**Physics 405 Lab** **NAME ____________________________**

# Digital Electronics

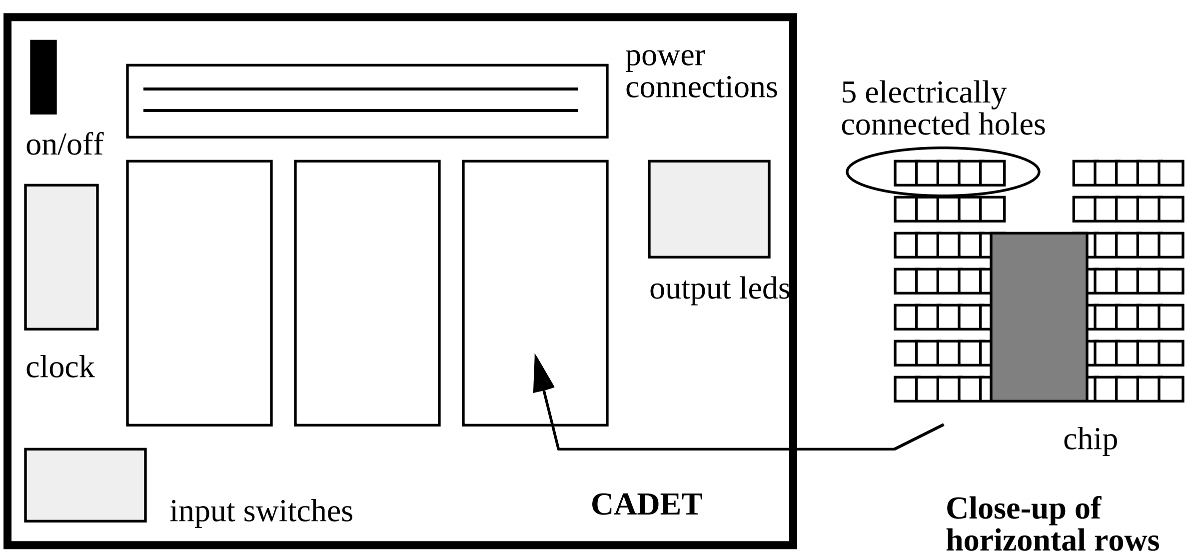
Parts needed: CADET electronic layout board,
Chips: 7404, 7402, 7411, 7486, and plenty of wire.

## 1. Wiring circuits

In this experiment you will investigate digital electronic logic gates. These gates are manufactured as integrated circuits in a black plastic, multiconnection package referred to as a “chip”. You will be using a special electronics layout box (CADET) to mount and connect the integrated circuits.

**Always be sure to turn off the power when setting up or changing the wiring in order to avoid short circuits or improper connections that could damage the chip.**

First, let us start with a description of the CADET system. Refer to the figure below. The function of the CADET is to provide quick connections between chips, input switches, and output indicators. In the center of the box are three white boards. You will immediately notice that there are a large number of holes on the boards. Wires are inserted into the holes to create circuits. The insulation is stripped off the end of each wire so that its metal can make contact with the metal beneath the hole. The color of wire you use is your option. Sometimes color coding the wires (i.e., red and black for power, blue for inputs, and green for outputs) can aid in checking the system later.




Notice that many holes are grouped into horizontal rows with five holes each. **You will be using these sets of horizontal rows for almost all of your connections.** Each hole of the five is electrically connected to the others. Thus a set of five holes is a node where five wires or electrical elements can be connected together. You will take chips and insert them into the board so that the pins straddle the gap between the two sets of holes as shown. Also notice the vertical columns of holes. Usually an entire column is connected together. For now, do not use the vertical columns.

**Power:** Since each chip requires power to run, power connections are provided. At the top of box are two power terminals labelled ground or 0V and +5V. The red 5V terminal is connected to a long row of holes (the top row on the CADET box) so that a wire connected into any of these holes can be used to provide power to a chip inserted below. The ground terminal is also connected to a row of holes (the bottom row of the four rows at the top). Use wires to connect from the row of power holes to the two power connections on each chip.

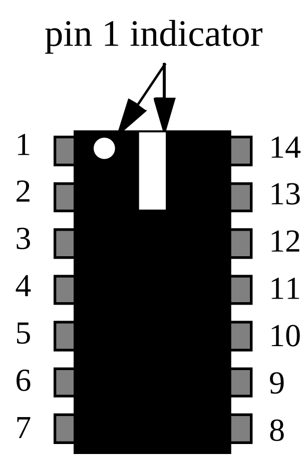
**Output Indicators:** Pairs of lamps, or LEDs, are provided on the right-hand side of the box to help indicate logic states. If a wire with a TRUE (logic 1) value is connected to hole 1, then the green light (on the top) will turn on. If a FALSE (logic 0) value is present, the red light (near the bottom) will turn on.

