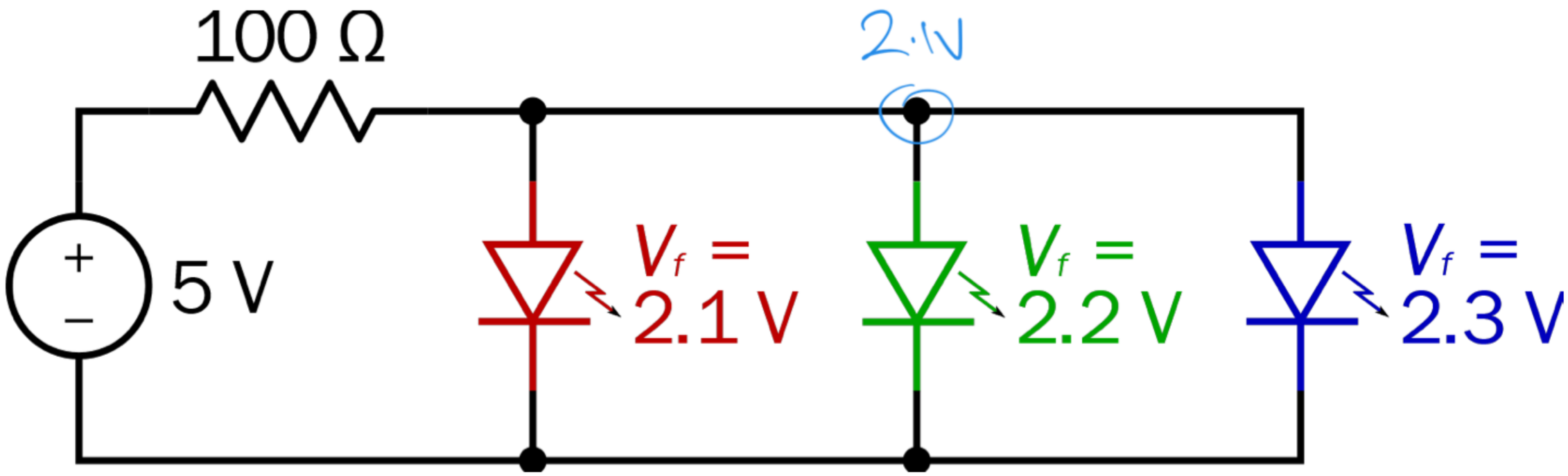
Go to **www.menti.com** and use the code **43 60 74**

Which LED(s) turn on?



Lab 3a
The LED cube

ENGR 40M

Chuan-Zheng Lee
Stanford University

5 May 2017

Announcements

- No prelab this week…
  - *except* to think about what color LEDs you want
  - *unless* you want to do a custom LED structure

white
red
green
blue

- No homework next week
- Mid-quarter survey open till midnight tonight

- Midterm is next Wednesday during class
  - Covers up to lecture slides 9, lab 2b, homework 4

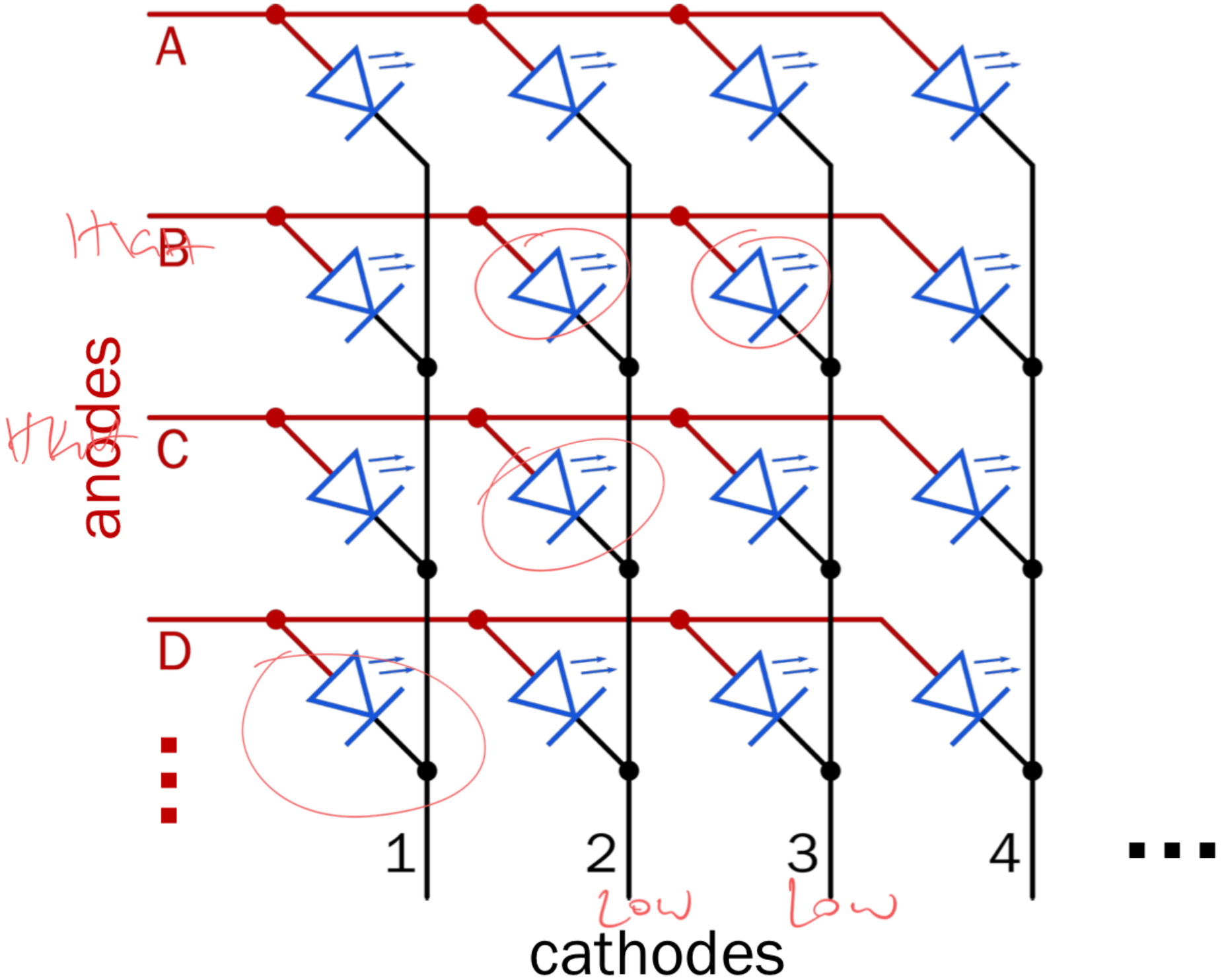
Outline

1. Hardware to make your LEDs work

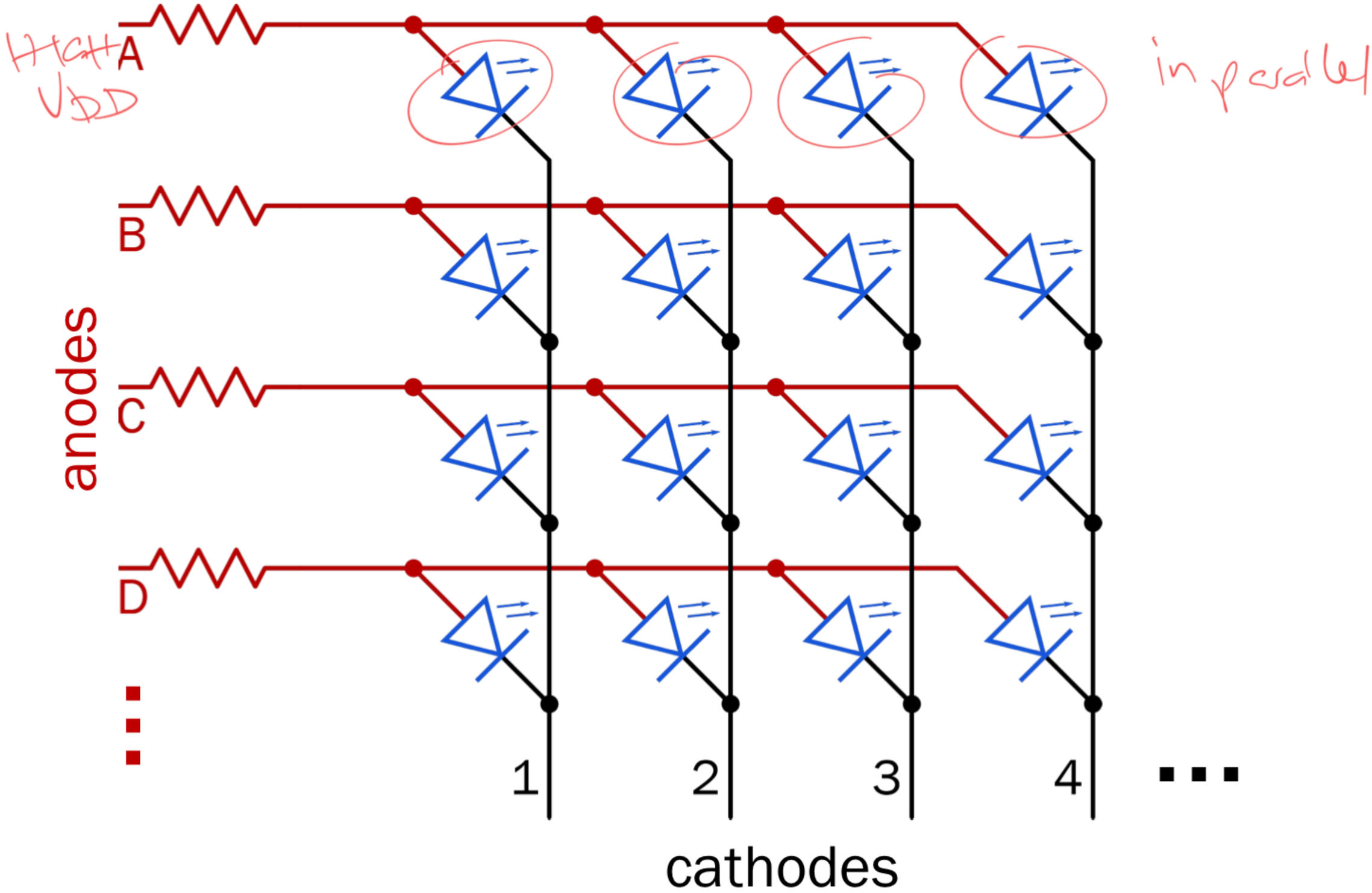
2. Getting from an 8 × 8 array to a 4 × 4 × 4 cube

