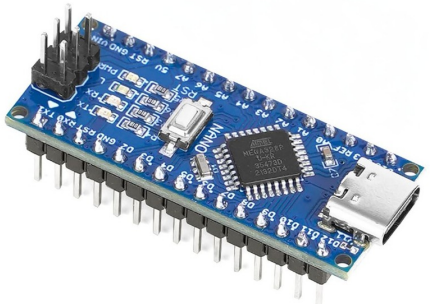
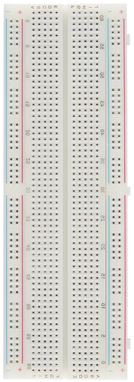
Lab 2: Basic “GPIO” output



Lab goals

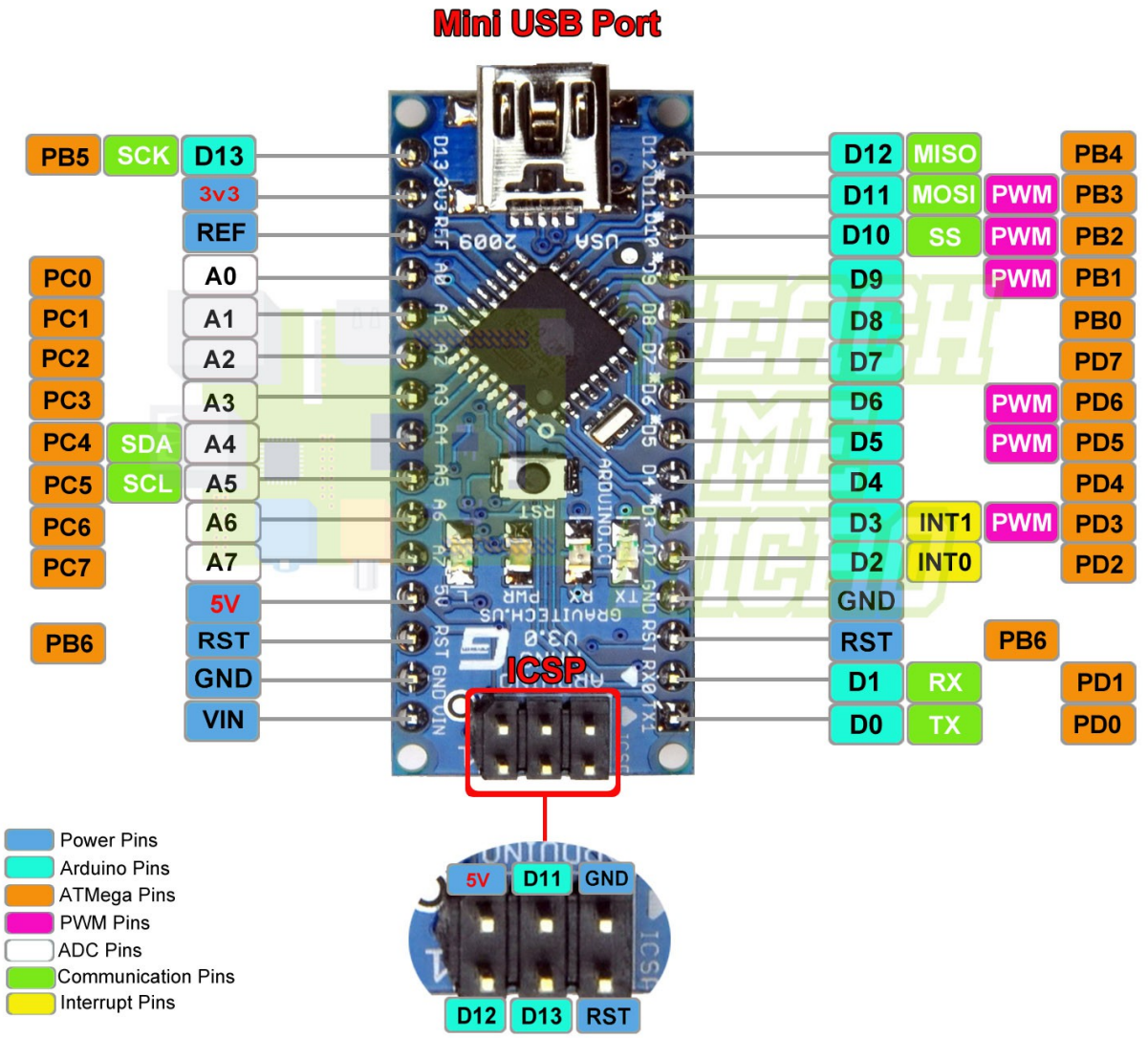
- Get acquainted with your development board's pins
- Get acquainted with General Purpose Input/Output (GPIO)
- Get acquainted with breadboards
- Get acquainted with the microcontroller's basic digital output



