

# GADGETS FINAL EXAM QUESTIONS

## Q1 Debugging Pt1

Given that you can make the following assumptions:

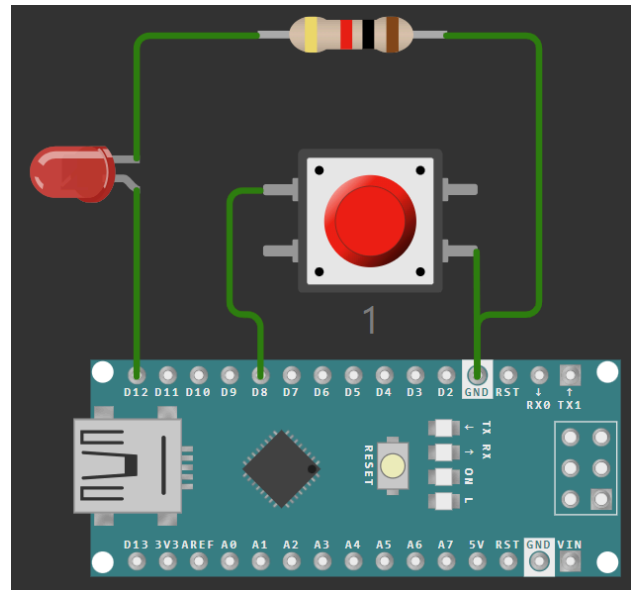
1. There is power coming into the Arduino via the USB connection
2. The button is normally open
3. Pressing the button will successfully close the circuit

What is wrong with the following diagram and code?

```
#define BTN_PIN 8
#define LED_PIN 12

void setup() {
  pinMode(BTN_PIN, INPUT_PULLUP);
  pinMode(LED_PIN, OUTPUT);
}

void loop() {
  int btn = digitalRead(BTN_PIN);
  if (btn == HIGH) {
    digitalWrite(LED_PIN, HIGH);
  } else {
    digitalWrite(LED_PIN, LOW);
  }
}
```



- a) There is no error
- b) It won't compile
- c) BTN\_PIN needs to be set to INPUT
- ✓ d) The if() statement clause is incorrect

### Answer:

The correct answer is **d**. This is because, in this configuration, we have the BTN\_PIN set as INPUT\_PULLUP, and therefore internally, it will be high unless otherwise connected to something. When we close the switch by pressing the button, we are connecting the BTN\_PIN to ground, which would mean pressing it results in a LOW reading. Therefore, in the if clause, we need to check if btn == LOW

## Q2 Debugging Pt2

Given that you can make the same assumptions as the previous problem:

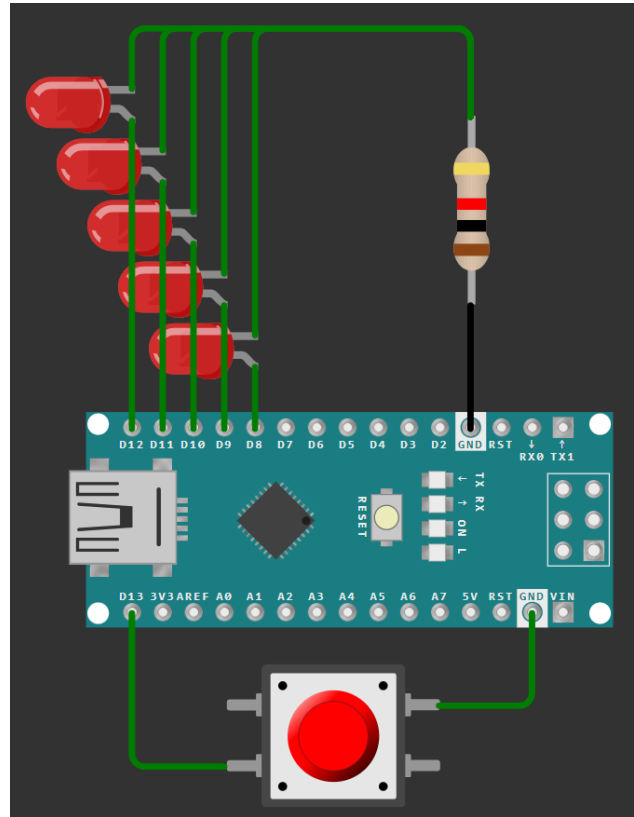
1. There is power coming into the Arduino via the USB connection
2. The button is normally open
3. Pressing the button will successfully close the circuit

What is wrong with the following diagram and code?

```
#define BTN_PIN 13
int mask = (0b1 << 5);

void setup() {
  DDRB = 0x3F ^ mask;
  PORTB = 0b00 ^ mask;
}

void loop() {
  int btn = digitalRead(BTN_PIN);
  if (btn == LOW) {
    PORTB = 0x3F ^ mask;
  } else {
    PORTB = 0x00 | mask;
  }
}
```