3. Tips for putting your cube together

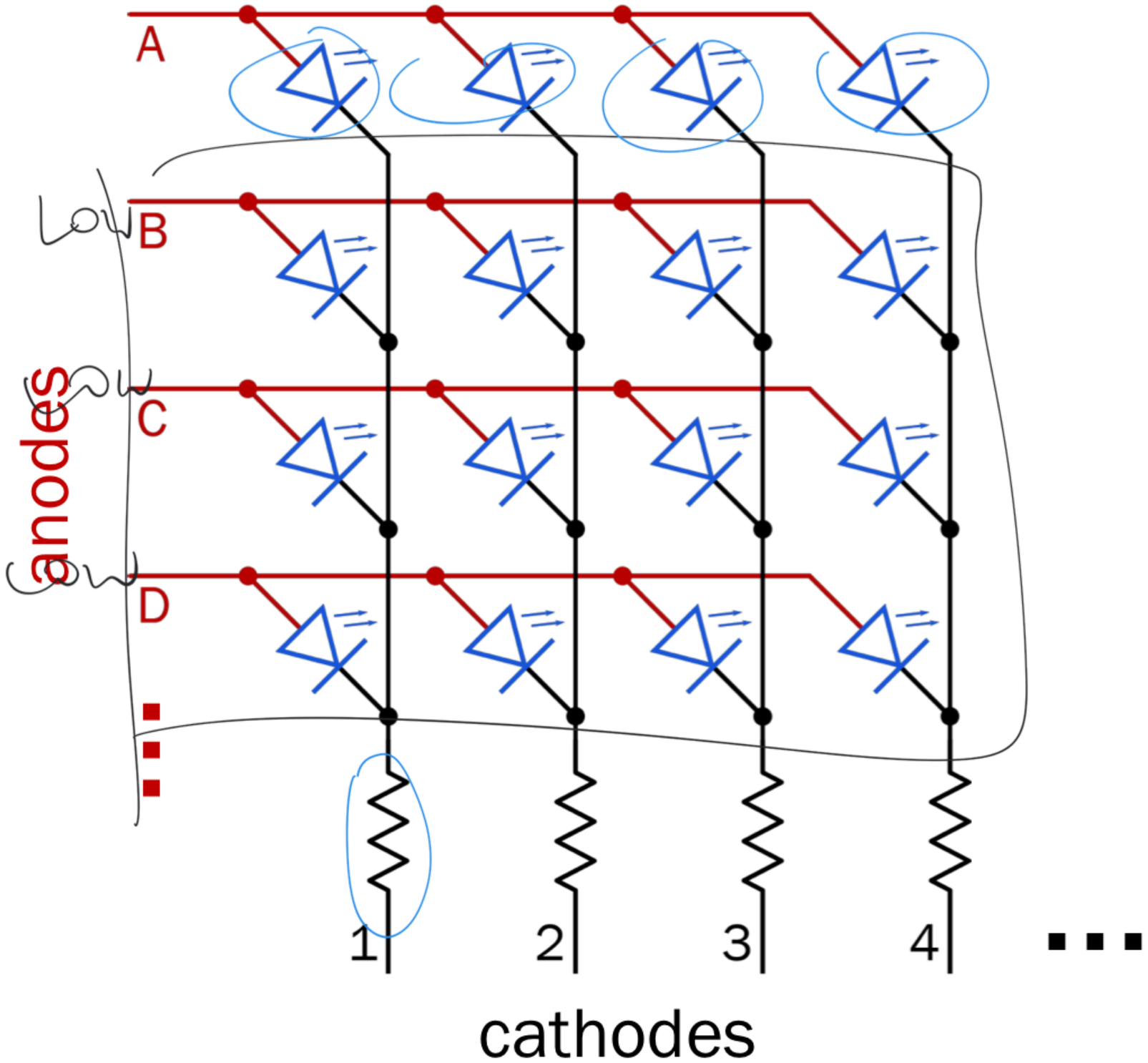
Review: Pin multiplexing



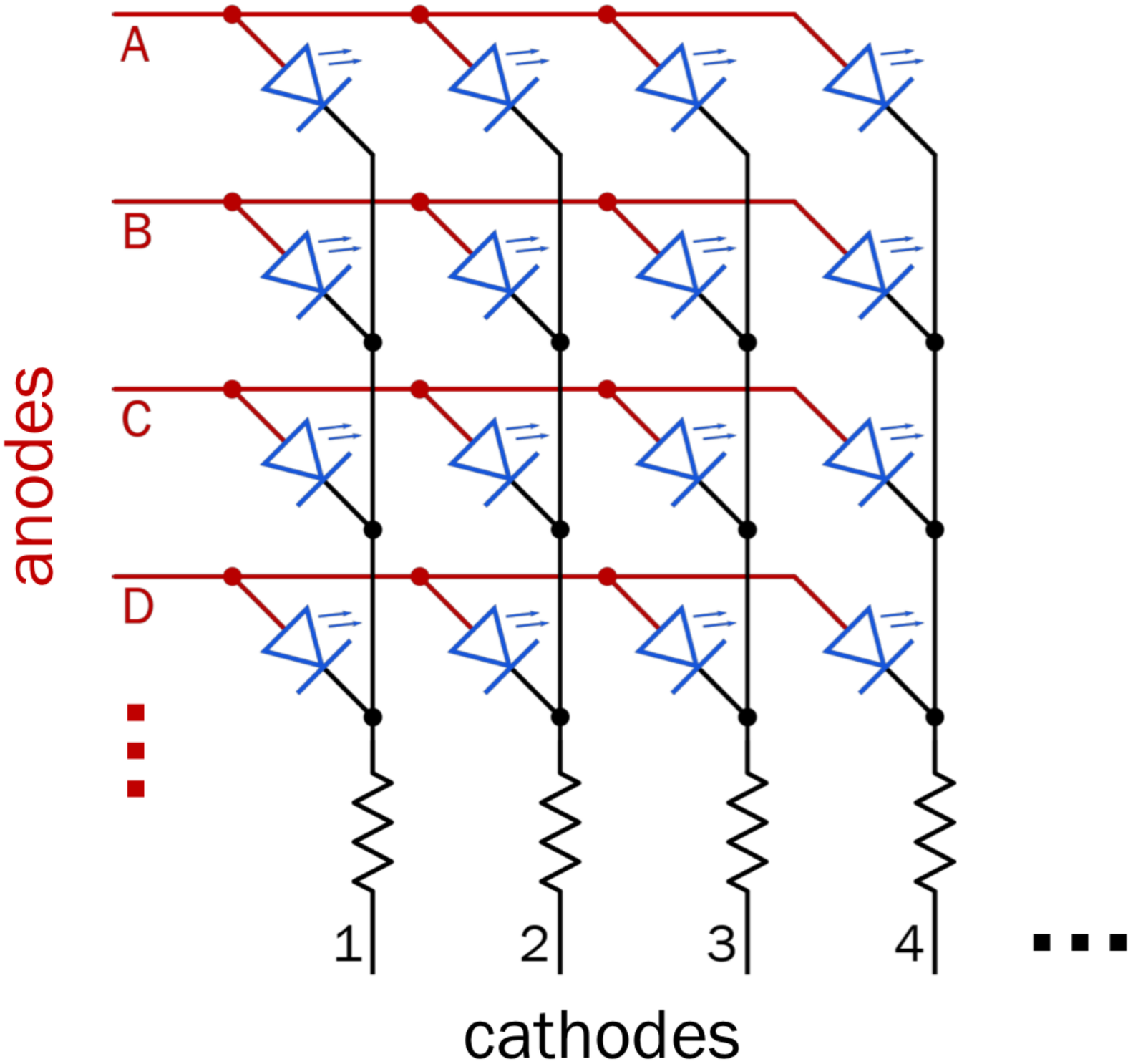
Where should we put the resistors?



Where should we put the resistors?

