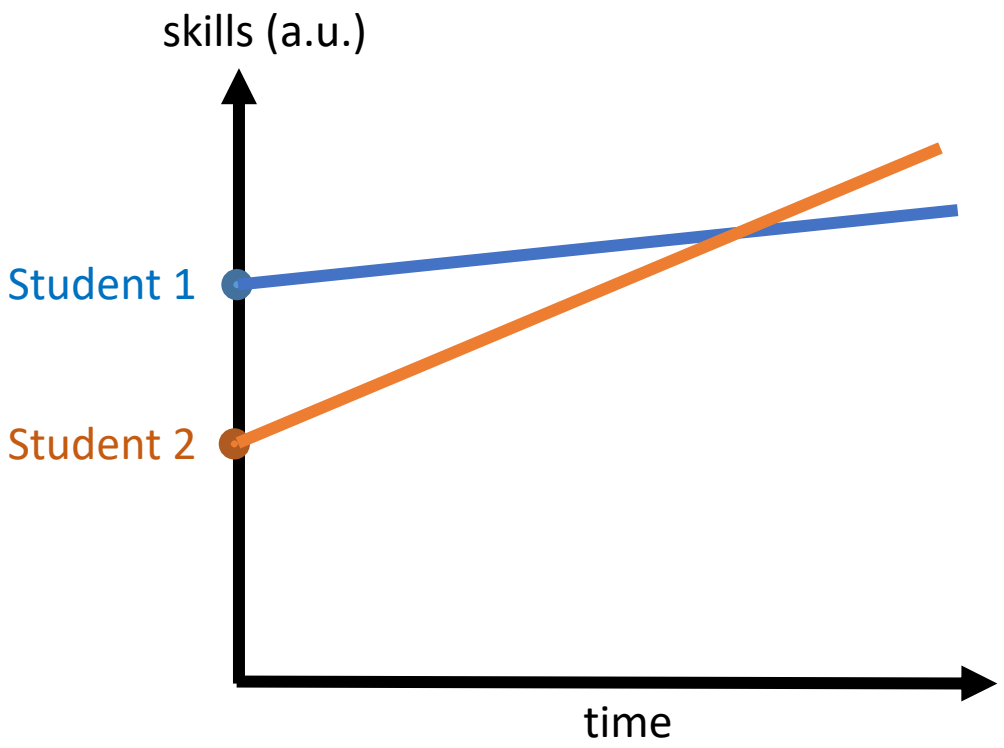
Systems thinking example: self-driving cars

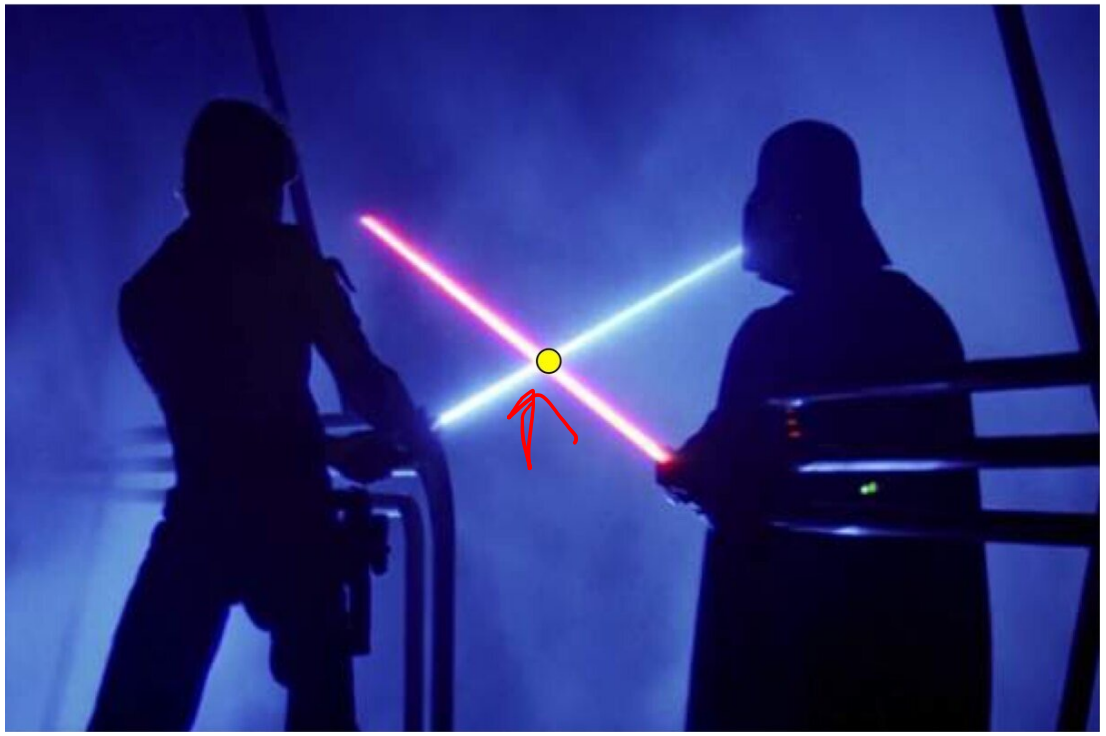


What is a Linear System?



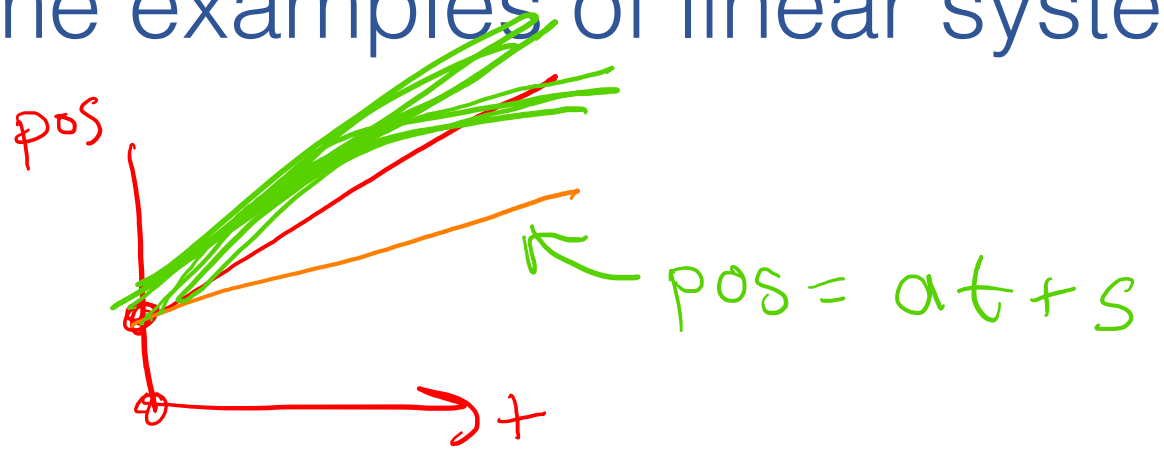
How do we solve linear systems of equations?