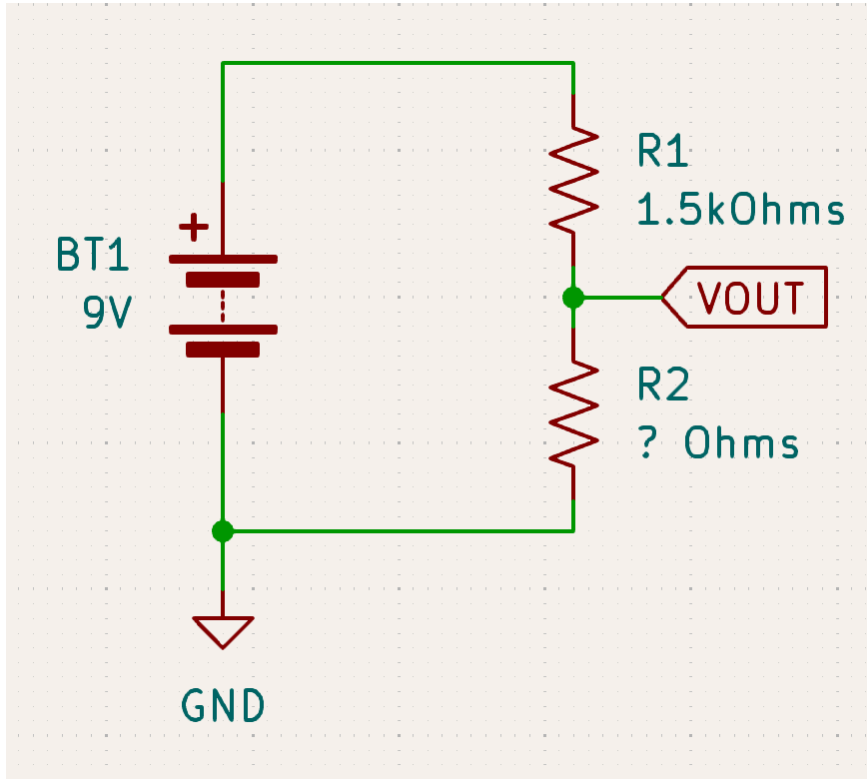


- a) PORTB does not correspond to the connected pins
- ✓ b) The INPUT\_PULLUP status of D13 is being toggled
- c) You must include a header file to use the ports directly
- d) The 1 is being shifted over by the wrong amount in the mask

**Answer:** The correct answer is **b**. This is because when assigning `PORTB = 0x3F ^ mask`, we are flipping the PORTB bit of D13 to a 0. This is happening because PORTB is only 6 bits, and the 6th bit of 0x3F is already a 1. Once this is ^ed with the mask, it gets set as 0 instead. To set INPUT\_PULLUP status while using the registers, we need the DDR bit to be 0, and the PORT bit to be 1. By including this ^ with the mask, we are leaving D13 as floating, and therefore sometimes the button press will not work when it gets shorted to ground.

### Q3 Ohm's Law

What resistance does R2 need to be such that VOUT is 5V?



- ✓ a) 1875  $\Omega$
- b) 2 k $\Omega$
- c) 1750  $\Omega$
- d) 1.5 k $\Omega$

#### Answer:

The correct answer is **a**. This problem is a simple voltage divider, where the unknown variable is  $R_2$ . We know the equation for a voltage divider is

$$V_{\text{out}} = V_{\text{in}} \left( \frac{R_2}{R_1 + R_2} \right)$$

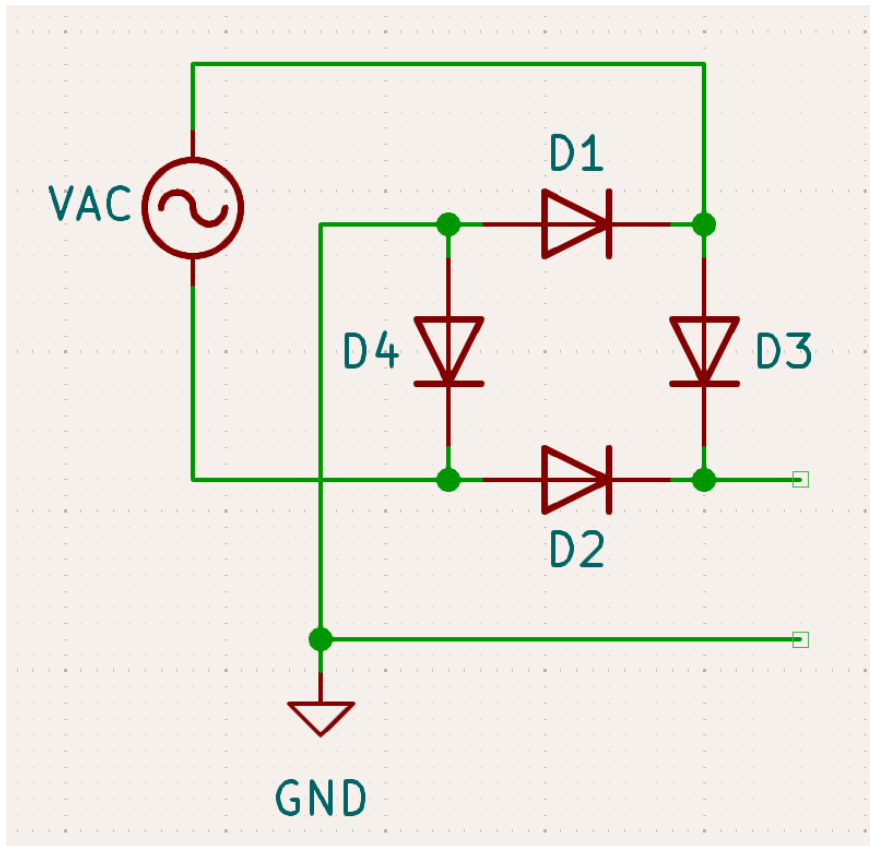
If we rearrange this to solve for  $R_2$  you get

