# Su22-ENGR-40M-01 Prelab 3a

Jannah Sabic El-Rayess

TOTAL POINTS

## 10 / 10

QUESTION 1

### 1 P1 2 / 2

✓ **- 0 pts** **correct -- 1/64 as bright**

**- 0.25 pts** 1/9 -- Solved for 3x3 case or in terms of n instead of 8x8

**- 1 pts** incorrectly said 1/8 or 1/3 (divided by number of rows)

**- 1 pts** other error

**- 1.5 pts** late

**- 2 pts** no work

**- 2 pts** Incorrect

**- 2 pts** late - not turned in 24 hrs before

QUESTION 2

### 2 P2 2 / 2

✓ **- 0 pts** **Correct -- 1/8th**

**- 0.5 pts** Answered 1/4th brighness

**- 0.5 pts** Answered 1/16th brighness

**- 0.5 pts** Answered 1/32nd brightness

**- 1 pts** says brightness depends on how many LEDs are on in each row.

**- 1 pts** Incorrect

**- 2 pts** No submission

**- 2 pts** late - not turned in 24 hrs before

QUESTION 3

### 3 P3 2 / 2

✓ **- 0 pts** **Correct - Resistor values should be about 100-110 ohms in Every Circuit. After adjusting for Arduino input resistance they will be 80-90 ohms.**

**- 0.1 pts** Resistor values are off. Current should be slightly below 20mA

**- 0.5 pts** Incorrect PMOS gate connections

**- 0.5 pts** Incorrect PMOS source connections

**- 0.5 pts** Incorrect LED connections

**- 1 pts** Not completed in everycircuit/no simulated current shown for resistor calculation

**- 1 pts** Incorrect

**- 2 pts** Incomplete

**- 2 pts** late - not turned in 24 hrs before

**- 0.2 pts** No current value simulated/shown

QUESTION 4

### 4 P4 4 / 4

✓ **- 0 pts** **Correct**

**- 1 pts** Transistor connected incorrectly

**- 0.1 pts** Error (see comments)

**- 0.25 pts** Did not label transistor connections

**- 0.25 pts** Has multiple wries in the same pad

**- 0.25 pts** Wiring is inefficient / messy

**- 1 pts** LED cathodes connect to ground.

**- 0.25 pts** Minor error

**- 4 pts** late - not turned in 24 hrs before

**- 2 pts** Other half missing

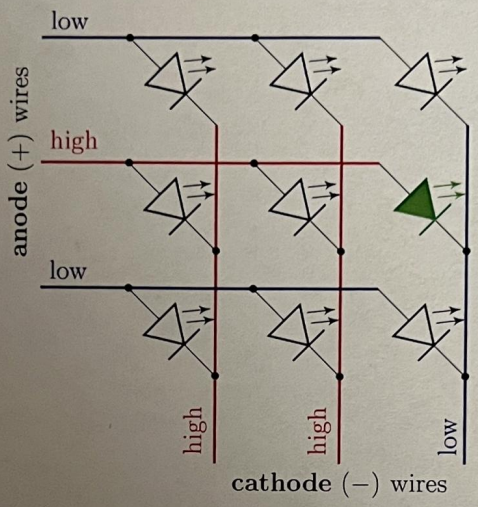
**- 4 pts** Incorrect

**- 0.5 pts** Issues with resistor representation and wiring

# 2 Prelab

## 2.1 Our LED multiplexing strategy

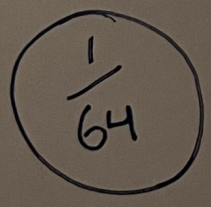
An LED is on when, and only when, its anode (+ side) is high and its cathode (− side) is low. Any other combination (high/high, low/low, low/high) will keep the LED off. Therefore, we can turn on any *single* LED by settings its anode (+) wire high and its cathode (−) wire low, and setting *all other* anodes low and all other cathodes high.




While the figures show a $3 \times 3$ array, the following questions refer to the **$8 \times 8$ array** that you will actually build.

One simple way to time-multiplex the LEDs would be just to turn them on one at a time. If you cycle through all 64 LEDs fast enough, your eyes will "fuse" them together and it will look like the LEDs that are on are on constantly—just dimmer, since they're not always on. To understand this, if an LED is turned on and off very rapidly such that on average it is on $\frac{1}{n}$th of the time, we say that its *relative brightness* is $\frac{1}{n}$.