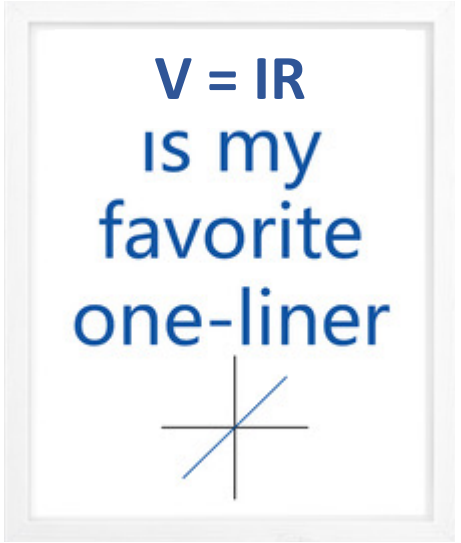


What are some examples of linear systems?

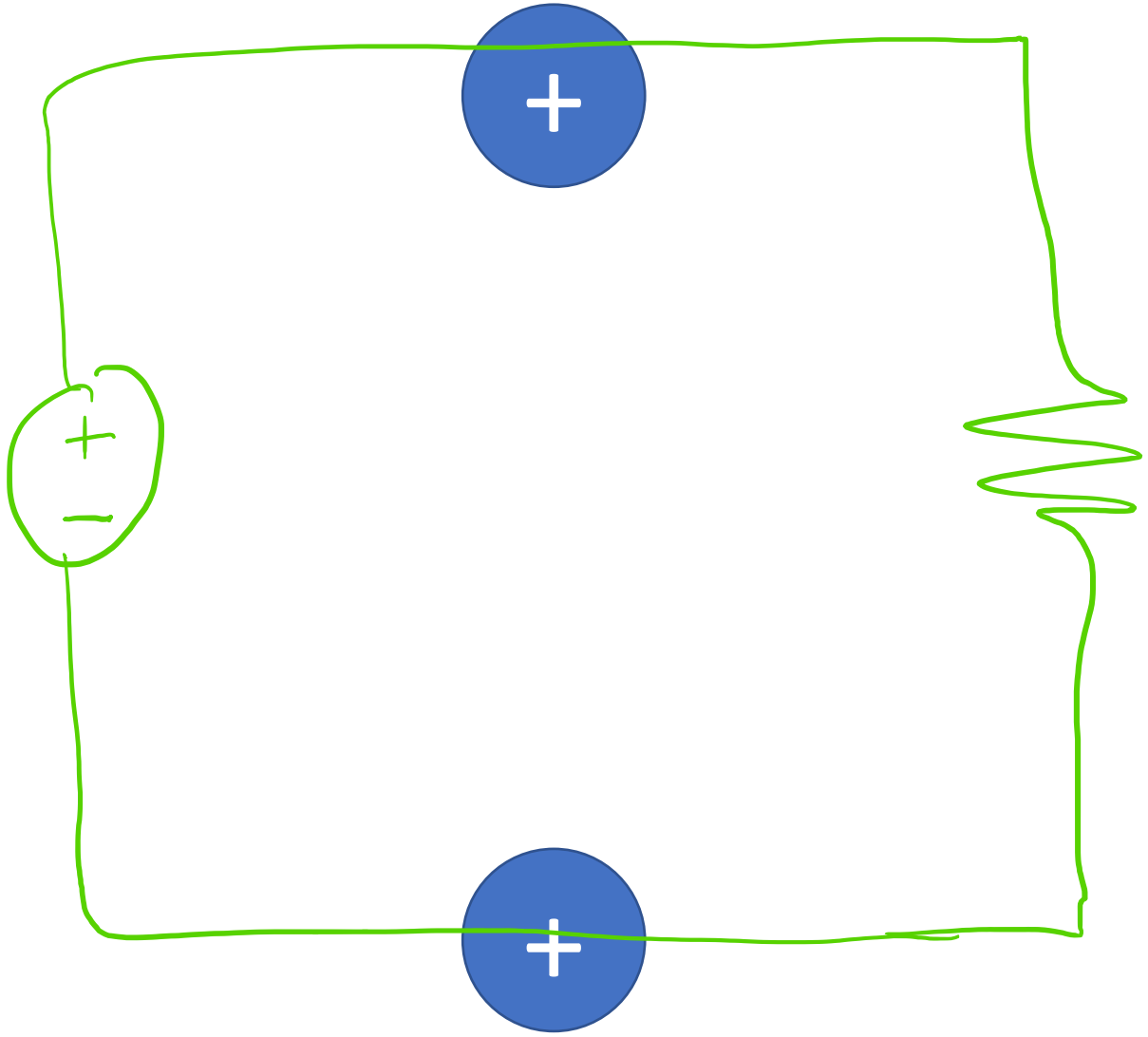
- race



$$y = ax + b$$



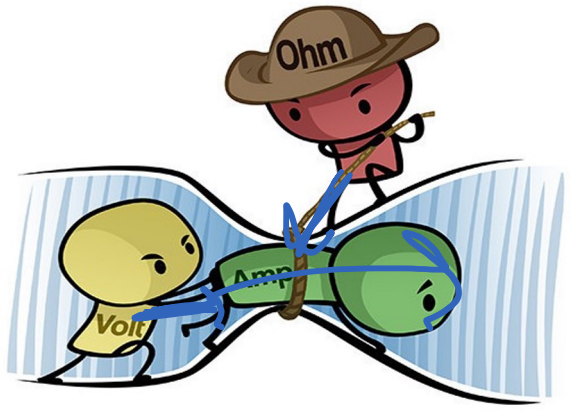
Electronic Devices Depend on the Movement of Charge



Electrical Quantities

$V = IR$ Ohm's Law

Quantities	Analytical Symbol	Units
Current	I	Amperes (A)
Voltage	V	Volts (V)
Resistance	R	Ohms (Ω)



