Student Name: _____ Student #:_____

Lab #3A (The Half - Adder)

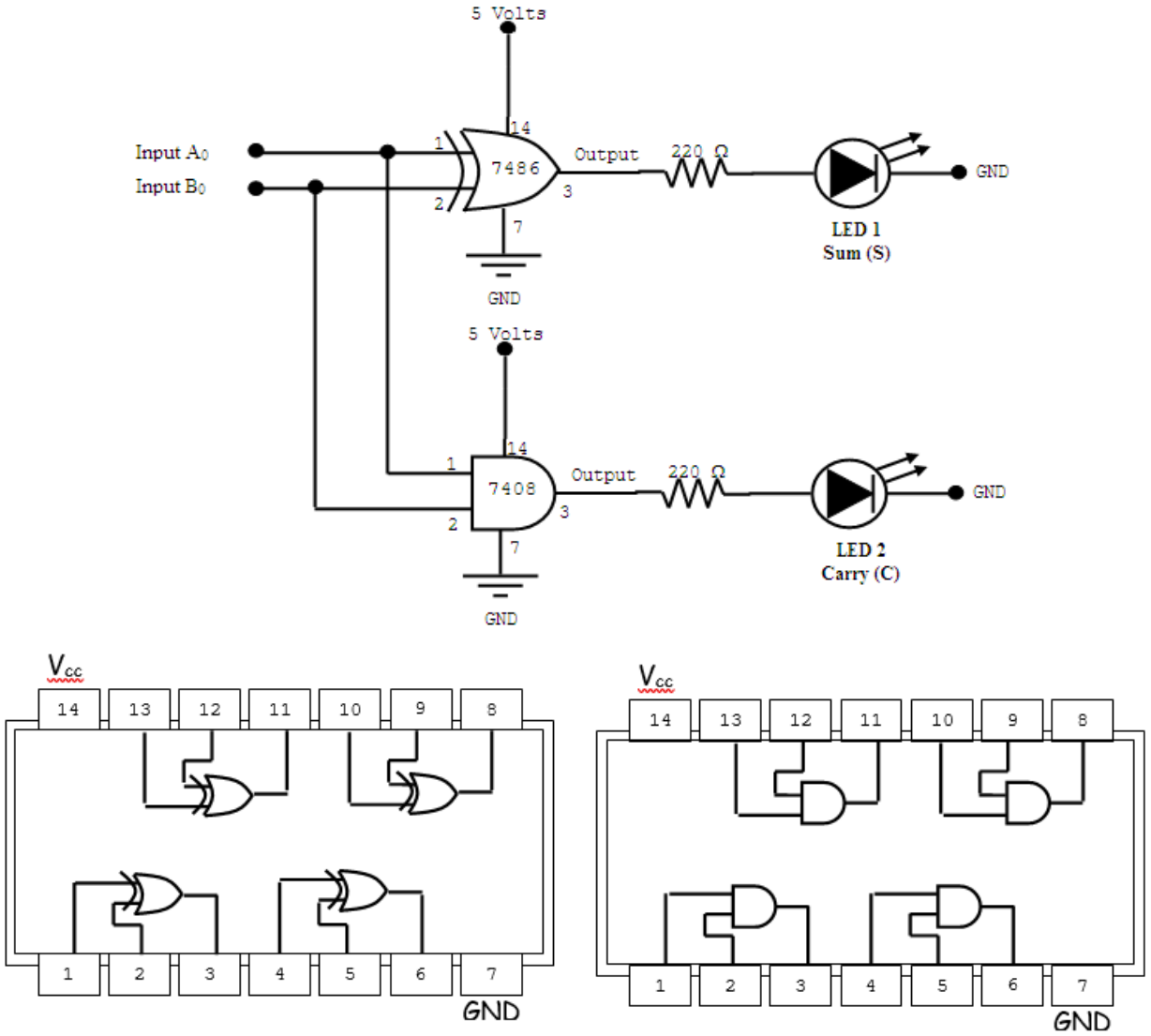
AIM:

To investigate a circuit that simulates the addition of two binary digits.