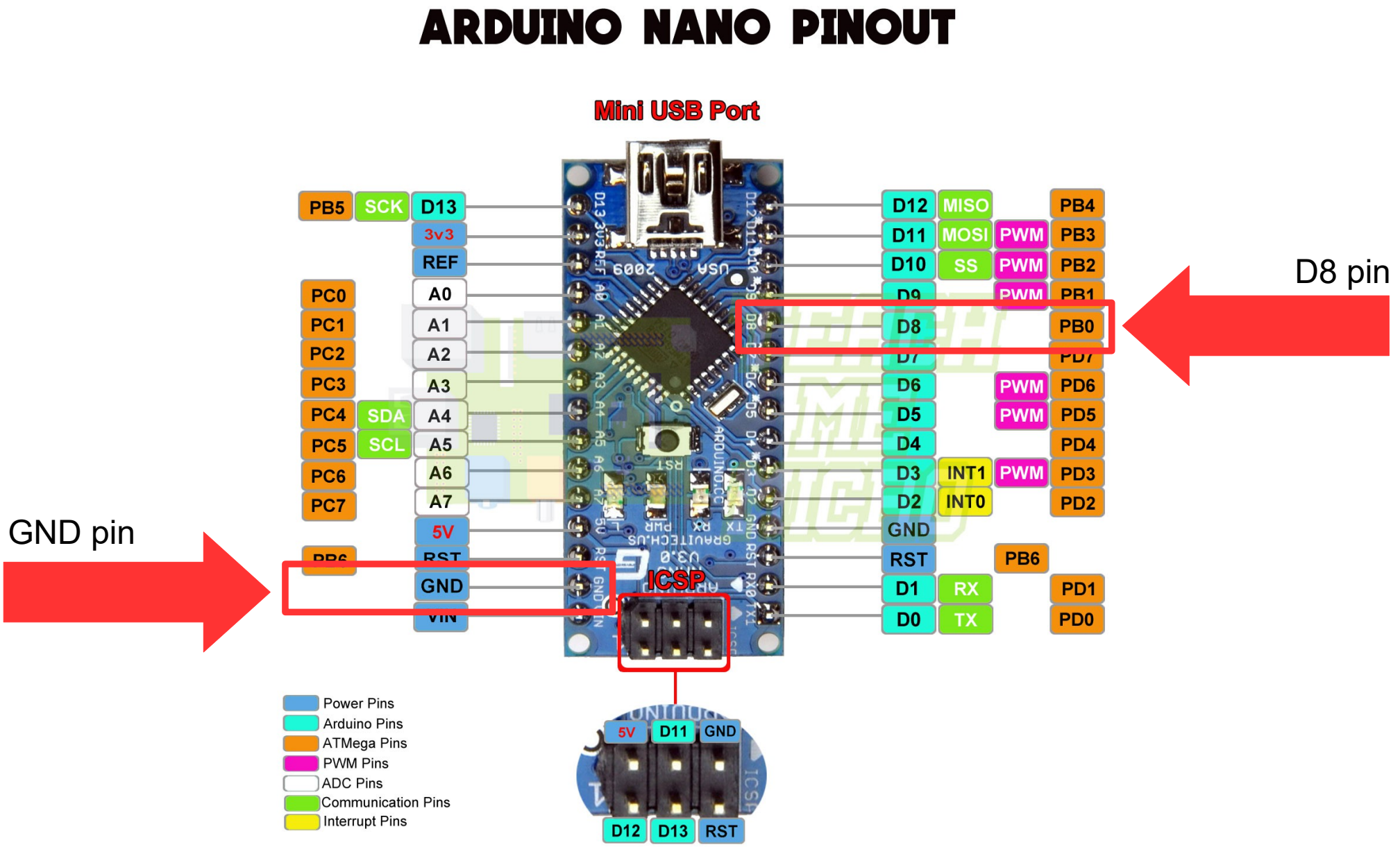
Required hardware/software

- Everything from lab 1, plus:
- Breadboard
- LED x 1
- 330 Ohm resistor x 1
