


# Welcome to EECS16A!

## Designing Information Devices and Systems I

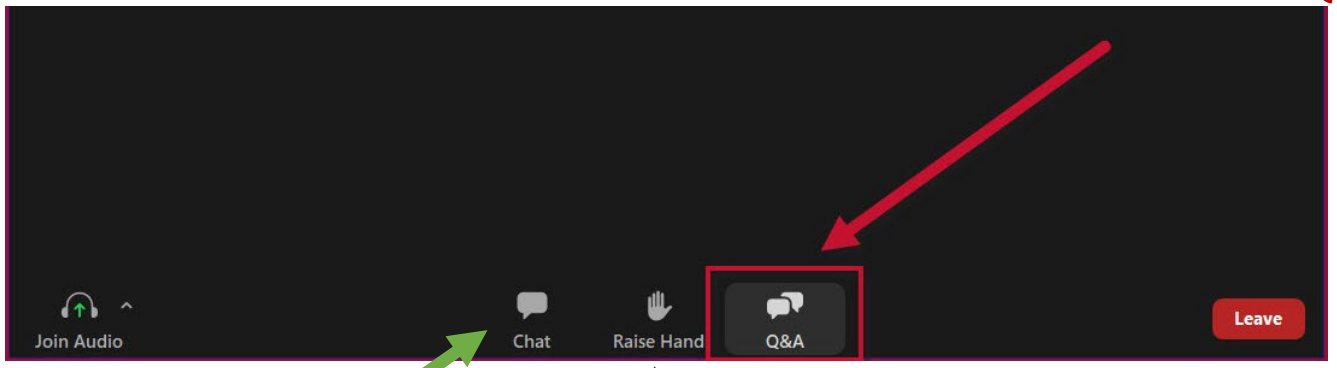
Prof. Laura Waller

Spring 2021


All of these extract information from the real world and interact with it; we will be learning how to design and understand these devices & systems

# zoom logistics

If you have a question for me, please type it into the Q&A




If you have a question other students can answer, please use the chat

If you would like to ask a question verbally, please use the raise hand feature

# Instructors

Prof. Laura Waller
waller@berkeley.edu

Prof. Elad Alon
elad@eecs.berkeley.edu

Office Hours: right after lecture, but at
https://berkeley.zoom.us/my/laura.waller

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

# About me

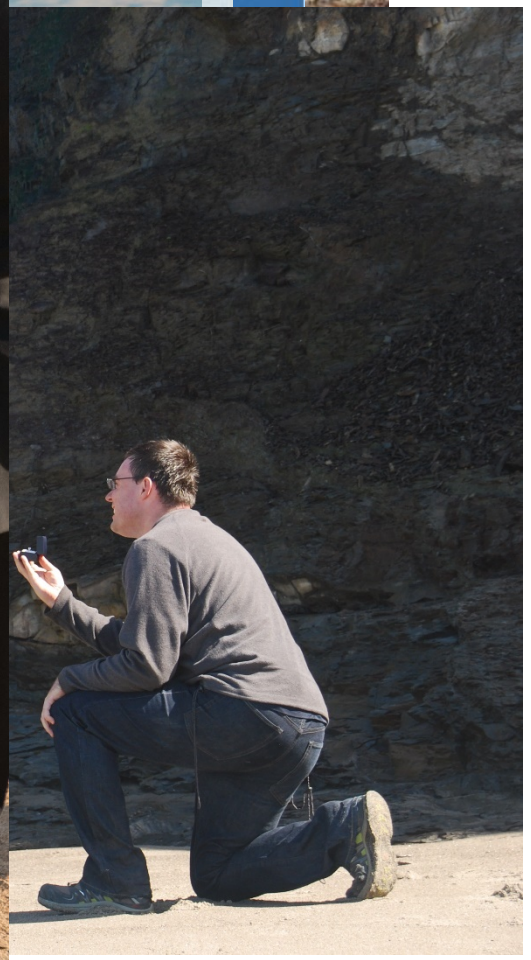
- Ph.D., EECS, Massachusetts Institute of Technology, 2010
- M. Eng., EECS, Massachusetts Institute of Technology, 2005
- B.S., EECS, Massachusetts Institute of Technology, 2004

- Lecturer in Physics, Postdoc in EE at Princeton 2010-2012

- Classes I teach:
  - EE118/218 Introduction to Optical Engineering
  - CS294 Computational Optical Imaging
  - EE84 Hands-on Optics
  - EE225A Statistical Digital Signal Processing

# My hobbies…


# My hobbies…



# Other Staff

Head GSIs:
eecs16a@Berkeley.edu
Email with:
- Questions not for Piazza
- Conflicts, accommodations for exams etc.
- Emergencies
- Administrative questions

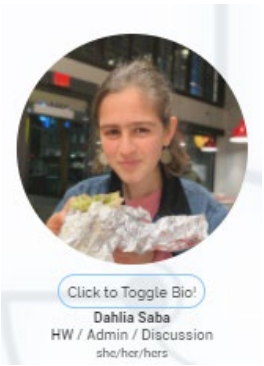
Amanda Jackson

Anika Ramchandran

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

Krystle Simon

# Teaching Assistants (TAs) Intro



Click to Toggle Bio!
**Dahlia Saba**
HW / Admin / Discussion
she/her/hers

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**Austin Patel**
Software / Dis
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austinpatel@

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**Mohsin Sarwari**
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mohsin.sarwari@

## Lab TAs

Click to Toggle Bio!
**Vidish Gupta**
Head Lab
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eecs16a.lab@, vidishgupta@

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**Raghav Gupta**
Head Lab
he/him/his

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**Teresa Yang**
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**Dixun Cui**
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**Aster Guan**
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**Rohan Sood**
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**Meghana Bharadwaj**
Content / Lab
she/her/hers
meghana.bharadwaj@

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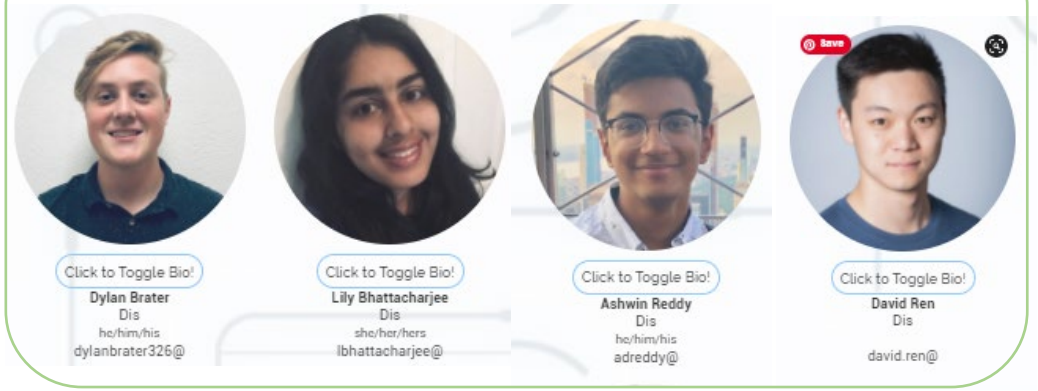
**Frederic Wang**
Lab
he/him/his
fredwang@

## Discussion TAs



Click to Toggle Bio!
**Dylan Brater**
Dis
he/him/his
dylanbrater326@

Click to Toggle Bio!
**Lily Bhattacharjee**
Dis
she/her/hers
lbhattacharjee@

Click to Toggle Bio!
**Ashwin Reddy**
Dis
he/him/his
adreddy@

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**David Ren**
Dis
david.ren@

## Content TAs

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**Miyuki Weldon**
Content / Dis
she/her/hers
m.weldon@

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**Tyler Reichanadter**
Content
he/him/his
jtreichanadter@

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**Xiaosheng Zhang**
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**Bob Zhou**
Content / Dis
he/him/his
bob.linchuan@

Click to Toggle Bio!
**Varun Menon**
Content / Dis
he/him/his
varunmenon@

# We are here to help

- ~23 TAs, ~45 Academic Student Employee (ASE)
  - Lots of different research areas and interests represented (by design)

- So you want to be on 16A staff? Here's the path:
  - Do great in 16A
  - Become an ASE
    - Grade homeworks, assist in labs, tutor and help out in OH, work on improving the notes …
    - Become a uGSI
    - Become head TA…

# Course policies

- Syllabus is on the course website: https://eecs16a.org/
  - You are responsible for reading and following all course policies listed
- Piazza: http://piazza.com/
  - a resource for you to help each other out
- Gradescope
- Exam proctoring via zoom

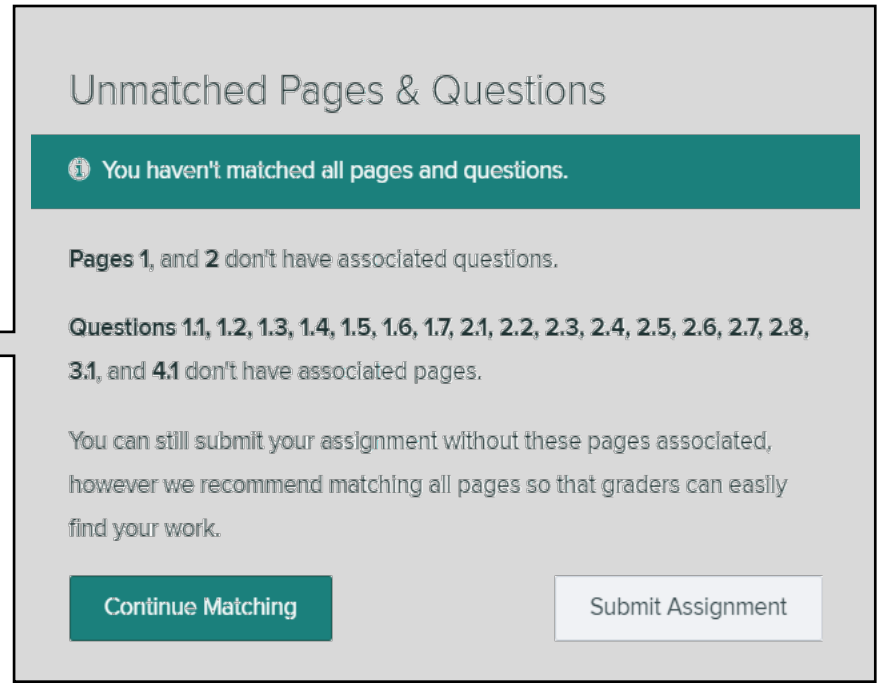
# Homeworks (HW)

- Due Fridays at 11:59pm
  - HW0 due Fri Jan 22
- HW Party: Thu 2-4 pm
- Office Hours (OH): at various times
- Self-grading:
  - due Mon at 11:59pm
  - resubmissions due Mon 11:59pm
  - resubmission self-grades due Mon 11:59pm

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

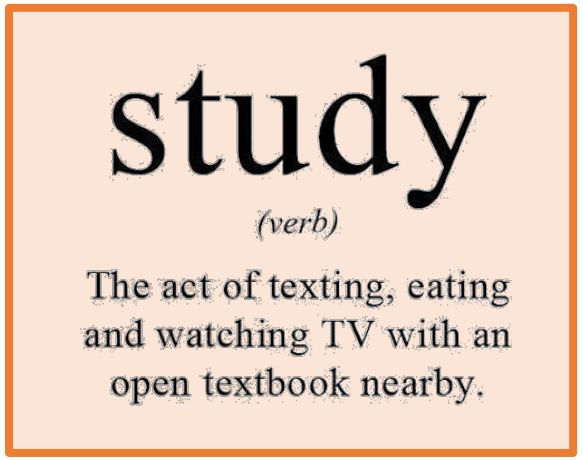
# Homework Submission

- Homework submitted on Gradescope
  - enroll if you haven't been automatically: code D5PEYX
  - You must select pages
  - You must submit printout of iPython code (see syllabus)