**Inputs:** A set of switches are located on the bottom left side of the board. They can be used to provide TRUE (5V) and FALSE (0V) values. (If a switch nearby is labeled with TTL as one option, make sure it is set to that option.) To see how they work, do the following: a) turn off the power, b) insert a wire into the hole for switch 1 and insert the other end into the hole for light 1, c) turn on the power, d) flip the switch to FALSE, notice that the light is red, e) flip the switch to TRUE, notice that the light is green.

**Clock:** The clock is located on the left side of the board. There are two slide controls, one to adjust the frequency and one to adjust the voltage amplitude. **Use the TTL connection for this experiment.** If there is a Hz/KHz or frequency control knob, set it to lowest frequency (about 1 to 10 Hz) so that you can observe its operation. To see how the clock works, do the following: a) turn off the power, b) connect a wire from the clock TTL output to light 2, c) turn on the power, d) watch the light alternate between red and green.

Please note that the chip names could be slightly different from those given in this lab. For example, you might have a 74LS04 instead of a 7404, or a 74H11 instead of a 7411. For now, ignore any letters that occur within the name on the chip.

## 2. 7404 Chip




**Top View of Chip**

Turn off the power and insert a 7404 chip so that it straddles the gap between the sets of holes. Note the notch or painted dot that marks the end where we will find pin 1. On the attached reference pages find the diagram for the 7404. Note that this is a top view of the chip and the boxes labeled 1 through 14 represent the pins or legs of the chip. Connect a wire from pin 14 ($V_{cc}$) to the +5V bus at the top of the box. Connect pin 7 to the ground bus. Connect wires from one logic switch to an output indicator. Also, connect a wire from the same logic switch to pin 1. Next, use a wire to connect pin 2 to a second LED. Turn on the power. Observe that for one set of lights the green light is on and for the other set, the red light is on. Flip the switch to the other logic state. Now, the red and green lights should interchange.

This gate is an inverter. Draw a truth table for it on the next page. (Let the top light be TRUE or 1, and bottom light be FALSE or 0.) The input state is the switch's logic value. The output state is the value of the light. This 7404 chip contains six independent inverters, hence the name "hex inverter."

| Input | Output |
|---|---|
| | |
| | |

**GATE NAME:**

Now, pull the wire out of the input (pin 1.) Does the output remain TRUE or FALSE?

An unconnected input is a typically a no-no, since it does not always give a consistent value.

## 3. 7402 chip

Turn off the power. Now, remove the 7404 (carefully, since the legs "bite" and bending them can also ruin the chip.) Insert a 7402 on your board. Wire the Vcc and ground as before (see the diagram), and connect pin1 to a light. Connect pins 2 and 3 to the logic switches. Collect data to generate the truth table for all four possible input combinations. What is the name for this logical gate?

| Inputs | | Output |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**GATE NAME:**

Disconnect the wire from one of the switches and connect it to the TTL clock output. Make the LED blink between red and green values by choosing the proper position for the remaining logic switch. What value of this switch allows the clock signal to appear on to the LED?

This device is now acts as a gate only allows a signal to pass when the other input is FALSE.

## 4. 7411 chip

Now insert the 7411 chip into the board. (Don't forget to turn off the power and also to attach the Vcc and GND wires.) Wire three logic switches to inputs on pins 3, 4, and 5. Connect the output pin 6 to an LED indicator. Fill in the following truth table and give the name of the logic gate.

| Input A | Input B | Input C | Output |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 0 | 1 | |
| 0 | 1 | 0 | |
| 0 | 1 | 1 | |
| 1 | 0 | 0 | |
| 1 | 0 | 1 | |
| 1 | 1 | 0 | |
| 1 | 1 | 1 | |

**GATE NAME:**

Now disconnect a wire from one of the switches and connect this wire to the clock, so that now one chip input is the clock. What value must the other two switches be so that the clock signal appears on the output?

## 5. 7486 chip

Now insert the 7486 chip into the board. The input pins are #1 and 2, while the output is #3. Connect a wire from the output to an output indicator. Also connect a wire from one input to another LED indicator. Write the truth table for this chip.

| Input A | Input B | Output |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

**GATE NAME:**

Change the connection so that one input (the one connected to the LED) is connected to the clock. Toggle the other switch. For what switch value are the clock and output are synchronized? For what value do the lights alternate?

Explain why this circuit could be referred to as a controllable inverter?