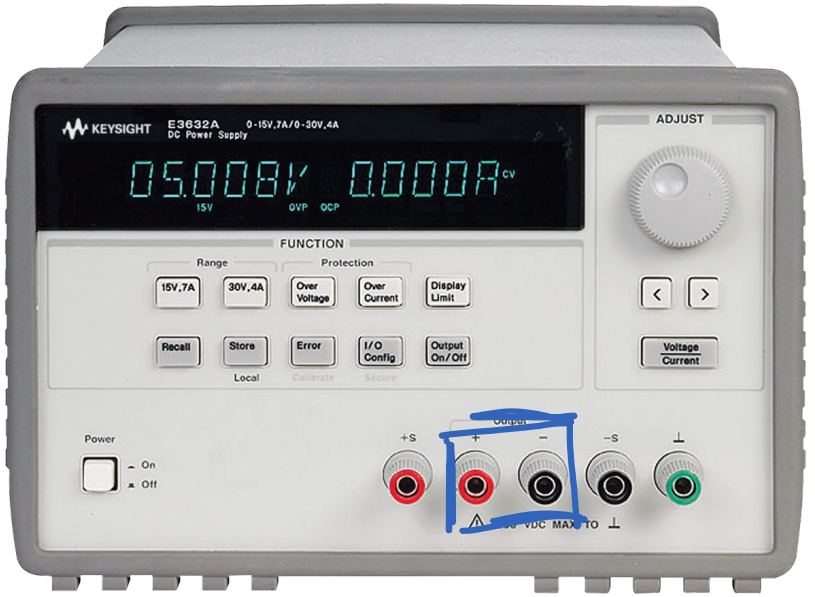
I → flows through an element

V → force applied across the element

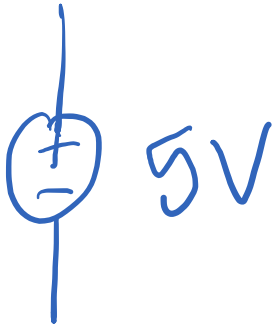
R → opposition to current flow

In the Lab!