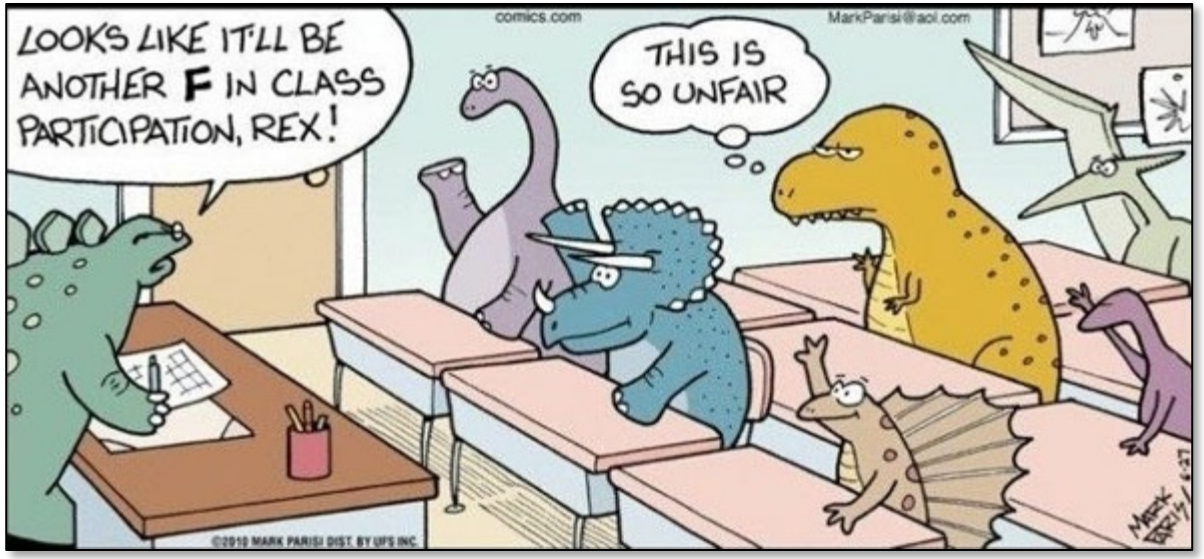
# Study groups

- System to match you into study groups
- Fill out the information form in HW0
- Chance to meet new friends and study buddies



# Course policies

- Attend lecture (required)
- Attend discussion (required, one on Mon, one on Wed. Automatic participation points, submit checkoff if watching recording.)
- Attend lab (required, at your scheduled time, checkoff during your lab)
- Attend office hours and homework party (optional)



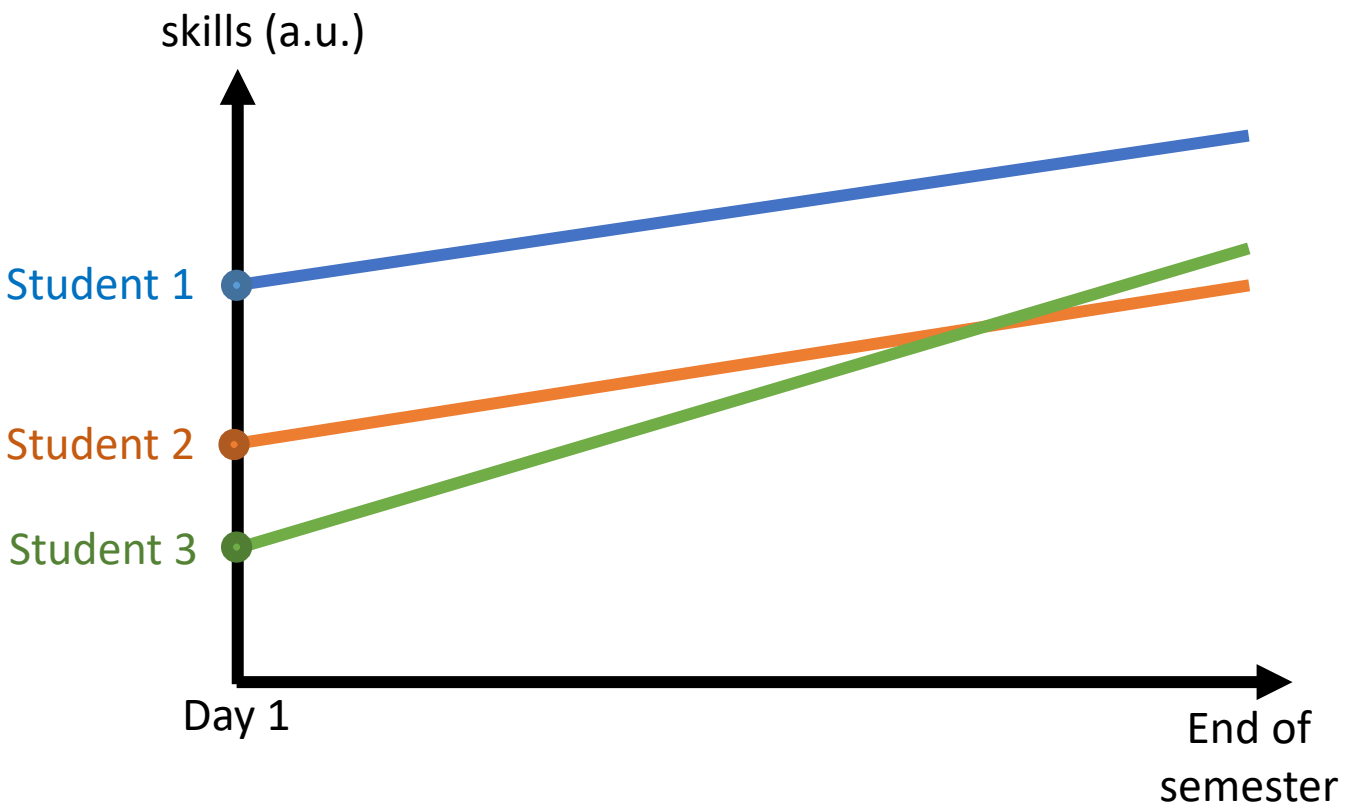
# You are here to learn!

- Learning can be hard and fun
- Collaborate and build community on Piazza/HW Party/Study Groups
- Encourage different perspectives – this is Berkeley!
- Cheating directly detracts from learning
  - Any cheating will be immediately sent to the Office of Student Conduct
  - Report bad behavior
- Everyone here is smart
  - Students have different backgrounds
  - Professors make mistakes – feedback helps
  - If you are struggling, ask for help!

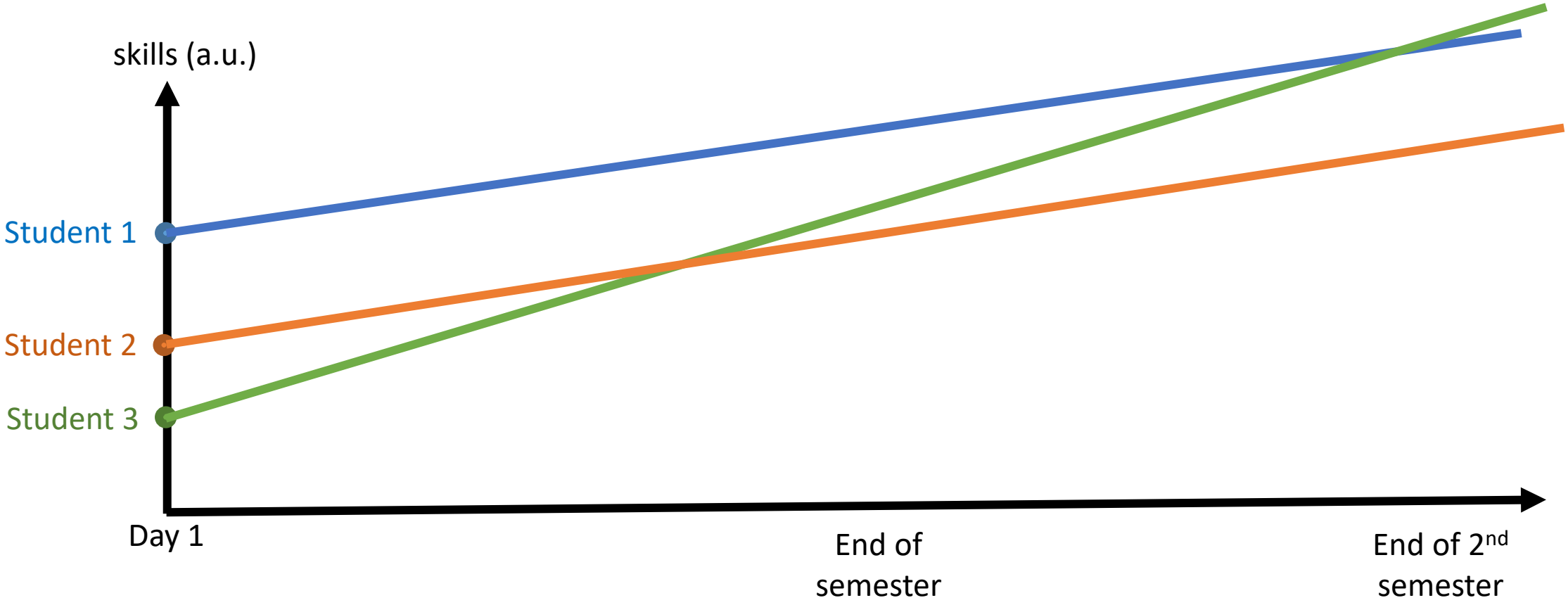
# How to succeed in16A

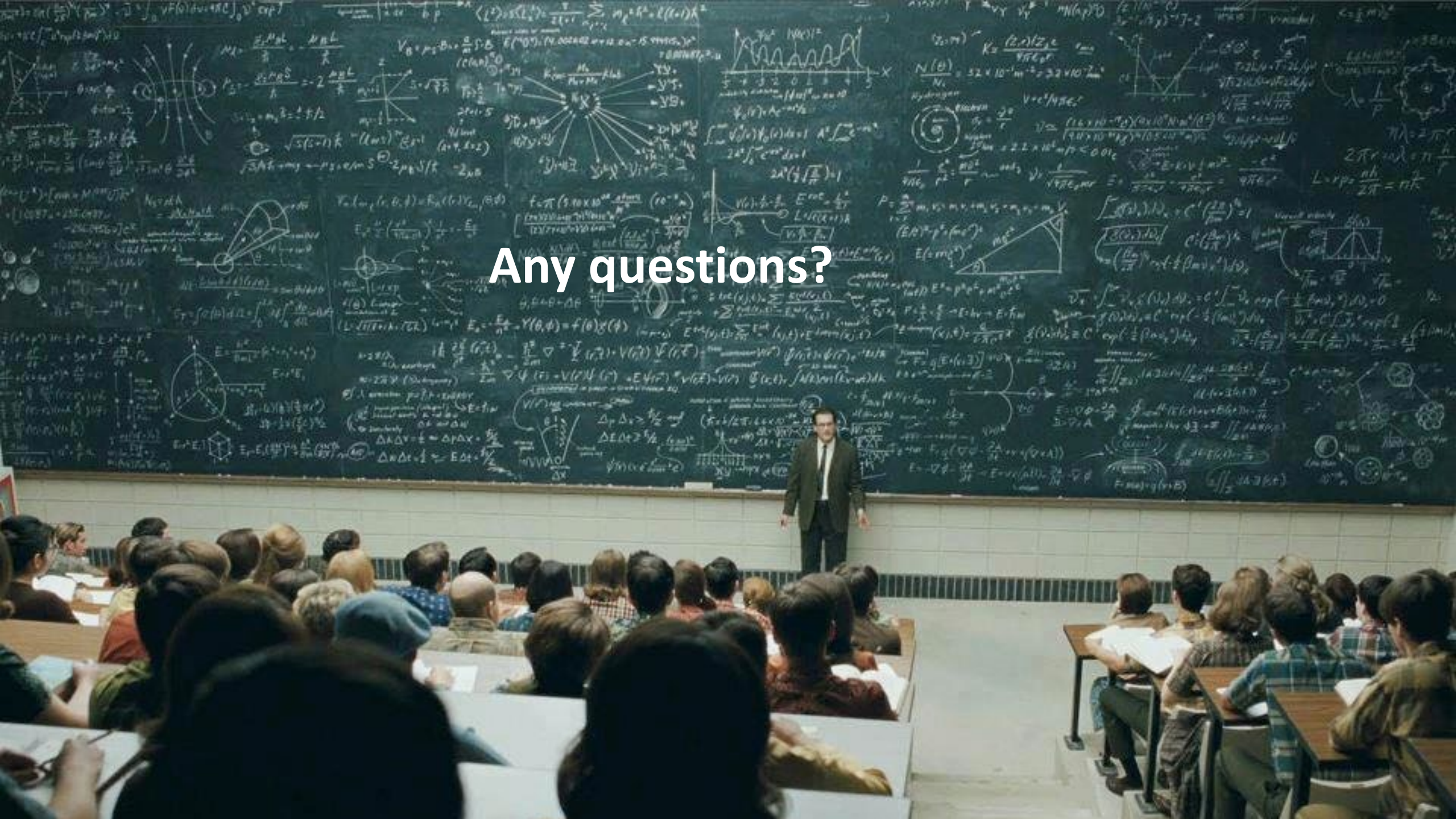
- Get enough sleep
- Attend lecture and discussion
- Do not do the above two at same time
- Actively read notes
- Try HW on your own, early
- Discuss problems with study group and/or at HW Party
- Help others on Piazza
- Study with others as well as alone
- Seek and offer help

