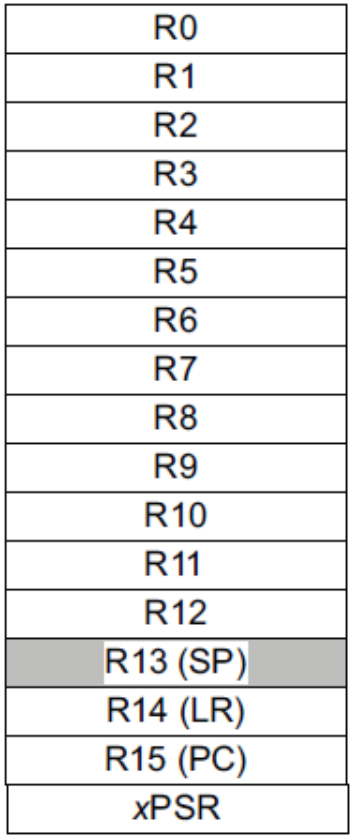
EECS 373
Introduction to Embedded System Design



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Lecture 3: Logic, MMIO, and project

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Outline

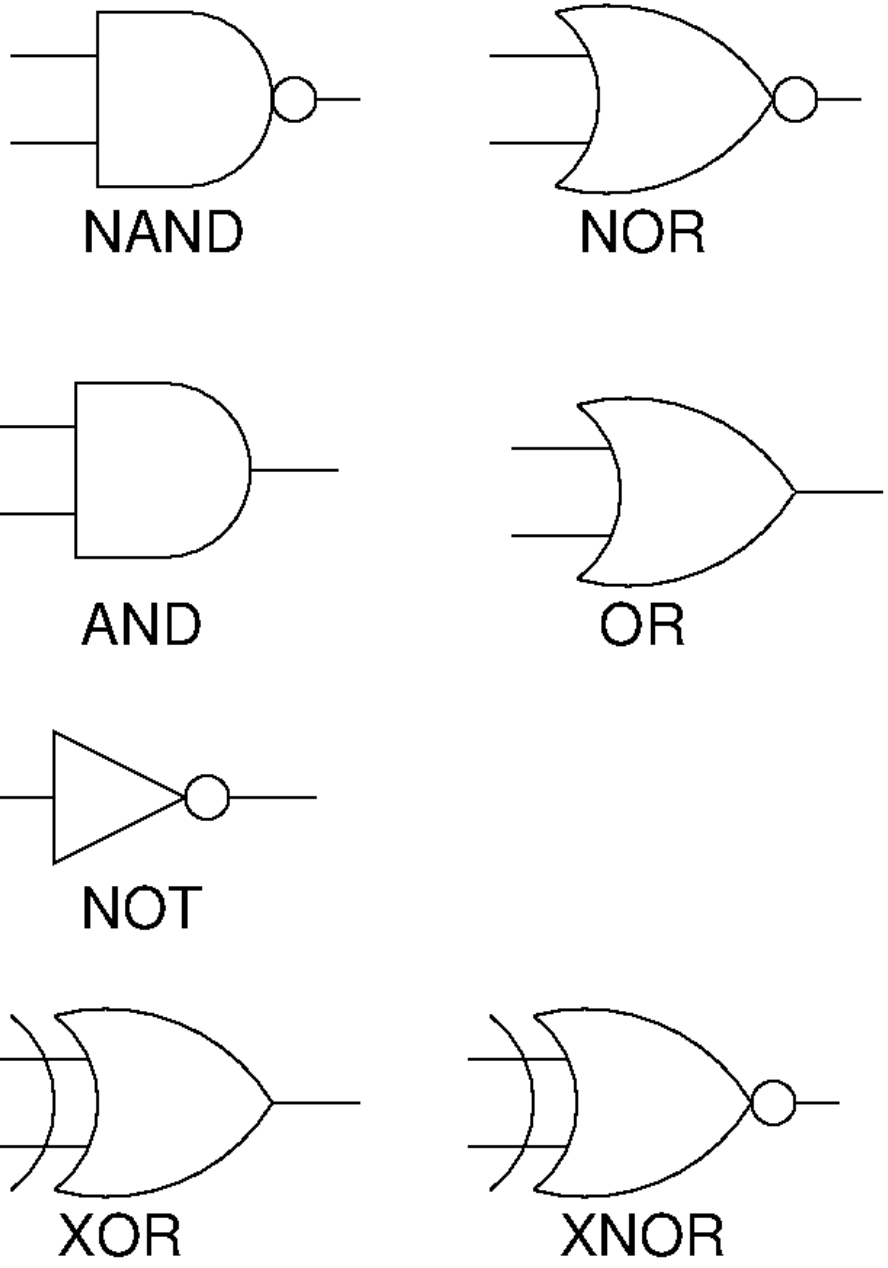
- **Logic review**
- Memory-mapped I/O
- Project