resistor



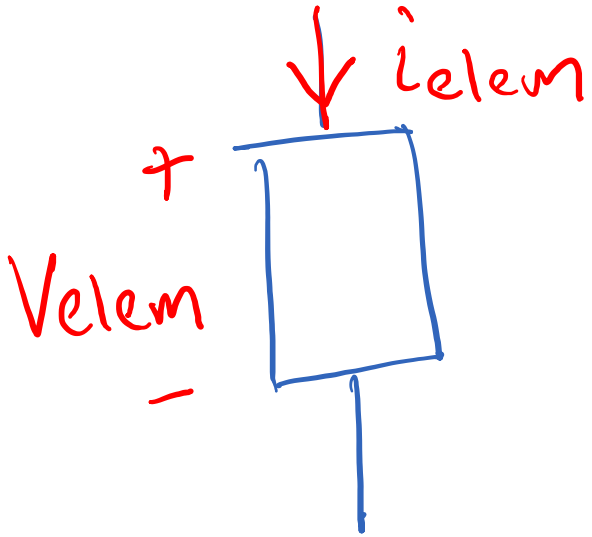
voltage source

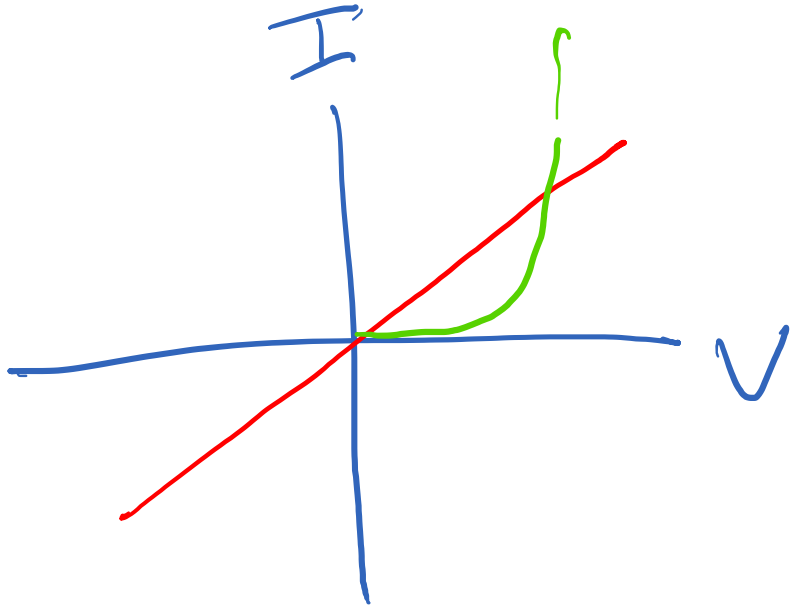


wire

Circuit Diagram Elements

Each element has some voltage across it and some current through it





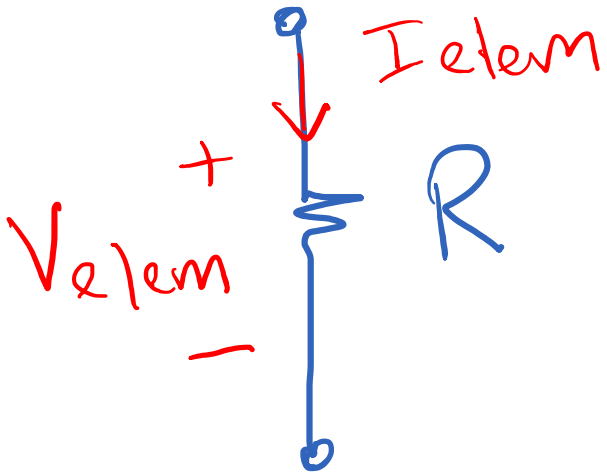
I-V curve

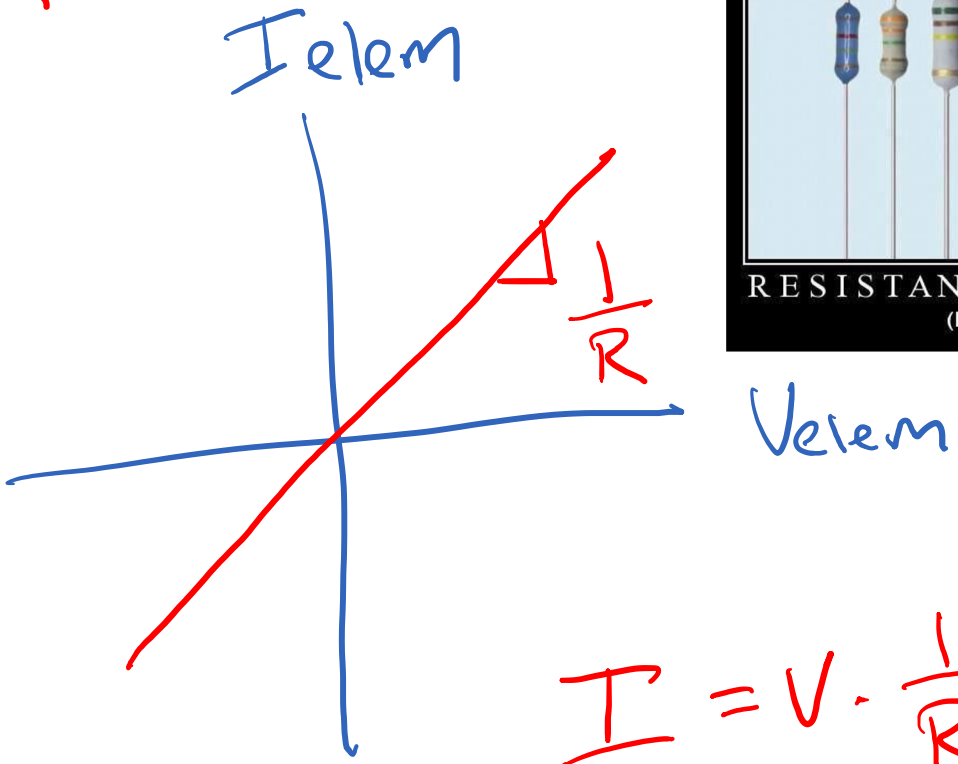
Velem: Voltage across element

Ielem: Current through elemt

Key circuit elements: Resistor

$$V = IR$$

