Lab 1 – Preparation

Lab Room Assignments

- Labs take place in BA3145, BA3155 and BA3165
  - L0101: Wednesdays 6-9pm.
  - L0201: Mondays 6-9pm.
  - L5101: Tuesdays 6-9pm.

- Tentative lab assignments (might change depending on last-minute additions or drops in the class):
  - **Section L0101 - Wednesday Labs**
    - BA3145: Angeli - Mao
    - BA3155: Marcok - Zhuang
  - **Section L0201 - Monday Labs**
    - BA3145: Afandiyev - McKinney
    - BA3155: Memon - Zhu
  - **Section L5101 - Tuesday Labs**
    - BA3145: Abukar - Loza Vega
    - BA3155: Lu - Zhao

Reminders

- Rules about the labs:
  - These labs are only open and available during your dedicated lab section.
  - You must work in pairs.
  - The lab station you pick during your first lab will be yours for the entire term. You are responsible for its upkeep and maintenance.
  - **No food or drinks permitted in the labs!**
    - Please respect this to protect the lab equipment.

- A brief lab guide:
  - http://www-ug.eecg.toronto.edu/msl/handouts/labguide_DE1.html
  - Note: some parts apply mainly to engineering students.

Lab 1 Learning Objectives

- Learn how to build logic circuits by using chips that contain individual logic gates .
- Produce truth tables for a given design (starting either from a given logic function or from a description of the design's behaviour).
- Gain familiarity with the schematic builder tool of Quartus.

Approach to Lab 1

- Experience is the best teacher.
  - Prepare a design. → Pre-Lab
  - Implement your design.
  - Debug the circuit. → In-Lab

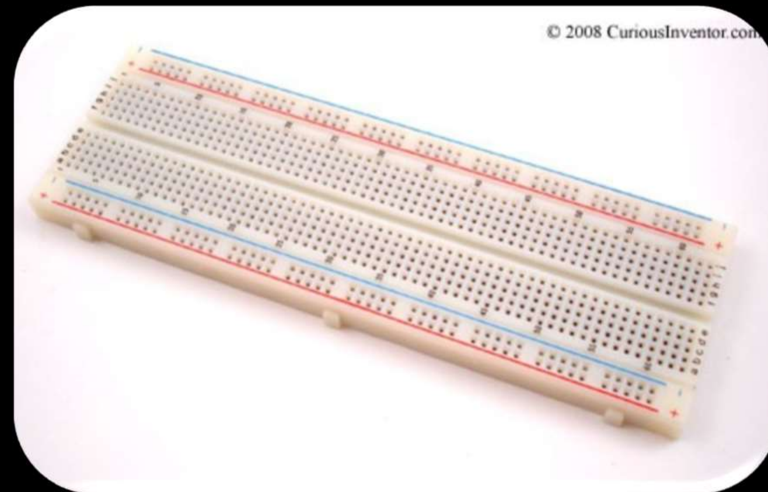
- Try to think of your prelabs as “an assignment due in the beginning of the lab”.