Logic review

- If you are ever stuck on a design problem involving a combinational network, write the truth table.

- If you are ever stuck on a design problem involving a sequential network, draw the state diagram.

Gates



De Morgan's Laws and bubble pushing

(ab)' = a' + b'
(a + b)' = a'b'

Example:
a'b' + b'c + ac
((a'b)' + (b'c)' + (ac)')'

Outline

- Logic review
- **Memory-mapped I/O**
- Project

Old-style I/O

- Special instructions for reading/writing peripherals.
- Wasteful: Already have load/store instructions.

Lab 3: Memory-mapped I/O

- Put peripherals at memory addresses.
- Turn LED turn on by writing 1 to address 5.
- Read button state (active-high) at address 4.
- Use a bus on which the peripheral sits.

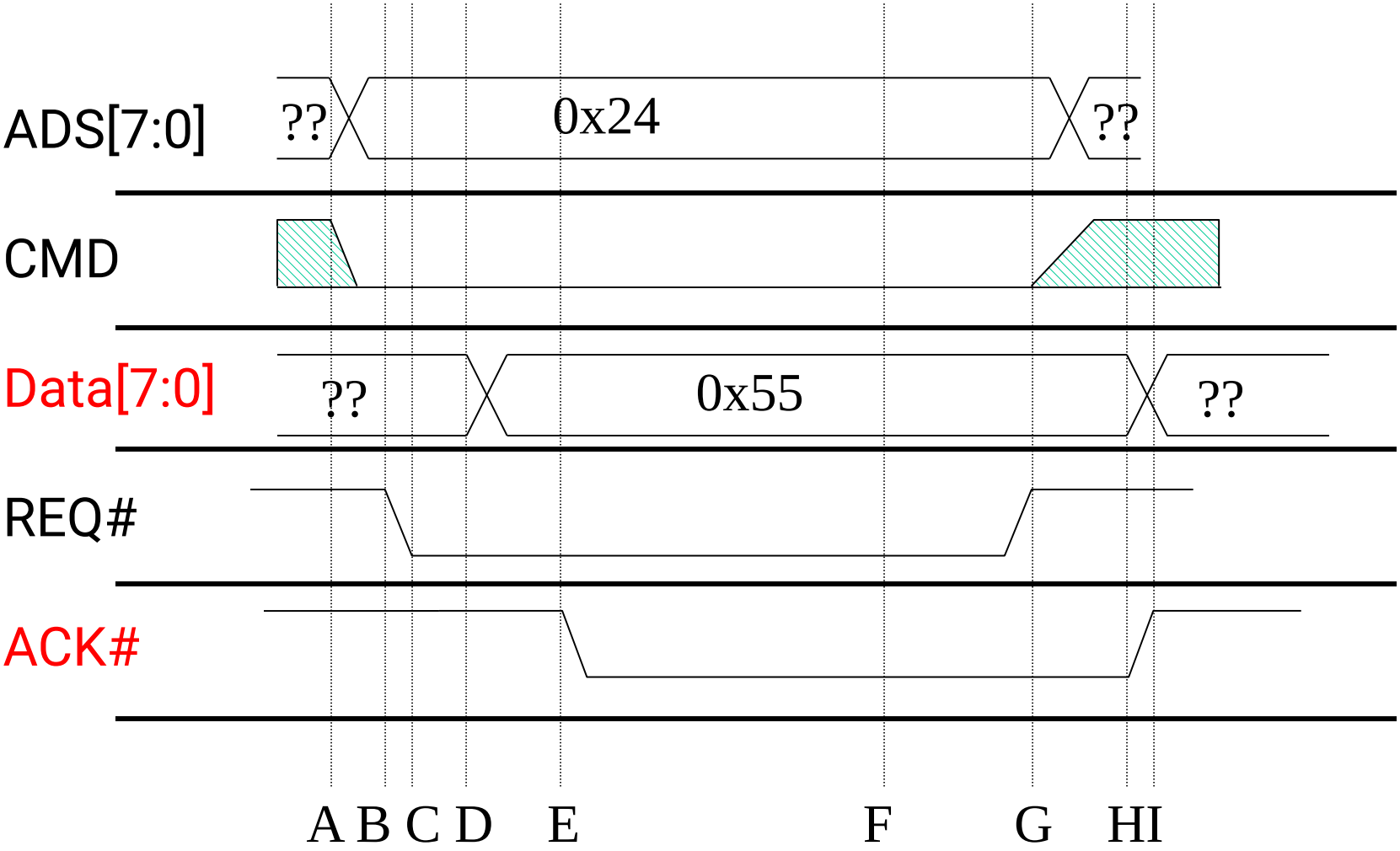
Bus access example

- Bus protocol.
- Asynchronous (no clock).
- Initiator and Target.
- REQ#, ACK#, Data[7:0], ADS[7:0], CMD.
  - CMD=0 is read, CMD=1 is write.
  - REQ# low means initiator is requesting something.
  - ACK# low means target has done its job.

A read transaction

- Initiator wants to read location 0x24.
- Initiator sets ADS=0x24, CMD=0.
- Initiator *then* sets REQ# to low.
  - Delay first.
- Target sees read request.
- Target drives data onto data bus.
- Target *then* sets ACK# to low.
- Initiator grabs the data from the data bus.
- Initiator sets REQ# to high, stops driving ADS and CMD.
- Target stops driving data, sets ACK# to high terminating the transaction.