- Male-to-male DuPont cables
- 9V battery and 9V battery-to-DuPont cables adapter

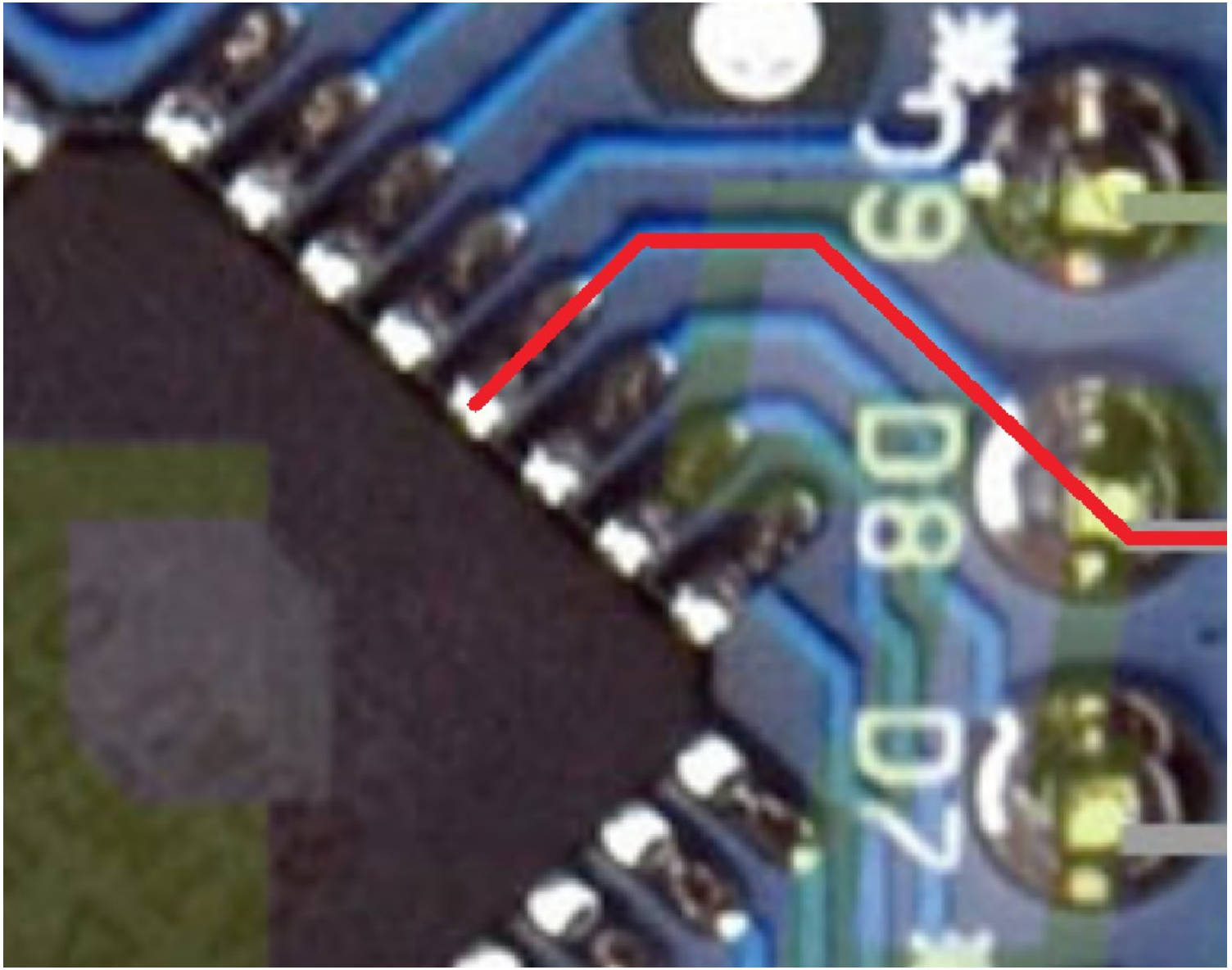
Lab 2: Basic GPIO output (background)



