ENGR-4300

Electronic Instrumentation

Quiz 3

Spring 2011

Name _____

Section ___

Question I (20 points) _____

Question II (20 points) _____
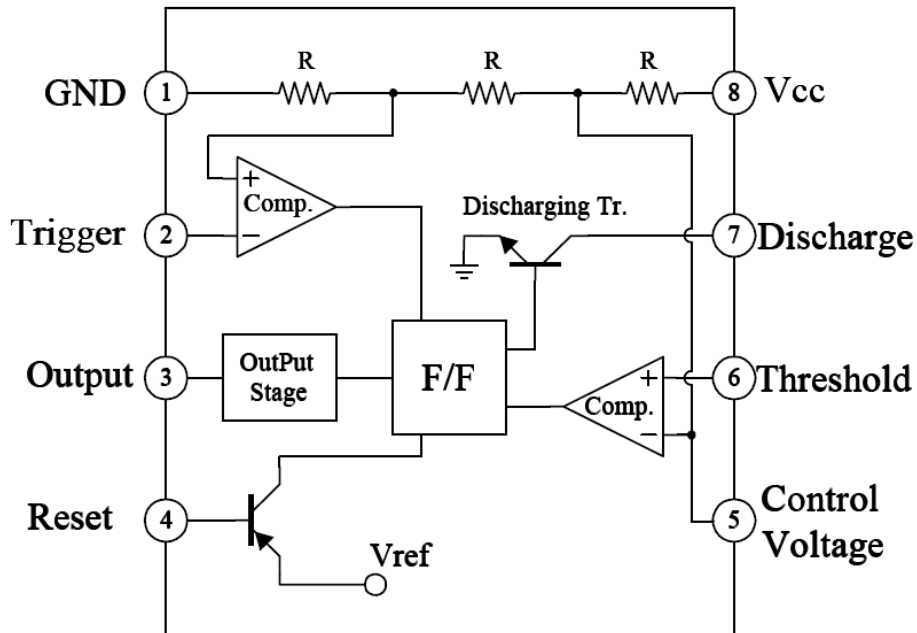
Question III (20 points) _____

Question IV (20 points) _____

Question V (20 points) _____

Total (100 points) _____

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES <u>AND UNITS</u>. No credit will be given for numbers that appear without justification.

K. A. Connor

Some Additional Background

Thomas Jefferson

The choice of quotes shows a lot about how engineers think.

13 April is his birthday. Who is he?

If you Google his name and 555 timer you will find some thoughts of his collected by people who like him and 555 timers: "The man who reads nothing at all is better educated than the man who reads nothing but newspapers" and "the most valuable of all talents is that of never using two words when one will do" and "I predict future happiness for Americans if they can prevent the government from wasting the labors of the people under the pretense of taking care of them."

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Question I: Astable Multivibrator (20 points)

1. (4pt) The 555 timer circuit shown is to have a duty cycle of 51.5%. For a given C1, what ratio of resistors R1/R2 will produce this duty cycle

Duty cycle is $\dfrac{R_1 + R_2}{R_1 + 2R_2} = 0.515$ **or**

$R_2 = \dfrac{.485}{.03} R_1 = 16.17 R_1$
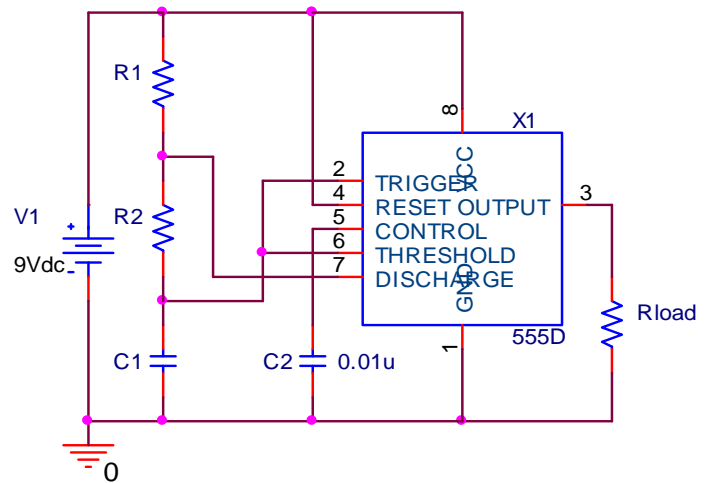
2. (4pt) Using a ratio from above and C1 = 4.7μF, calculate the values for R1 and R2 needed to yield an oscillation period of 0.695s?

$T = .693*(R_1 + 2R_2)C_1 = .693*(R_1 + 2R_1(16.17))C_1 = .695$

Or R₁=6.4k and R₂=103k

3. (2pt) For an ideal 555, what are the maximum and minimum voltages on pin 2 above during normal operation?

Vmin = 1/3 V1 = 1/3 x 9 =3V   Vmax = 2/3 V1 = 2/3 x 9 =6V

4. (4pt) For an ideal 555, what are the maximum and minimum voltages on pin 7 above during normal operation?