Read transaction



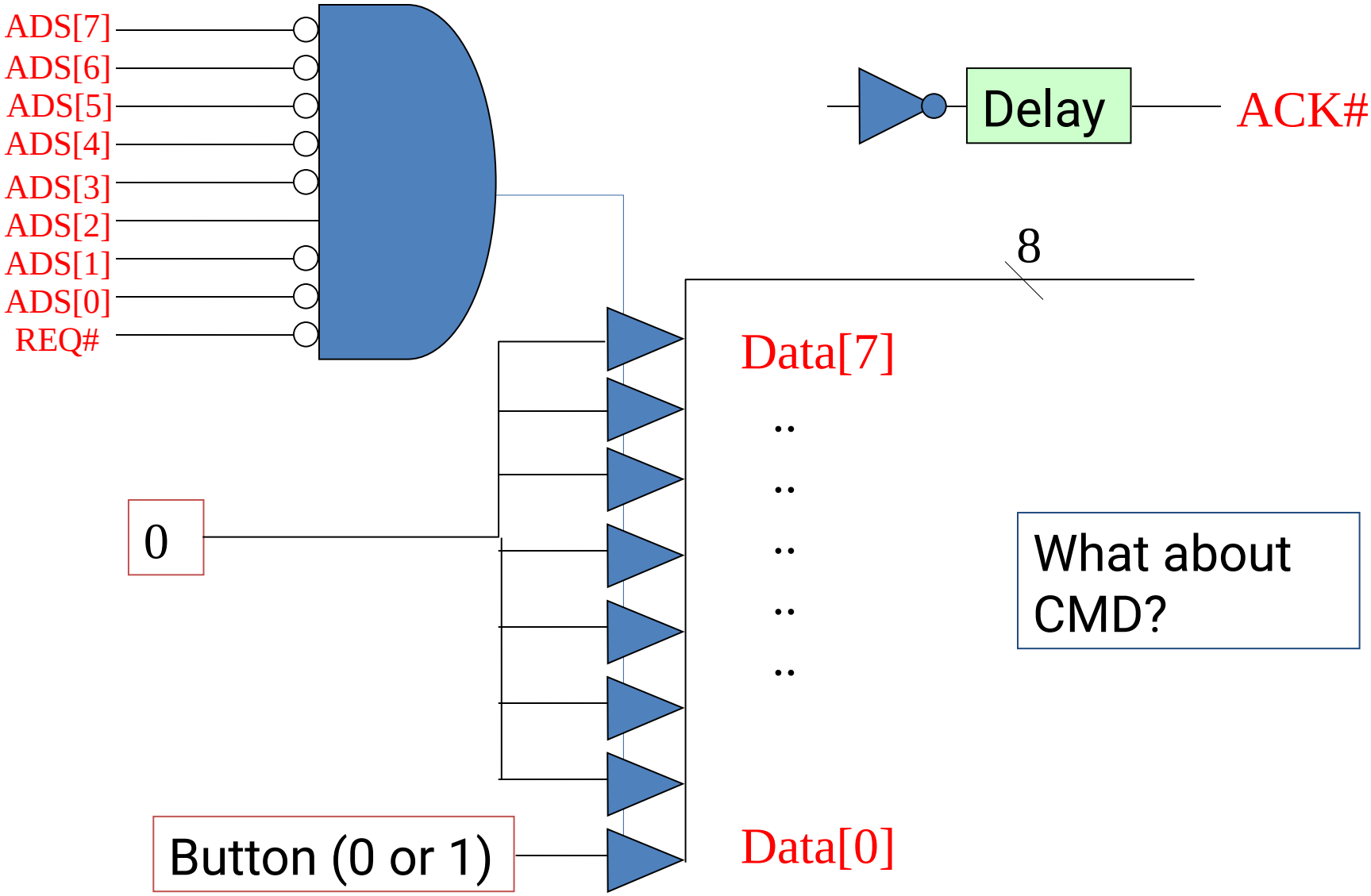
Write transaction

(write 0xF4 to location 0x31)

- Initiator sets ADS=0x31, CMD=1, Data=0xF4.
- Initiator *then* sets REQ# to low.
- Target sees write request.
- Target reads data from data bus.
- Just has to store in a register, need not write all the way to memory!
- Target *then* sets ACK# to low.
- Initiator sets REQ# to high & stops driving other lines.
- Target sets ACK# to high terminating the transaction.

