Prep Work:

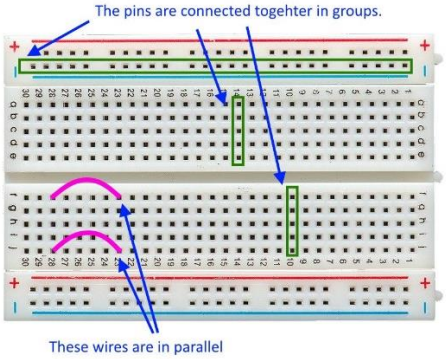
Go to the Texas Instruments website and download the datasheets for the SN74HC08N, SN74HC32N, SN74HC04N, and the SN74HC86N.

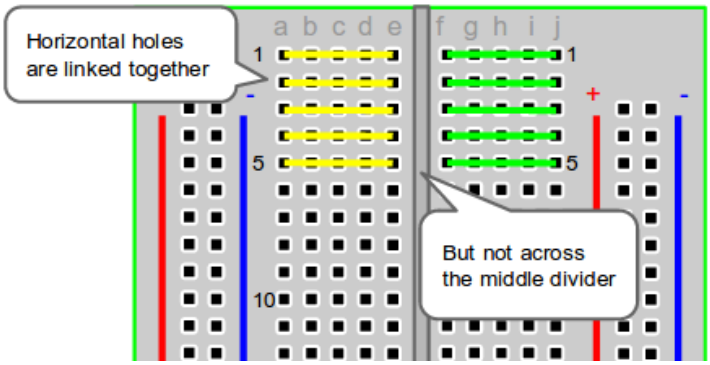
When you complete this lab or when the lab session is over, the lab TA should enter your score into Canvas. Do not leave the lab until you verify that the lab TA has entered the score correctly by checking your score on Canvas.

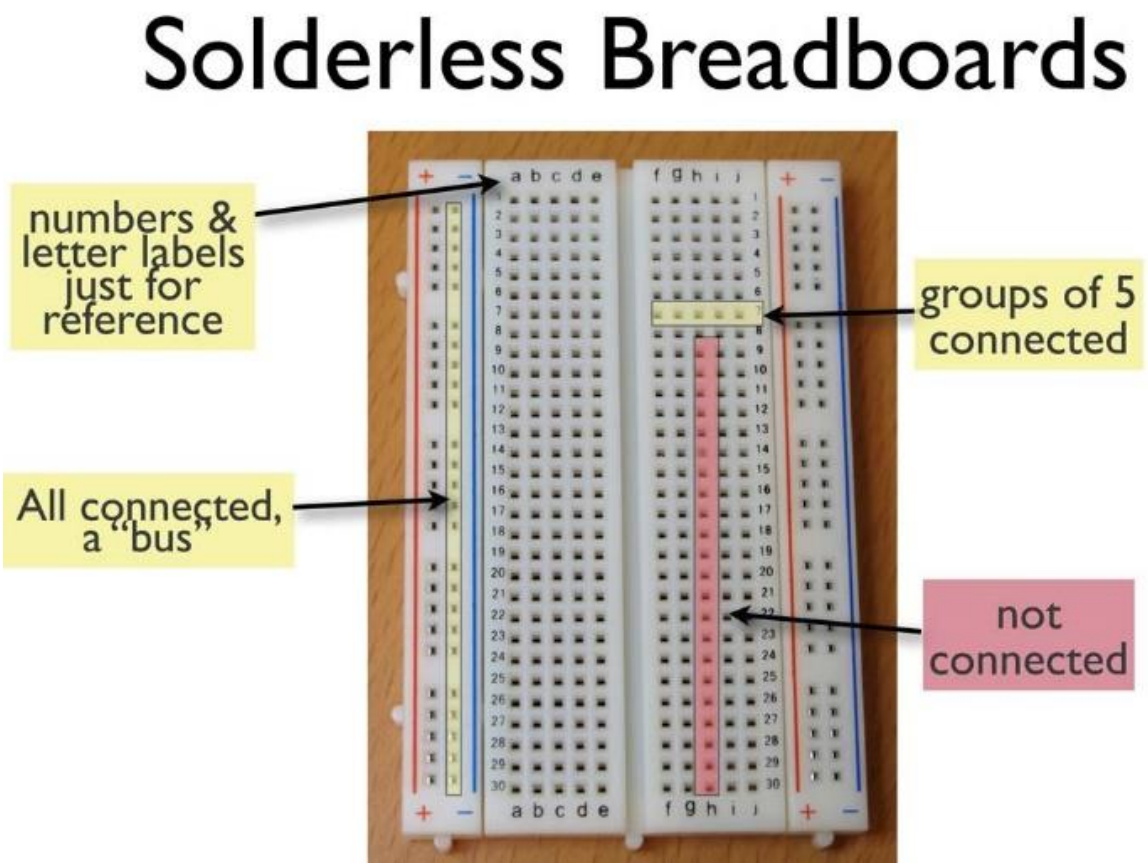
Lab Work:

1) Your breadboard has two rows of holes that stretch across the top of the board and another two that stretch across the bottom of the board. One set of holes has a red stripe, the other has a blue stripe. We're going to use these as power supplies (also called power rails). The red stripe will be +3.3V and the other stripe will be 0V (also called ground).

See this video and the below images for more information on breadboards if needed: https://www.youtube.com/watch?v=6WReFkfrUIk







2) Some breadboards have a break or small separation in the middle of the power rail rows. If you board is like that, put a wire in a hole on one side of the break and the other end of the wire on the other side of the break. That will connect both sides. You'll need to do that for all four rails.

3) Use a wire to connect the top red rail to the bottom red rail. Use another wire to connect the top blue rail to the bottom blue rail.

4) Find a short red and black wire from your wiring kit to wire up your power supply

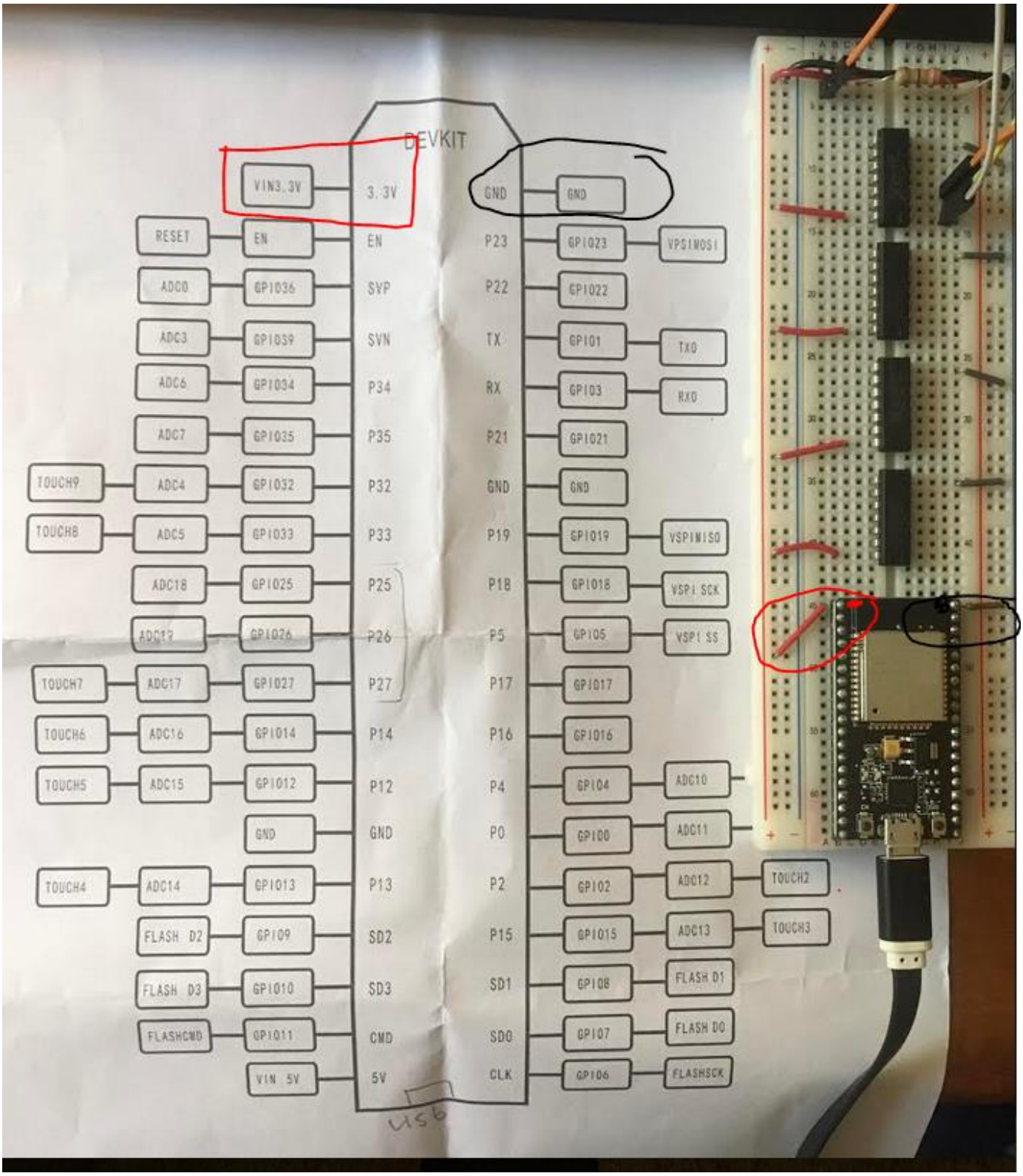
5) Connect your red wire into the ESP32 3.3V output pin