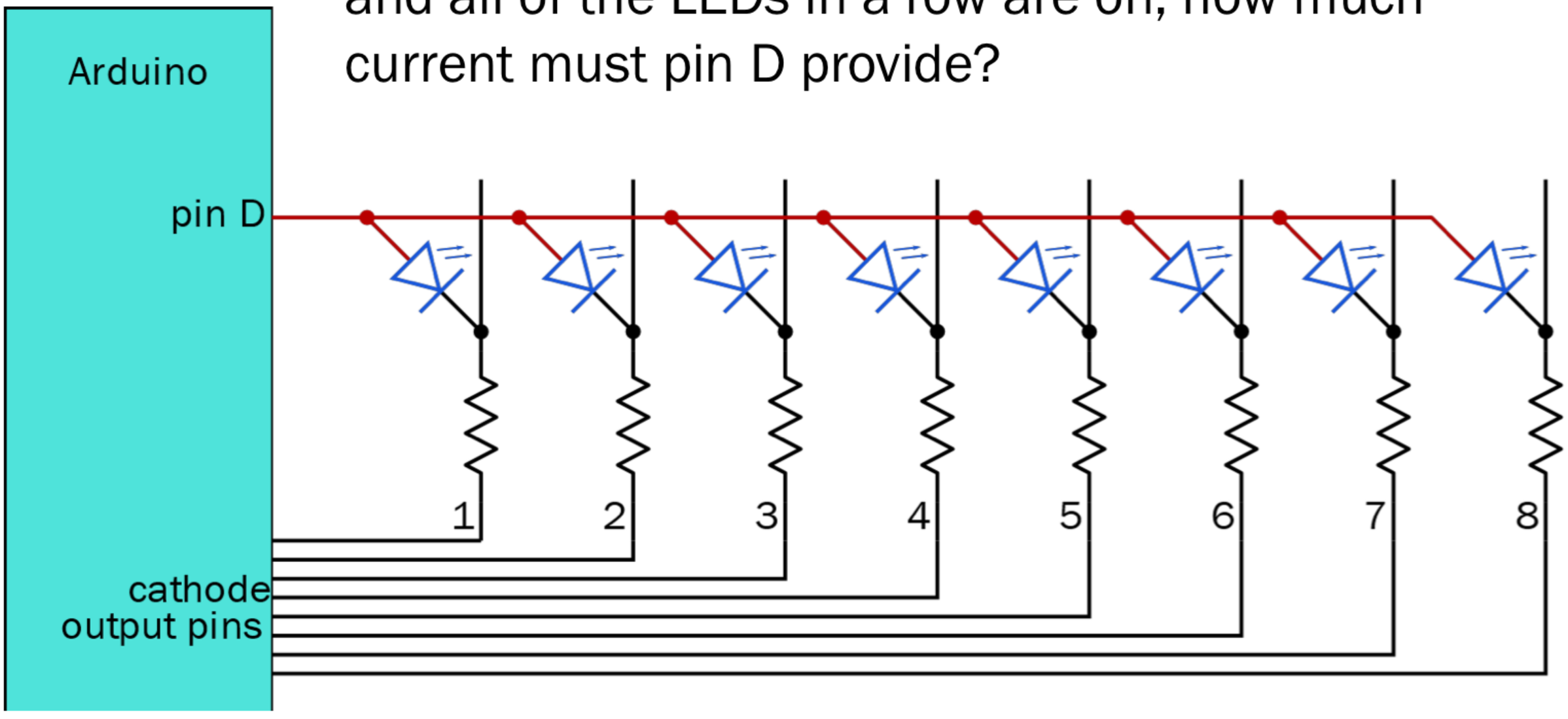


How many LEDs could be on at once?



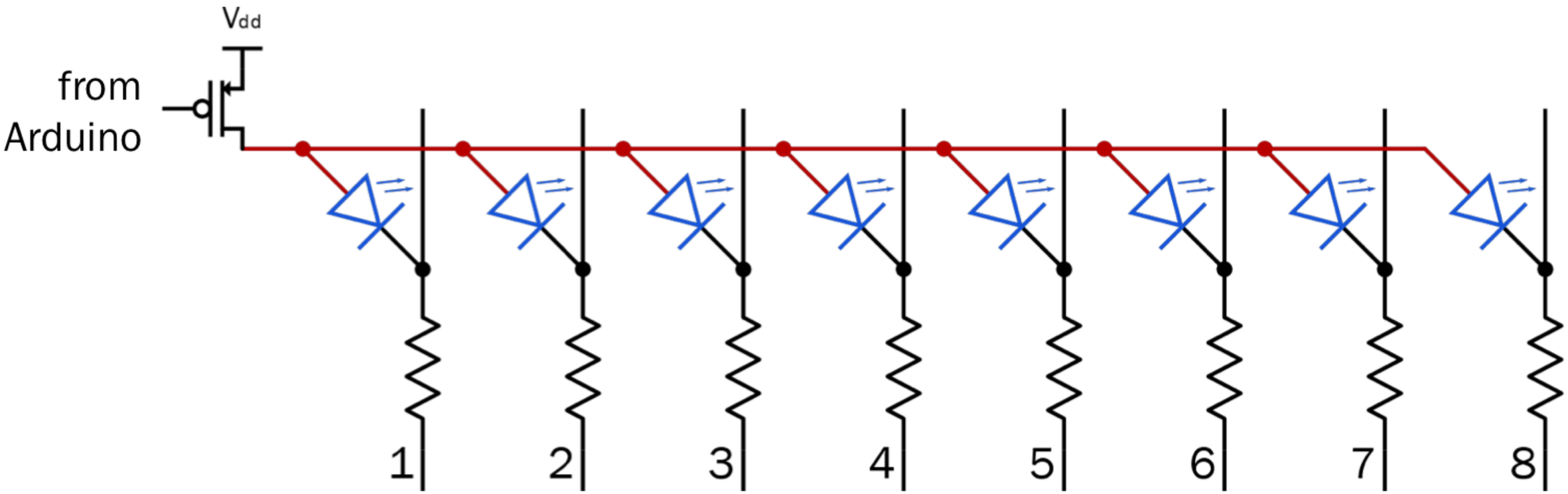
How many LEDs could be on at once?

If I want each LED, when on, to conduct 10 mA, and all of the LEDs in a row are on, how much current must pin D provide?