# Slope is more important than intercept



# Slope is more important than intercept




Any questions?


START

# Did you know…

The same idea that allows touchscreens to detect touch,

Also allows an autonomous car drive in a straight line,

And allows search engines to rank webpages,

And trains deep learning neural networks.

Eigenvalues!

# Did you know…

That the same idea that makes Shazam work

Also make the GPS on your phone work?

Cross-correlation!

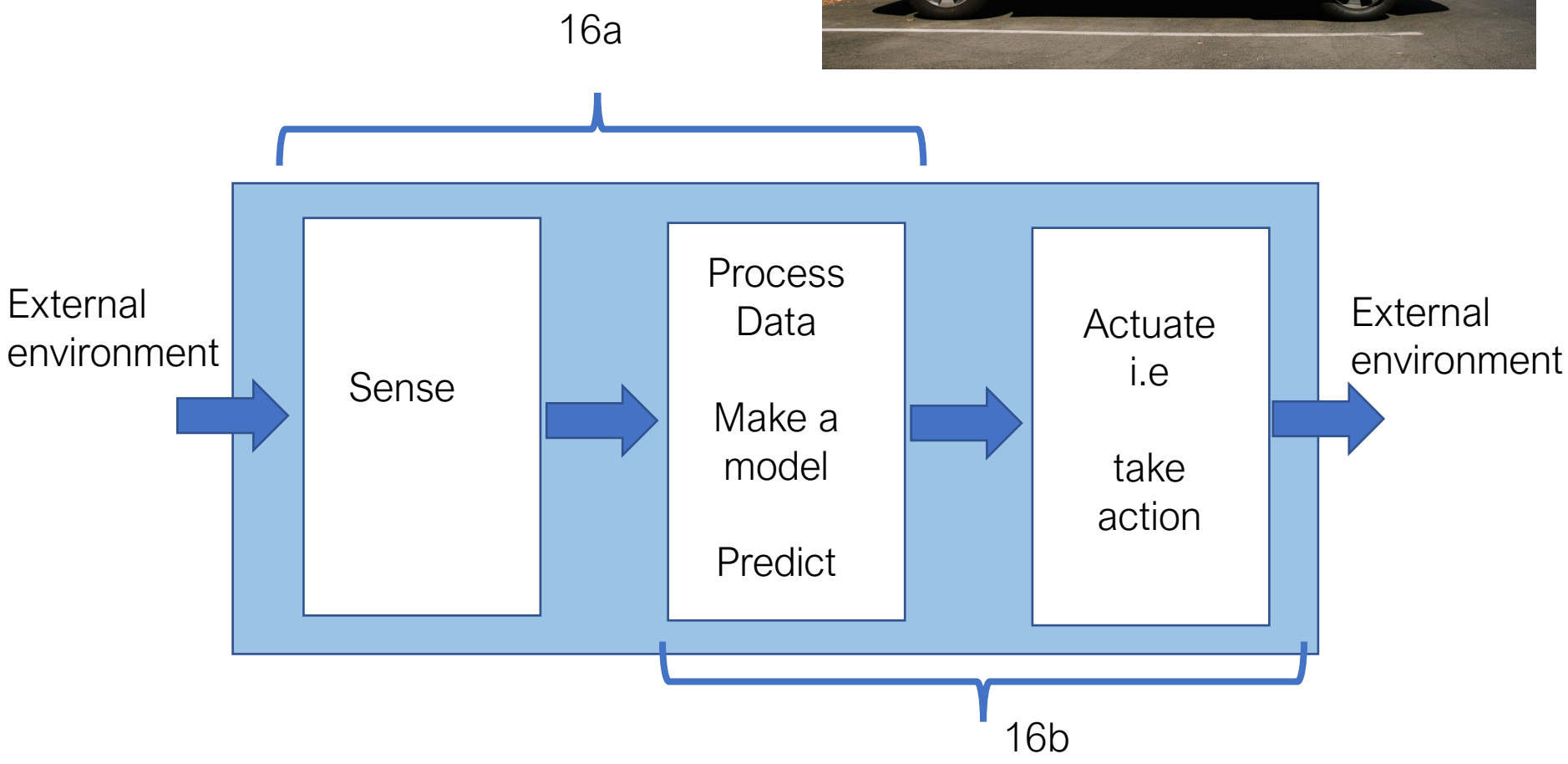
# Did you know…

A fundamental algorithm in machine learning and artificial intelligence

Is used to make predictions in biology, brain-machine interfaces, social sciences, imaging algorithms and more?

Least-squares!

# Example application: self-driving cars

# Learning goals

**16A**

Module 1: Introduction to systems

How can we collect data? How do we build a model?

Module 2: Introduction to circuits and design

How do we use a model to solve a problem?

Module 3: Introduction to Machine Learning

How do we “learn” models from data and make predictions?