Lab 2: Basic GPIO output (background)

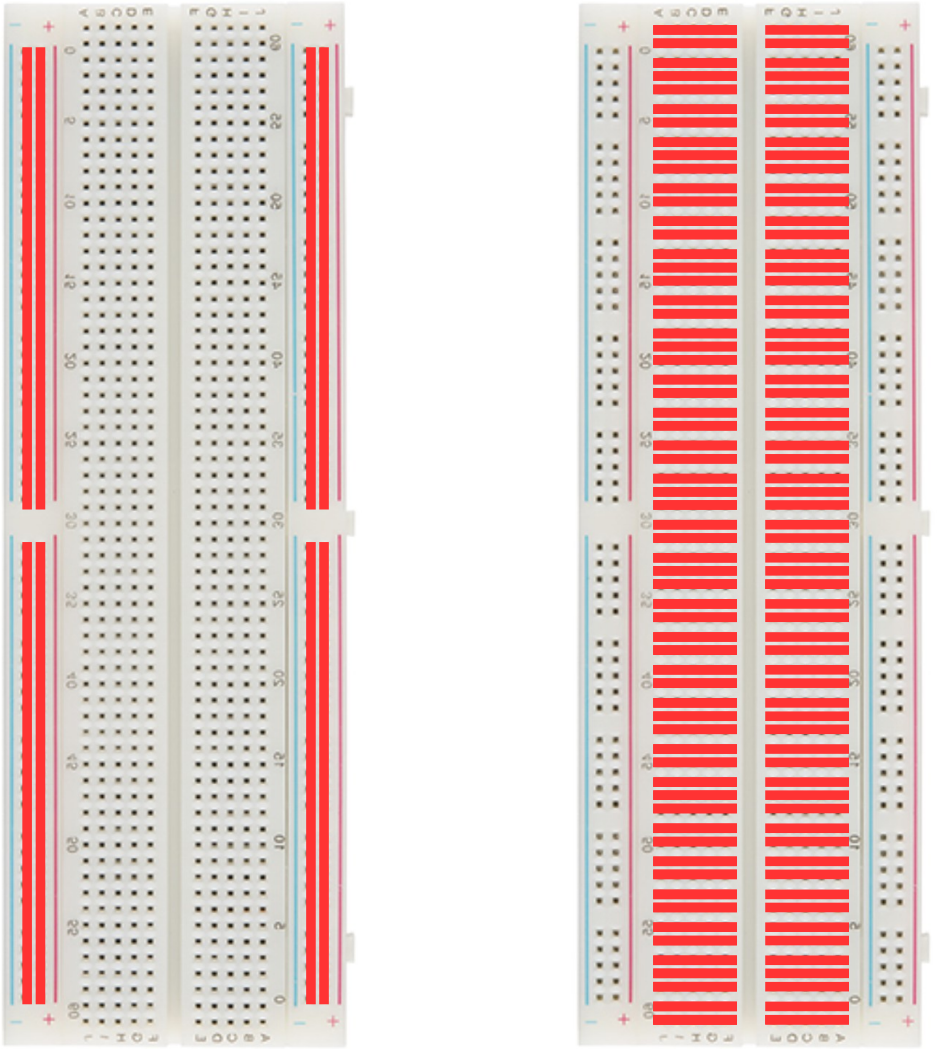


Lab 2: Basic GPIO output (background)



PCB trace goes from pin of microcontroller to header pin on development board

Lab 2: Basic GPIO output (background)