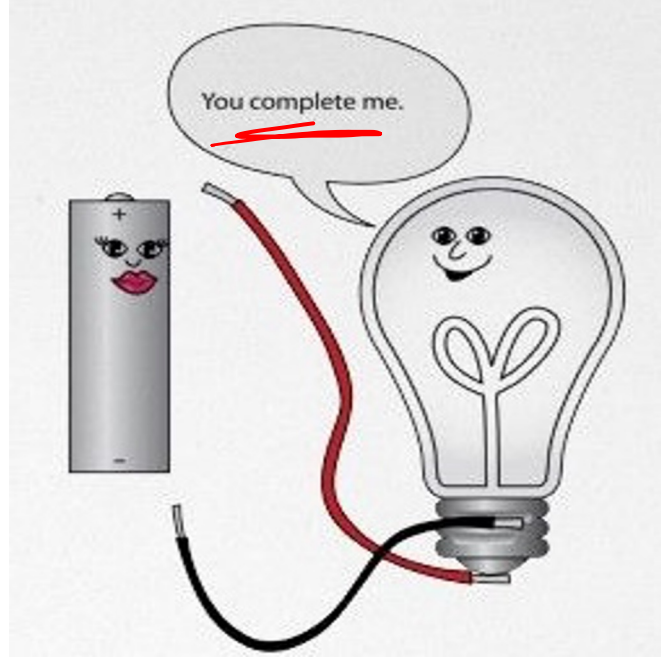


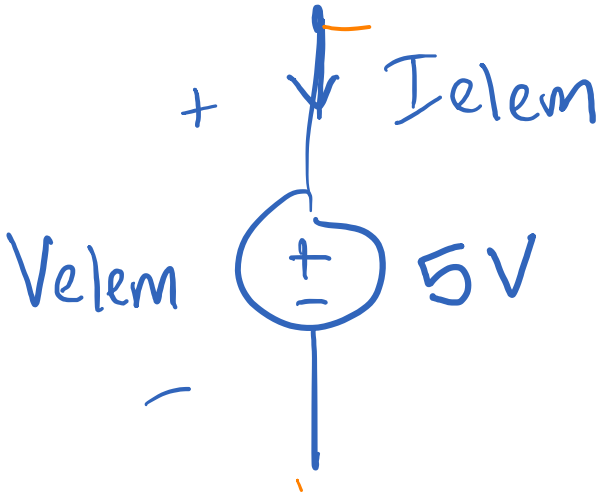


$$I = V \cdot \frac{1}{R}$$

$$V_{elem} = R \cdot I_{elem}$$

Key circuit elements: Voltage Source

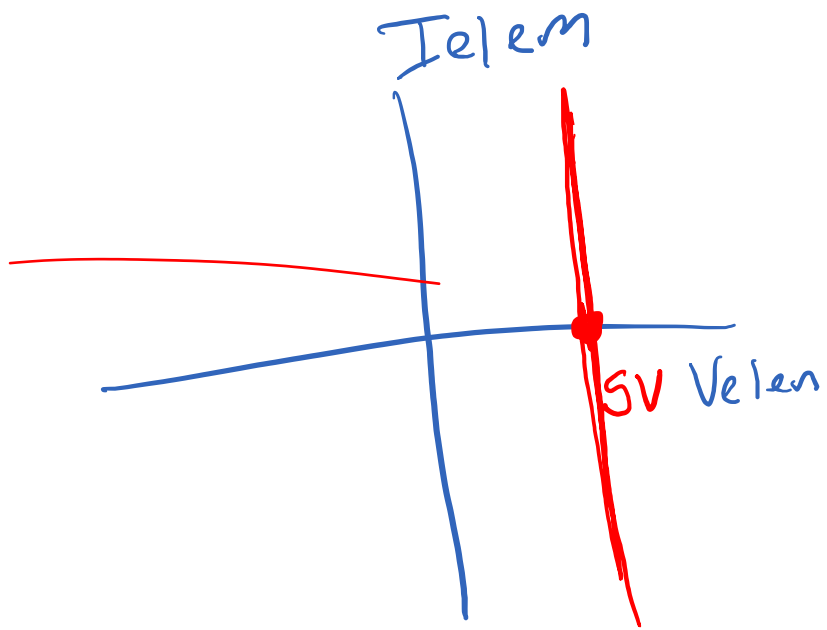




Velem = 5V

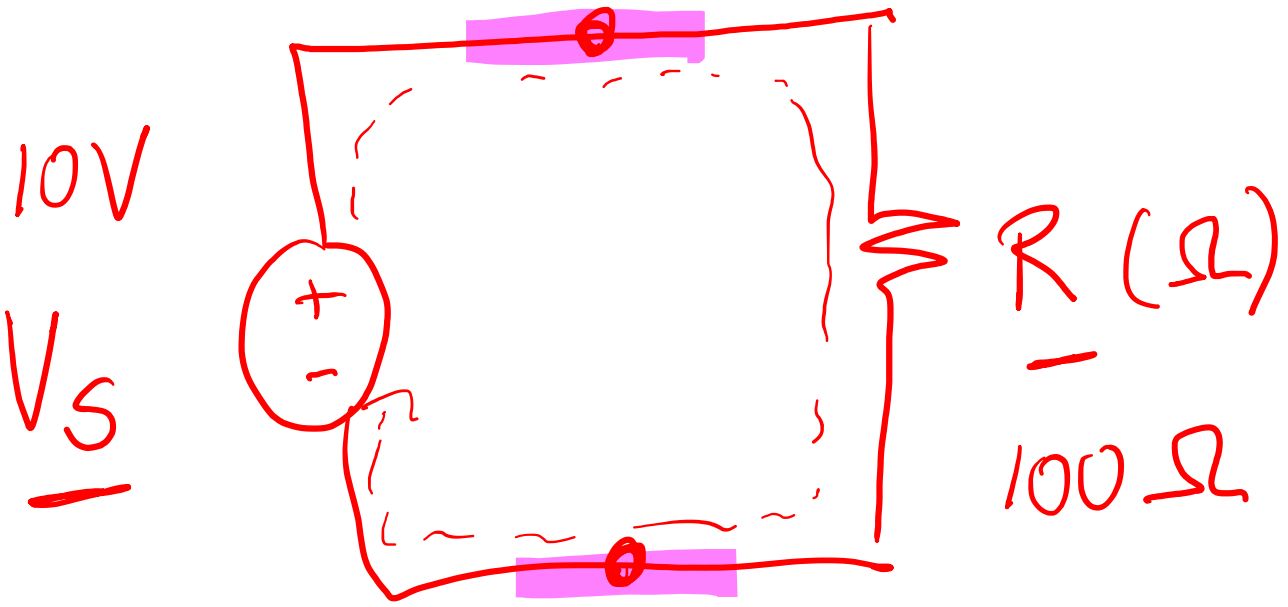
Ielem = ?

I is set by external circuit



Circuit Diagram

Collection of elements, where each element has some voltage across it and some current through it