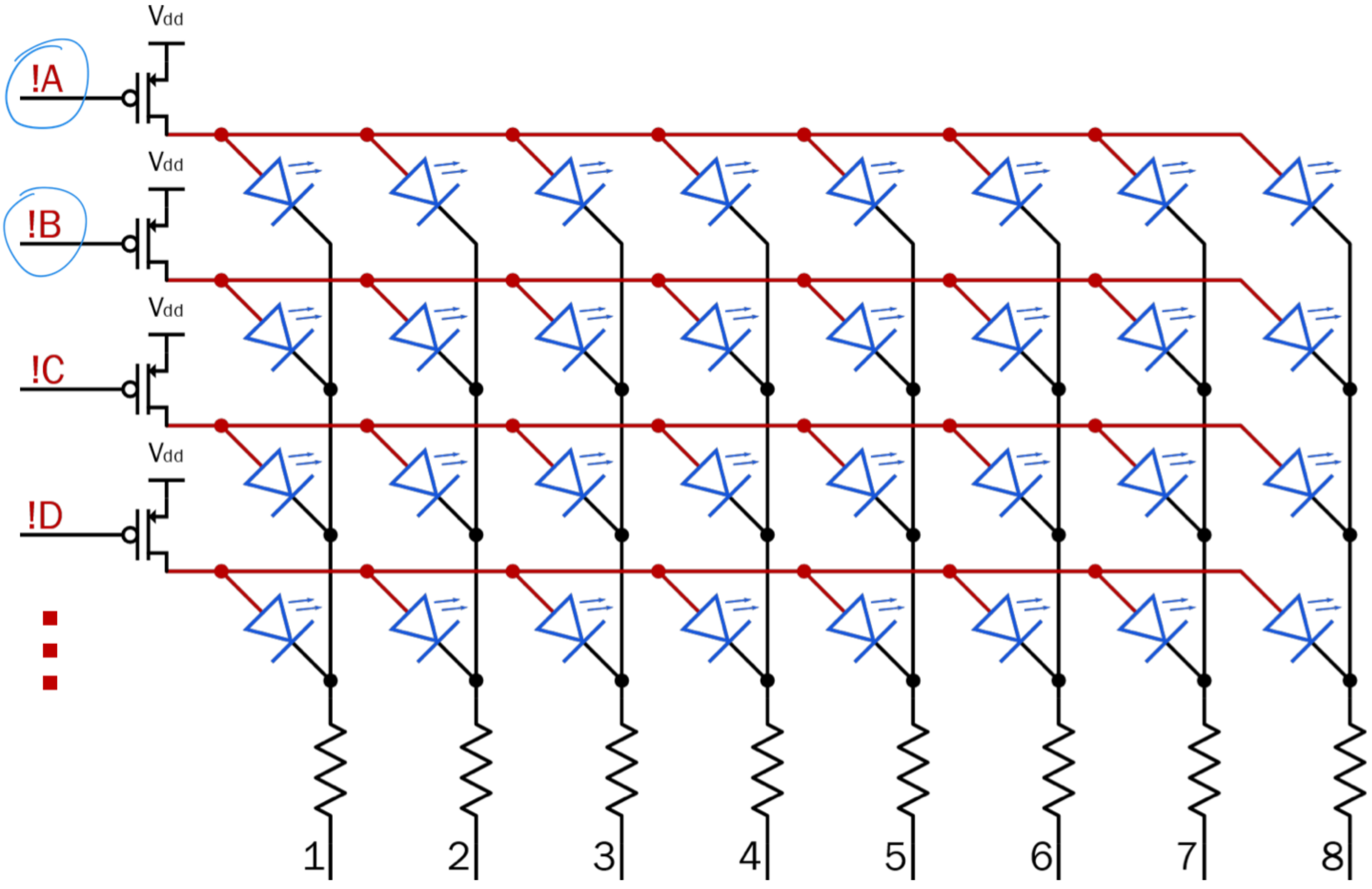


Providing enough current

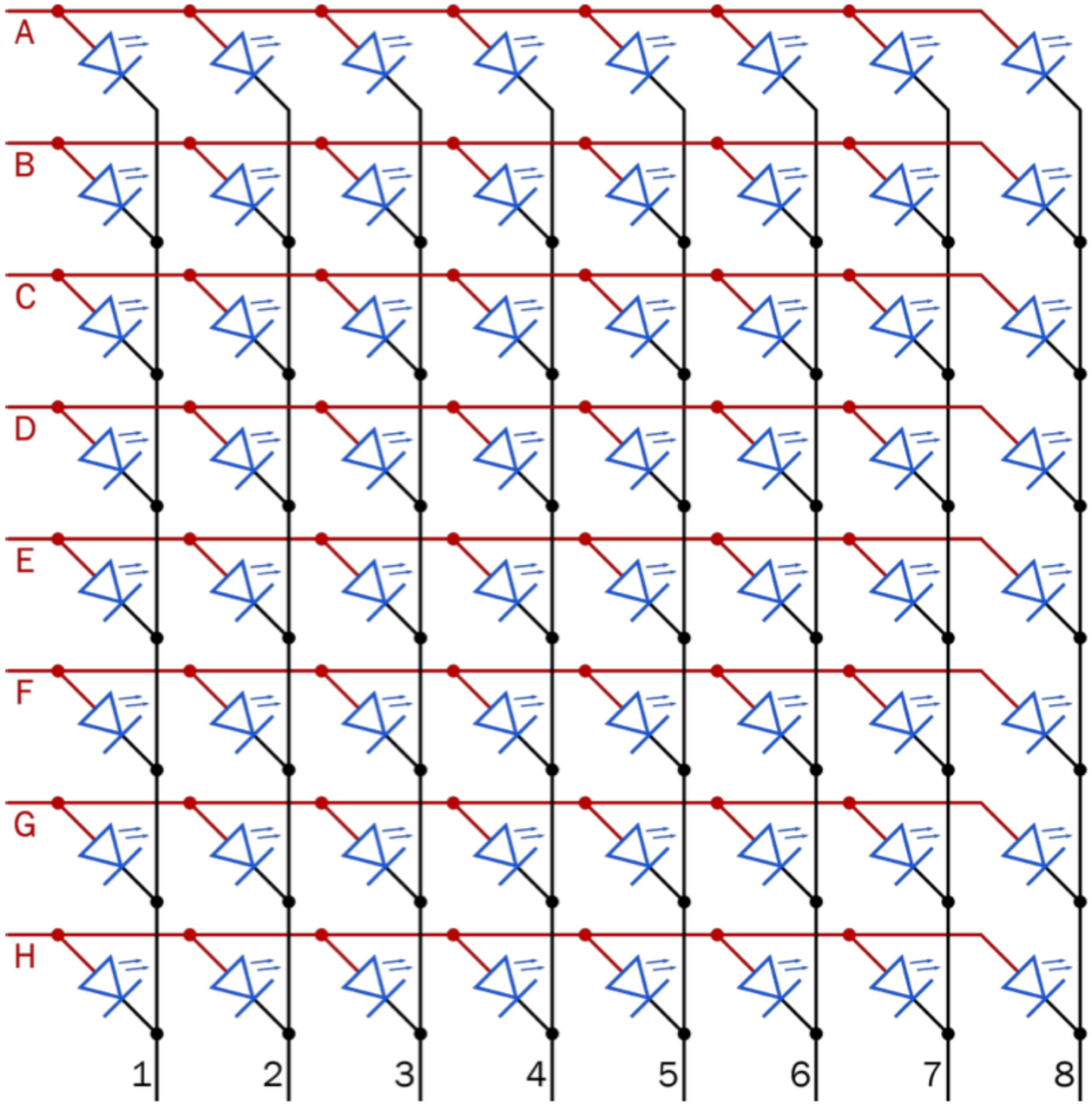
Use a PMOS to provide enough power to the LEDs



Putting it all together



Electrically it's an array, but physically…

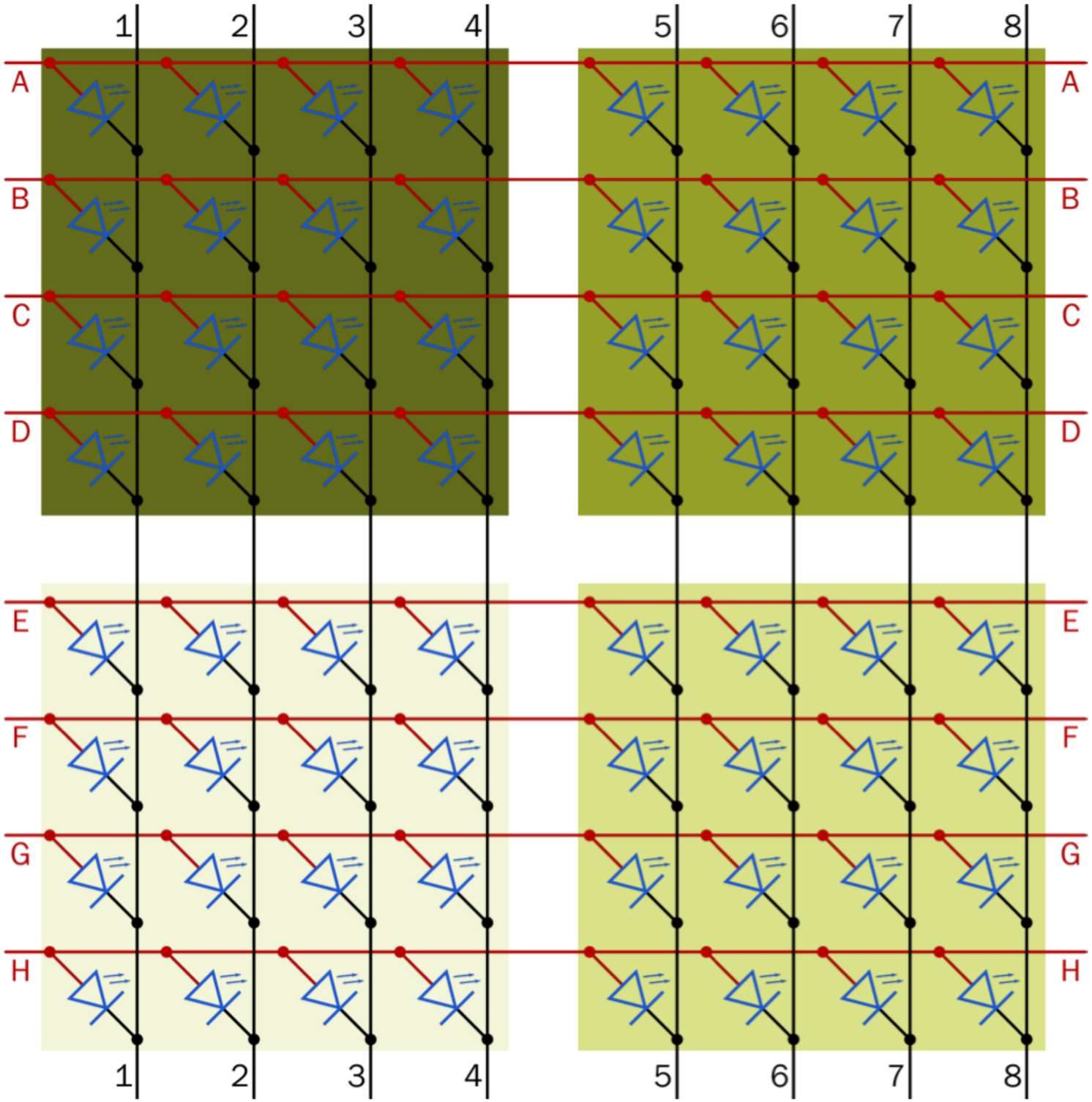


How do we arrange these in a $4 \times 4 \times 4$ cube?

...it's a cube?

...it's a cube?