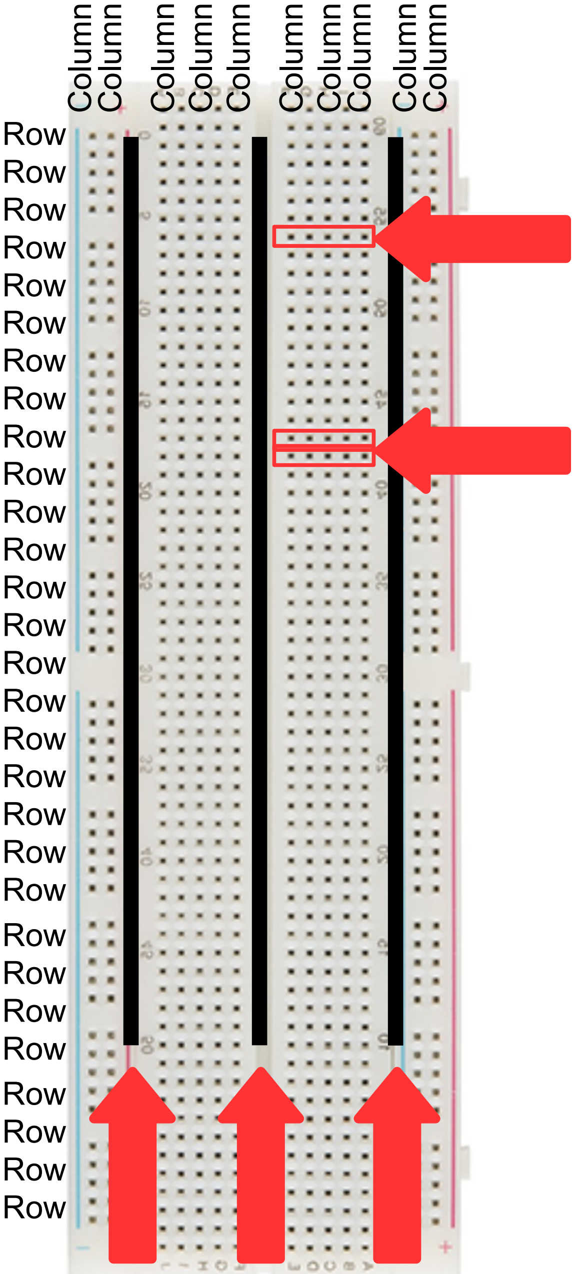
Solderless breadboard – Great for prototyping

In general, the long columns running along each side of the breadboard are electrically connected.

The long columns running along each side of the breadboard are typically used as “power rails” and “ground rails.”

In general, the shorter rows running all the way down breadboard are connected, with the exception that the rows are generally split in two so that typical components with two rows of pins, such as development boards, can be accommodated.

Lab 2: Basic GPIO output (background)