$V = IR$

$10V = I \cdot 100\Omega$

$I = 0.1\,A$

Nodes: points where elements meet

Devices as part of a system

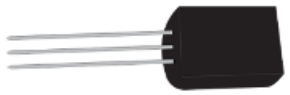
Discrete Components

Resistor

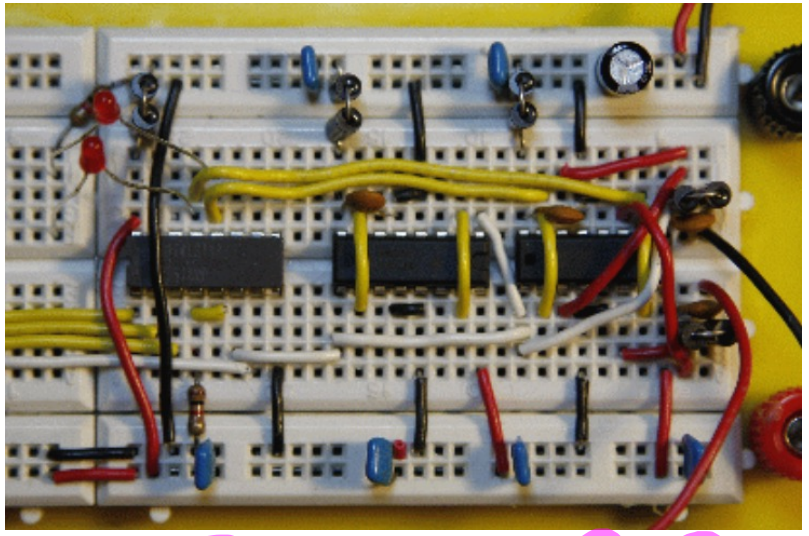
Capacitor

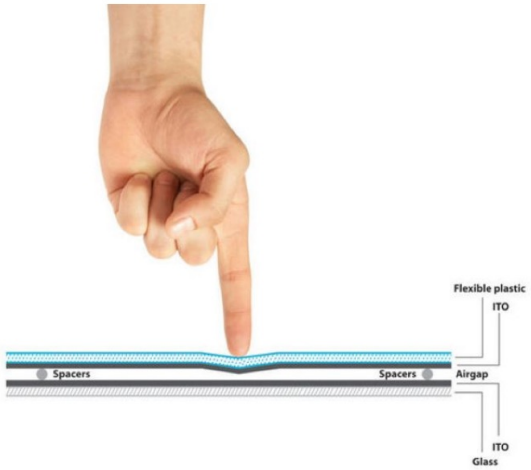
Inductor

Diode

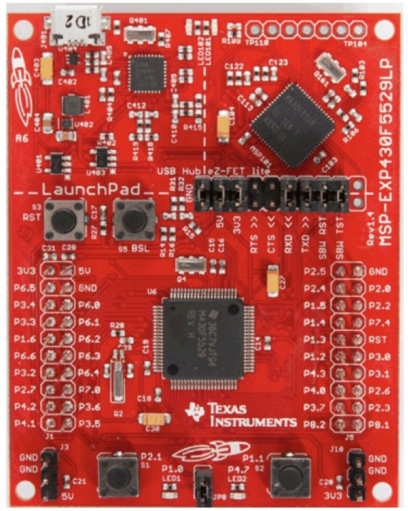


Transistor



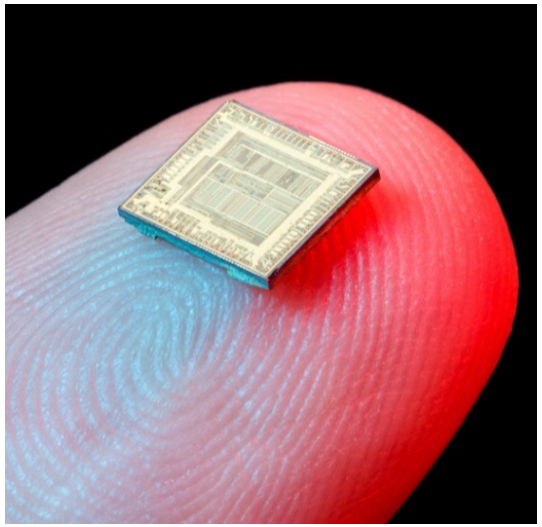


Resistive touchscreen



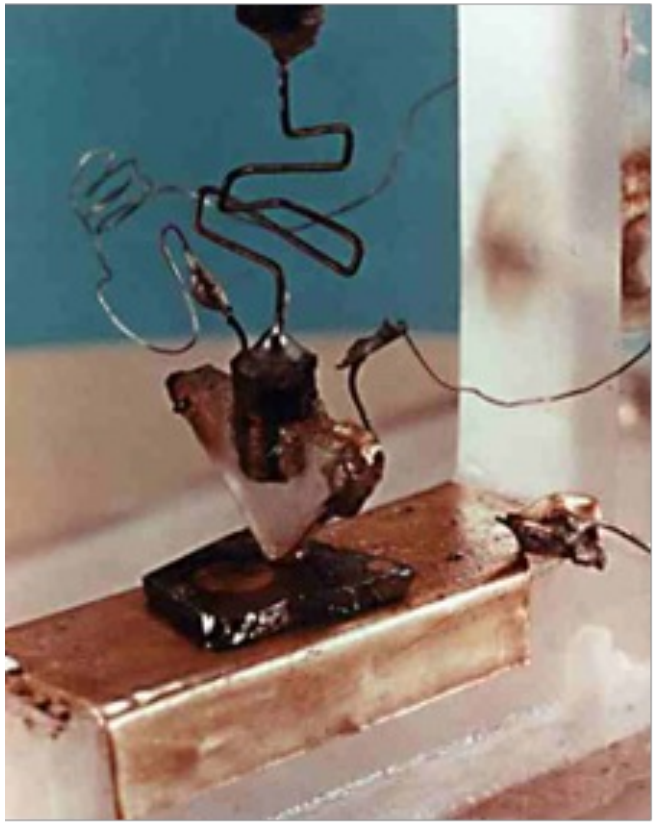
Printed Circuit Board

Surface Mount Components

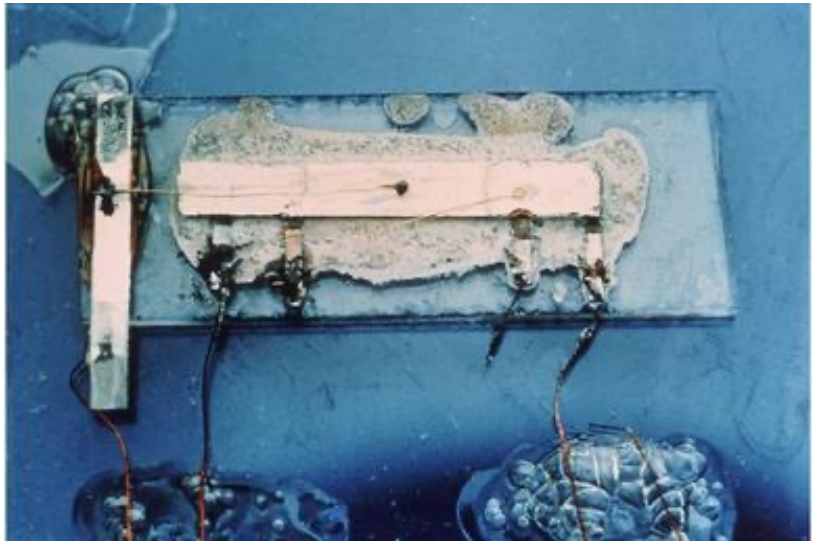


Integrated Circuit

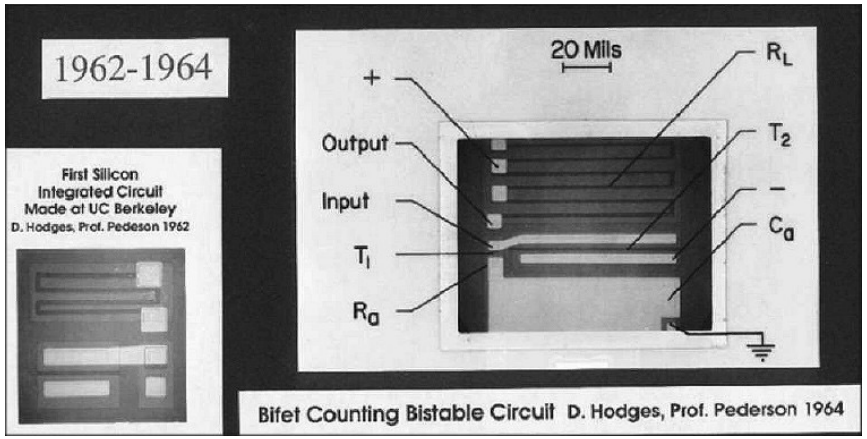
Transistor



First transistor – Dec 1947



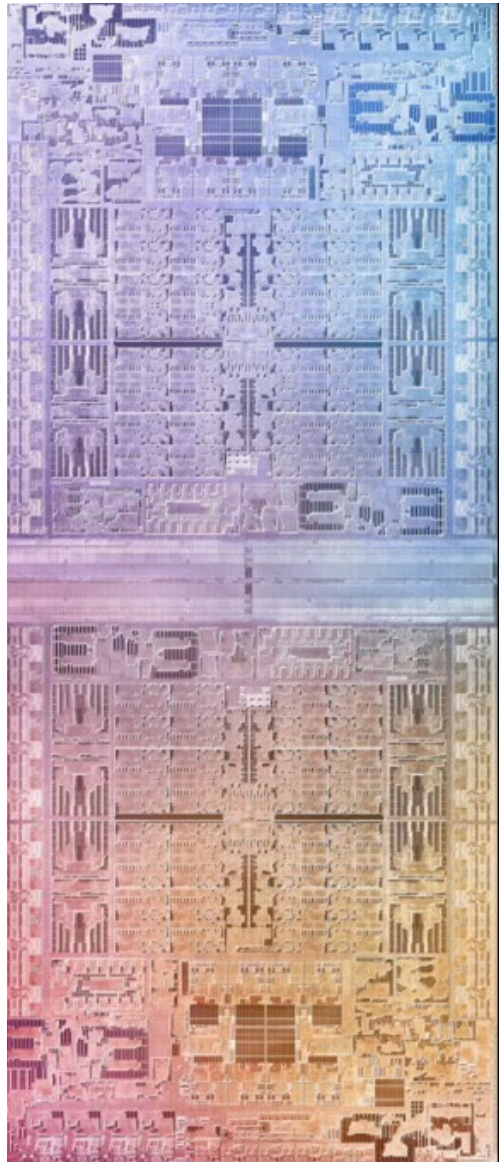
First integrated circuit 1958



Modern IC:

2022: Apple M1 Ultra Processor

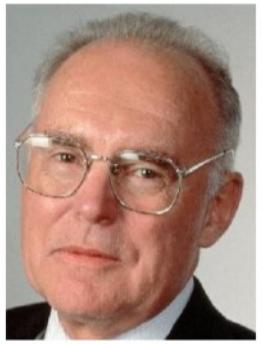
5nm transistors, 114 billion of them!