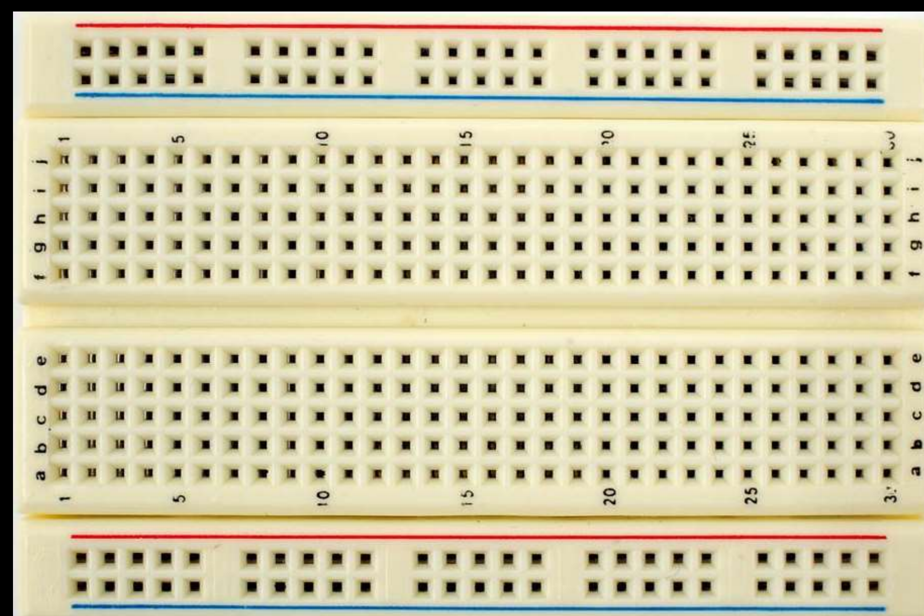
Equipment

- Breadboard
- Wires
- Gates

Breadboard

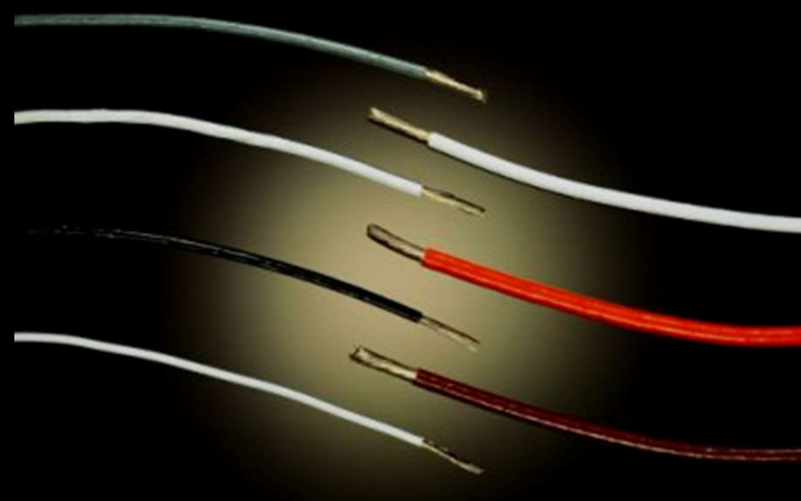
- The standard working area for connecting digital components together.
- Red and blue horizontal rows at top are connected.
- Columns in middle sections are connected.

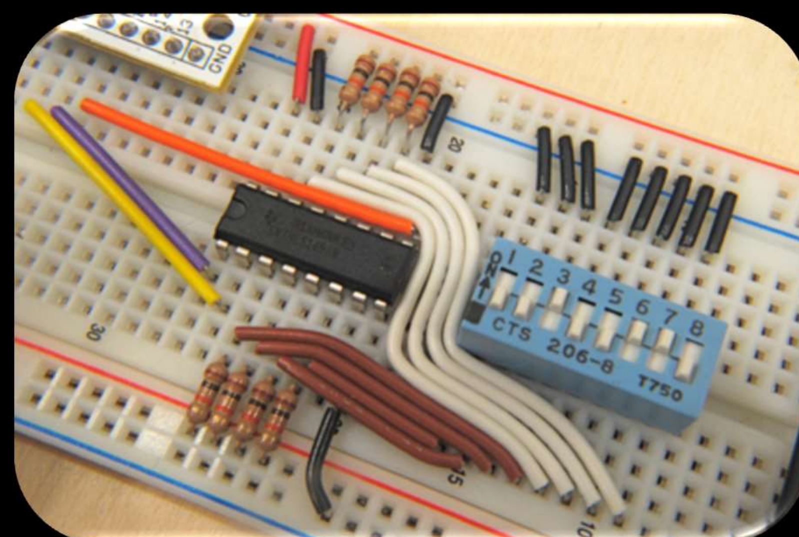




Wires

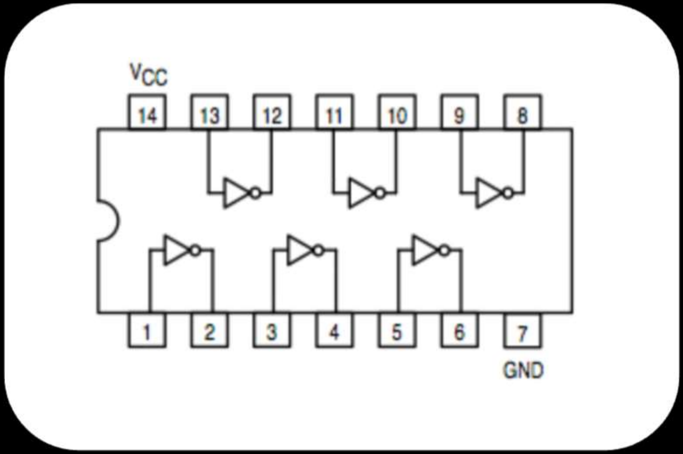
- Use this to connect different components together.
- Use the pre-cut wires whenever possible.
- Learn how to strip the coating off the end of a wire.