bottom

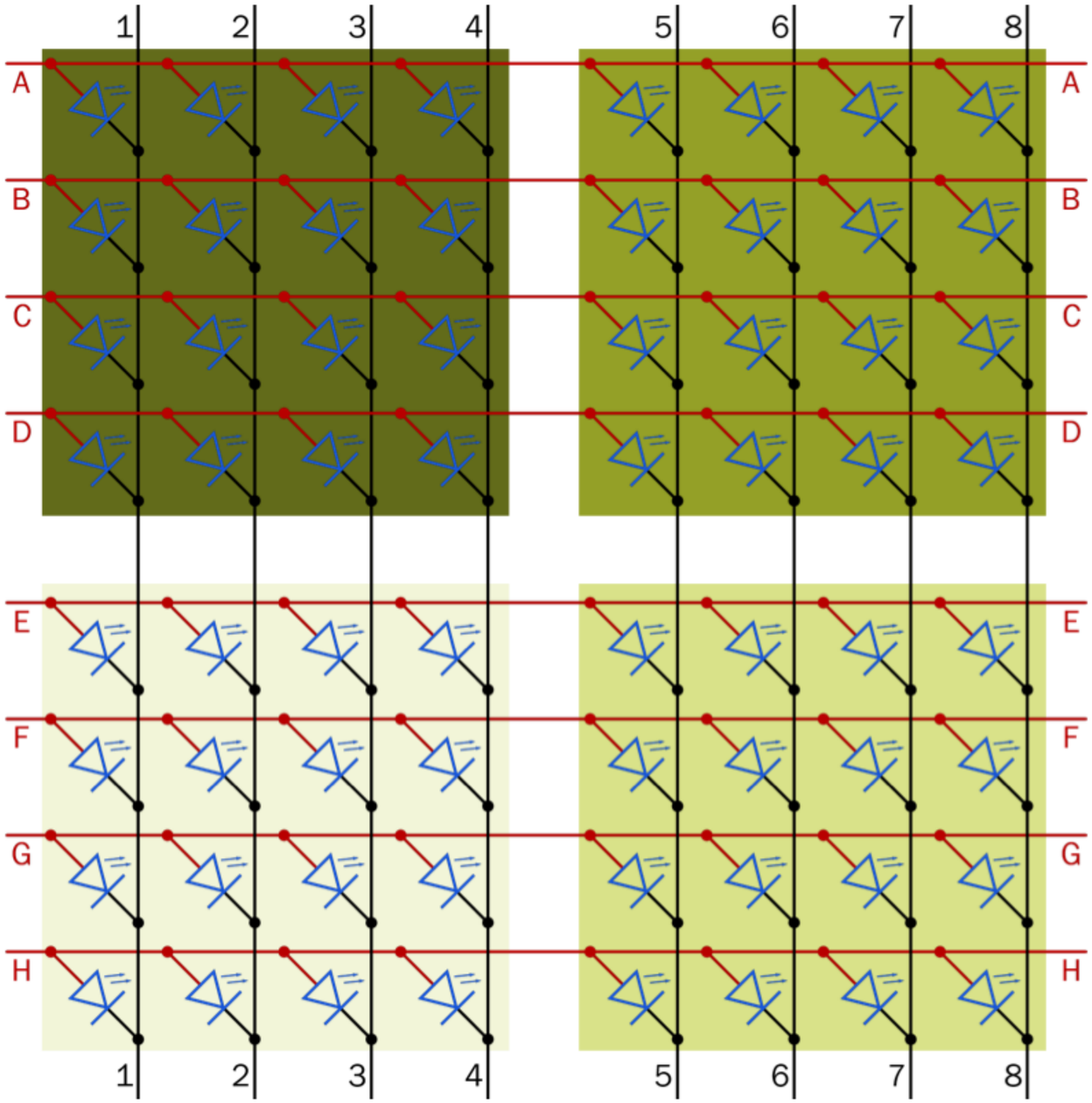


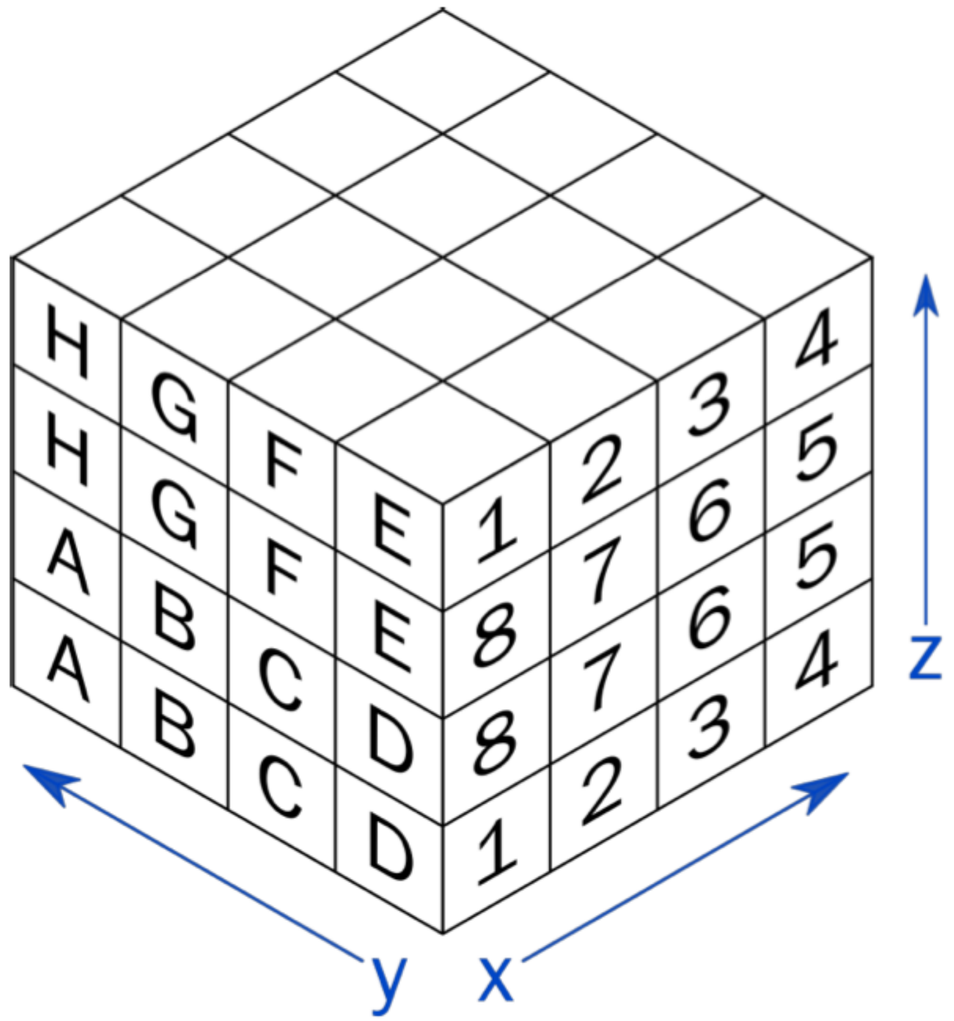
second from bottom

top

second from top

Mapping between 2-D and 3-D





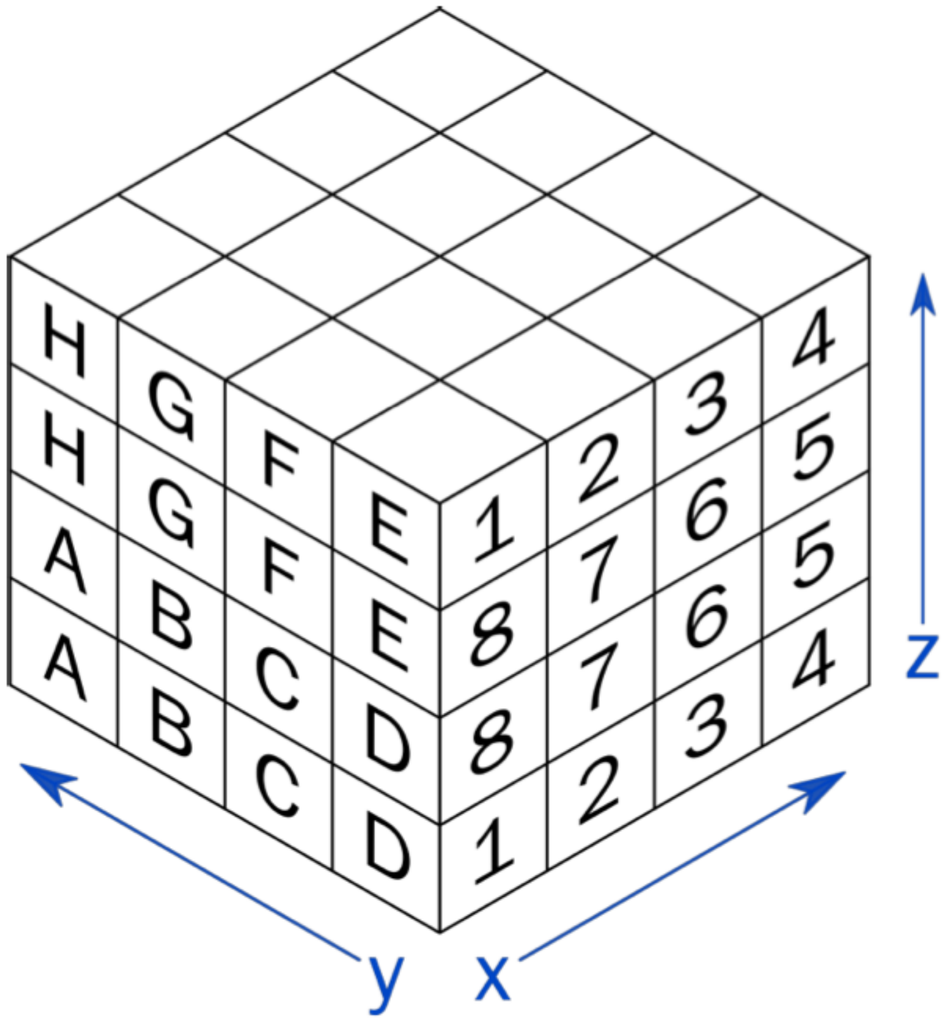
Mapping between 2-D and 3-D

We want a function that maps

from 3D coordinates (x, y, z)

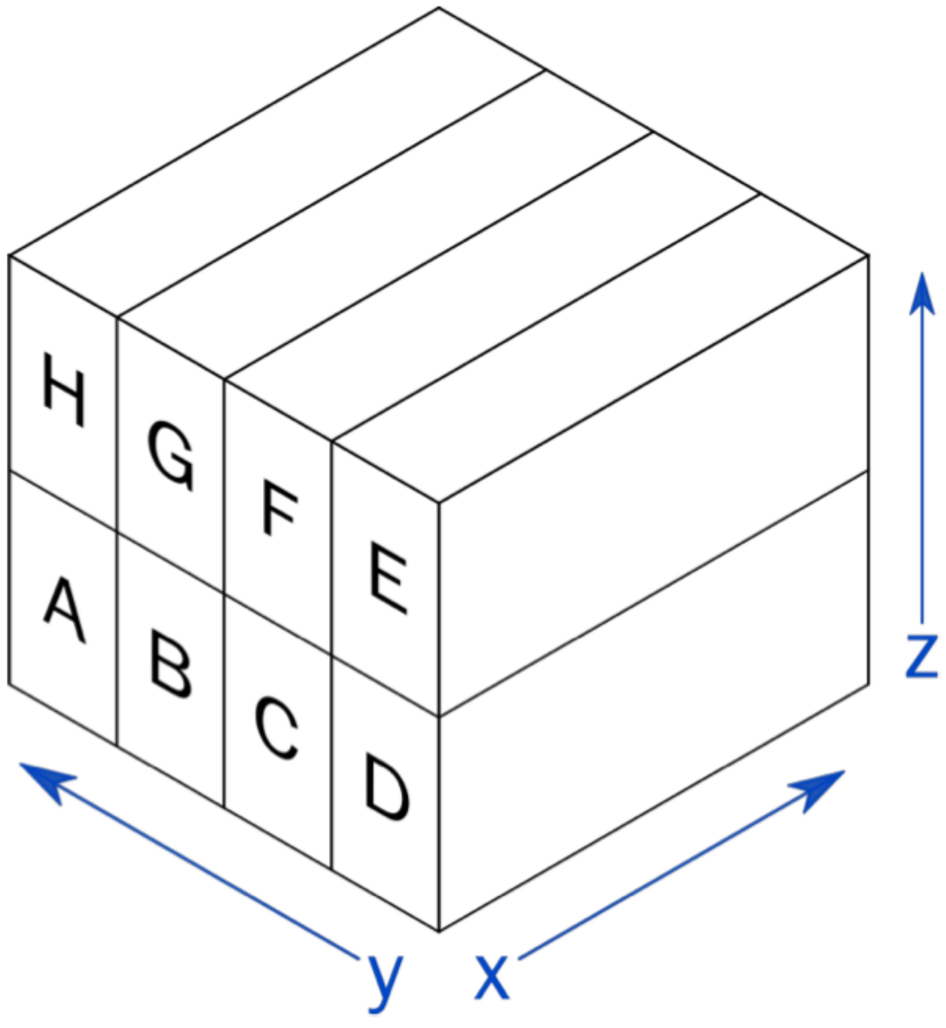
to anode/cathode pairs (a, c)