Go Bears!

Computational advances due to fabrication advances

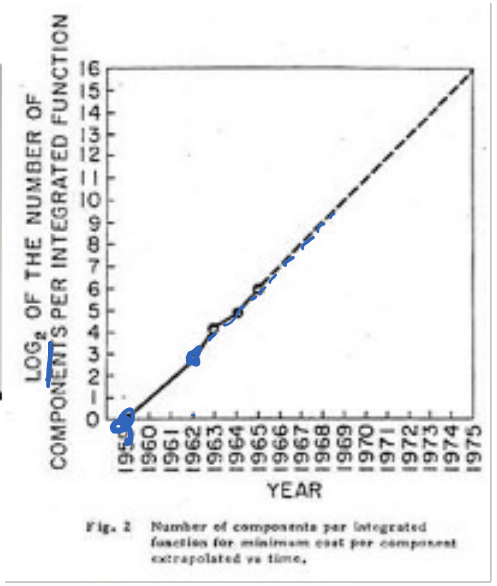
Moore's Law: # of transistors in a dense integrated circuit doubles ~every two years.



Gordon Moore

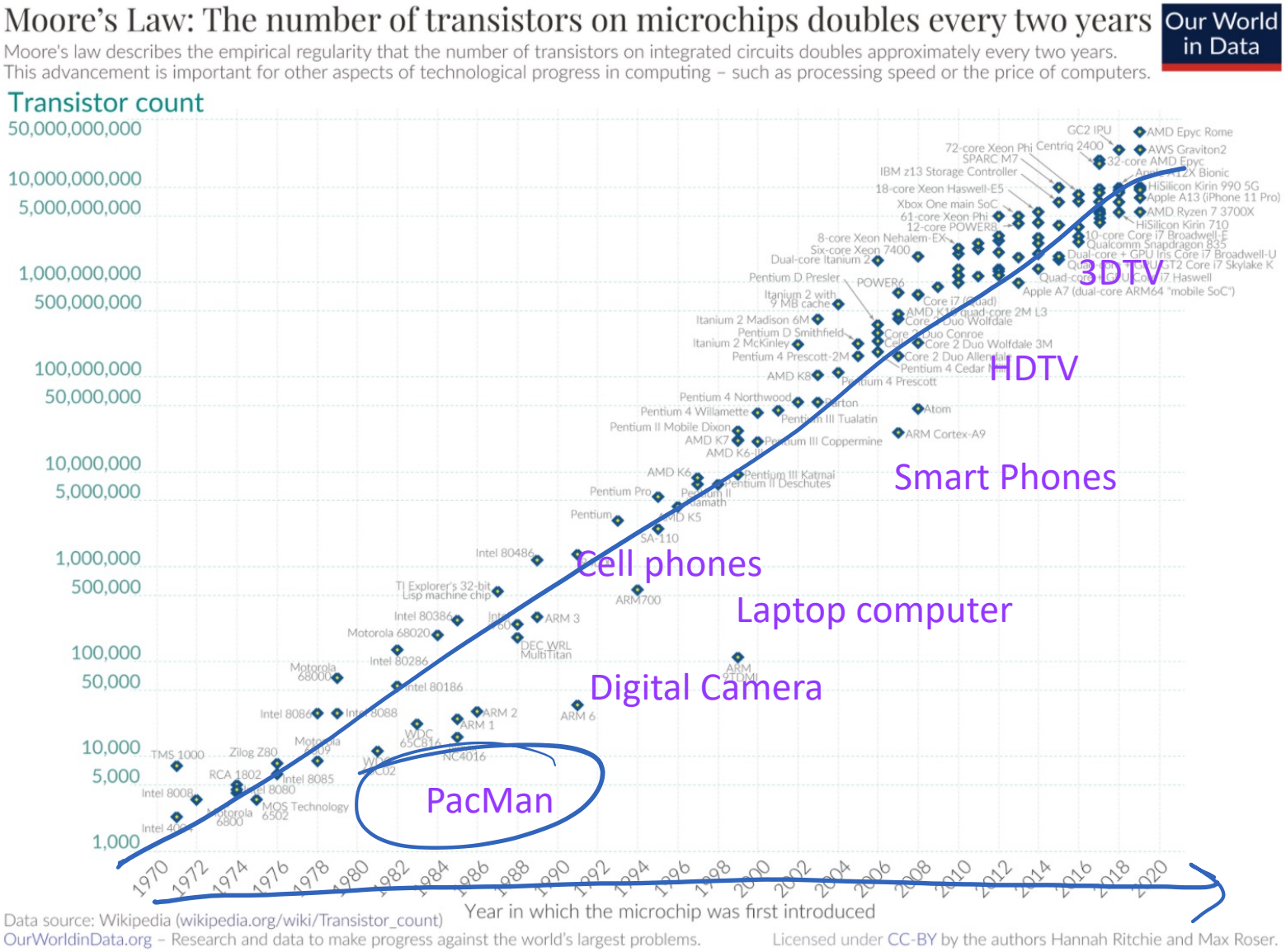
Intel Cofounder

B.S. Cal 1950!



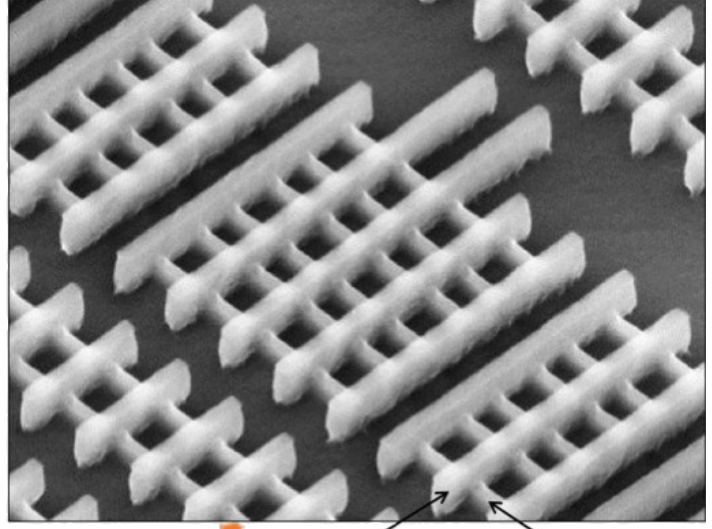
Electronics Magazine, 1965

Go Bears!