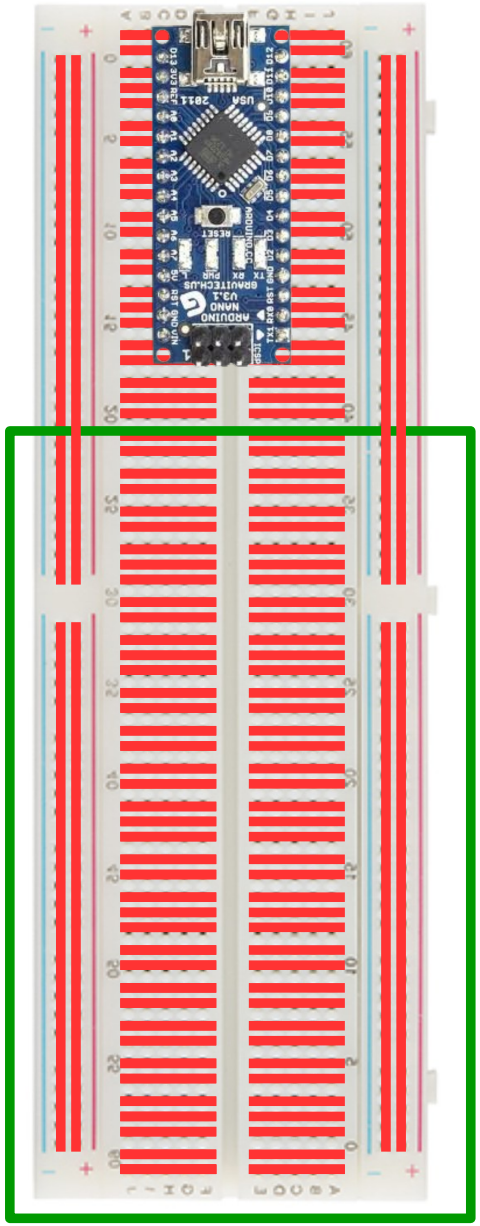


All holes in a row which do not have an obvious divider between them are all electrically connected. It's as if the entire row is connected by wires – without needing to run your own wires!

Rows are NOT electrically connected to other rows.

Note the divisions among columns. There are essentially two main columns of rows making up the majority of the breadboard, plus a column of rows running along each side of the breadboard (typically called “rails”).

Lab 2: Basic GPIO output (background)

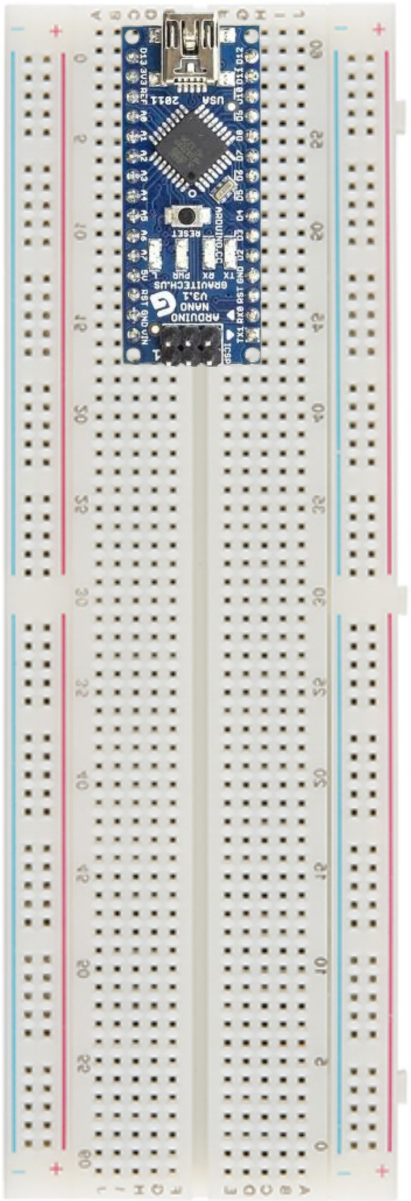


With your development board placed on the breadboard like this, it is easy to get access to every pin on the development board with male-to-male DuPont cables and to connect any pin on the development board to any other component on the breadboard.

With the development board placed on the breadboard like this, we can easily place other components in the area shown by the green rectangle, giving us a “prototyping area” for connecting various things to the development board (and thus, connecting various things to the microcontroller).

Each row's red line in the upper part of this diagram (where the development board is) is now a direct connection to a specific pin on the microcontroller.

Lab 2: Basic GPIO output (background)



General Purpose Input/Output (GPIO) is a basic foundation of all microcontrollers.

Many of the pins on a microcontroller can be used for GPIO, either to get basic digital input (voltage present or not) or to perform basic digital output (turn a pin “on” or “off”).

With digital, many things tend to be thought of in terms of being either fully off or fully on, 0 or 1, LOW or HIGH.

In this lab, we will use a pin for GPIO output to turn an LED on or off. In this sense, we can think of a GPIO output pin as a microcontroller-controlled on/off switch.

Caveat: you cannot switch a lot of electrical current (power) without an additional component such as a transistor or relay.