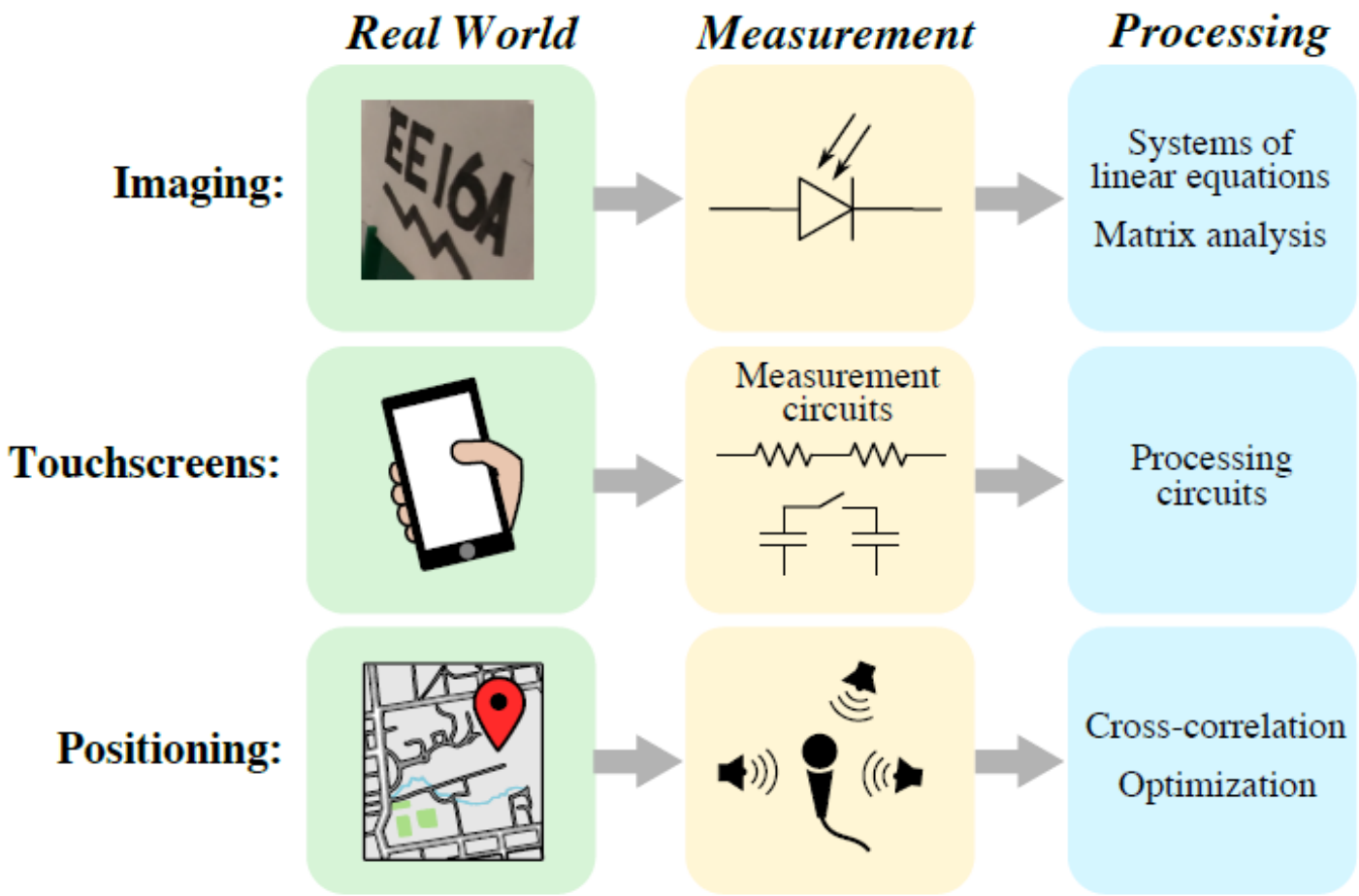
**16B**

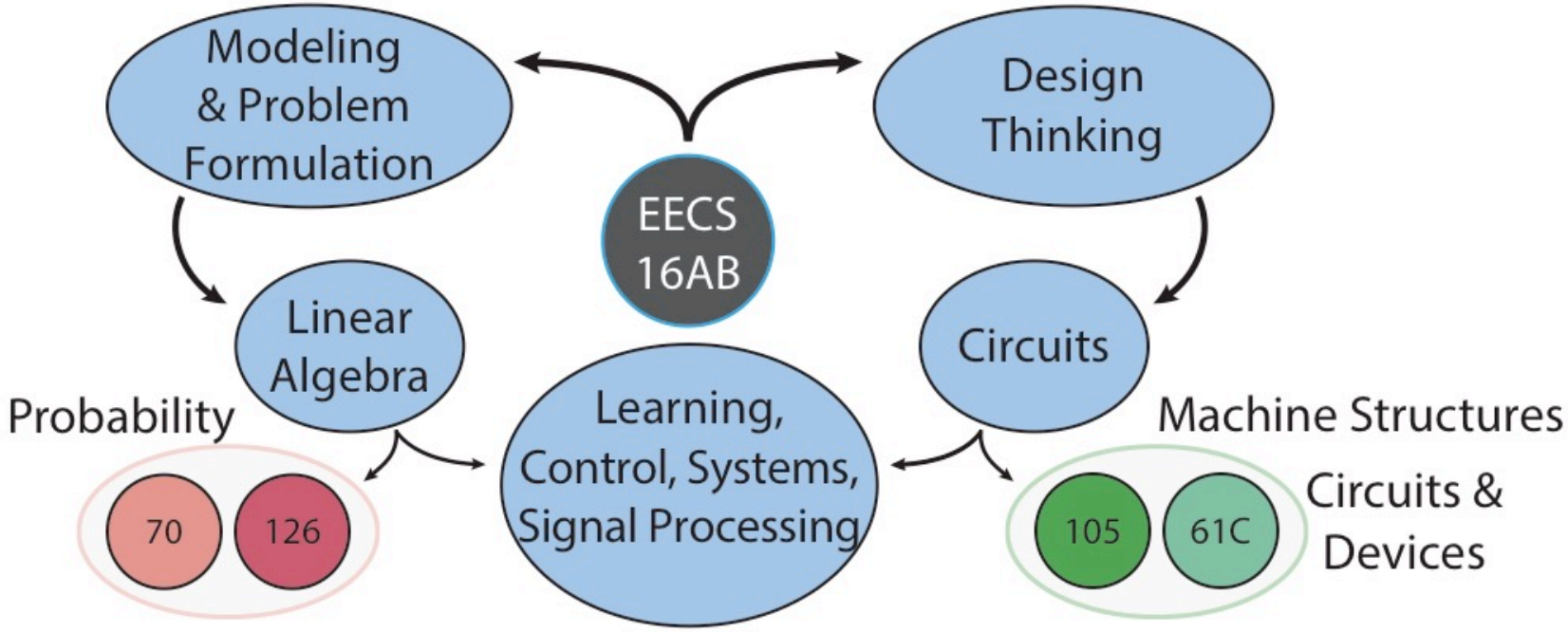
Module 4: Advanced circuit design

Module 5: Introduction to robotics

Module 6: Introduction to unsupervised learning

# 16a Examples



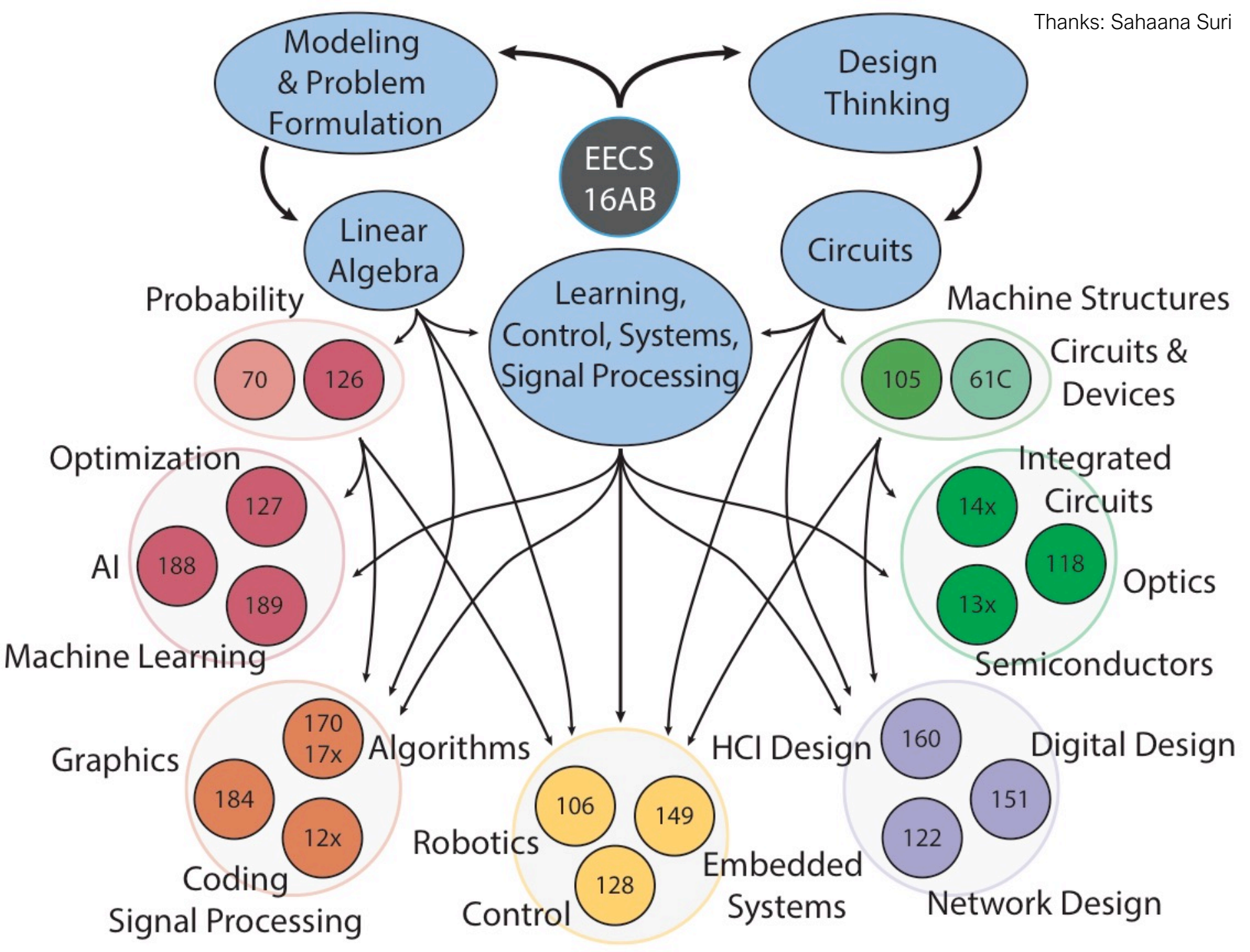



How to approach something unfamiliar
and systematically build understanding

Linear Algebra: conceptual tools to model
Circuits: How to go from model to design, grounded in physical world

Intro to foundational concepts in Machine Learning

Thanks: Sahaana Suri

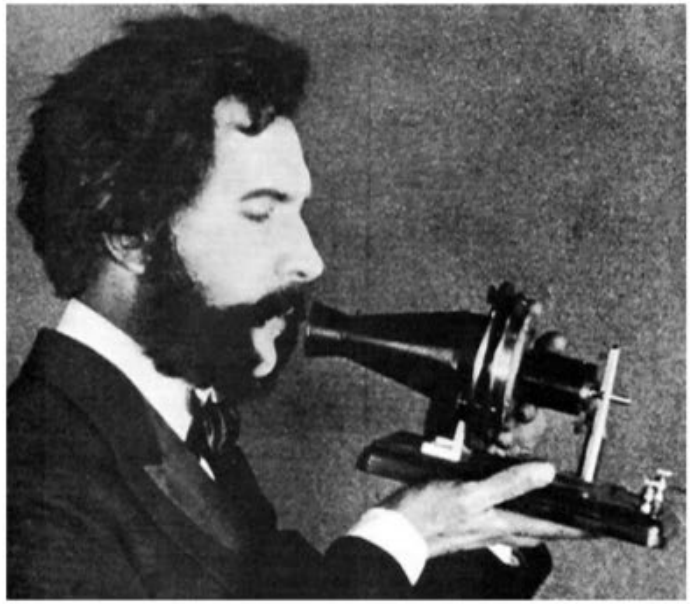


# How did we get from this…

1837

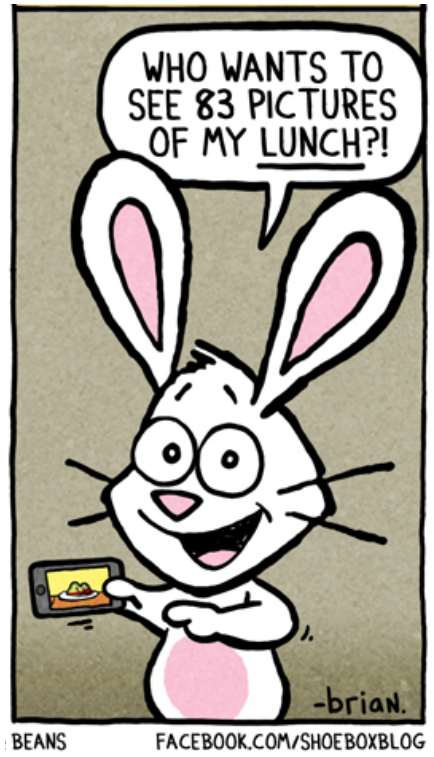
1866

1876



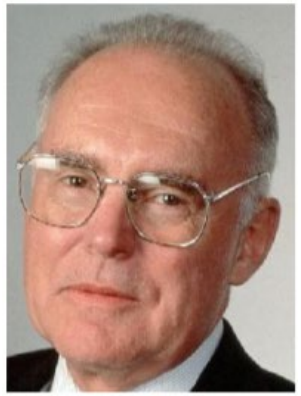
# To this…


Zoom Participant ID:52 Meeting ID: 520-729-3829
Speaker View
Shon Prins
Aileen Ewers
Micaela Brinegar
Brandon Letsinger
Bertram Layman
Ervin Dahlberg
Nickolas Wiest
Verena Bilodeau
Marcela Panther
Winston Jeong
Eleonor Slade
Adam Wang
Christian Mes Tarantino
Kristen Vandam
Nickolas Pietrowski
Leighann Bowne
Calista Parkhill
Cathy Holland
Bertram Layman
Emory Craney
Benton Joines
Christian Bowne
Wesley Abernathy
Winston Parmer
Genevieve Philippi
1/2
1/2
Mute
Stop Video
Invite
Manage Participants
42
Share
Chat
Record
Closed Caption
More
End Meeting