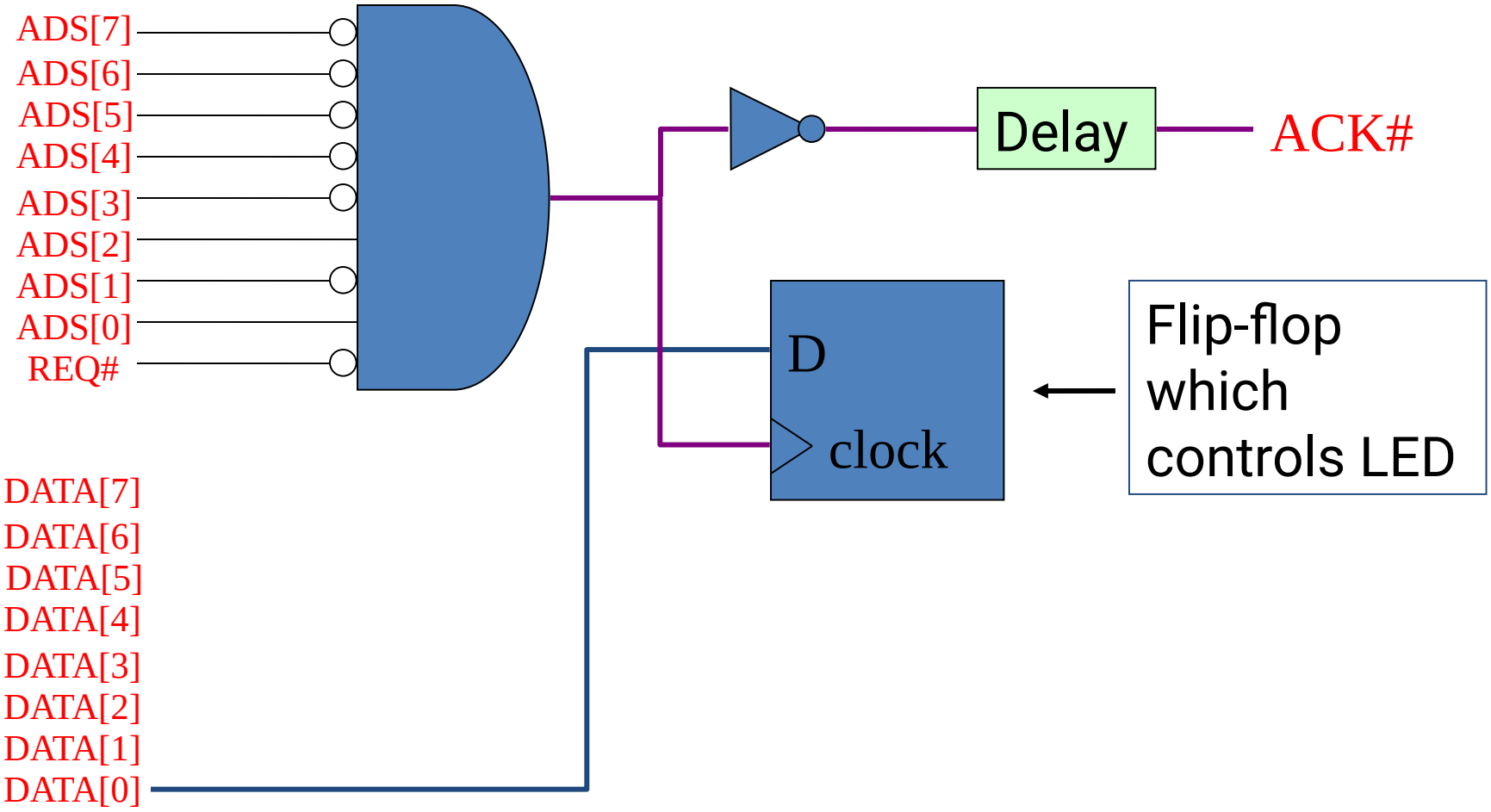
The push-button

(if ADS=0x04 write 0 or 1 depending on button)



The LED

(1 bit reg written by LSB of address 0x05)



What does this look like from software perspective?

```
volatile char * button_ads = (char *)(0x24);

char read_button(void) {
        return *button_ads;
}
```

```
.equ BUTTON_ADS, 0x24

movw r0, #:lower16:BUTTON_ADS
movt r0, #:upper16:BUTTON_ADS
ldr r1, [r0, #0]
```

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- Logic review
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- **Project**

Project timeline

- 29 Jan: Every student finishes preparing three, high-level, half-page shared proposals.
  - Customer
  - Values
  - Approach
  - Components
- 30 Jan: Team formation meeting.
- 6 Feb: Draft proposals on which we provide feedback
- 13 Feb: Final proposals about which we will meet.
- 27 Feb: Parts list ready for ordering and submitted.
- 14 Mar: Checkpoint 1.
- 4 Apr: Checkpoint 2.
- 23 Apr: Demo day.

