NET 1010
Logic Gates and ICs Workbook

1. **Logic Gate Truth Tables**
   For each basic logic operation, complete the truth table:

NOT

A	Out
0	
1	

AND

A	B	Out
0	0	
0	1	
1	0	
1	1	

OR

A	B	Out
0	0	
0	1	
1	0	
1	1	

NAND

A	B	Out
0	0	
0	1	
1	0	
1	1	

NOR

A	B	Out
0	0	
0	1	
1	0	
1	1	

XOR

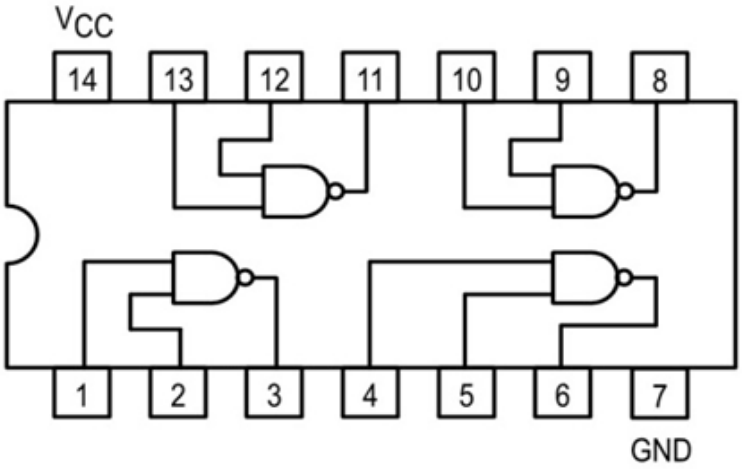
A	B	Out
0	0	
0	1	
1	0	
1	1	

XNOR

A	B	Out
0	0	
0	1	
1	0	
1	1	

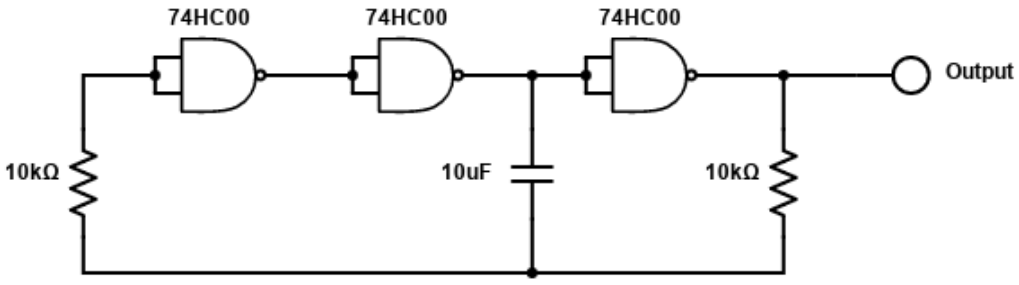
2. **NAND Circuits**

Complex logic systems can be build using a combination of the basic logic gates, including the CPUs in your computers. It is also often possible to construct these systems using just one type of logic gate. The following two examples use only NAND gates. Your 74HC00 IC contains 4 NAND gates. Using the following image from the 74HC00 datasheet, construct each circuit on the breadboard and show your instructor.



a) Oscillator

It is often useful to generate a repeating on/off signal, for example to blink an indication light, act as a clock signal for a more complicated circuit, or even generate sound. The following circuit uses three NAND gates to generate an oscillating (repeating) signal. (**don't forget your current limiting resistor or you could damage the IC or the LED)**.



Try replacing the resistors with a potentiometers and see what effect different resistances have on the frequency.

b) Half Adder

The core computational component of a CPU and the ALU (Arithmetic Logic Unit) which is essentially a complex system of logic gates that can perform binary math. Your computers' CPU's ALUs can perform binary math with 32- or 64-bit numbers. A 64-bit adder circuit is essentially 64 1-bit adders chained together.

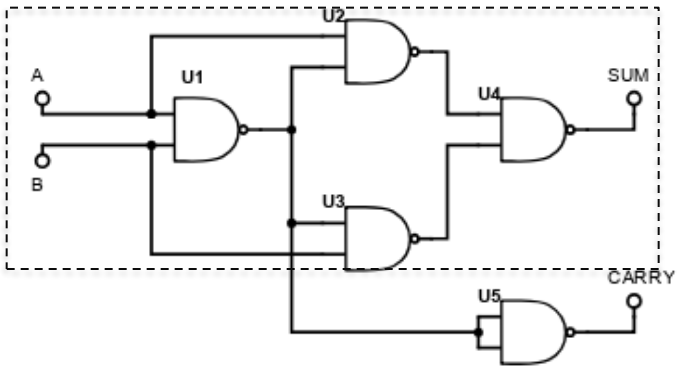
Binary addition works the exact same as out regular base-10, once we go beyond our biggest numeral (9), the digit is reset to 0 and 1 "carries over" to the next place value:

0+1=1 1+0=1 0+0=0 and 1+1=0 (with a carry over)

Fill out the truth table for this adder system:

A	B	Out
0	0	
0	1	
1	0	
1	1	

If this looks familiar, it should! This is the same truth table as XOR. While we could just use an XOR IC for our adder and call it a day, I didn't give you one so let's make an adder out of NAND gates:
(NOTE: your 74HC00 has only 4 NAND gates, so we will leave out U5 and the CARRY logic)



NAND Half Adder

This is called a "half adder" because it doesn't account for the carry-over from a previous adder. If we include that, we have a "full adder", which can be chained together to add binary numbers of any size. A full adder made of NAND gates needs 9 NAND gates.

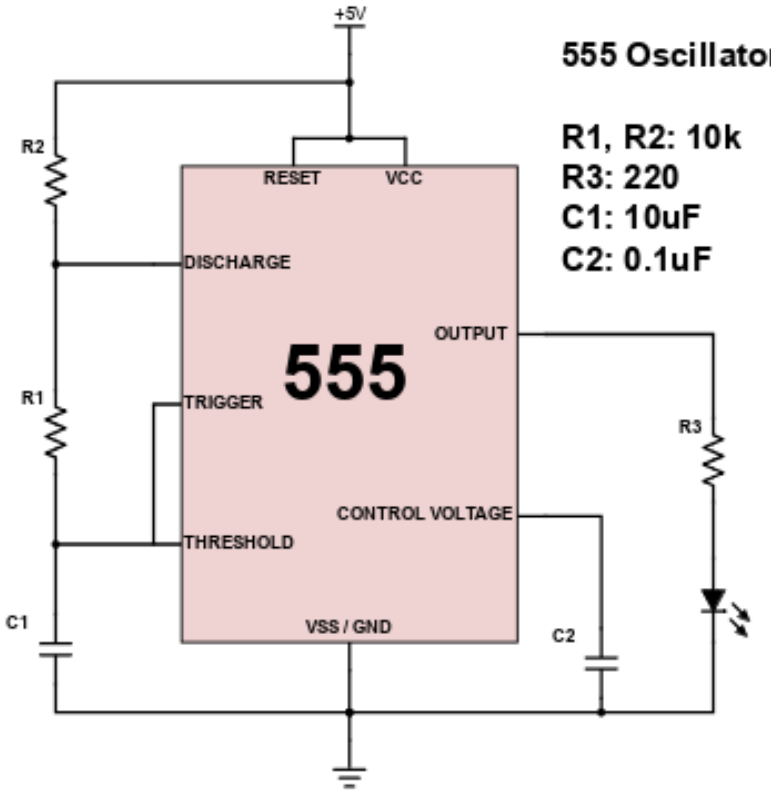
3. **More Fun with ICs**

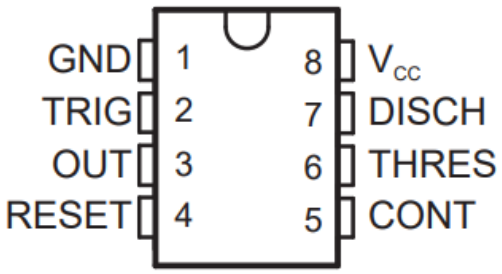
   Logic gates aren't the only circuits that have been made into ICs, in fact there are thousands of varieties, each with their own specifications, pinouts, and applications. You've been provided with 4 additional ICs, the most famous of which is the 555.

   The 555 IC can be used for a number of purposes: it can generate an oscillating signal similar to what you constructed out of NAND gates, it can act as a timer, or can hold its output LOW or HIGH until a button is pressed, it all depends how you hook it up.

   Here you will use the 555 to generate an oscillating signal, but feel free to look around online for how to use it in other ways.

   Using the electrical schematic along with the pinout from its datasheet, construct the circuit on your breadboard:





4. **Even More IC Fun**

   You were also provided 3 addition ICs. They are described below, but it's up to you to find something interesting to do with them. Either design a system yourself or look online for inspiration.

   4017 – Decade Counter: 10 output pins, only one is HIGH at a time. When the CLK pin is pulsed, a different output pin goes HIGH.

   4019 – 4-Bit Binary Counter: 4 output pins represent a 4-bit binary number that is incremented or decremented when the Up or Down pins are pulsed

   4511 – 7 Segment Encoder: 4 input pins (representing a 4-bit binary number) determine the output of 7 output pins to drive the LEDs in a 7 segment display

   You will need to use the internet to find the pinouts and example schematics for these ICs.

   You do not need to use all of the ICs you have, this is just a toolbox to select from.