**P1:** Consider the brightness of a single LED that is turned in the above pattern (i..e 8 x 8 array with 64 LEDs). Under the above regime, where we cycle through LEDs one by one, what is the relative brightness of this LED?



1 P1 **2 / 2**

✓ **- 0 pts correct -- 1/64 as bright**

**- 0.25 pts** 1/9 -- Solved for 3x3 case or in terms of n instead of 8x8

**- 1 pts** incorrectly said 1/8 or 1/3 (divided by number of rows)

**- 1 pts** other error

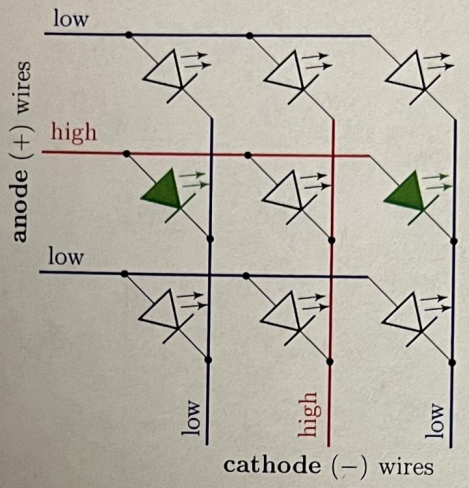
**- 1.5 pts** late

**- 2 pts** no work

**- 2 pts** Incorrect

**- 2 pts** late - not turned in 24 hrs before

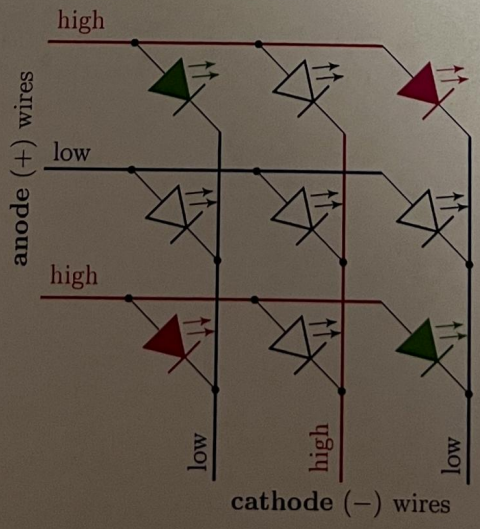
We can improve this by turning on more than one LED at a time. More precisely: We can cycle through *anode (+) wires*, setting them to high one at a time, but now set *all* of the *cathode (−) wires* corresponding to LEDs we want to be on *in that row* to low. Because every other row is off (due to a low anode), and each LED in a single row is on a different cathode wire, we would still have independent control of the LEDs.




**P2:** What is the relative brightness of a single LED under this scheme (still using the 8 x 8 LED array)?

1/8

We might be a little more ambitious still, and ask: if we can have multiple *cathode (−) wires* low at the same time, can we also have multiple *anode (+) wires* high? Sadly, things fall apart. Suppose we wanted to light up the top-left and bottom-right LEDs in the diagram below. We can't do this without turning the two other LEDs on the same wires:




To keep this from happening, we need to make sure we're only driving one anode (+) wire at a time.