WHO WANTS TO SEE 83 PICTURES OF MY LUNCH?!
-brian.
BEANS
FACEBOOK.COM/SHOEBOXBLOG


WAYMO

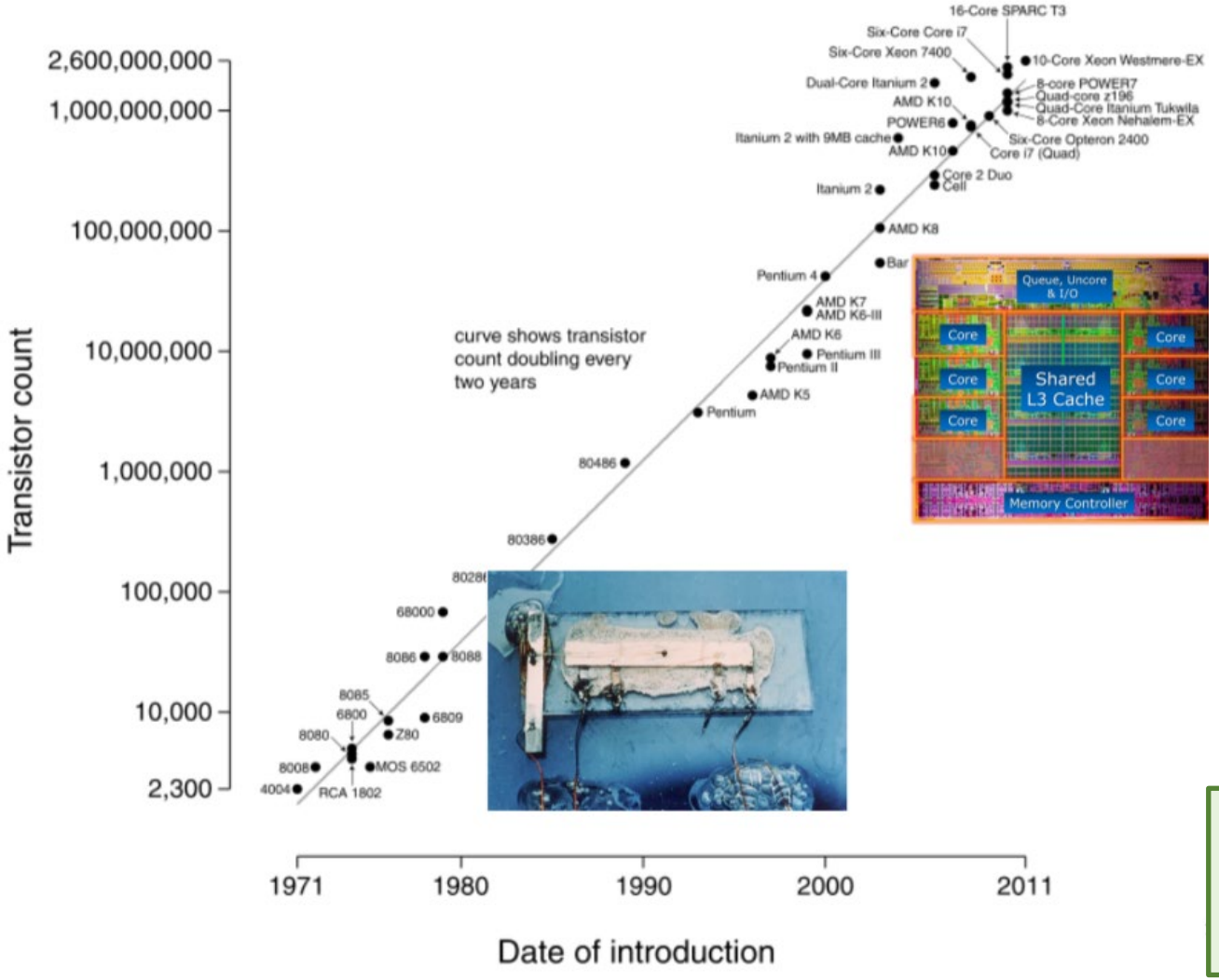
# Computational advances have been riding Moore's Law



**Gordon Moore**

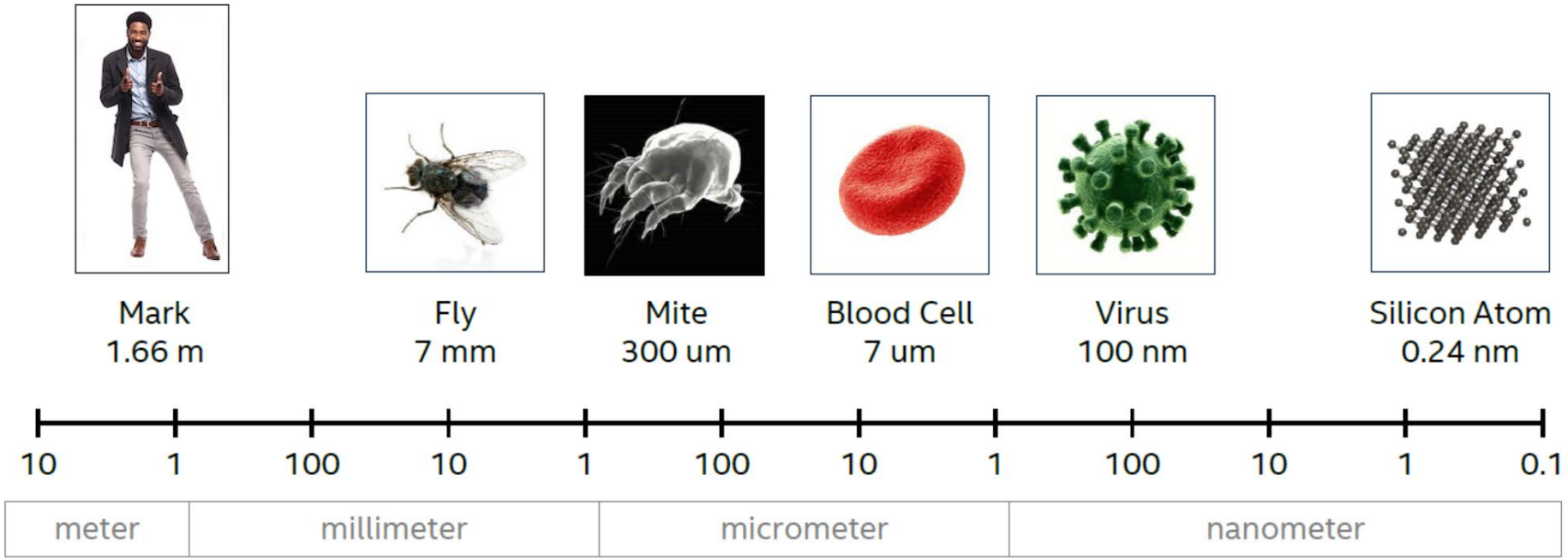
**Intel Cofounder**

**B.S. Cal 1950!**




What is a transistor?