Sense of Scale

Transistors!
As small as 5nm!



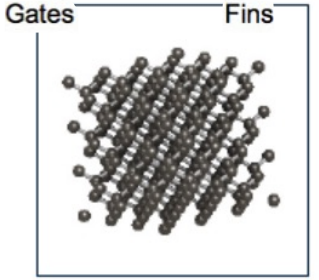
Laura
1.73m

Fly
7 mm

Mite
300 um

Blood Cell
7 um

Virus
100 nm



Silicon Atom
0.24 nm

10 1 100 10 1 100 10 1 100 10 1 0.1

meter | millimeter | micrometer | nanometer

LOG SCALE

Source: Mark Bohr, IDF14

FinFET

2320 IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 47, NO. 12, DECEMBER 2000

FinFET—A Self-Aligned Double-Gate MOSFET Scalable to 20 nm

Digh Hisamoto, *Member, IEEE*, Wen-Chin Lee, Jakub Kedzierski, Hideki Takeuchi, Kazuya Asano, *Member, IEEE*, Charles Kuo, Erik Anderson, Tsu-Jae King, Jeffrey Bokor, *Fellow, IEEE*, and Chenming Hu, *Fellow, IEEE*

***Abstract*—MOSFETs with gate length down to 17 nm are reported. To suppress the short channel effect, a novel self-aligned double-gate MOSFET, FinFET, is proposed. By using boron-doped $Si_{0.4}Ge_{0.6}$ as a gate material, the desired threshold voltage was achieved for the ultrathin body device. The quasiplanar nature of this new variant of the vertical double-gate MOSFETs can be fabricated relatively easily using the conventional planar MOSFET process technologies.**

***Index Terms*—Fully depleted SOI, MOSFET, poly SiGe, short-channel effect.**

I. Introduction

TO DEVELOP sub-50-nm MOSFETs, the double-gate structure has been widely studied. This is because

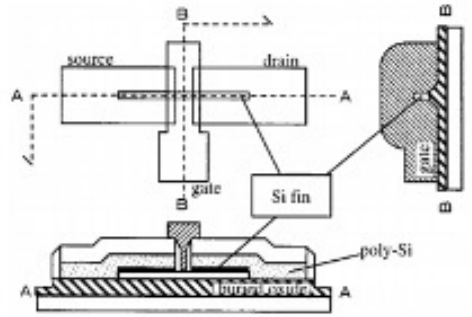


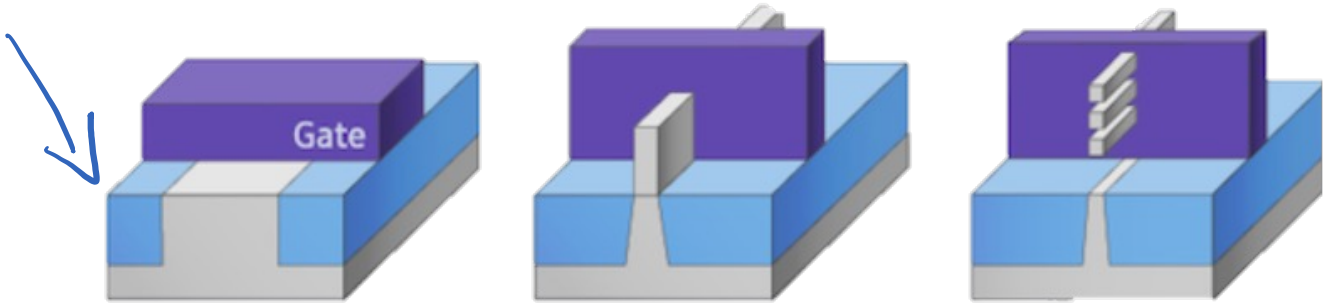
Fig. 1. FinFET typical layout and schematic cross sectional structures.

Prof. Tsu-Jae King Liu

Prof. Jeff Bokor

Prof. Chenming Hu (left)

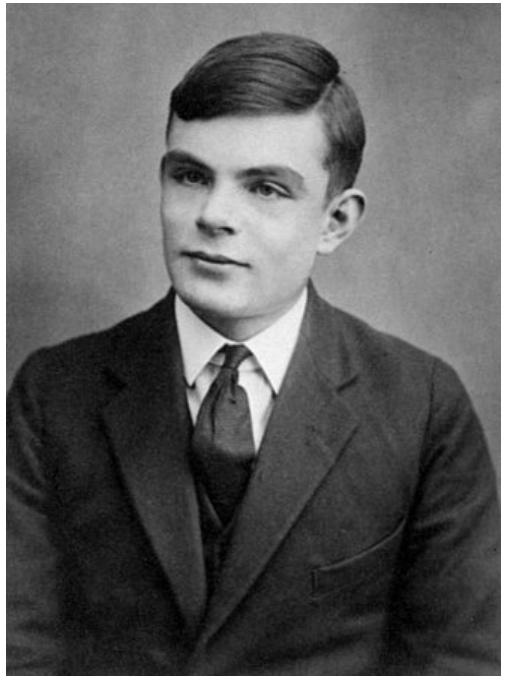
Go Bears!



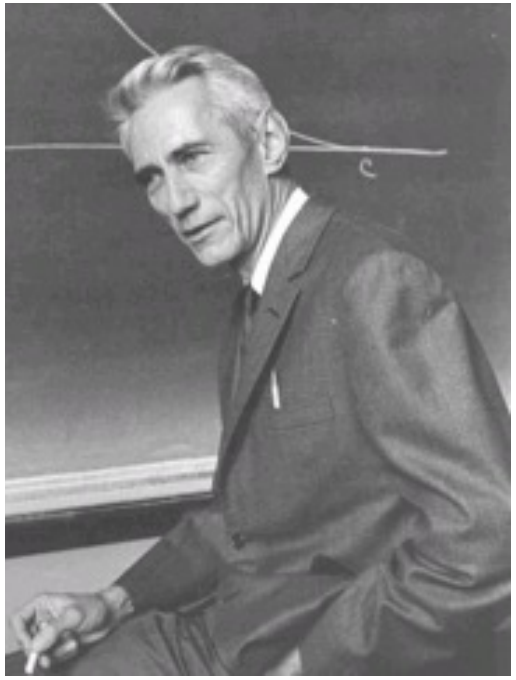
MOSFET FINFET GAAFET

Completing the puzzle… coding!

Ada Lovelace
wrote the first computer program



Alan Turing
figured out how to build a computer to execute programs



Claude Shannon
Information theorist

Module 1: Imaging