## 2 P2 2 / 2

✓ **- 0 pts Correct -- 1/8th**

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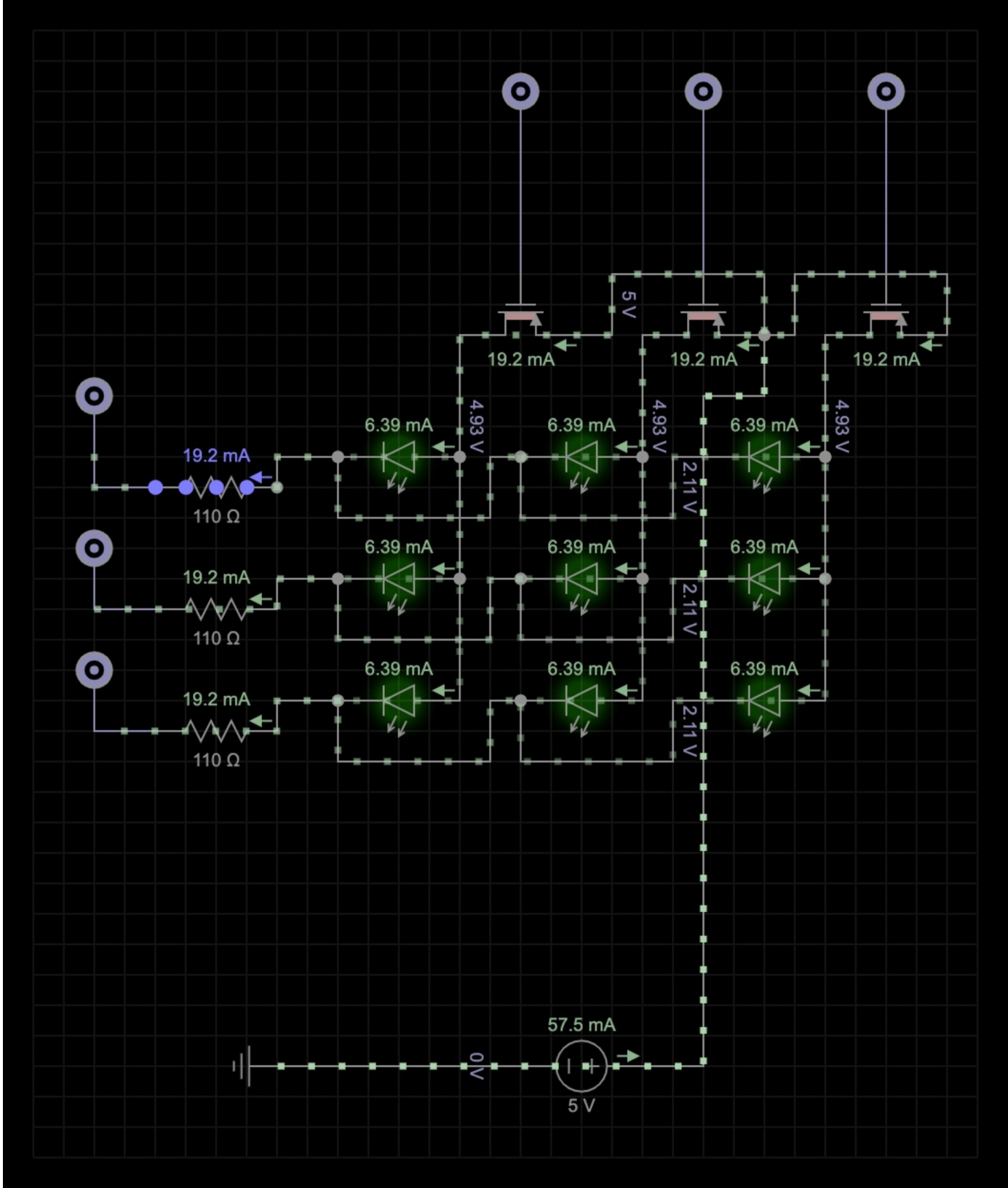
5 V
19.2 mA
19.2 mA
19.2 mA
6.39 mA
6.39 mA
6.39 mA
4.93 V
4.93 V
4.93 V
19.2 mA
110 Ω
2.11 V
6.39 mA
6.39 mA
6.39 mA
19.2 mA
110 Ω
2.11 V
6.39 mA
6.39 mA
6.39 mA
19.2 mA
110 Ω
2.11 V
57.5 mA
0 V
5 V

### 3 P3 2 / 2

✓ **- 0 pts Correct - Resistor values should be about 100-110 ohms in Every Circuit. After adjusting for Arduino input resistance they will be 80-90 ohms.**

