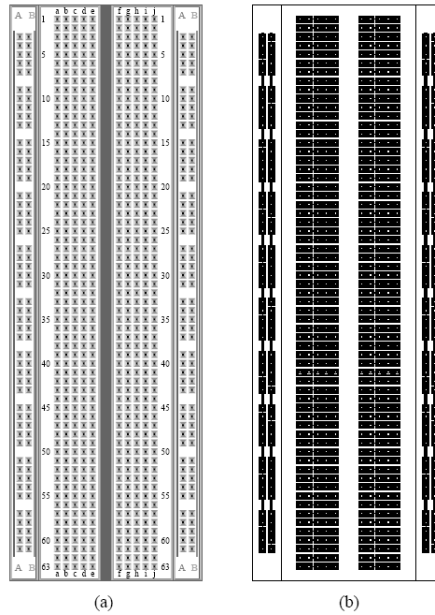


TECH 3232  
 Fall 2024  
 Lab #1  
 Into To Digital Circuits  
 ver 1.00

Name: \_\_\_\_\_

**Purpose:** To review basic logic gates and digital logic circuit construction and testing.

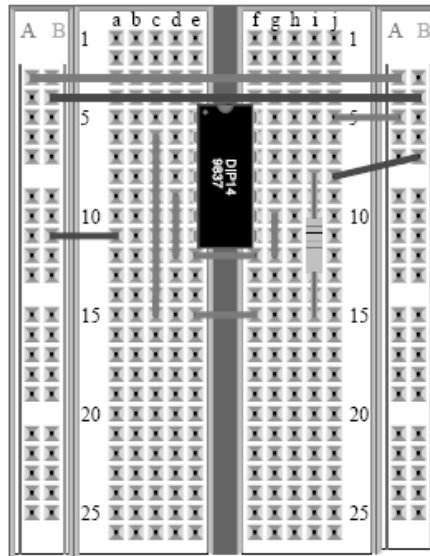
**Introduction:** The most common way to connect circuits for testing purposes is to use a protoboard (aka breadboard). Protoboards typically look like the following figure:



**Figure 1 - Protoboard.**  
 a) top  
 b) bottom

A few features should be noted. First of all the two columns on each side of the board typically used for power and ground. These connections go the length of the board on most protoboards, but not always. You should always verify this each time you use a new board.

The space in the center of the board is designed for Integrated Circuits (aka IC's). Since the rows on each side of this space are NOT connected, this allows the IC to be connected properly by straddling this space (see below).



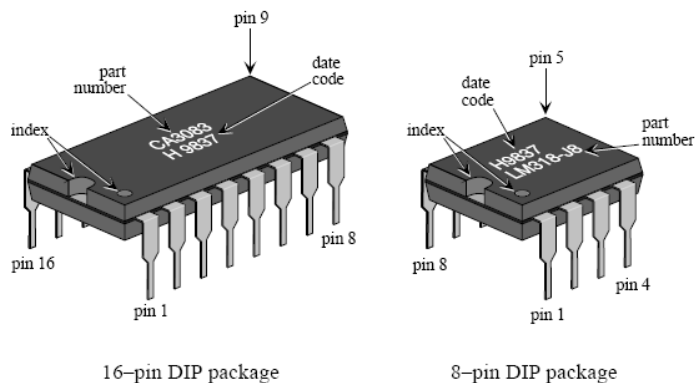
**Figure 2 - IC on breadboard**

Since we will be using IC's in Dual Inline Packages (aka DIP Package) in this class. You will need to be able to identify PIN 1 on IC's. This can be done using the following indicators:

- the U shaped indentation is the top of the IC. The pin to the left is PIN 1
- a small dot is sometimes placed above PIN 1 (but not always)

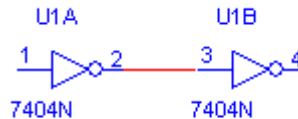
The pins are then counted in a U pattern (from pin 1 down, across the IC then back up the other side).