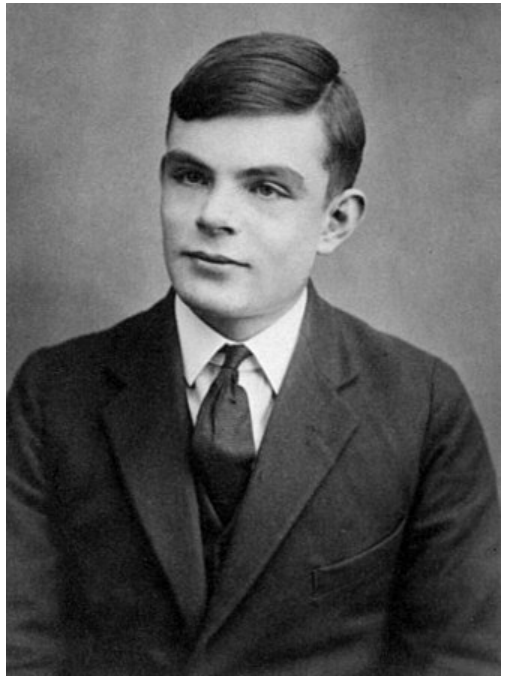
# Sense of Scale



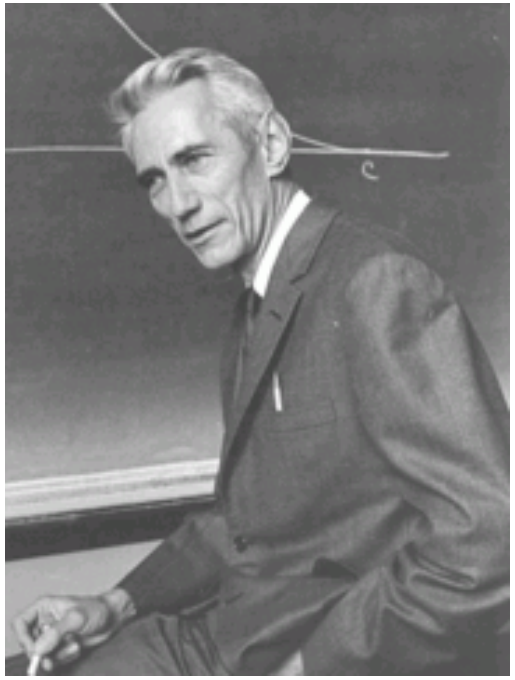

Source: Mark Bohr, IDF14

# Completing the puzzle …

**Ada Lovelace**
wrote the first computer program

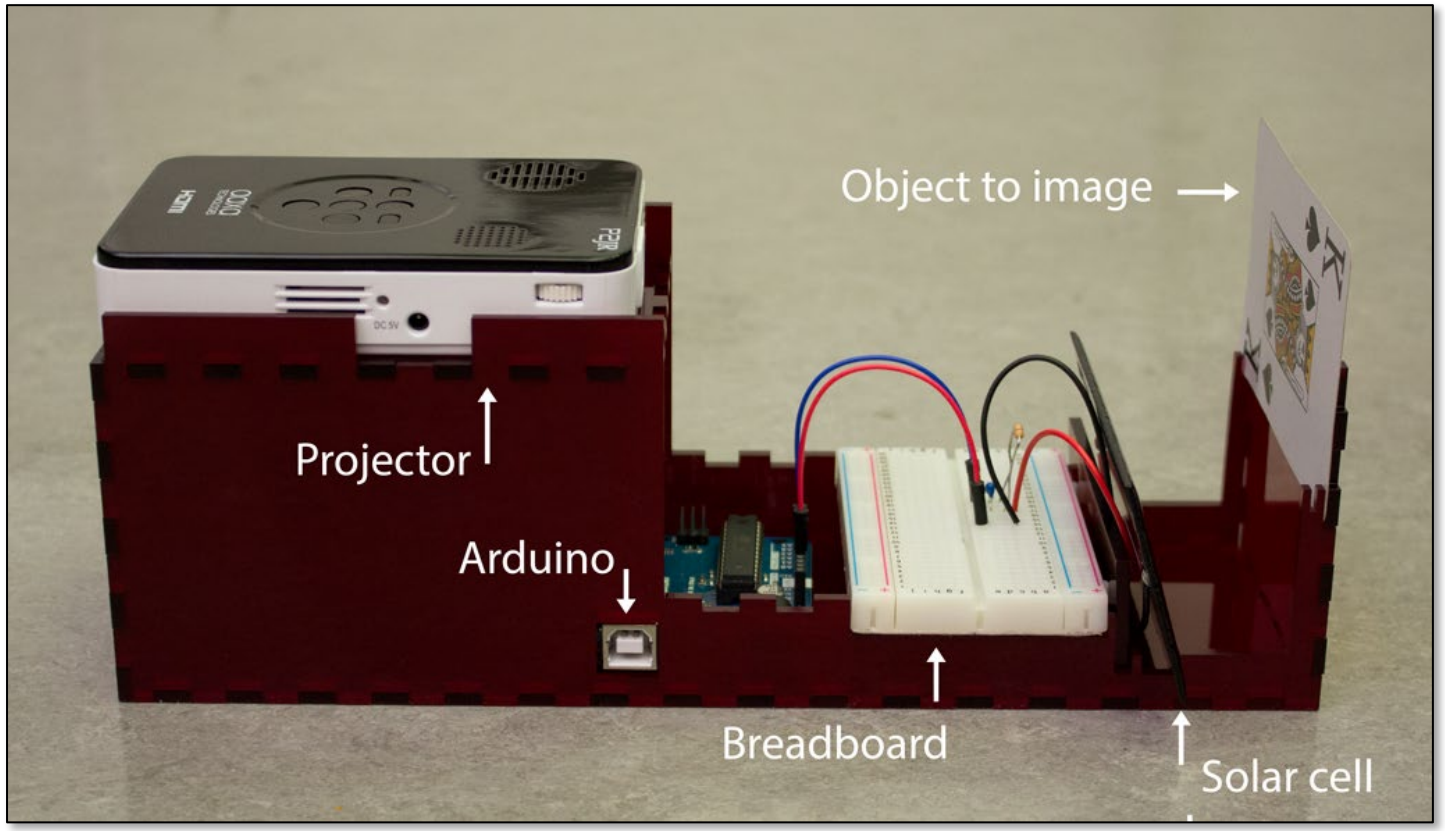


**Alan Turing**
figured out how to build a computer to execute programs



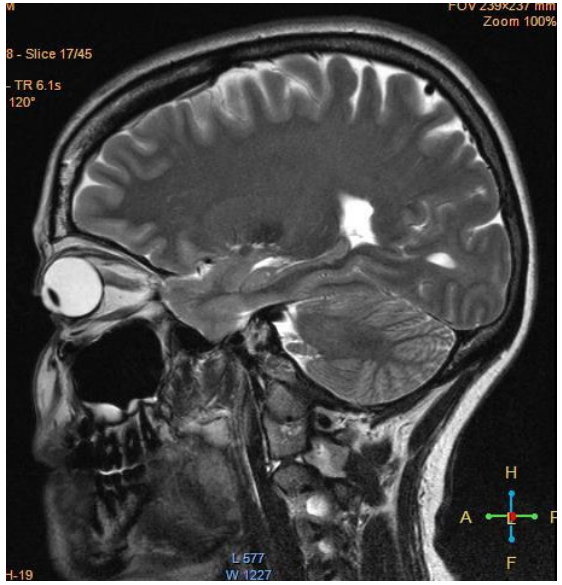
**Claude Shannon**
Information theorist

# Module 1: Imaging



# Seeing inside bodies: sans surgery…

MRI



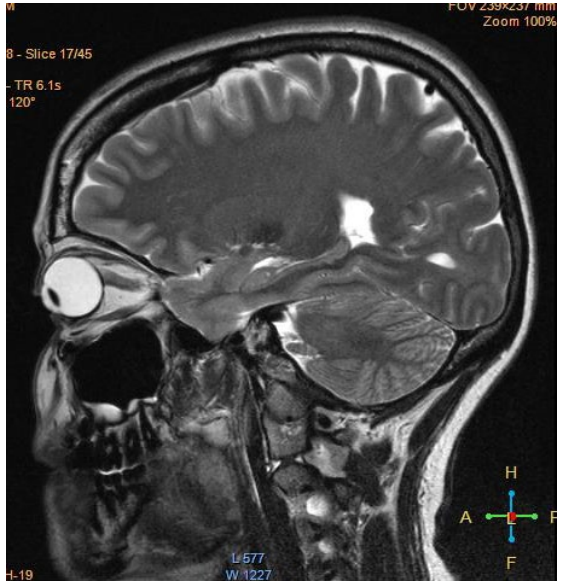

X-Ray

CT

**All of these benefitted from the math/hardware design techniques you will learn in this class!**


Ultrasound

# Tomography

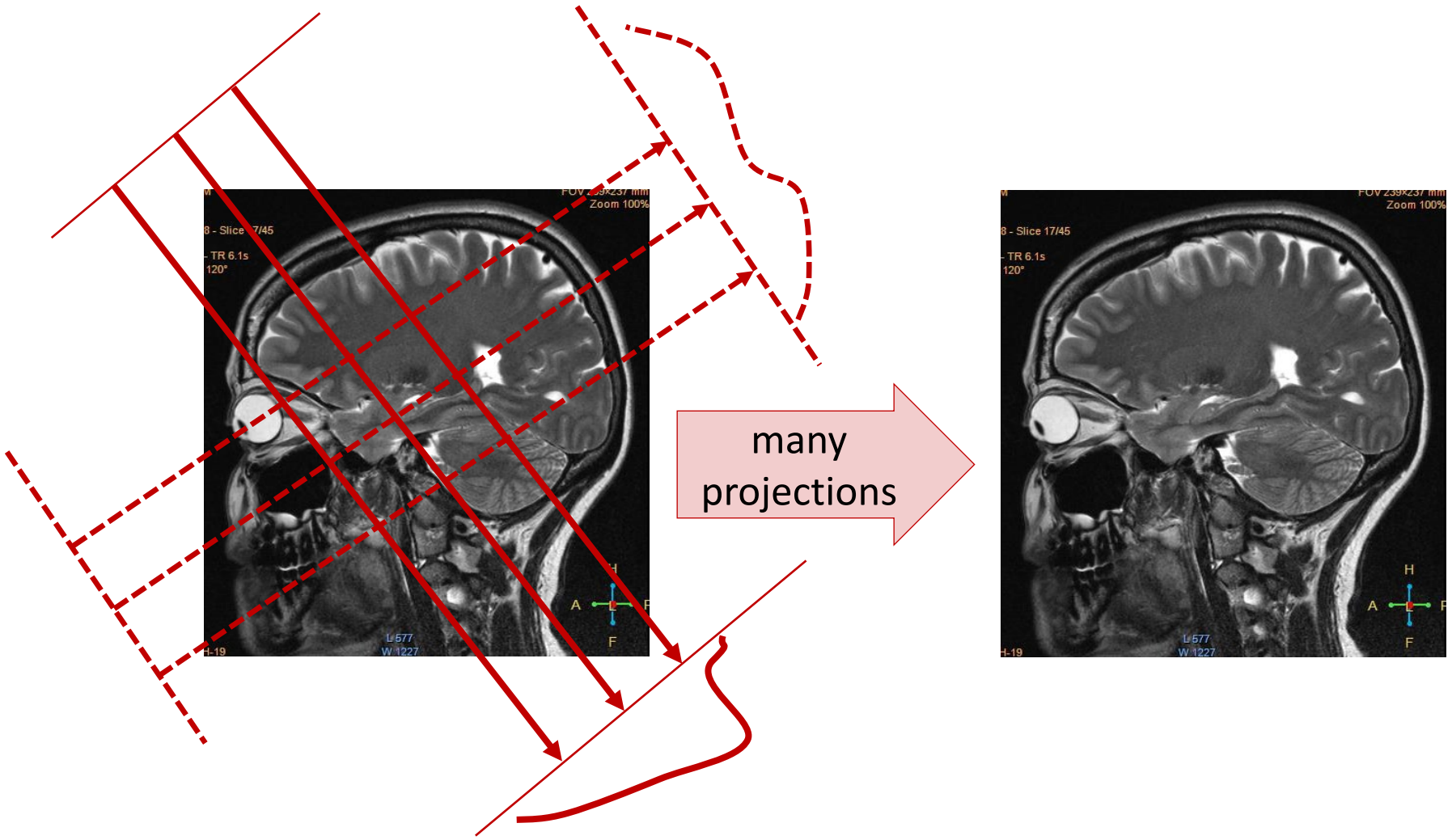




‘tomo’ – slice

‘graphy’ – to write

Assume it is not desirable to slice open my brain.
How does tomography ‘see’ inside?

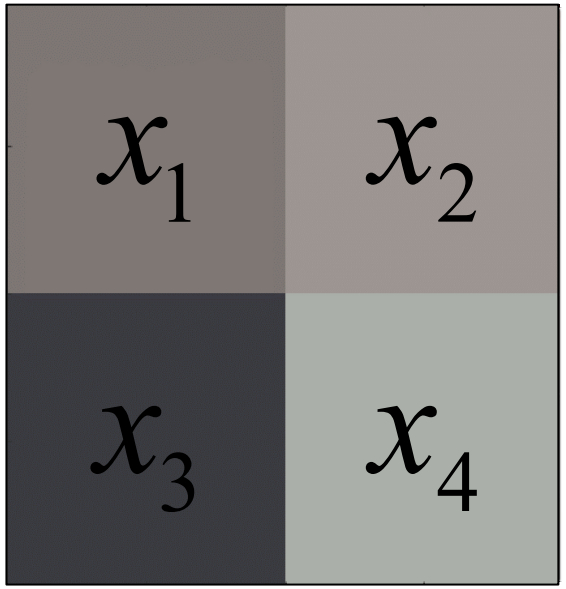
# Tomography




What is a projection?

Sum of values along a line.

# Example: Tomography



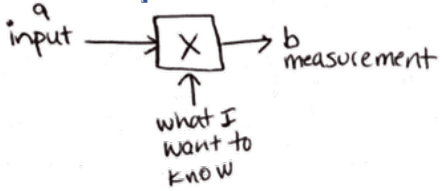

What do pixel values represent?

e.g. density, absorption, etc.

Can we solve for the pixel values from projections?

Yes, with tomography.

# Example: Tomography




Trust Me that:

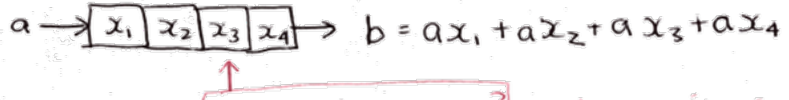
$b = ax$

Solve this:

$x = a^{-1}b$

**Now I have 4 pixels:**

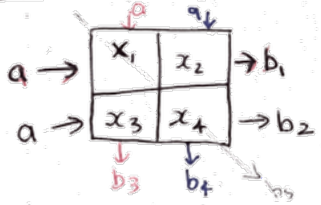
Take a projection:




Can I solve for $x_3$? No! Not with single measurement

1 equation, 4 unknowns = ☹

**Now square grid 4 pixels:** (My Brain)




4 unknowns → need 4 measurements!

$$ax_1 + ax_2 = b_1 \quad ①$$
$$ax_3 + ax_4 = b_2 \quad ②$$
$$ax_1 + ax_3 = b_3 \quad ③$$
$$ax_2 + ax_4 = b_4 \quad ④$$

Can I now solve for all $x_i$?
If yes, why/how? If no, why not?

No. 4 unknowns + 4 equations does not mean you can solve it! They need to be 'linearly independent' i.e. each provides new information!
eg. if I can derive one eqn. from other 3, it's not new info!

In this case: ① + ② = ③ + ④

↳ ② = ③ + ④ − ① so ② is not new info! = REDUNDANT

So these 4 measurements are not sufficient... REDUNDANT

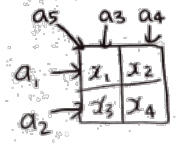
What different measurement can I take to help?

Diagonal.


$b_5 = ax_1 + ax_4$

Is it redundant? No.

**Now consider changing illumination:**




Not all a's are equal now.

Can I solve it? Yes if I know what the a's are.

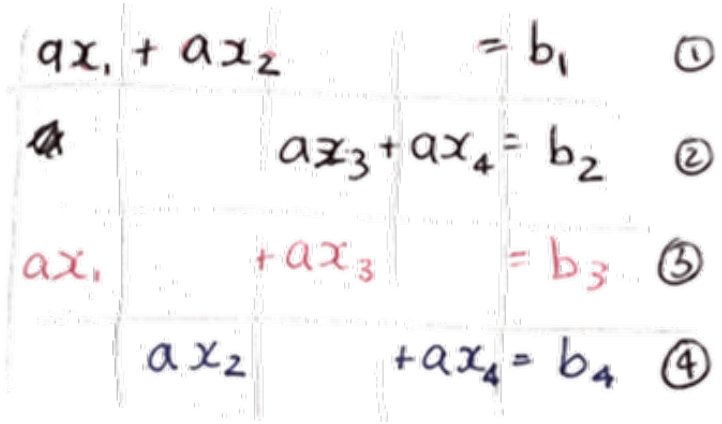
e.g. $b_1 = a_1x_1 + a_2x_2$

becomes $\left(\frac{b_1}{a_1}\right) = x_1 + x_2\left(\frac{a_2}{a_1}\right)$

# All our measurements are *linear*

What does that mean?

