OBJECTIVES
The objectives of this lab are to familiarize the students with the EEL 3701 lab prototyping environment, to start to build strong debug techniques in the students and to give the students an opportunity to exercise the Altera Quartus circuit design/simulation software tool.

MATERIALS
- Printouts (required) of the below documents:
  - Parts List (from lab 0)
  - Pinouts of our 74’xxx parts
  - Your prelab design and simulation.
  - All designs and simulations done in pre-lab must be printed and brought to lab (for this lab and every lab). All pre-lab material is turned in at the beginning of lab. You will not get this paperwork back until the following week. If you think you will need this material during lab, you should make a second copy for yourself before coming to lab. (This includes both computer generated printouts and hand written work.)
- Download onto your laptop (not just links):
  - The lab assignment (this document)
  - Hardware: Getting Started
  - Quartus Tutorial
  - Pinouts of our 74’xxx parts
  - NOTE: I recommend that you also print and bring the above files to lab
- The toolbox containing the following were given to you in lab 0:
  - Prototyping bread board, power supply, wires, multi-meter and chip extractor
  - IC components, resistors, LEDs, and switches
  - CPLD board parts
- Email all pre-lab design and simulation files (using Quartus’ archive feature) to eel3701uf@gmail.com BEFORE the start of your lab. For email subject requirements, see the syllabus.

INTRODUCTION
The purpose of this lab is to illustrate the basic usage of the components founds in your toolbox and to test your ability to create a circuit in Quartus. Read through all the printouts list in the materials section of this document well before your lab.

Parts 1 & 3 of this lab are informative only and do not require any pre-lab work. Part 2 however does have a pre-lab design for you to work through and this material will also be tested in lab by your TA.

It is highly recommended that you take notes while your TA lectures or performs demonstrations. Feel free to ask question. You will be responsible for this all the material discussed.

PRE-LAB REQUIREMENTS
As described elsewhere in this document, you must do the following before lab and bring the documents and files to your lab section. (Two copies of each printout of your work are strongly advised, since one copy of the printouts of your work will be submitted to the TA when you enter lab. You will also submit your design and simulation work by email BEFORE entering the lab.)
- Read all the required printouts before your lab.
- Bring all the printed lab documents.
- Complete parts I and II of the “Quartus Tutorial” and submit printouts of this to your TA. Email the design and simulation as an archive file.
- Complete the Part 2 design and simulation and submit this to your TA, both in paper form and as an archive file.

PART 1. USING YOUR TOOLBOX DEVICES
Your lab TA will demonstrate the following items contained in your toolbox. Verify that you can do the same with your parts. You will answer questions at the end of your lab based on the below items.

1. Make sure the power supplier and the multi-meter work.
2. The electrical node connectivity of the prototyping board, i.e. power/ground buses & general signal rows.
3. How to place an IC (integrated circuit) device on the prototyping board and where power/ground are connected. Students should be able to find pin 1 on all their 74’xxx ICs.
4. How to measure the voltage of the power supply. Also, how to measure the voltage across a device once the device has been connected to power and ground.
5. How to use a multi-meter to determine the resistive configuration of the resistor packages (also know as RPACK) provided in the lab kit. Once determined, draw this out and save it for future labs.
6. How to use an LED circuit (with a current limiting resistor) as an output device. Measure the voltage drop across the current limiting resistor and diode and also the current through the circuit. Discuss why the current limiting resistor is needed and how it functions in the circuit.
7. How to connect an LED (again using a current limiting resistor) to the output (or input) of a TTL gate to test if it is high or low voltage. The TA should show you two circuits with LEDs: in one circuit the LED turns on when the output is a high voltage (active-high) and in the other circuit the LED
is turned on when there is a low voltage (active-low). Draw and save both circuits. If an output signal is used to drive another IC input, why can’t we simply connect an LED to the output and the other end to ground or power, without using a resistor, in order to view the output signal voltage? Build and demonstrate an active-high LED circuit and an active-low LED circuit.

8. How to build switch circuits to use as inputs. Use only pull-up resistors (not pull-down resistors) in switch circuits.

9. How to wire up a simple AND-gate (74HC08) with two input switches and an output LEDs. Do it!

**Special Notes:**
The pull-up resistor is typically in the range of 1-5 kΩ. This resistor pulls the input pin on the gate to very nearly 5 volts because the gate input resistance (when measured to ground) is comparatively very large. For example, the input resistance of the gate is usually in the 100 kΩ ohm range. Thus if we consider this resistance in series with a 1 kΩ pull-up resistor, 100 kΩ/101 kΩ * 5V is the voltage across the input of the gate.