(e.g. “D6”)

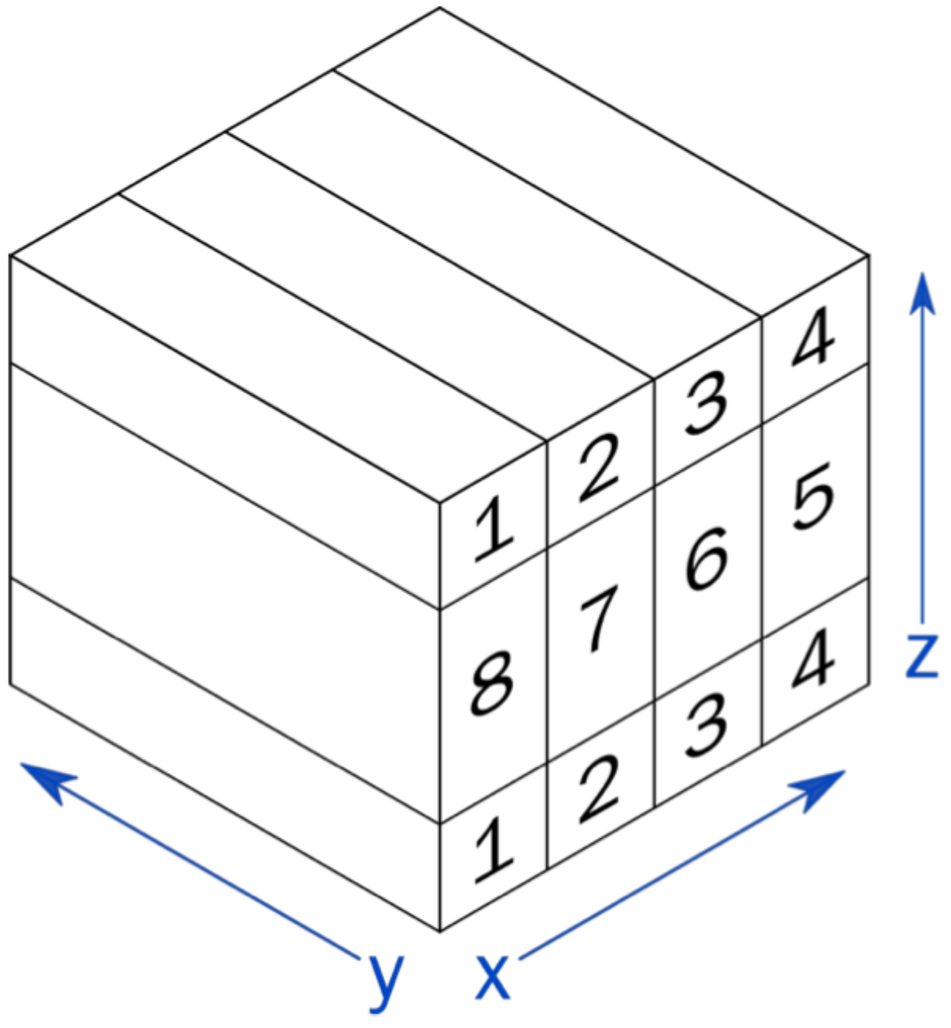


Mapping between 2-D and 3-D

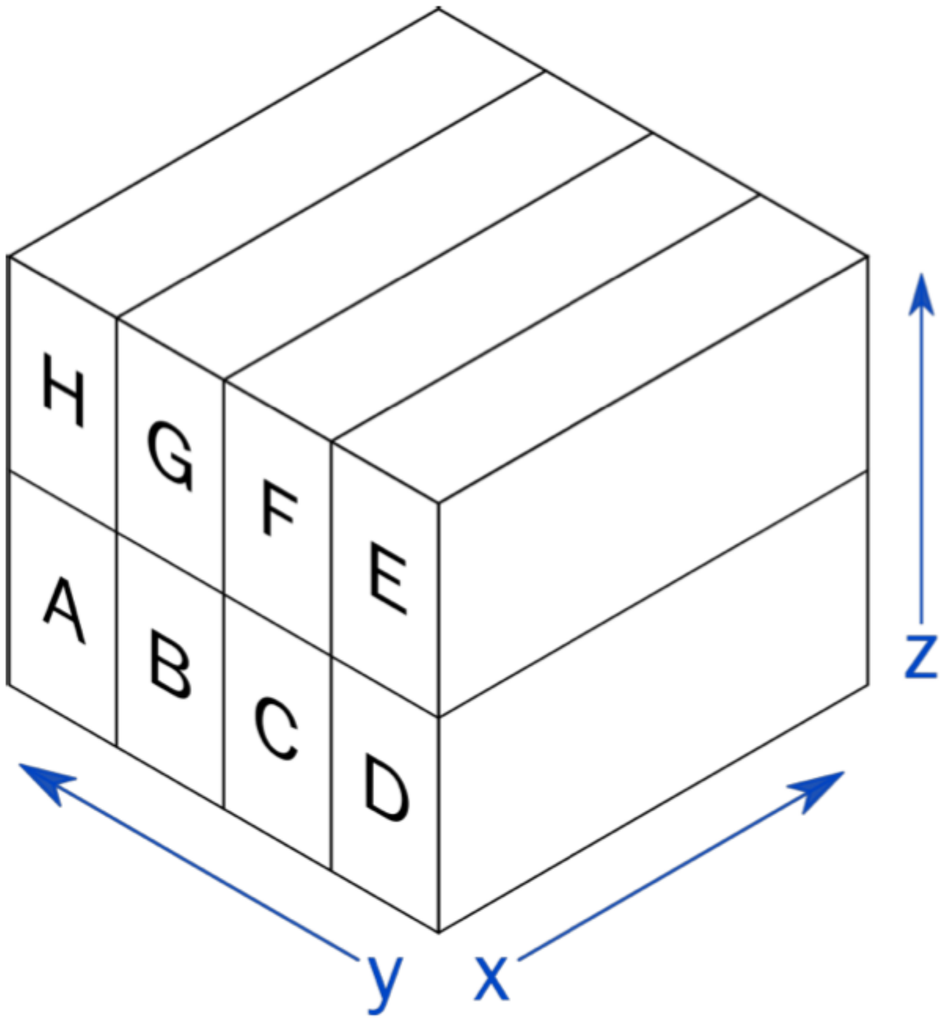
Anodes



Cathodes



Mapping between 2-D and 3-D



Operations we might consider using:

- * (multiplication)
- % (modulo division) 3% 2 == 1
- / (integer division) 3/2 == 1
- & (bitwise and)
- | (bitwise or)
- ^ (bitwise xor)

What do bitwise operations do?

- Bitwise operations apply to **each bit** in the binary representation of a number **individually**

Examples (in binary):