Lab 2: Basic GPIO output (background)

LED

Resistor

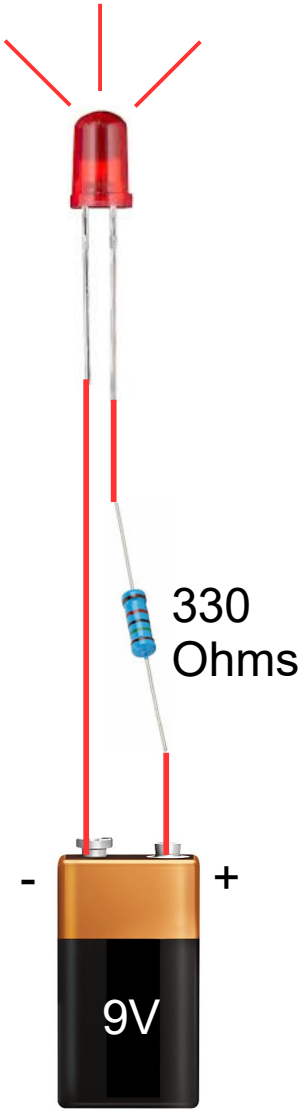
Here is a basic Light Emitting Diode (LED) and resistor.

An LED is always paired with a “current-limiting resistor. Without such a resistor, too much electrical current will flow through the LED and immediately destroy it.

Common resistor values used with LEDs include 330 Ohms and 1,000 Ohms, depending on how bright one wants an LED to be.

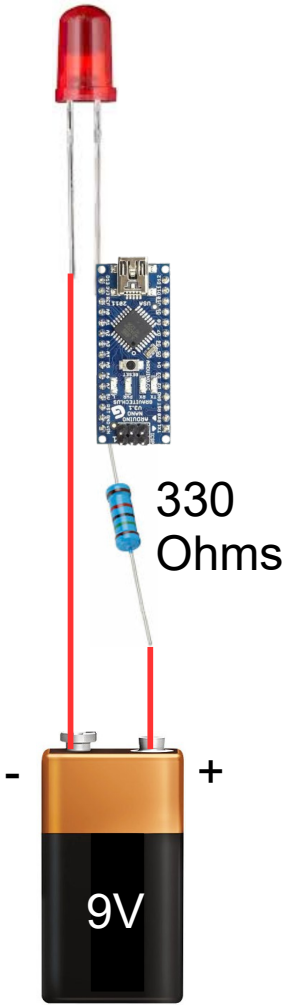
Note that one leg of the LED is longer than the other. The longer leg represents the “anode” and the shorter leg represents the “cathode.” For our purposes, we can simply think of the longer leg as + (positive voltage) and the shorter leg as – (GND).

Lab 2: Basic GPIO output (background)



LED always on

LED on if switch
in on position

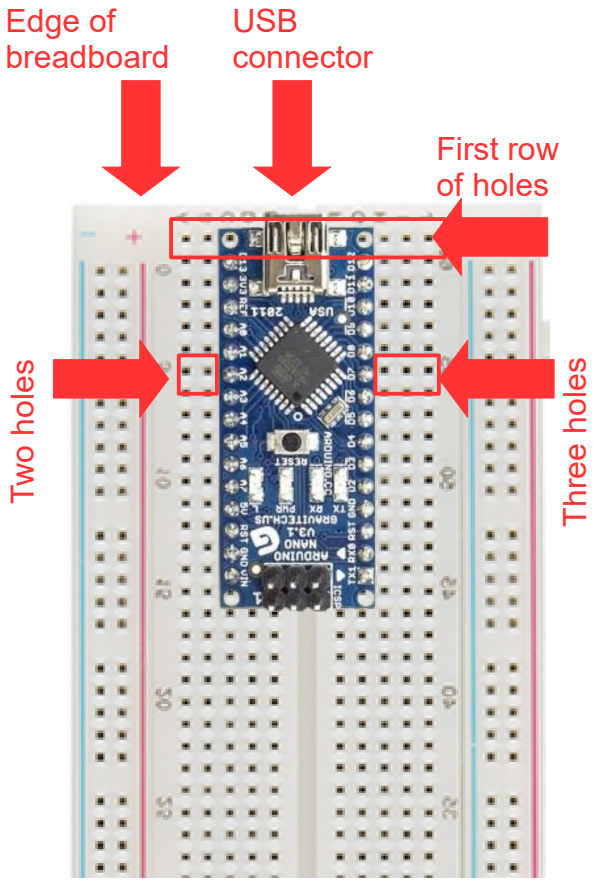


LED on if GPIO pin commanded
on by microcontroller (software control)