Here are two examples:



**Figure 3 - IC Pin Identification**

Typically, when digital logic circuit schematics are drawn (using Multisim or other schematic capture program) the pin numbers are shown on the schematic. It should be noted that many IC's in the digital logic family contain more than ONE GATE PER IC. Usually each gate in the same IC are labeled with the same ID number and a letter (A is the first gate, B the second gate and so on). The U<sub>x</sub> (where x is a number) shows the IC number. An example is shown below:



**Figure 4 - Schematic Example**

So in this circuit, there is one IC (U1), and it uses two gates on that IC. Gate one's (A) input is on pin 1 and the output is on pin 2. The second gate (B) has its input on pin 3 and its output on pin 4. The IC is a 7404N (74xxx series is TTL and is the most common digital logic series of IC's).

It should be noted the POWER and GROUND are **NOT SHOWN** on most digital logic schematics. To find where Power and Ground should be connected, look on a "DATA SHEET". A Data sheet is the technical specifications of the electronic component. Electronics manufacturers provide these for the IC's they produce. Typically you can find a data sheet for a component by typing in the PART NUMBER of the component into an internet search. So if you type in "7404" into a search engine (like Google), you will probably find a link to a data sheet in .pdf format.

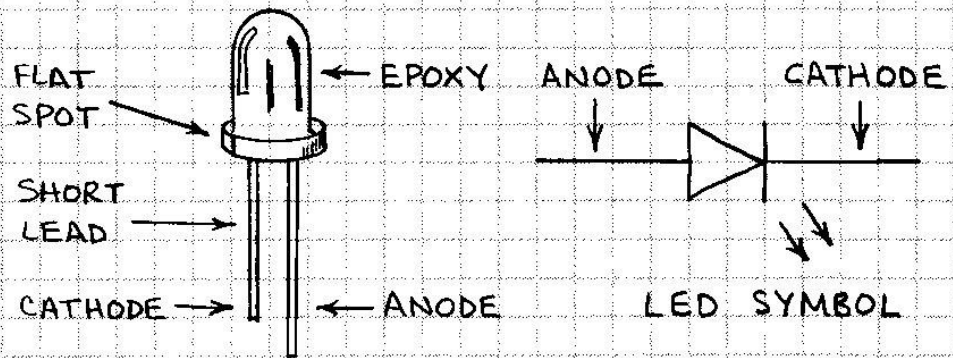
Power is typically labeled as VCC and Ground is labeled as GND. VCC for all IC starting with '74' is +5 VOLTS (Applying higher voltages or a negative voltage can result in damage to the component!!!)

Inputs to digital logic circuits have to be supplied with +5v to indicate a high and Ground to indicate a low. For this circuit, read the section on "THE PULL UP RESISTOR" at <http://www.seattlerobotics.org/encoder/mar97/basics.html>.

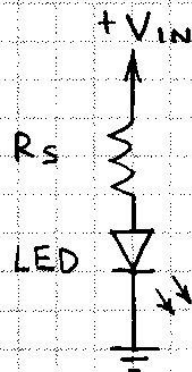
We will also be connecting LED's to the outputs as indicators. NOTE: LED's are polarity sensitive devices, make sure they are connected correctly. Below is a quick summary of LED's (how to calculate current limiting resistors and how to determine polarity)

# HOW TO USE LEDs

LIGHT-EMITTING DIODES ARE VERY RUGGED, LONG-LIVED OPTICAL SOURCES. THE LIGHT THEY EMIT HAS AN INTENSITY THAT IS LINEAR WITH RESPECT TO THE FORWARD CURRENT THROUGH THE LED. TO PREVENT IRREVERSIBLE DAMAGE, ALWAYS OPERATE AN LED WITHIN ITS RATINGS.



USE A SERIES RESISTOR ( $R_s$ ) TO LIMIT THE CURRENT THROUGH AN LED TO A SAFE VALUE.



USE THIS FORMULA TO DETERMINE THE RESISTANCE OF  $R_s$ :

$$R_s = \frac{V_{IN} - V_{LED}}{I_{LED}}$$

$I_{LED}$  IS THE SPECIFIED FORWARD CURRENT.

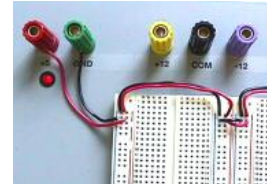
$V_{LED}$  IS THE LED VOLTAGE DROP. IT RANGES FROM ABOUT 1.3 VOLTS (940 nm INFRARED EMITTERS) TO ABOUT 2.5 VOLTS (GREEN EMITTERS).