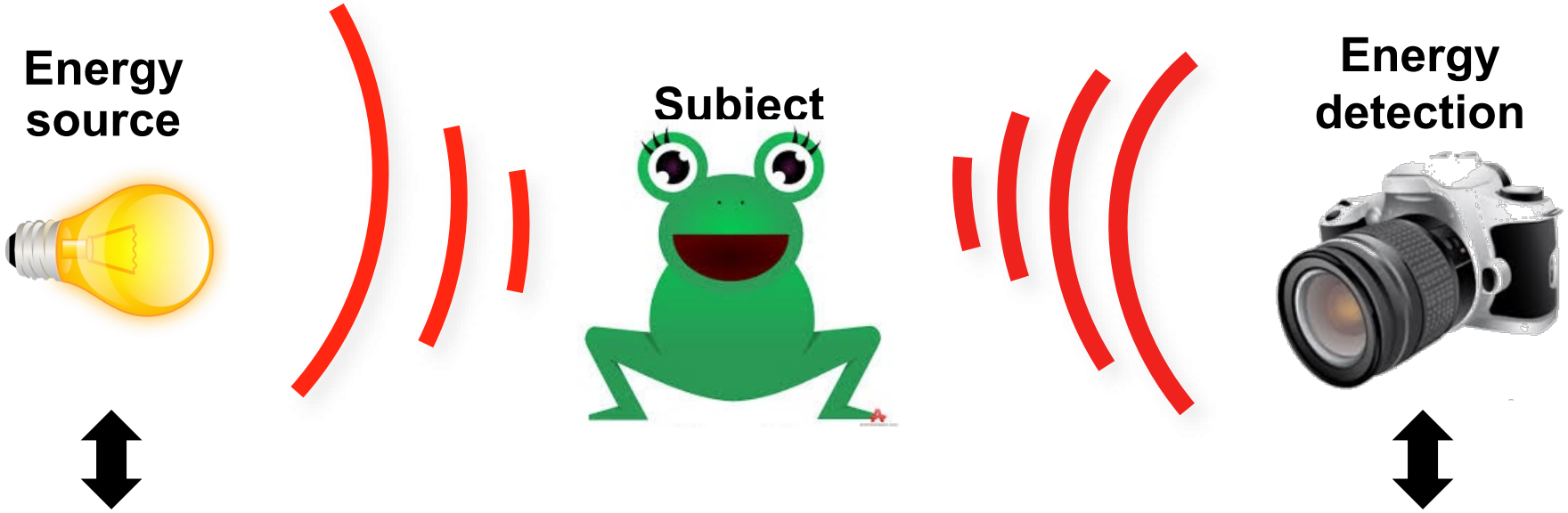
Each variable (x) is multiplied by a scalar (a) to contribute to the measurement




**This is called a *system of linear equations***

***Linear Algebra* is what we need to solve it!**

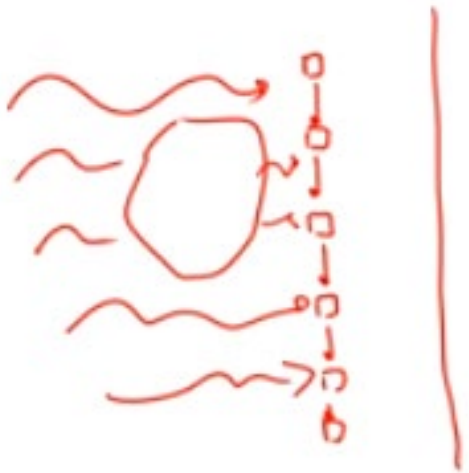
# Imaging in general



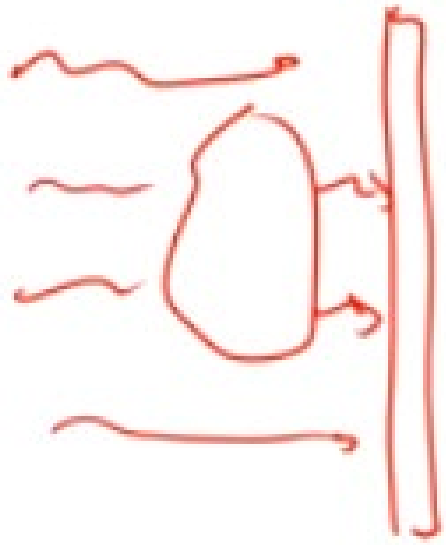

**Imaging System**

**(electronics, control, computing, algorithms, visualization…)**

What is the absolute smallest number of components you need to make an imaging system?

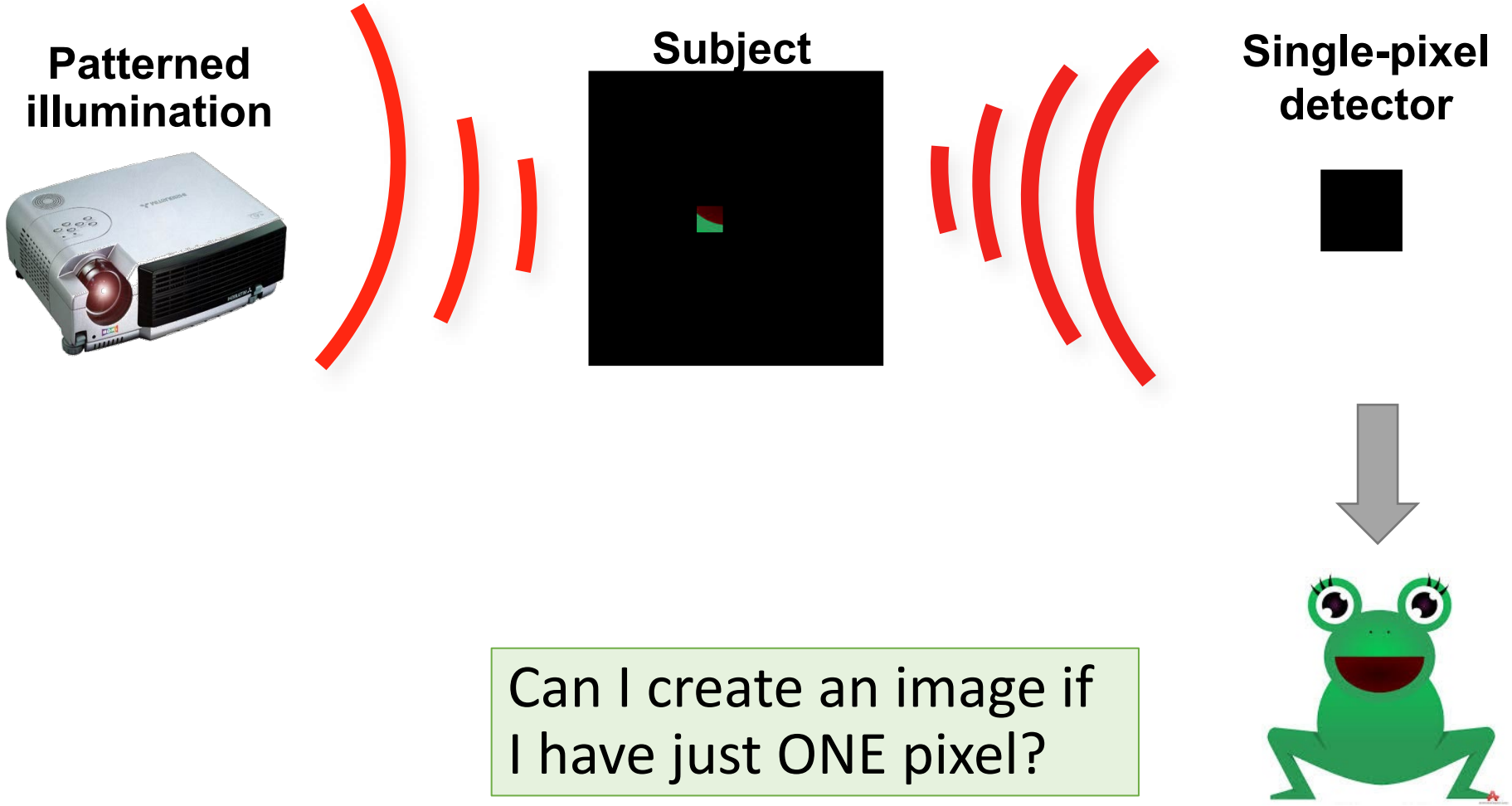


Example: flat illumination, one photosensor scans through pixels



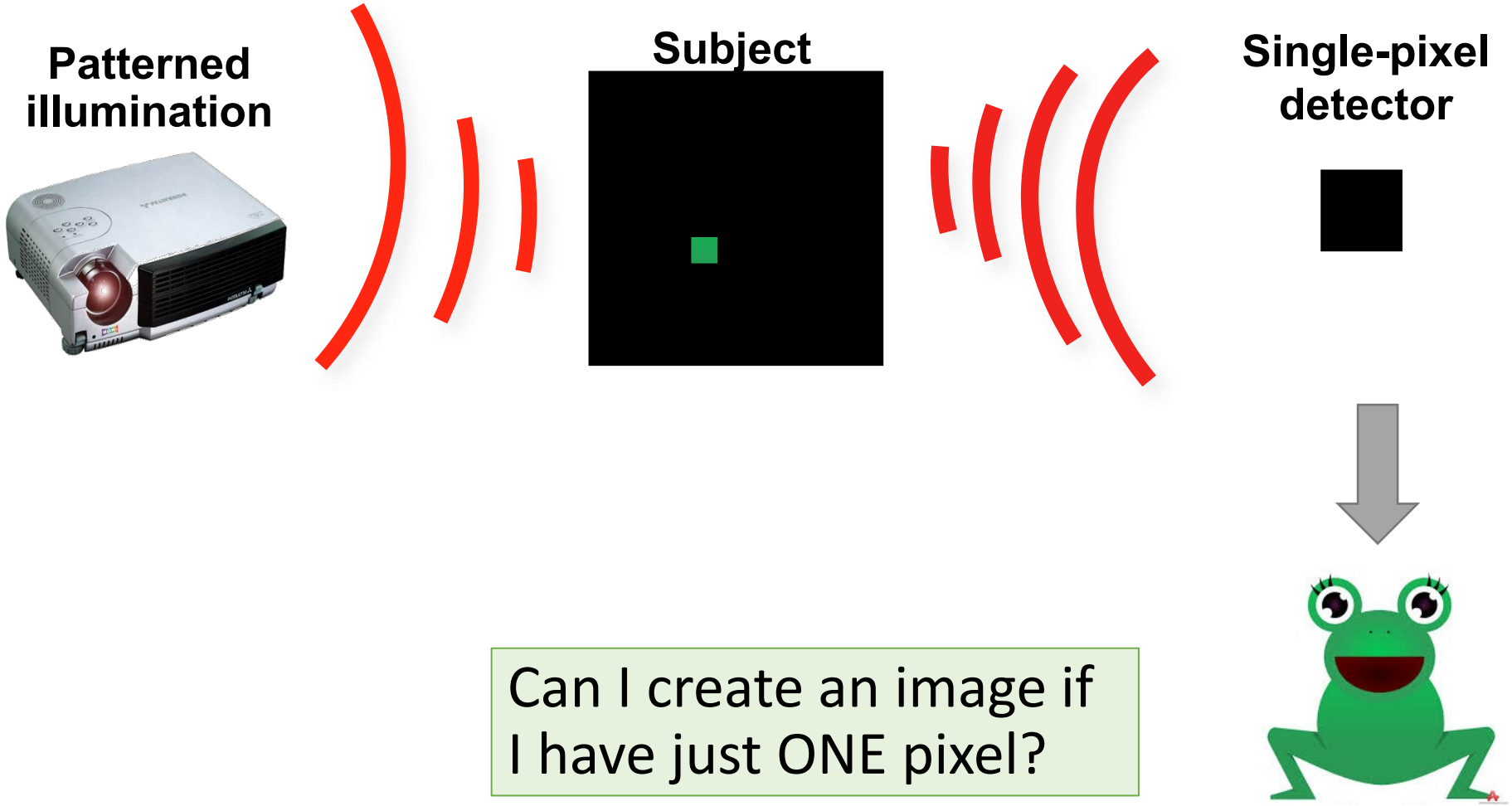
OR scan the illumination, use only one big pixel