If we assume the input resistance of the gate is 1 MΩ and we use a 1 MΩ pull-up resistor, what voltage should be seen at the input of the gate where the pull-up resistor is tied?

Build and demonstrate an input switch with a pull-up resistor and an input switch with a pull-down resistor. *(NOTE: Do NOT use switch circuits with pull-down resistors for the remainder of the semester.)*

**PART 2. QUARTUS SOFTWARE CIRCUIT CREATION**

*Pre-Lab:* Given the logic equation \( Y = \overline{A + B} \cdot \overline{C} \), implement this equation using a 2-input AND gate, a 2-input OR gate and two inverters using Quartus. Do not simplify this equation. All signals are active-high.

Upon completion of the schematic entry portion of the lab, simulate the circuit with a timing (not functional) simulation. Annotate the simulation to show that it works properly (i.e., writing notes with arrows pointing to important results). You can use Quartus to annotate your simulation; an alternative to annotating with Quartus is to write the simulation to a file and use some other software (like MS-Word) to annotate. You can not annotate by hand. Every simulation that you turn in this semester should be annotated.

Print a copy of the circuit design and simulation with annotations. You will turn in this copy at the beginning of your lab section. *(You may want a second copy to help you during lab.)* Always add your name on each schematic using the Quartus package.

**PART 3. TROUBLE-SHOOTING SUGGESTIONS**

In your future bread board designs, your circuit will probably not work the very first time you build it. Therefore, trouble-shooting is a basic skill that you will have to learn. The followings are some helpful suggestions (please feel free to ask your TA any questions you may have on this subject): Keep this handout for use in future labs.

- Come prepared with a large, neat PRE-LAB schematic diagram (printed at home), with room for notes and corrections. **REQUIRED.**
- Your schematic should identify which gate on the IC chip that you are using and should also have the pin numbers labeled. The schematic must also have your name printed on it (with Quartus). **REQUIRED.**
- In a large circuit, identify, build, and debug a small portion of the circuit at a time to isolate the problem. In other words, decompose your design and your construction.
- Start trouble-shooting at the point, at which the voltage value is wrong, in the circuit and continue to check your circuit backward, making sure that at each point the value agrees with your prediction.
- Construct your circuit neatly. Use appropriate length wires for connections; i.e. use short wires for short distance connections. Your circuit should not look like a bowl of spaghetti or bird’s nest.
- Use your multi-meter as a logic probe. Ask your TA to demonstrate this if you don’t understand this statement.
- Check IC insertion to make sure all the pins are in the holes correctly and the IC does not have any missing legs.
LAB 1: Introduction to Laboratory Equipment

- Check power and ground connections (and other connections) before plugging the power supply into the wall outlet.
- Make sure that the power and the ground are properly connected to all IC's before plugging the power supply into the wall outlet.
- **DO NOT** strip wire ends longer than 1/4" and jam long bare ends into the breadboard holes. This will cause shorts and ruin the board.
- **DO NOT** short (connect) the power supply outputs together, i.e., do not allow the exposed wires to touch each other. This will cause permanent damage to the power supply.
- **DO NOT** connect the power supply to the breadboard with reverse polarity. This will cause the permanent chip damage.
- **DO NOT** connect an output of any gate to the output of another gate, to a switch, to power (+5V), or to ground. These situations will cause excessive currents and result in the permanent damage to the chip or chips involved.

LAB QUESTIONS

Answer the following questions on paper, and submit them to your TA **before leaving your lab**, i.e., determine the answers before or during your lab.

1) Draw the resistor configuration of all resistor packages in your lab kit and determine the resistance values by using your multimeter.

2) What is the value of the resistor used in one of your LED circuits (as measured with your multimeter)? What is the voltage drop across the LED when the LED is on and when it is off? What is the voltage drop across the resistor when the LED is on and when it is off? What is the voltage drop across both the LED and the resistor when the LED is on and when it is off.

3) What is the value of the resistor used in one of your switch circuits (as measured with your multimeter)?
   a) Answer the following for both switch positions for a switch circuit with a pull-up resistor. Make these measurements when the input of the switch goes to an input (e.g., pin 1) of one of your 74HC08 chips.
      i) What is the measured voltage across the resistor?
      ii) What is the measured voltage across the switch?