Lab 2: Basic GPIO output

Steps

1. Insert your development board into your breadboard as shown below.



DO NOT INSERT YOUR DEVELOPMENT BOARD INTO THE BREADBOARD UNTIL I COME AROUND TO EACH OF YOU

1a. Note that the development board will not mount dead center on the breadboard – there will be two exposed breadboard holes on one side and three exposed breadboard holes on the other side

1b. Note that we will place your development board so that there are ***TWO*** exposed holes on the left side and ***THREE*** exposed holes on the right side – this choice is arbitrary, but if everyone positions their board in the same way it will make the labs easier for everyone involved

1c. We will position your development board on the breadboard so that the topmost pins of the development board are inserted into the topmost holes of the breadboard

1d. Note position of USB connector with respect to top edge of breadboard

(Next slide)

Lab 2: Basic GPIO output

Steps

2. Disconnect the USB cable from your development board.

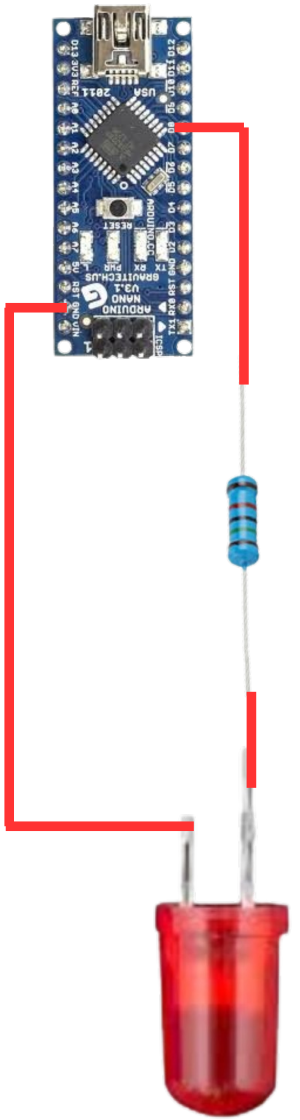
3. Choose a row on your breadboard and insert your resistor. Make sure that the two legs of the resistor straddle the divider running down the center of your breadboard so that the two legs are not electrically connected to one another.

4. Insert an LED into two other holes in another row on your breadboard. Make sure that the two legs of the LED straddle the divider running down the center of your breadboard so that the two legs are not electrically connected to one another. **Note which side of the row has the longer leg of the LED inserted into it.**

5. Run a wire from the “D8” pin of your development board to one side of your resistor.

6. Run a wire from the other side of the resistor to the longer leg of the LED.

(Next slide)



Lab 2: Basic GPIO output

Steps (continued)

7. Run a wire from the shorter leg of the LED to a “GND” pin on your development board.

8. Copy and paste the code found at the following URL into the Arduino IDE's text editor window:
https://raw.githubusercontent.com/dandandrea/intro-microcontrollers-lab-002/refs/heads/main/intro-microcontrollers-lab-002.ino

9. Save the “Arduino Sketch” (program) and name it ***intro-microcontrollers-lab-002***
(File > Save)

10. Connect your development board to your laptop via the included USB cable.

11. Program your development board with the program displayed in Arduino IDE.
(Sketch > Upload)

12. Verify that the LED on your breadboard is now blinking.

13. Change values of LED_ON_DURATION_MILLISECONDS and LED_OFF_DURATION_MILLISECONDS, program your board, and observe the effects.

(Next slide)

Lab 2: Basic GPIO output

Steps (continued)

14. Disconnect the USB cable from your development board.

15. Connect the 9V battery to your development board. The red (+) or “positive” lead should be connected to the “VIN” pin on your development board and the black (-) or “negative” lead should be connected to the “GND” pin on your development board.

Observe that the microcontroller continues to run without being connected to a computer.

WARNING: Do not ever connect a USB cable and a battery to your development board at the same time.

VIN and
GND pins