# Single-pixel camera



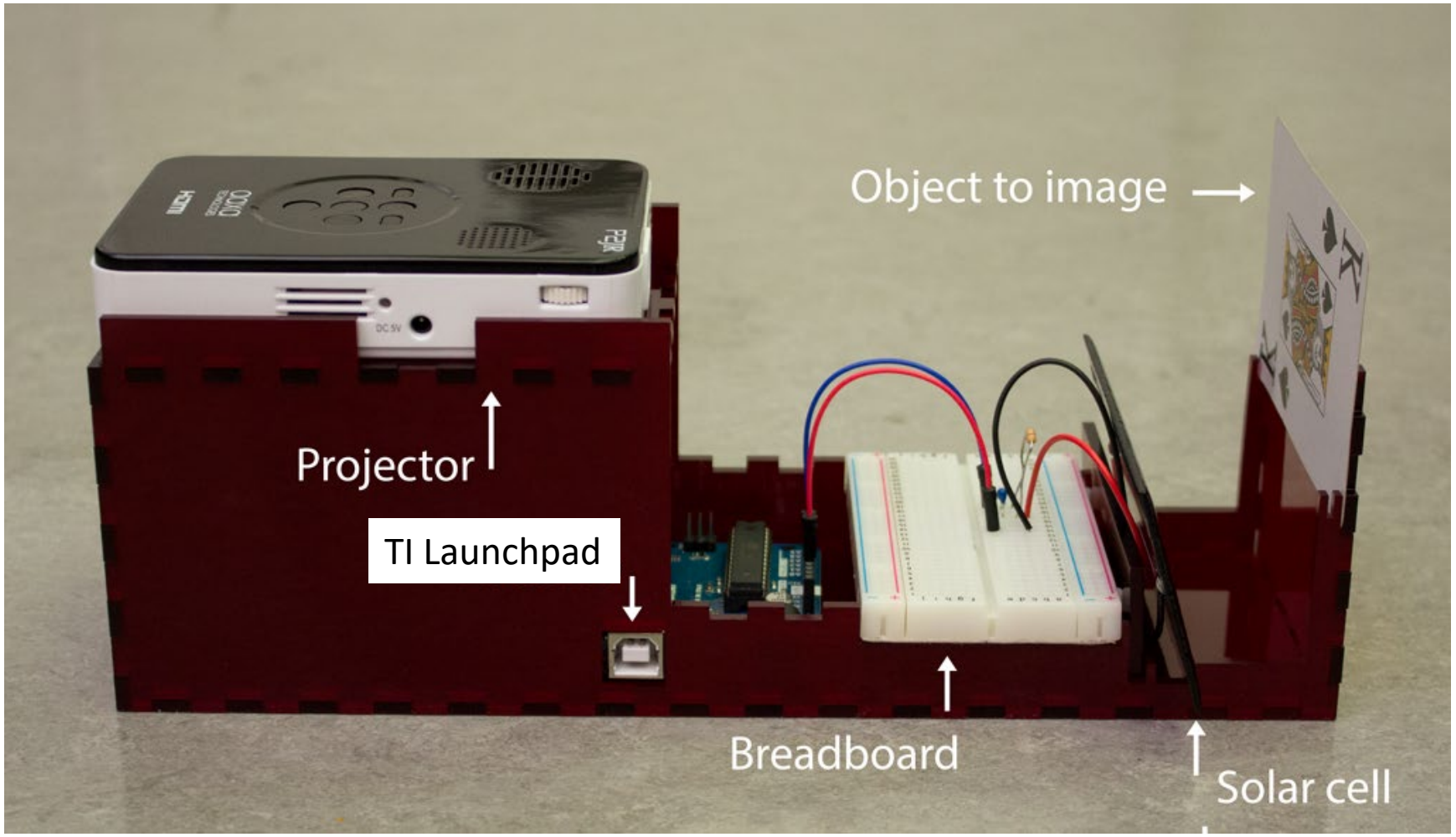

Can I create an image if I have just ONE pixel?

# Single-pixel camera

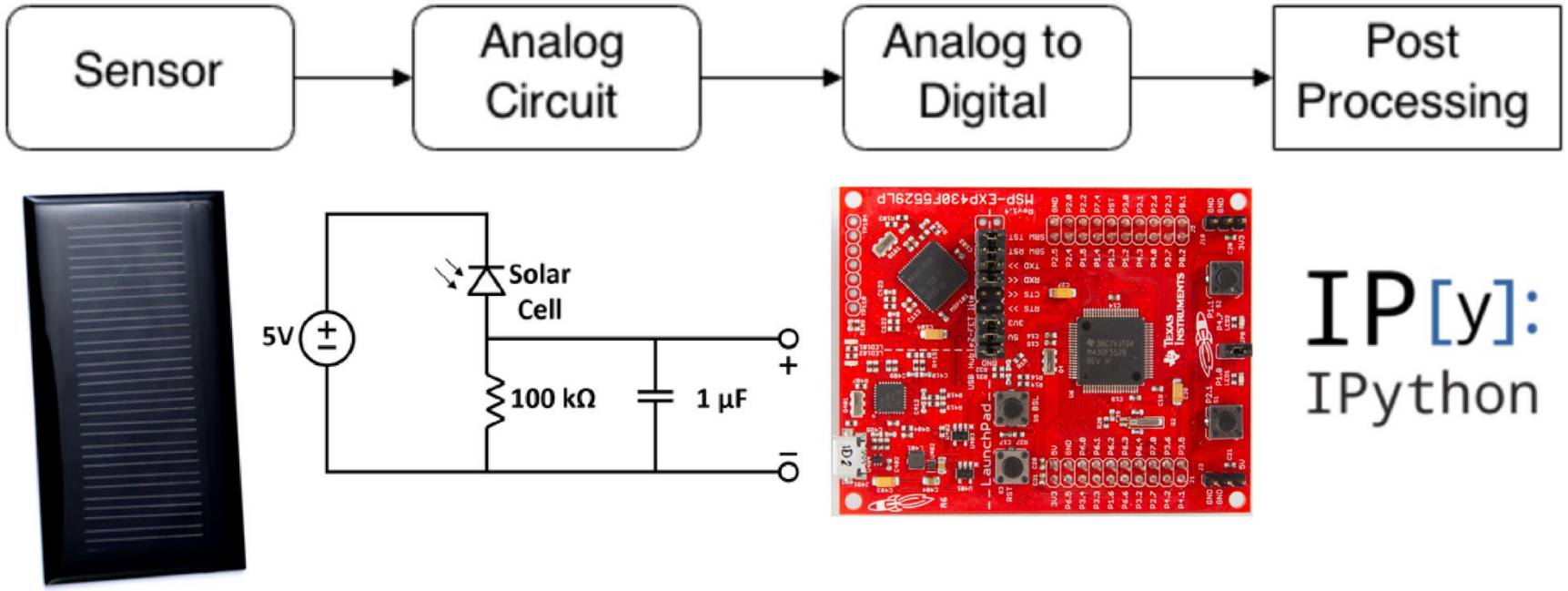



Can I create an image if I have just ONE pixel?

# Imaging Lab #1 Setup

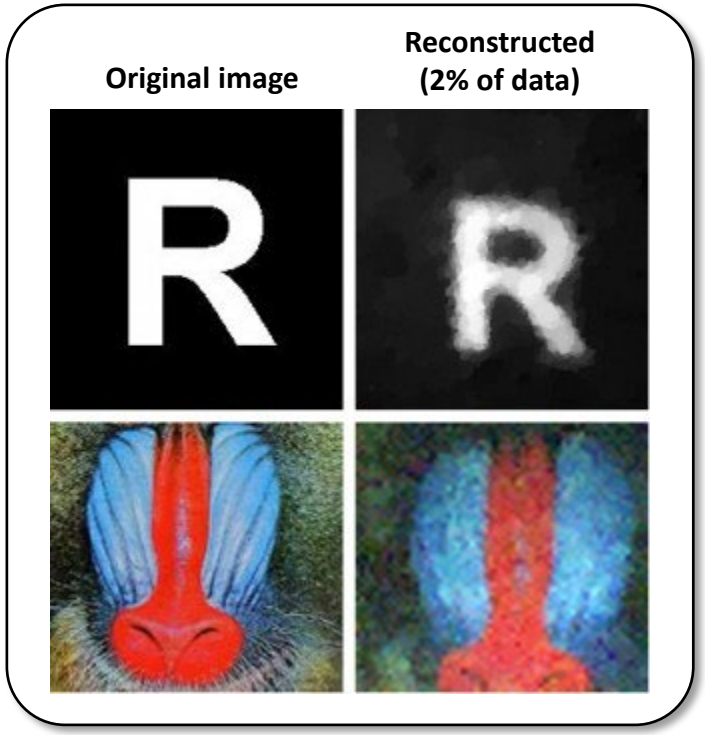


# Imaging Lab #1

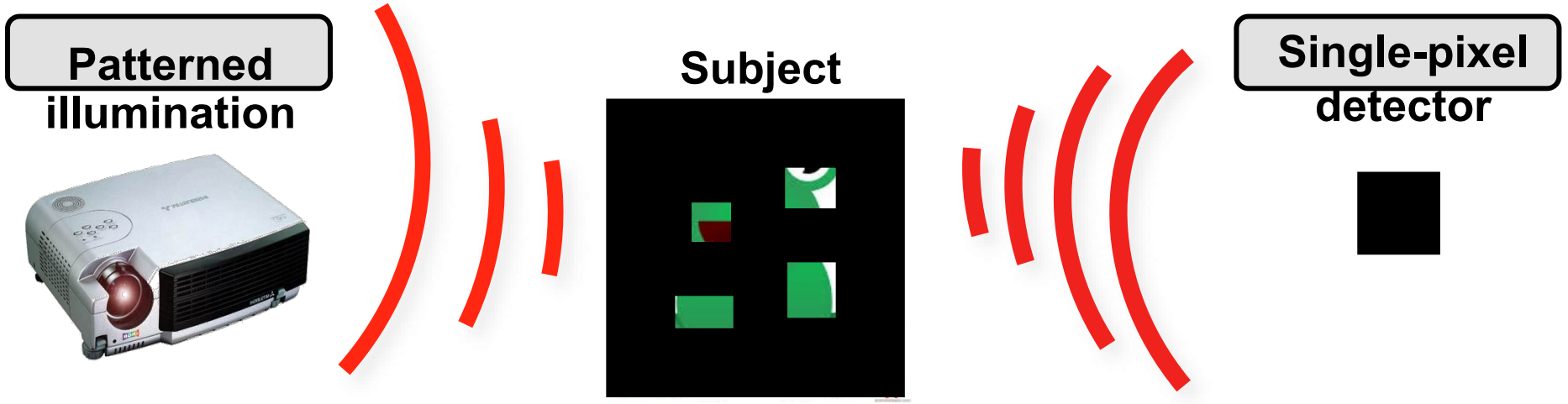


# Example: single-pixel camera

Pictures taken with ONE PIXEL!



# Single-pixel camera

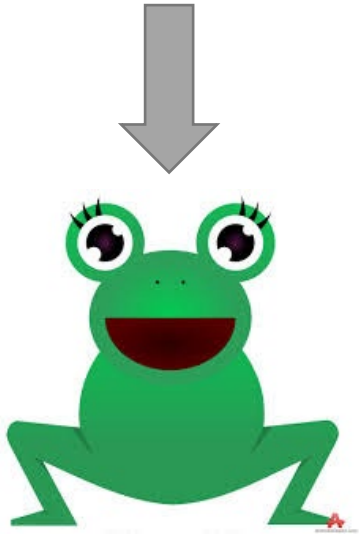



What if I can't light up just one pixel at a time?

Can we recover the frog?

How many measurements do I need?

How should I choose illumination patterns?



# What is linear algebra?

- The study of linear functions and linear equations, typically using vectors and matrices
- Linearity is not always applicable, but can be a good first-order approximation
- There exist good fast algorithms to solve these problems