HINTS<sup>1</sup>:

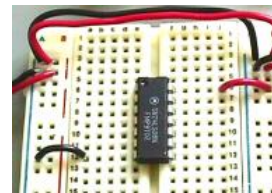
If the IC is new and never used, straighten all leads on each side by placing the IC on its side on the bench and press firmly on it in order to bend the pins to a 90-degree angle.



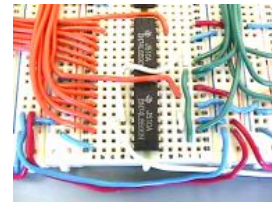
Connect +5V and GND to vertical rails on the solderless breadboards. Distribute these to all other vertical rails to create +5V and GND buses. Use wire of the same colour for all +5V connections, e.g. red, orange or yellow. Use another color for GND, e.g. black, brown, green, blue.



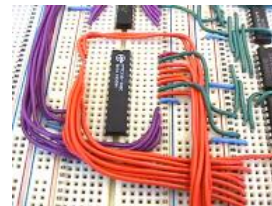
Connect the Vcc and GND pins of the IC to the power bus using short jumpers. Be consistent with use of color.



Make use of colored wires to differentiate different connections.



Try to keep all wiring short and tidy and avoid laying wires over the IC, just in case you have to remove the IC. Make use of colors to differentiate the signal functions.



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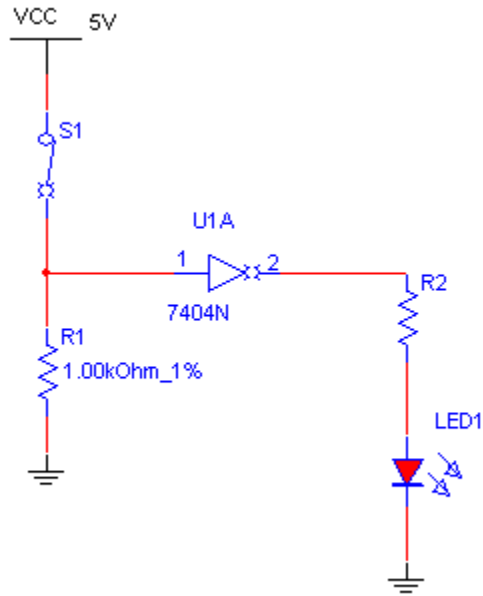
<sup>1</sup> <http://www.physics.mcmaster.ca/phys4d06/Lab/chapter5.htm>

Parts Required: 7404, 7408, 7432, LED, DIP SW and various resistors

Note: Do NOT use the LED's or Switches on the Digital logic trainer for this lab!

Lab Procedure: **NOT GATE**

Connect the following circuit:



R2=330Ω

Once connected *complete the truth table below:*

Input	Output

*Demonstrate the circuit to the instructor:*

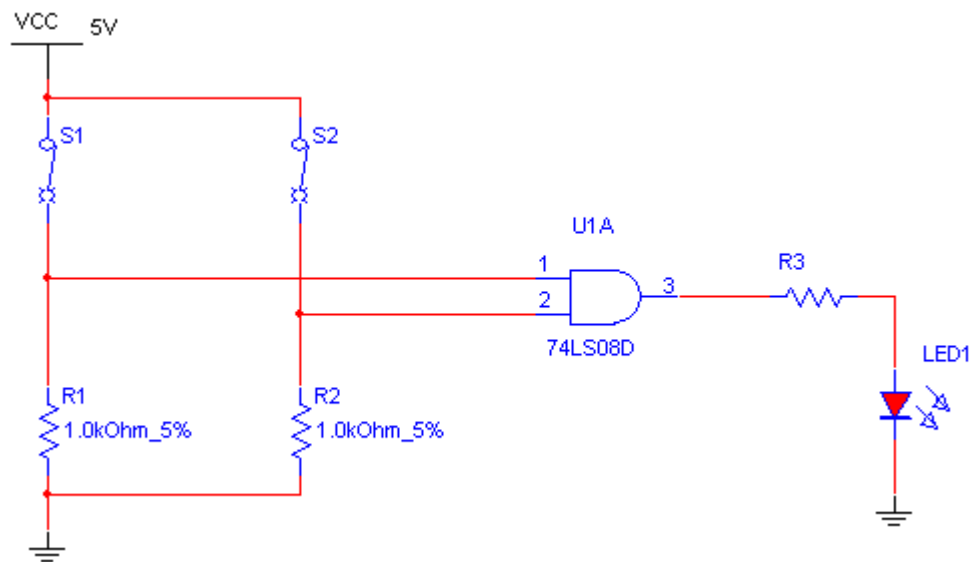
Answer the following questions:

*In your own words, tell why the resistor (R1) is needed in the input part of the circuit? What would happen if the resistor was left out?*

*What is the Boolean algebra expression for the circuit?*

### AND GATE

Connect the following circuit:



R3=330Ω

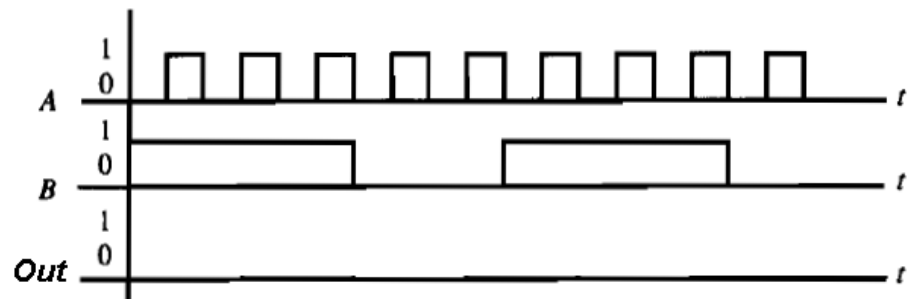
Once connected *complete the truth table below:*

Input A	Input B	Output

*What is the Boolean algebra expression for the circuit?*

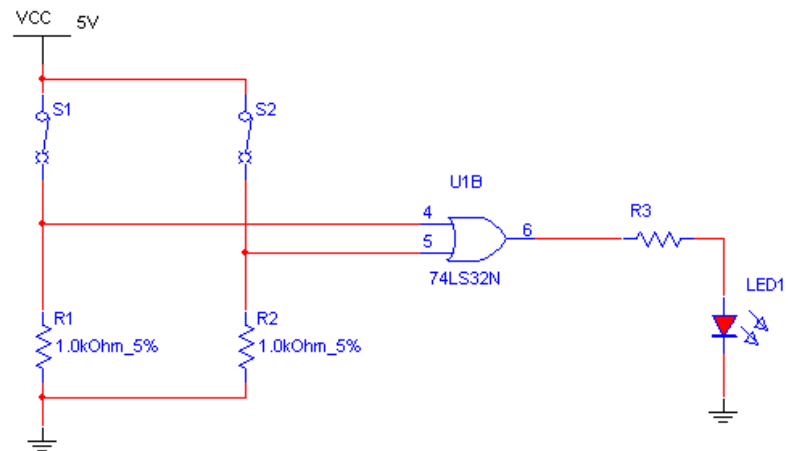
*Demonstrate the circuit to the instructor:*

*Given the timing diagram below, fill in the timing diagram for the output of the AND Gate:*



### OR GATE

Connect the following circuit:



R3=330Ω



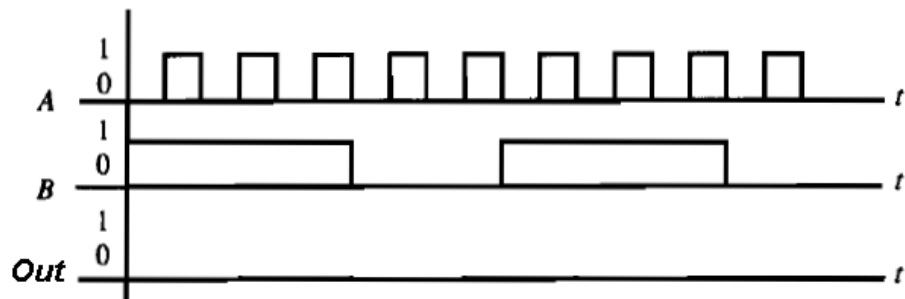
Once connected *complete the truth table below:*

Input A	Input B	Output

*Demonstrate the circuit to the instructor:*

*What is the Boolean algebra expression for the circuit?*

*Given the timing diagram below, fill in the timing diagram for the output of the OR Gate:*



*Calculate the resistor needed if you want to power an LED with 5V and the LED's Forward Current is 19mA and its voltage drop is 1.35V using a 1/4W resistor (show work on back of sheet)*