6) Connect your black wire into the ESP32 GND pin slot

A picture of this wiring can be seen on the next page.

Your power wiring is now complete! You'll be able to use this power wiring for the rest of the course, so don't disconnect it at the end of the lab.

To power your board/circuit, plug your ESP32 board into your computer/USB power supply. A red light on the board should turn on when it is powered.


DEVKIT
VIN 3.3V
3.3V
GND
GND
RESET
EN
EN
P23
GPIO23
VPSIMOSI
ADC0
GPIO36
SVP
P22
GPIO22
ADC3
GPIO39
SVN
TX
GPIO1
TXO
ADC6
GPIO34
P34
RX
GPIO3
RXO
ADC7
GPIO35
P35
P21
GPIO21
TOUCH9
ADC4
GPIO32
P32
GND
GND
TOUCH8
ADC5
GPIO33
P33
P19
GPIO19
VSPIMISO
ADC18
GPIO25
P25
P18
GPIO18
VSPI SCK
ADC19
GPIO26
P26
P5
GPIO5
VSPI SS
TOUCH7
ADC17
GPIO27
P27
P17
GPIO17
TOUCH6
ADC16
GPIO14
P14
P16
GPIO16
TOUCH5
ADC15
GPIO12
P12
P4
GPIO4
ADC10
GND
GND
P0
GPIO0
ADC11
TOUCH4
ADC14
GPIO13
P13
P2
GPIO2
ADC12
TOUCH2
FLASH D2
GPIO9
SD2
P15
GPIO15
ADC13
TOUCH3
FLASH D3
GPIO10
SD3
SD1
GPIO8
FLASH D1
FLASHCMD
GPIO11
CMD
SD0
GPIO7
FLASH D0
VIN 5V
5V
CLK
GPIO6
FLASHSCK
USB

Making LED circuits:

On your breadboard, there is an array of holes that are between the power rails. There are about 60 columns of holes with each column having five rows of pins on the top and five rows on the bottom of a center trench that separates the top from the bottom. For each column, the five holes on the top are connected together and the five holes on the bottom are all connected together, but the top holes are not connected to the bottom holes.