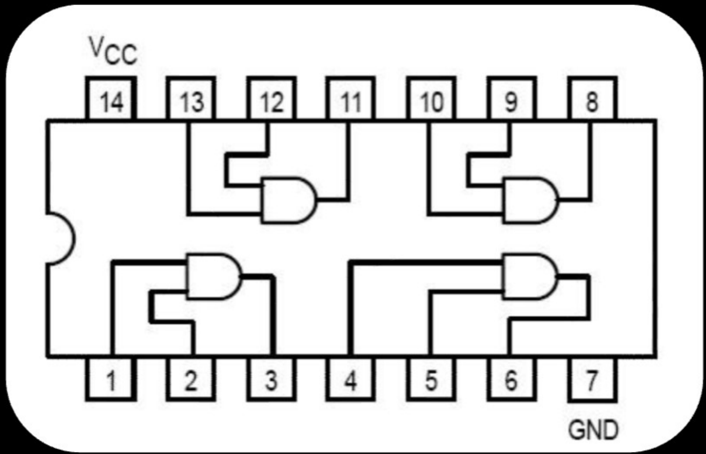
Gates

- IC chips will be supplied, which house the gates that you will use to create circuits.
- <u>Example:</u> 74LS04 (NOT)
  - Notch at one end helps determine alignment.
  - Usually a dot at pin #1.
  - V_{cc} and GND always have to be connected to the power source and the ground, respectively.

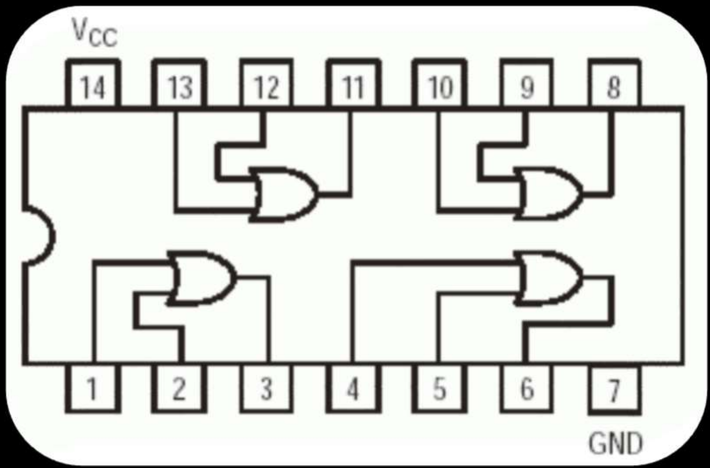


Other Gates

- 74LS08 (AND)



- 74LS32 (OR)



What you’re going to do

1. Determine the Boolean logic equation that you need to implement.
   - Might require you to create a truth table first.
2. Convert this equation into an equivalent circuit of AND, OR and NOT gates (using order of operations when necessary).
3. Determine how many chips you’ll need to implement all the gates for this circuit.
4. For each gate in your diagram, indicate the IC pin number for each input and output.

Warm Up Example

- Design a circuit that implements the following logic function, using only 2-input AND and 2-input OR gates.

```
f = ab + (c + b)
```

- Write down the truth table for this design.
  - Note: This expression is common shorthand for:

```
f = a AND b OR (c OR b)
```

Warm Up Example cont'd

- Is there a cheaper implementation (i.e., with fewer gates)?
  - `f = ab + (c + b)`

Pre-lab report

- Pre-lab reports are submitted online through Canvas. For Lab 1, submit a PDF of your designs for Parts I and II.
- Should include the following:
  - Lab number and title
  - Student info (last name, first name, student #)
  - Exercise parts
    - Each in its own clearly-labeled section.
    - Restate the question (summarized).
    - Provide the calculations (if applicable).
    - Illustrate the solution (including pin labels).
  - BE NEAT.

In-Lab Tasks

- The TAs will demonstrate how to plug the chips and wires into the breadboard, and how to connect the breadboard to the lights and switches on the side.
  - Don't be late to the first lab!!

- Helpful tips:
  - Remember to turn off the power supply when connecting/plugging in components in the breadboard.
  - Using some sort of colour convention for your wires can be helpful.
    - e.g. have all wires connected to the ground be one colour and use another colour for all `Vcc` wires.
  - Use the logic probe (provided in the lab kit) to test each connection when debugging!

Things to note

- This will be the easiest lab you do in the course.

- Whenever possible, use the tools and submit a printed pre-lab report (one per person).

- Try to come up with the smallest circuits possible.
  - How do you reduce a complex circuit?
  - For now, think back to boolean algebra axioms!
  - Simple reasoning helps as well ☺

After the lab reflect on

..how long it took you to implement even simple logic circuits on the breadboard.

- Can you imagine doing this for more complex circuits?!
  - Hardware Description Languages (HDL), like Verilog, and design tools to the rescue! ☺