MATERIALS:

1. 1 x 7486 integrated circuit (IC)
2. 1 x 7408 integrated circuit (IC)
3. 4 x 220 ohm resistors
4. 1 x DIP Switch
5. 2 x LEDs (Light Emitting Diode)
6. Wires

SCHEMATIC DIAGRAM:



TEJ4M – Digital Lab #1 Adder Circuits

Student Name: _____ Student #:_____

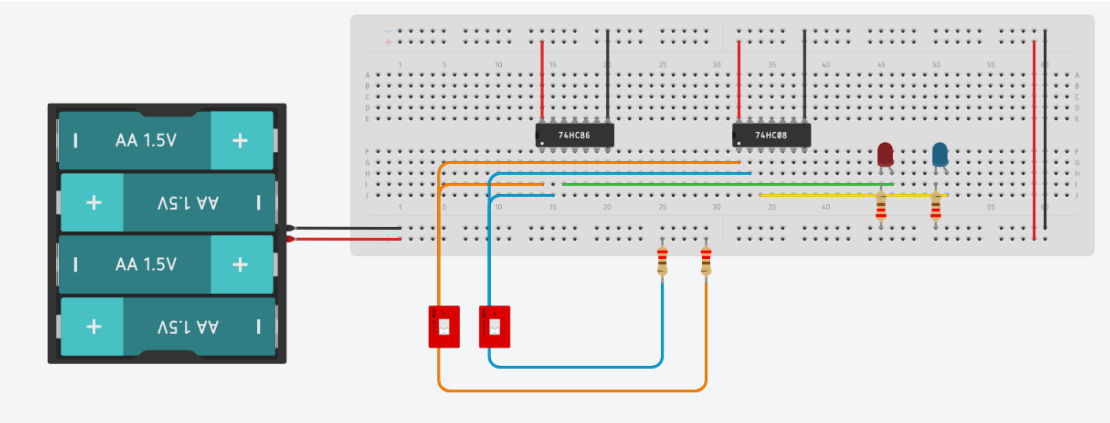
PROCEDURE:

1. Assemble the circuit on Tinkercad. Connect pins 7 and 14 to ground and +6 Volts respectively.

   Note:  connected wires  no connection

2. You will need to wire a DIP switch (see the PowerPoint) to toggle the inputs A_0 and B_0 for this experiment.

3. Toggle the inputs to the circuit using the two push buttons to complete the table below.
   a. Set inputs A_0 = LOW and B_0 = LOW. Record outputs in truth table.
   b. Switch input A_0 = LOW and input B_0 = HIGH. Record outputs in truth table.
   c. Switch input A_0 = HIGH and input B_0 = LOW. Record outputs in truth table.
   d. Switch inputs A_0 = HIGH and B_0 = HIGH. Record outputs in truth table.



Half Adder Truth Table

Input A_0	**Input B_0**	**Carry (C) (LED On or Off)**	**Sum (S) (LED On or Off)**
Low (0)	Low (0)	**0**	**0**
Low (0)	High (1)	**0**	**1**
High (1)	Low (0)	**0**	**1**
High (1)	High (1)	**1**	**0**

4. Using the completed truth table in #3 (above), determine the Min-term Boolean expressions for the Sum(S) and Carry(C) outputs. Remember that the inputs are A and B.

   Min-term Boolean Expression for Sum (S) output: $S = \overline{A}B + A\overline{B} + AB$

   Min-term Boolean Expression for Carry (C) output: $C = AB$

TEJ4M – Digital Lab #1 Adder Circuits

Student Name: _____ Student #:_____

Questions:

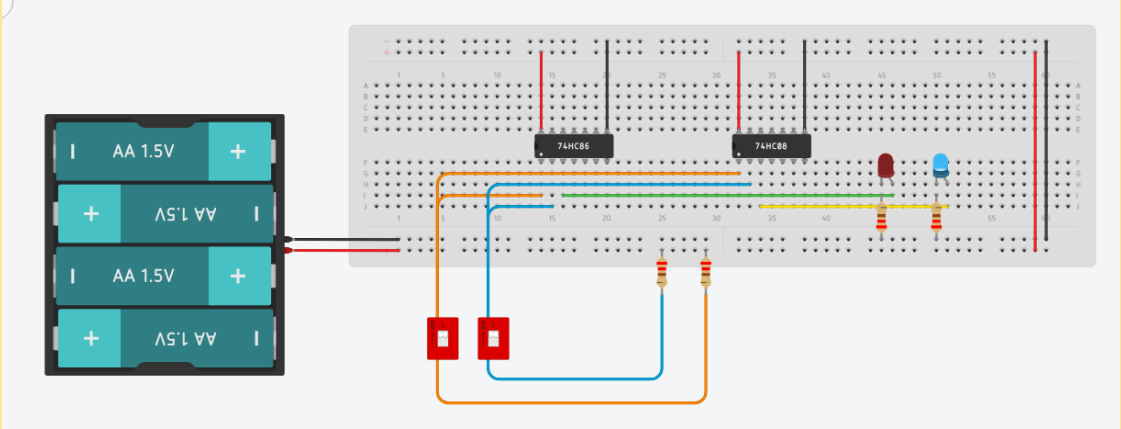
1. Write out the binary addition rules for each of the four cases for adding two binary digits. (Eg.: 0 + 1 = 1 + carry 0)

    1. 0+0 = 0 + carry 0
    2. 0+1 = 1 + carry 0
    3. 1+0 = 1 + carry 0
    4. 1+1 = 0 + carry 1

2. When two digits are added a sum and a carry value are obtained. For example 1+ 1 has a sum of 0 and a carry of 1. How should the LED outputs in this experiment be interpreted with respect to the operation of the circuit?

    With respect to the operation of the circuit, the LED output should be interpreted such that the Sum LED should be off and the Carry LED should be on.

    In my circuit, the red LED represents the Sum and the blue LED represents the Carry. In the circuit below, when the input of A and B is 1 only the blue LED turns on while the red LED remains off.

3. Summarize the operation and capability of a half-adder circuit in plain english.

    Half adders are capable of adding 1 bit values including 0 and 1. Half Adders operate using 2 logic gates including a XOR gate which adds the values and the AND gate which determines the carry over of the addition.

TEJ4M – Digital Lab #1 Adder Circuits

Student Name: _____ Student #:_____

Lab #3B (The Full - Adder)

AIM:

To investigate a circuit which simulates the addition of two binary digits.