8) On the four rightmost columns of your breadboard, put a 300 ohm resistor between one of the holes on the top and one of the holes on the bottom.

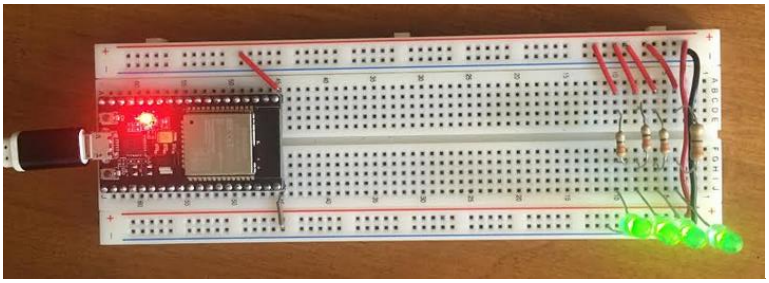
9) Put a green LED between one of the holes on the bottom and the blue power rail on the bottom of the board. Do this for each of the four rightmost columns.

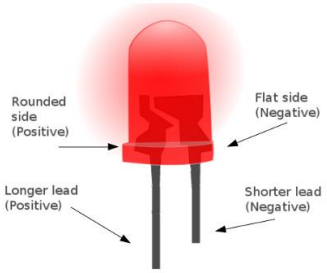
10) Find four short red wires. Connect each wire to one of the top holes in the four rightmost columns. So now you should have a wire in series with a resistor in series with an LED.

What we've made here is a circuit that will light up whenever the wire is connected to +3.3V and will be dark whenever it's connected to 0V. We'll use these circuits to test whether something is a high (3.3V) or a low (0V).

In this lab we will use these circuits to test the output of three different types of logic gate: AND, OR, NOT.

11) Plug one of the four wires into the red rail. The LED should light up. If it doesn't, reverse the LED and see if it lights up. LEDs only work in one direction, so if you have it backwards, it won't light up. Repeat for the other four wires.

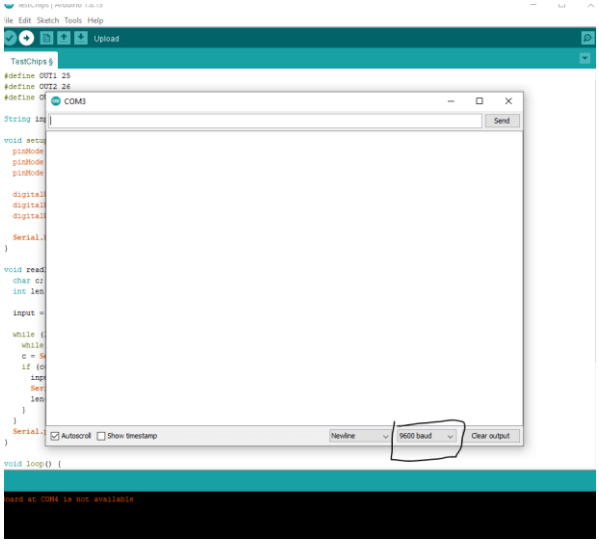




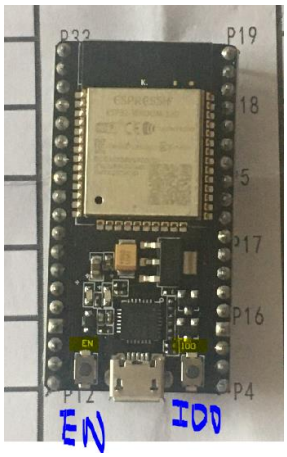
http://owlcircuits.com/resources/how-to-determine-led-polarity/