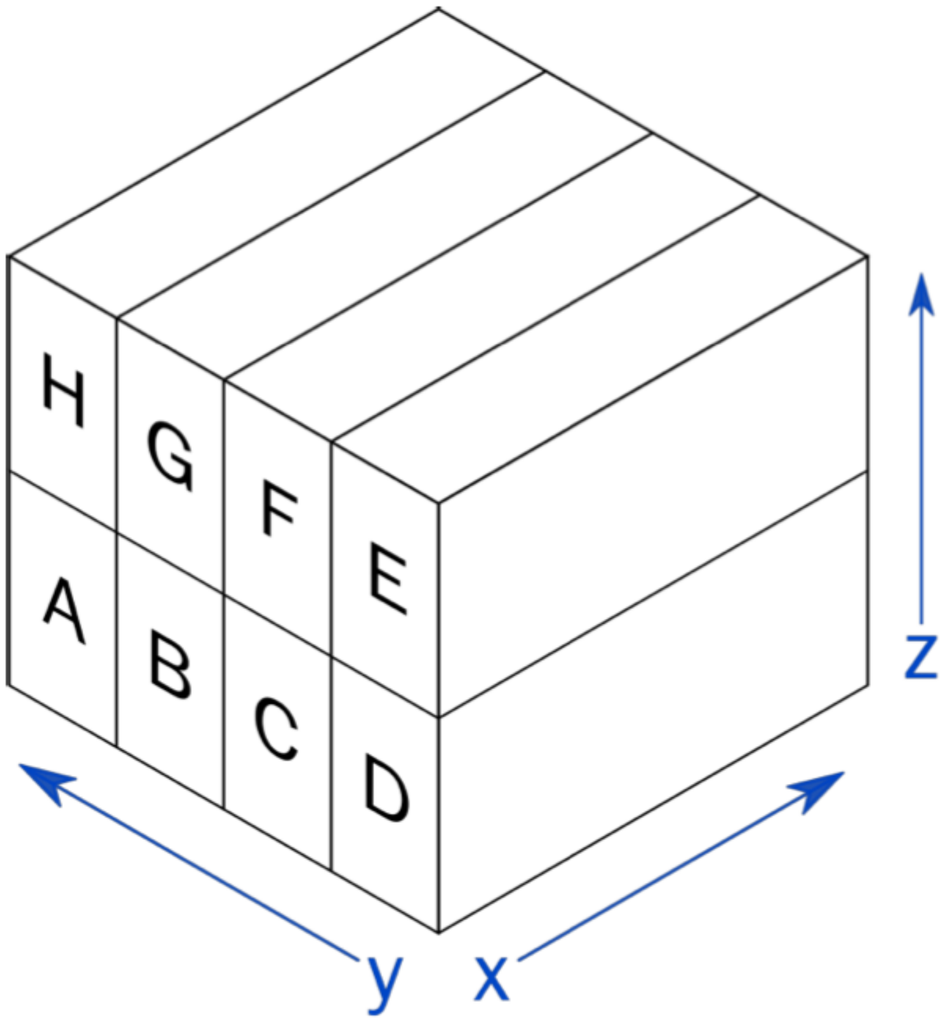
00110101 | 01100011 == 01110111

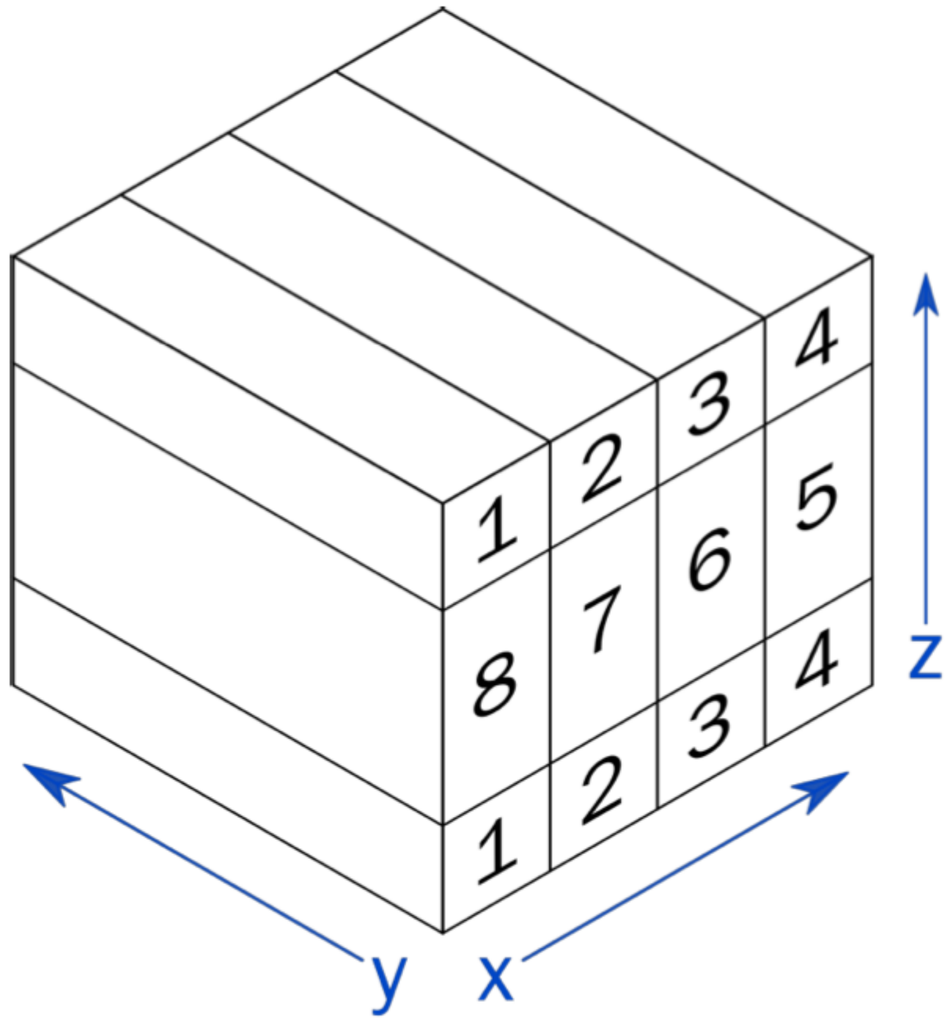
00110101 & 01100011 == 00100001

$$\begin{array}{r} 00110101 \\ \underline{| \;\; 01100011} \\ 01110111 \end{array} \qquad \begin{array}{r} 00110101 \\ \underline{\& \;\; 01100011} \\ 00100001 \end{array}$$

Making the mapping function easier

You can reorder the anodes/cathodes however you like.
Would a different ordering make the relationship simpler?





Building an LED cube: Key tips

Plan ahead

- Read the entire handout first

Test often, fail quickly

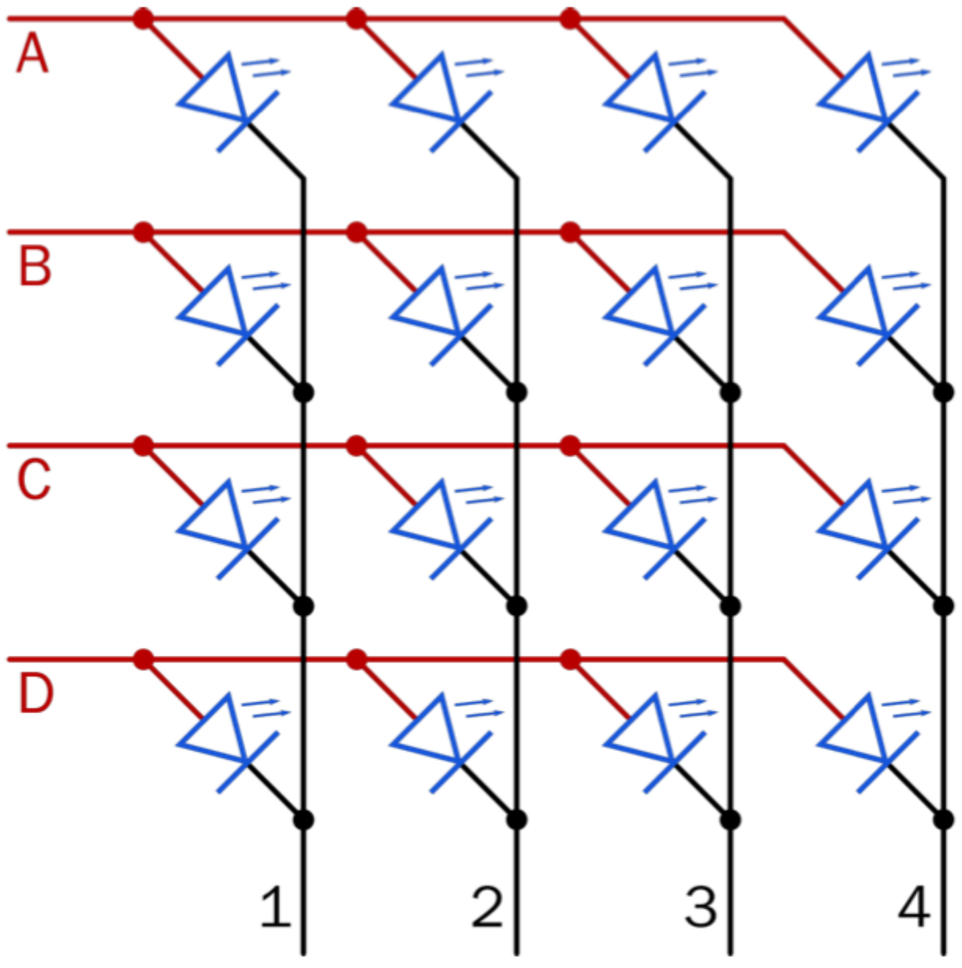
- Mistakes are easier to fix earlier than later
- It helps you avoid making the same mistake twice

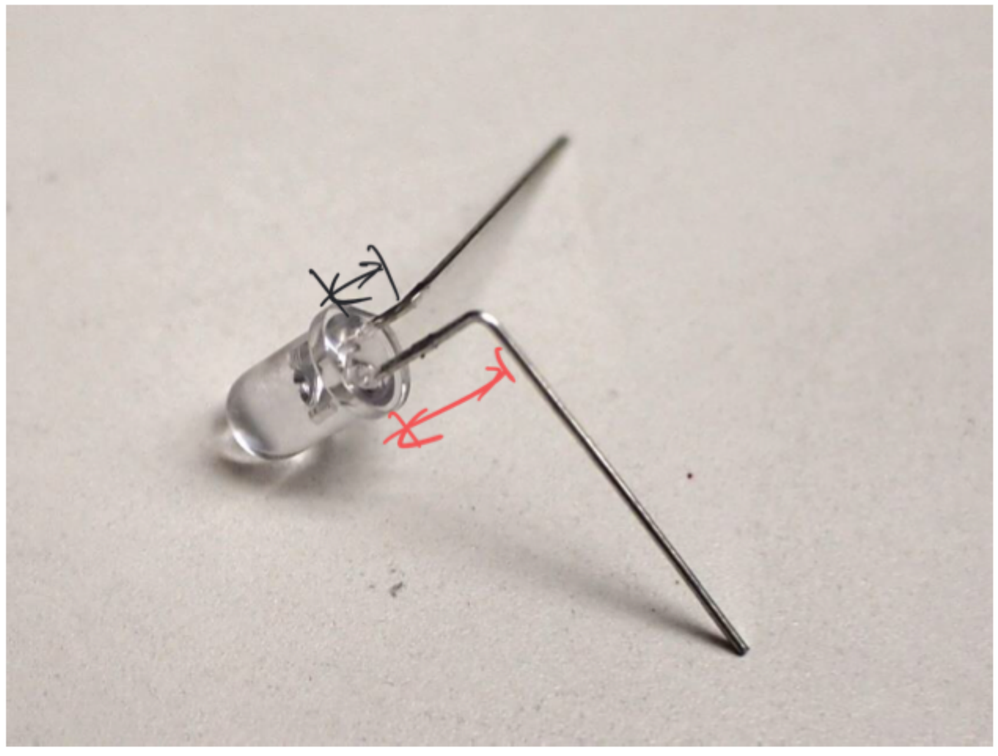
Optimize repetitive tasks

- Think of procedures to make tasks easier
- Use tools effectively—you only have two hands