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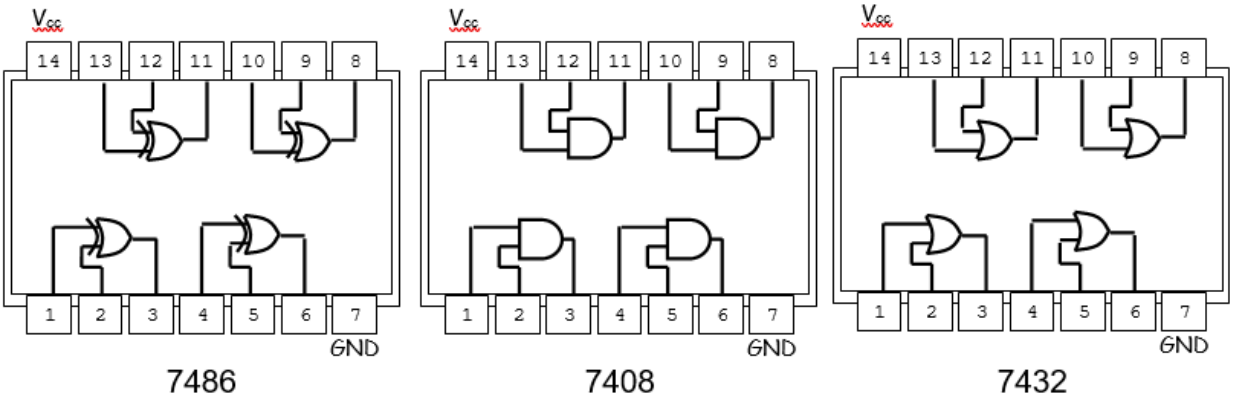
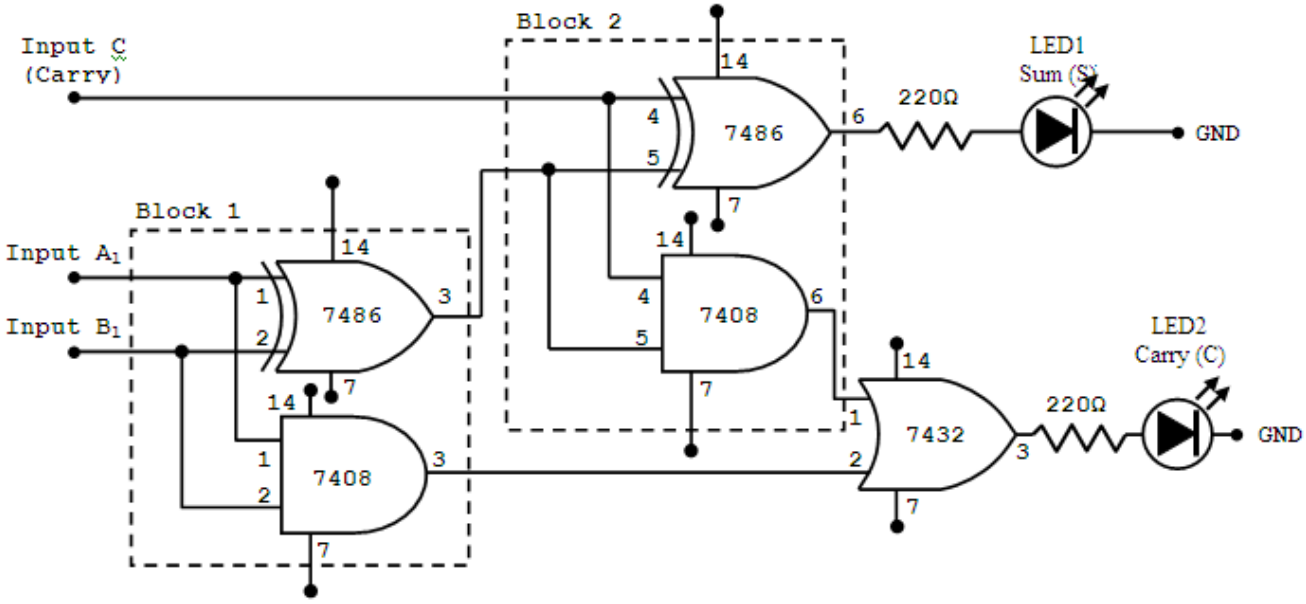
MATERIALS:

1. 1 x 7486 integrated circuit (Exclusive OR)
2. 1 x 7408 integrated circuit (AND)
3. 1 x 7432 integrated circuit (OR)
4. 5 x 220 ohm resistors
5. 3 x Push Buttons (represented by the DIP switch used in the PowerPoint video)
6. 2 x LEDs (Light Emitting Diode)
7. Wires



SCHEMATIC DIAGRAM:



TEJ4M – Digital Lab #1 Adder Circuits

Student Name: _____ Student #:_____

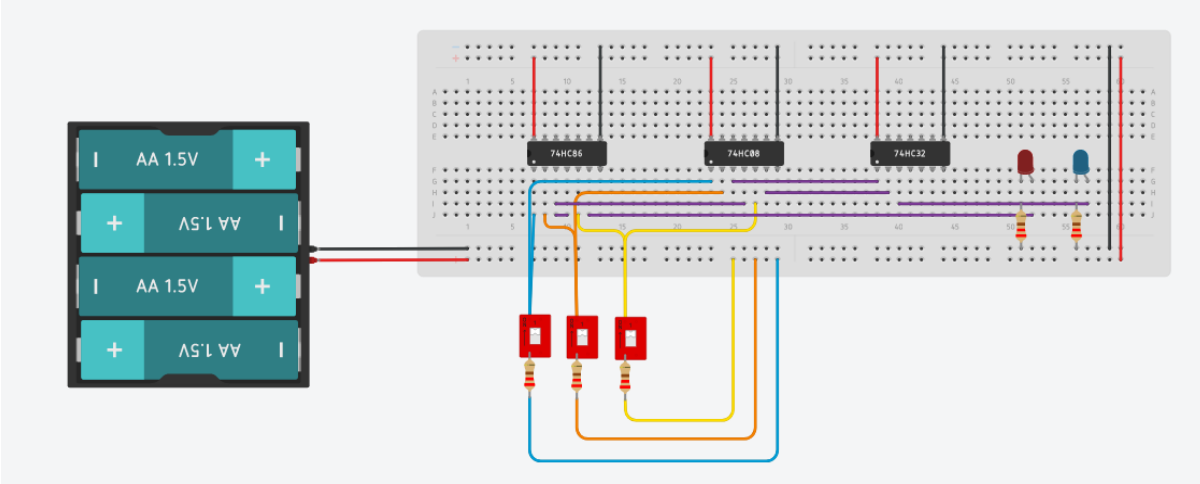
PROCEDURE:

1. Plug all three integrated circuits into the breadboard leaving some room at the right end for resistors and LED's.

Note: ● connected wires + no connection

2. Connect all ground and 6 volt wires.
3. Connect all other pins and then check all connections. Read the diagram carefully to see which pins the wires should be connected to. Note that there are four gates contained within each chip that can be used to produce this circuit.
4. Connect the three input wires using the DIP switch.
5. Insert the LED's and resistors.
6. Toggle the switches and observe the output of the two LEDs.

Circuit:



Full Adder Circuit Truth Table

Input A_0	Input B_0	Input C (Carry)	Output Carry (C) (LED On or Off)	Output Sum (S) (LED On or Off)
Low (0)	Low (0)	Low (0)	**0**	**0**
Low (0)	High (1)	Low (0)	**0**	**1**
High (1)	Low (0)	Low (0)	**0**	**1**
High (1)	High (1)	Low (0)	**1**	**0**
Low (0)	Low (0)	High (1)	**0**	**1**
Low (0)	High (1)	High (1)	**1**	**0**
High (1)	Low (0)	High (1)	**1**	**0**
High (1)	High (1)	High (1)	**1**	**1**

Student Name: _____ Student #:_____

7. Using the completed truth table in #6 above, determine the Min-term Boolean expressions for the Sum(S) and Carry(C) outputs. Record this in the Lab #2 answer sheet. The inputs will be A, B, and C.

   Min-term Boolean Expression for Sum (S) output: $S = \overline{A}\overline{B}\overline{C} + A\overline{B}\overline{C} + \overline{A}\overline{B}C + ABC$

   Min-term Boolean Expression for Carry (C) output: $C = AB\overline{C} + \overline{A}BC + A\overline{B}C + ABC$

Questions:

1. Write out the binary addition rules for each of the eight cases for adding two binary digits and a carry in bit, i.e. adding three binary digits together. (Eg.: 0 + 1 + 1 = 0 + carry 1).

   1. 0 + 0 + 0 = 0 + carry 0
   2. 0 + 1 + 0 = 1 + carry 0
   3. 1 + 0 + 0 = 1 + carry 0
   4. 1 + 1 + 0 = 0 + carry 1
   5. 0 + 0 + 1 = 1 + carry 0
   6. 0 + 1 + 1 = 0 + carry 1
   7. 1 + 0 + 1 = 0 + carry 1
   8. 1 + 1 + 1 = 1 + carry 1

2. Summarize the operation and capability of a full-adder circuit in plain English.

   Full adders are capable of adding 3 input bits including A, B and Ci, where A and B are the bits to be added and the Ci is the carry bit. It has 2 outputs, including the sum of the 3 bits and the carry over of the entire sum Full adders operate using 3 logic gates, including XOR gate which adds the values, the AND gate which represents the carry bit and lastly the OR gate which determines if there is an overall carry bit in the current sum