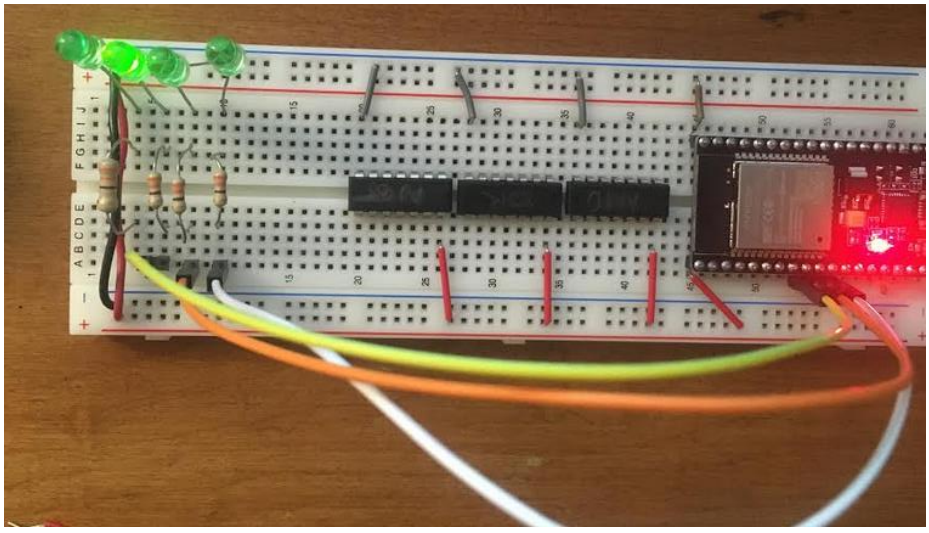
Setting up the ESP32 board to generate input for logic chips:

1. Plug your ESP32 board into your computer and open the Arduino IDE
2. Select your comm port by going into the Tools menu
    - Tools > Port > Click on the one that shows up
    - If you have multiple devices plugged into your computer (such as Bluetooth mouse or headphone) there might be multiple comm ports showing up
    - By going into your systems device manger, you can identify the correct port if needed
3. Open the serial monitor by clicking on the magnifying glass in the upper right corner of the Arduino IDE.
    - 

4. This will open the serial monitor, make sure that the baud rate (lower right) is set to 9600 baud
    - 

5. Once this window has been opened, press the reset button switch labeled EN. This will cause the board to reset. Follow along with the instructions to change ESP32 outputs to input into your circuit
6. If you do not get text in the serial monitor after resetting your board, your board may not have the code pre-downloaded. If this is the case, follow along with the ESP32 setup guide posted on Canvas and then return to this step after that is finished.

- 

- Type lowercase l to select a lab
- Type 2 to select lab 2
- Type a to enter auto mode
  - Auto mode will cycle through the ESP32 outputs 00, 01, 10, 11
  - This will be on ESP32 pins 13 and 14
  - Hook the output of your circuit up to pin 16 to read it back into the ESP32 to measure your value
    - You will also be hooking up the output of your circuit to the LEDs to be able to visually see your output
    - This will be very important in future labs as TAs will ask you to show them the autotest results to get checked off
- 

Testing a logic gate:

12) Get an AND gate package from your lab kit (hint: it's the HC08). You'll see that one side of the package has a half-moon cut out of one end. That shows you where pin 1 is.

13) Turn off your power supply (by unplugging the ESP32 from USB power). Whenever you remove or add chips to your breadboard, turn the power off first to avoid damaging the chips.

14) Plug the AND gate package into your breadboard with the half-moon on the left. One row of pins should be above the center of the board and the other row should be below the center of the board. You may need to bend the pins of the package in very slightly to get them to fit into the board correctly. The best way to do this is to use a flat surface like the lab bench to bend all of the pins at the same time.

15) Turn the power supply back on.

16) Use the datasheet to determine where ground is for the chip. It may also be labeled VSS. Connect a wire between that pin and the bottom blue rail.

17) Use the datasheet to determine where the VCC or VDD pin is on the chip. That's the positive power pin. Connect a wire between that pin and the red rail at the top of the board.