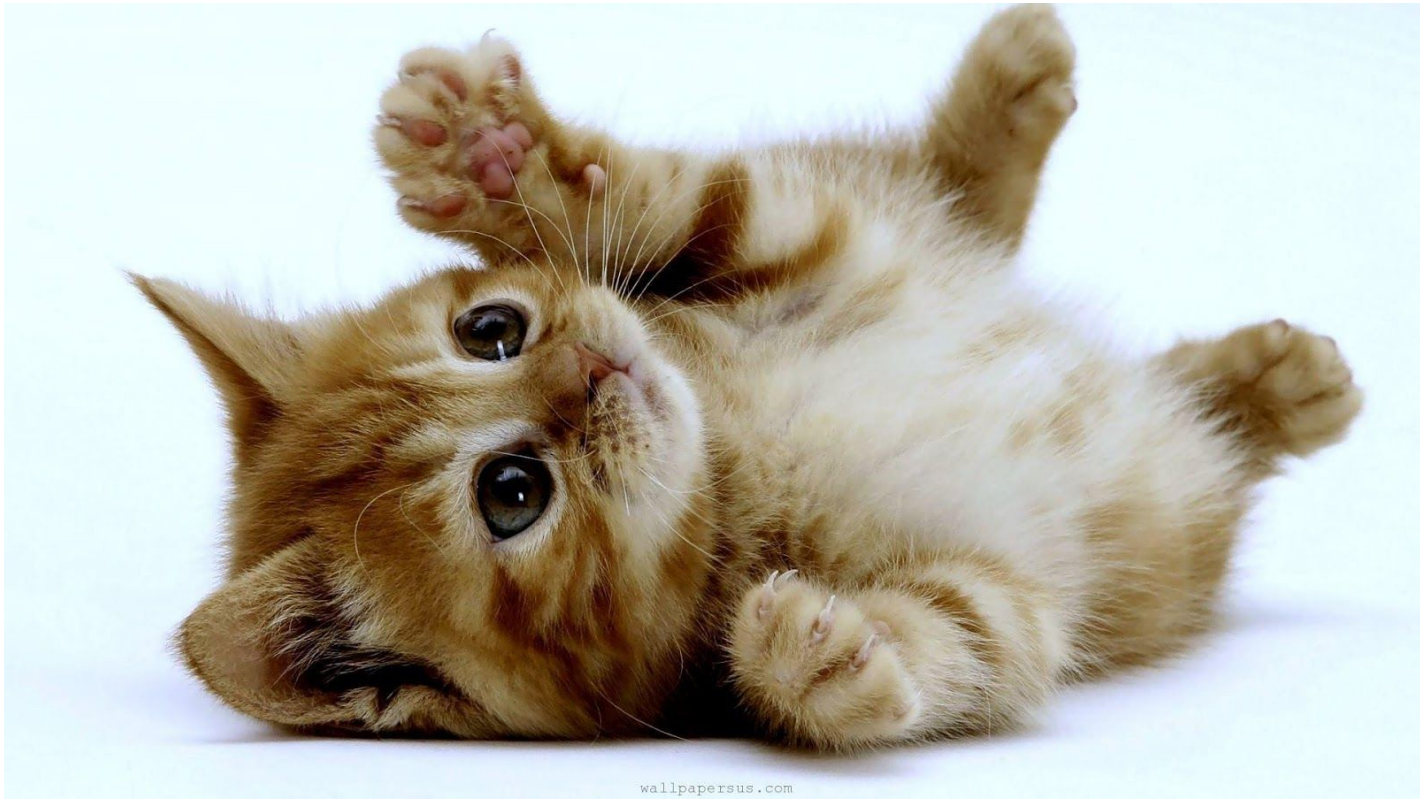
Problem selection

- Early in the course, many EECS 373 students feel that they are too inexperienced to make something useful to others.
- **That's wrong!!!** You will be able to do amazing things before the course is finished.
- Ideal: Find a problem you understand and want to solve for your own sake, that many other people also want to have solved for them.
  - But this takes some work / interview up-front.
- Acceptable: Find a problem you understand and want to solve for your own sake.

Identifying important problems

- The easy, luck-dependent way
  - Pick a problem that you understand deeply and that is very important to you.
  - Only works if many people are similar to you.
  - That's rare, especially for engineers.
- The easy, risky way
  - Take the problem from a competitor.
- The hard, more reliable way
  - Customer discovery interview process
  - Counterintuitive. Hard.
  - Social pressures undermine the process.

How you see your idea



How others see your idea

How others see you

That's a great idea!

- That's a great idea!
  - I don't want to hurt your feelings you cute little engineer.
- I would definitely use that!
  - There are almost no circumstances in which I would use that, let alone consider paying for or supporting it.
- I have some ideas on how to make it better!
  - I'm pretending to be someone who would use it and leading you down a false path.
- Follow your dreams man!
  - Squander your life, man!

If you want to follow the reliable path

- Talking to Humans by Giff Constable
- The Startup Owner's Manual by Steve Blank and Bob Dorf
- Market Research on a Shoestring by Naeem Zafar
- Steve Blank's online videos (steveblank.com)
- Contact me for more

What do they teach?

- How to design, sequence, and deliver questions to minimize bias (both yours and theirs).
- How to talk with strangers.
- This is not natural. Most must learn it.

Done.