Step 1: Build the arrays

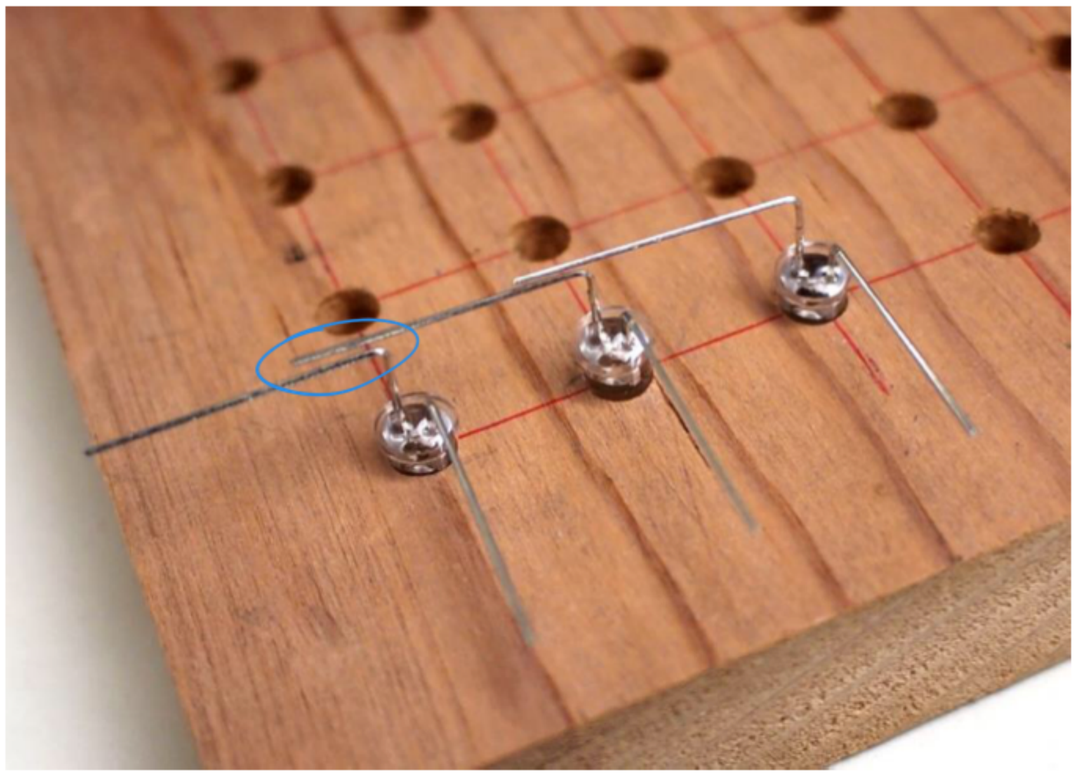
Bend the anodes and cathodes at different heights, so they don't touch. *Use pliers, not your fingers.*



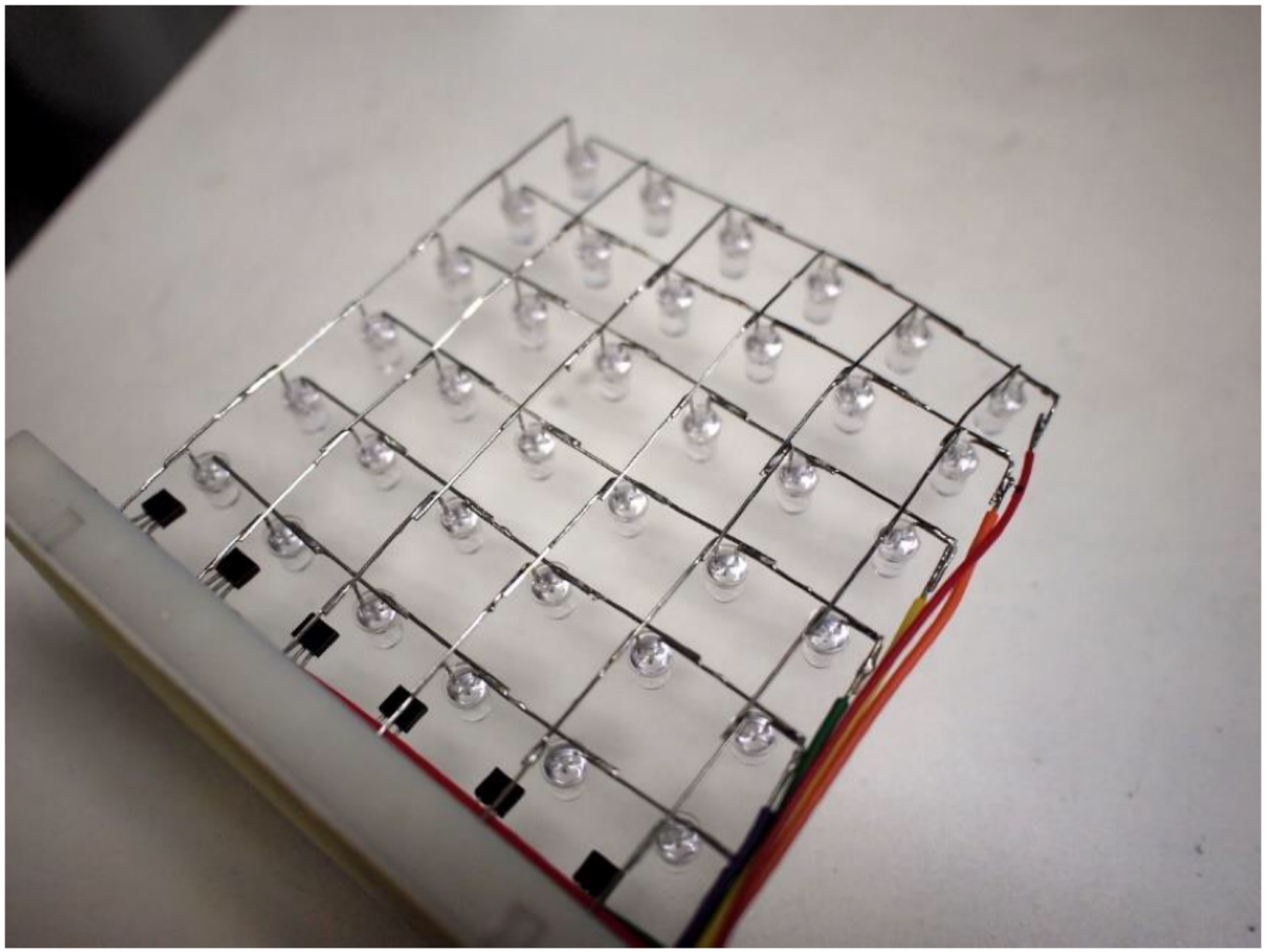


Step 1: Build the arrays

Jigs will help you keep the LEDs in place.

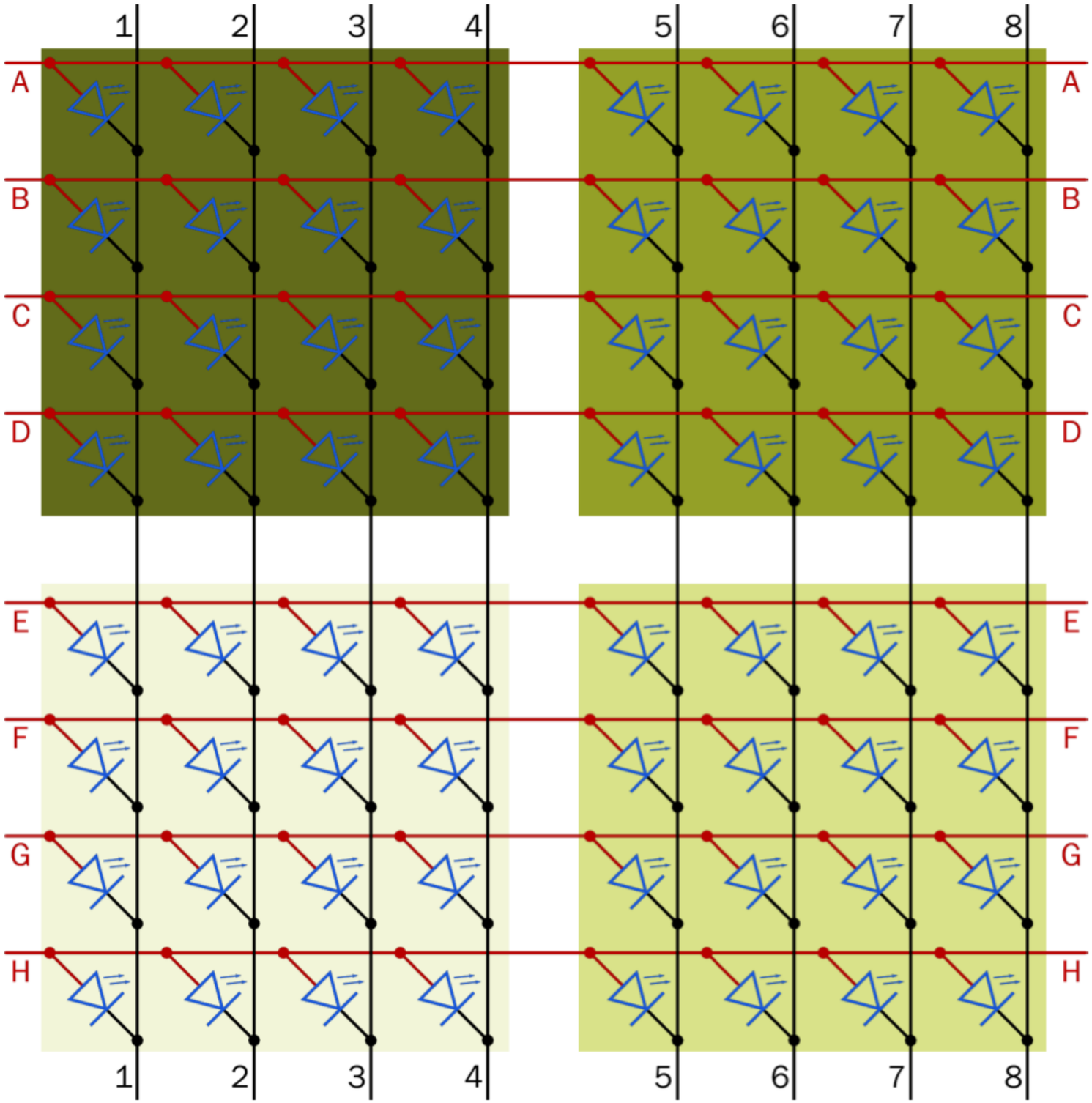


Step 1: Build the arrays



Test that the LEDs light up as you'd expect!

Step 2: Connect the arrays together



Step 2: Connect the arrays together