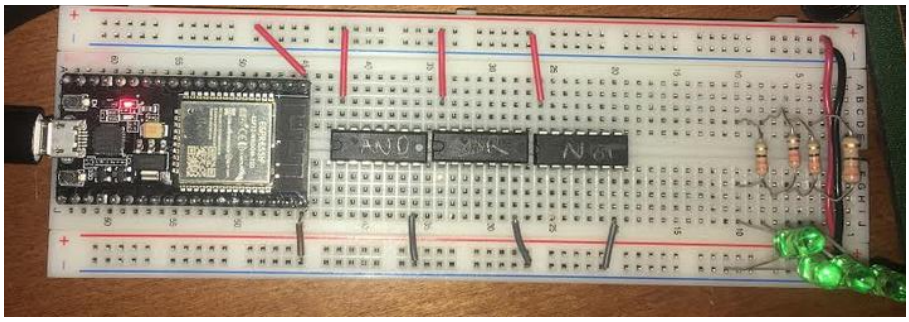
18) When you look at the datasheet, you'll see that there are four gates inside the package. Connect one of your LED circuits to the output of the first gate (pin 3). Connect both inputs of the first gate (pins 1 and 2) to the red rail. What you've done is put two 1's into the AND gate. We expect the output to be a 1, so the LED should light up. If it doesn't, figure out where your error is.

19) Test the other input patterns (00, 01, 10) and make sure the output is correct (for the AND gate, they should all be 0 or dark). Record your measurement in the Measurement section at the back of this lab.

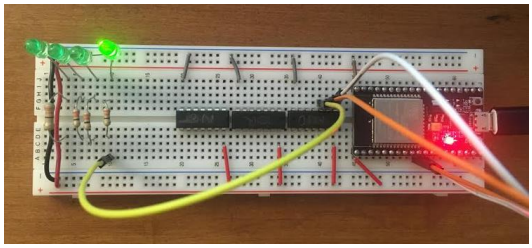
20) Repeat for all the other gates in the package.

21) Repeat steps 13-20 for the OR package. When you remove a chip, make sure to use the chip-puller tool or if you don't have one, then you can use a small screwdriver to lift one end of the chip slightly, then the other, back and forth. That will keep you from bending the pins on the end when the chip comes out of the breadboard. You want both ends to come out at about the same time.

22) Repeat steps 13-20 for the NOT package.



AND, OR, NOT gates placed in board



AND gate with input of 11

Measurements:

Exercise 1: Testing the AND Gate (SN74HC08N)

Gate	Input A	Input B	Measured Output Y	Expected Output	Gate Functioning Properly (Yes or No)?
1	0	0		0	
1	0	1		0	
1	1	0		0	
1	1	1		1	
2	0	0		0	
2	0	1		0	
2	1	0		0	
2	1	1		1	
3	0	0		0	
3	0	1		0	
3	1	0		0	
3	1	1		1	
4	0	0		0	
4	0	1		0	
4	1	0		0	
4	1	1		1	

Exercise 2: Testing the OR Gate (SN74HC32N)

Gate	Input A	Input B	Measured Output Y	Expected Output	Gate Functioning Properly (Yes or No)?
1	0	0		0	
1	0	1		1	
1	1	0		1	
1	1	1		1	
2	0	0		0	
2	0	1		1	
2	1	0		1	
2	1	1		1	
3	0	0		0	
3	0	1		1	
3	1	0		1	
3	1	1		1	
4	0	0		0	
4	0	1		1	
4	1	0		1	
4	1	1		1	

Exercise 3: Testing the NOT Gate (SN74HC04N)

Gate	Input A	Measured Output Y	Expected Output	Gate Functioning Properly (Yes or No)?
1	0		1	
1	1		0	
2	0		1	
2	1		0	
3	0		1	
3	1		0	
4	0		1	
4	1		0	
5	0		1	
5	1		0	
6	0		1	
6	1		0	

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