**- 0.1 pts** Resistor values are off. Current should be slightly below 20mA

**- 0.5 pts** Incorrect PMOS gate connections

**- 0.5 pts** Incorrect PMOS source connections

**- 0.5 pts** Incorrect LED connections

**- 1 pts** Not completed in everycircuit/no simulated current shown for resistor calculation

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**- 2 pts** Incomplete

**- 2 pts** late - not turned in 24 hrs before

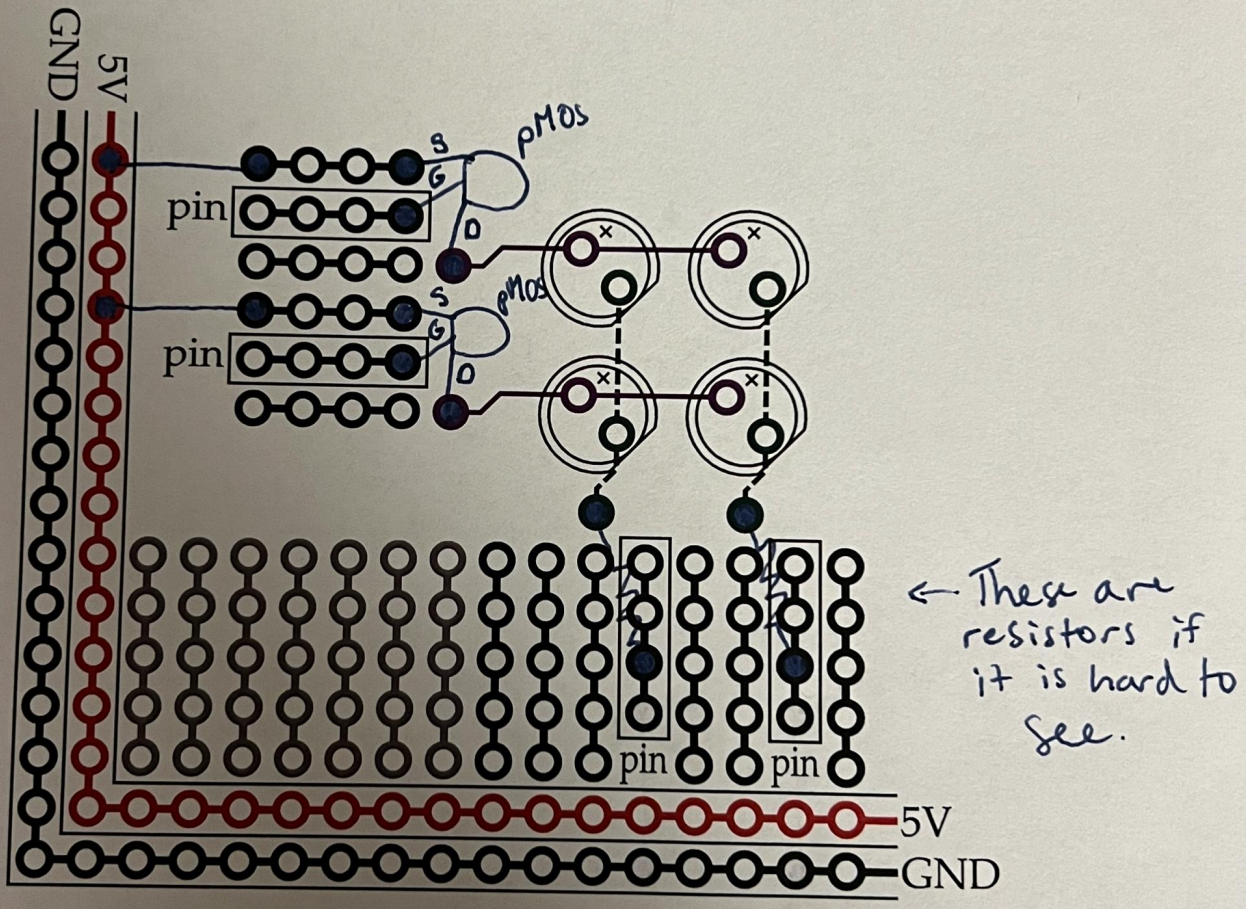
**- 0.2 pts** No current value simulated/shown

You'll need to build this circuit on the generic space of your PCB. But because things get soldered onto the PCB, once they're in, they can't be easily changed—so there's not really a way to test the circuit on the PCB before locking things in. For this reason, this lab requires more careful layout planning.

**P4:** Below is an image of part of your PCB—the tracks relevant to a $2 \times 2$ portion of your array. Holes connected by a line are joined electrically. Tracks inside a box marked "pin" are also connected (via the PCB) to an Arduino input/output pin.

Draw two transistors and two resistors to indicate in which holes you intend to solder them, as well as any additional jumper wires (if any) that you need to complete this $2 \times 2$ part of your circuit. For your drawing, please indicate GATE, SOURCE, and DRAIN of the transitor on your picture.

*Tip: Your transistor legs will only reach so far, so it's best practice to put them in adjacent or near-adjacent holes.*




# 3 Lab procedure

## 3.1 Soldering everything into the PCB

*Before you start:* If your TA didn't indicate to you in your prelab feedback that your answer to P4 was good to go, please check your revised layout with your TA before you commit to soldering anything in.

*Tip:* When your board is upside down (so you can solder things in), things might fall off a little! It's best for components like LEDs and resistors to be flush against the board, so you'll need to hold them in place. A common strategy is to bend the legs of components slightly, so that the bend holds them in place. Another strategy is to tape them down with masking tape.

## 4 P4 4 / 4

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