$$R_2 = R_1 \left( \frac{V_{\text{out}}}{V_{\text{in}} - V_{\text{out}}} \right)$$

and after plugging in the values, you get 1875  $\Omega$

## Q4 Circuits

What is the purpose of the following circuit?



- a) Light up when powered to show the device is on
- ✓ b) Convert AC current into DC current
- c) Poll from more inputs than available GPIO pins
- d) Measure the voltage drop over a diode

### Answer:

The correct answer is **b**. This is a Full Wave rectifier, which will convert AC to DC current. It does so by using diodes to limit the direction of the current. Whichever direction the AC current is flowing, there is a path to ground and the output through the same point of the diodes, resulting in a strictly “positive” voltage.

## Q5 PWM

What is the purpose of using a PWM signal?

- ✓ a) It allows you to toggle a signal rapidly, effectively allowing you to set a state other than 1 or 0
- b) It allows you to read analog data at a much faster rate
- c) It allows you to send data wirelessly
- d) It allows you to measure the clock speed of the processor

**Answer:**

The correct answer is **a**. A PWM signal is used to rapidly switch on and off a signal, which the receiver on the other side of the signal is able to use as a non-binary value. A common example of using this would be when driving motors or with LEDs to have a medium brightness that is not either fully off or on.

## Q6 Project Design

Explain how you would go about designing a system that would check to see if a door is open in your house, and if it is open for too long, to send some sort of notification to your phone. Make sure to include information such as the  $\mu$ Controller used, the sensors selected, what form of communication will be used, and all other relevant details for completing this project.

### Answer:

#### Part 1: Detection

I want to start with how I would go about detecting whether the door is open or not. There are multiple ways that you could achieve this, but the two that seem the most reliable to me are using either a Hall effect sensor or some sort of ultrasonic or laser sensor. To achieve the detection of whether the door is open or not, you can attach the sensor to the door jam, and attach either a magnet (if using hall-effect) or a painted block (if using one of the other two sensors). When the door is open, the sensors will no longer detect the item placed on the door, and return the correct reading of the door being open.

#### Part 2: $\mu$ Controller

For the microcontroller, I would select either an ESP32 or an Arduino with an additional module that adds WiFi capability. The benefit that the ESP32 provides is it already comes with WiFi capability by default on nearly all models.

#### Part 3: Communication

Once connected to the internet, you can register your device with a bot that allows for messages on popular chat platforms, such as Signal/Telegram/WhatsApp or even Gmail. You would just need to register the device and send an API request to the bot. The code would be quite simple: it would poll the sensor every second or so, and store whether the door is open or not. If the door is open, it will store the time in which the first detection of this occurred, and when the current time is far enough away from that, send the API request to the bot.

#### Part 4: Power

The final part to consider is how the microcontroller which is powering this operation is going to be powered. The first option would be to just run a cable to the device and let it remain connected to the power. The downside of this is that you have to run a cable, and it won't work if the power is out. The alternative is to add a battery back to the device and lower the polling rate (maybe every 10 seconds now) so that you can put the device in deep sleep and drastically lower the power consumption.

## Q7 Paper Argument

One of the key points brought forth in the paper “The Computer for the 21st Century” by Mark Weiser at Palo Alto Research is that there will be ubiquitous pads, tabs, and boards in every room for everyone to use. Do you agree or disagree with this statement? Explain why that is the case. If you agree, what parts did you particularly like? If you disagree, what would be your counterarguments?

### **Answer:**

I disagree with this statement, in general, because it relies on the goodwill of people to not steal the devices, and the infrastructure to keep them charged, and in a good, useable condition. One of the key issues with the premise of ubiquitous computing is that there has to be either some sort of infrastructure to keep the devices in good condition or someone who will constantly service them. I can't imagine this as being profitable, at least in today's time. Additionally, while the tabs might be cheap enough to not warrant stealing (on the order of cents) I think the pads and boards would be expensive enough that they would be stolen to some capacity.

I believe that this would be feasible but with a few caveats. The first is that I don't see it happening in the 21st century, but I can imagine a world in the 22nd or so where we have the infrastructure for this. The final caveat is that I'm not sure how possible it would be to have this for the general public, at any location; I think having this in corporate offices, or in select people's homes is a possibility, where there is someone to fund the purchasing and upkeep, but I don't see this being rolled out the general public.