Vmin = ground =0V   Vmax = R2/(R2+R1)x(9 - 6) + 6 = (.95)(3)+6 = 8.8V

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**Question I: Astable Multivibrator (continued)**

5. (6pt) The plot below shows the voltages on pins 8, 3 and 1 for the circuit above. The vertical scale goes from 0V to 10V and the horizontal scale goes from 8s to 10s. Label each voltage with the pin number. Then draw the voltages on pins 2 and 7 of the circuit above and label each with its pin number. *Need one more number – after 7 disconnects so the capacitor can charge again, the voltage on 7 is (0.95)*6+3=8.65V*
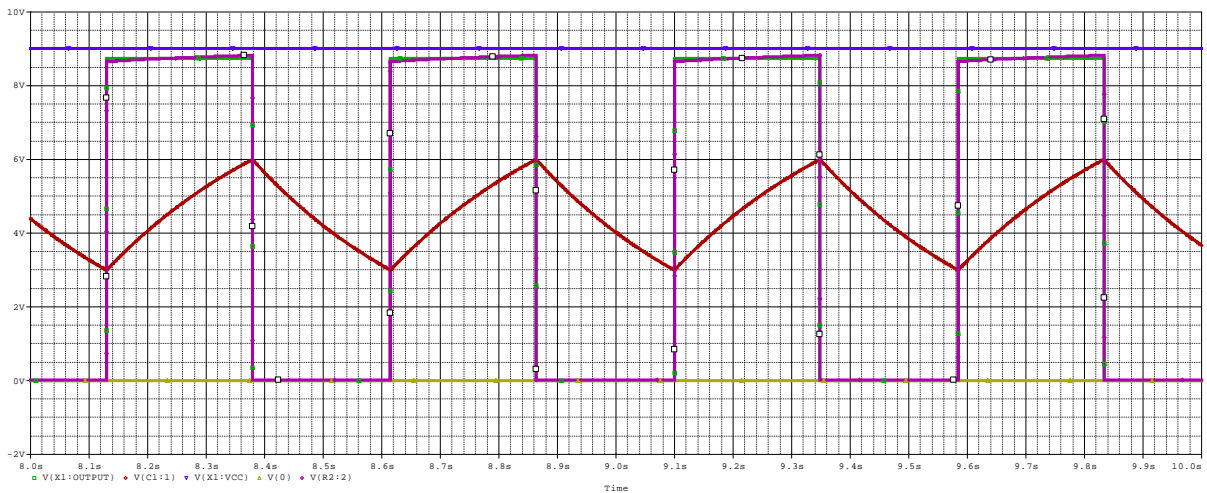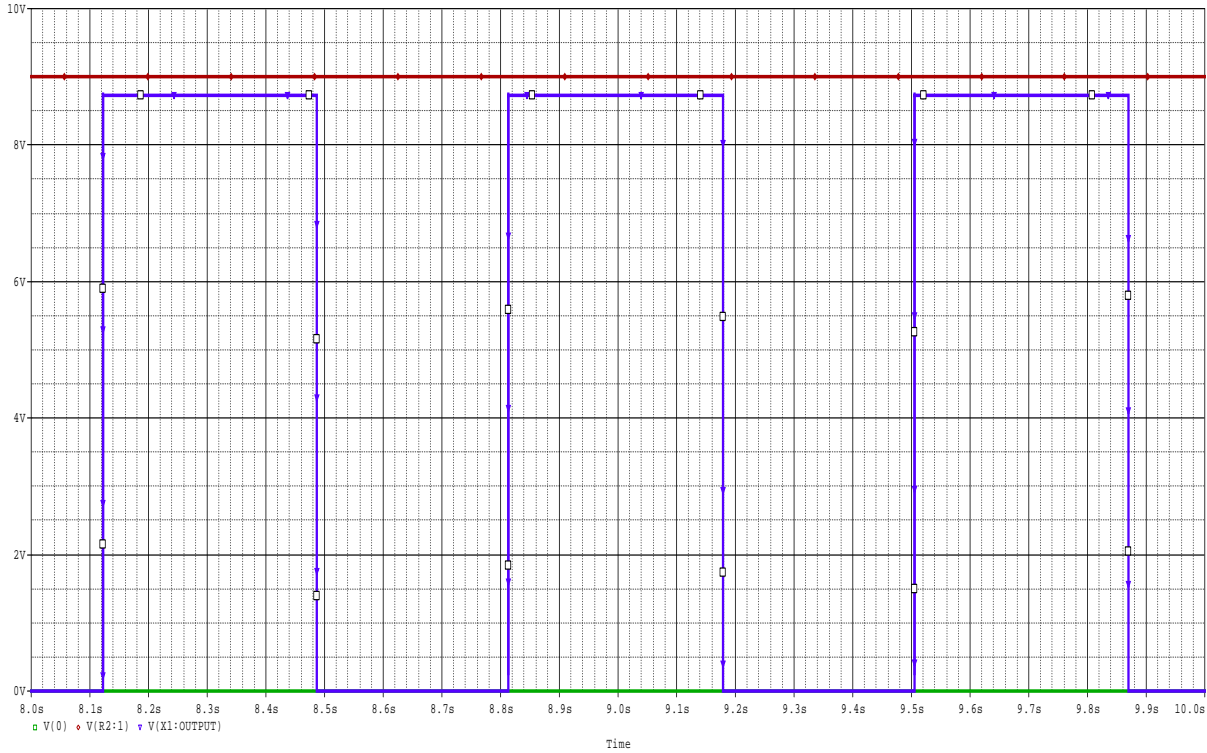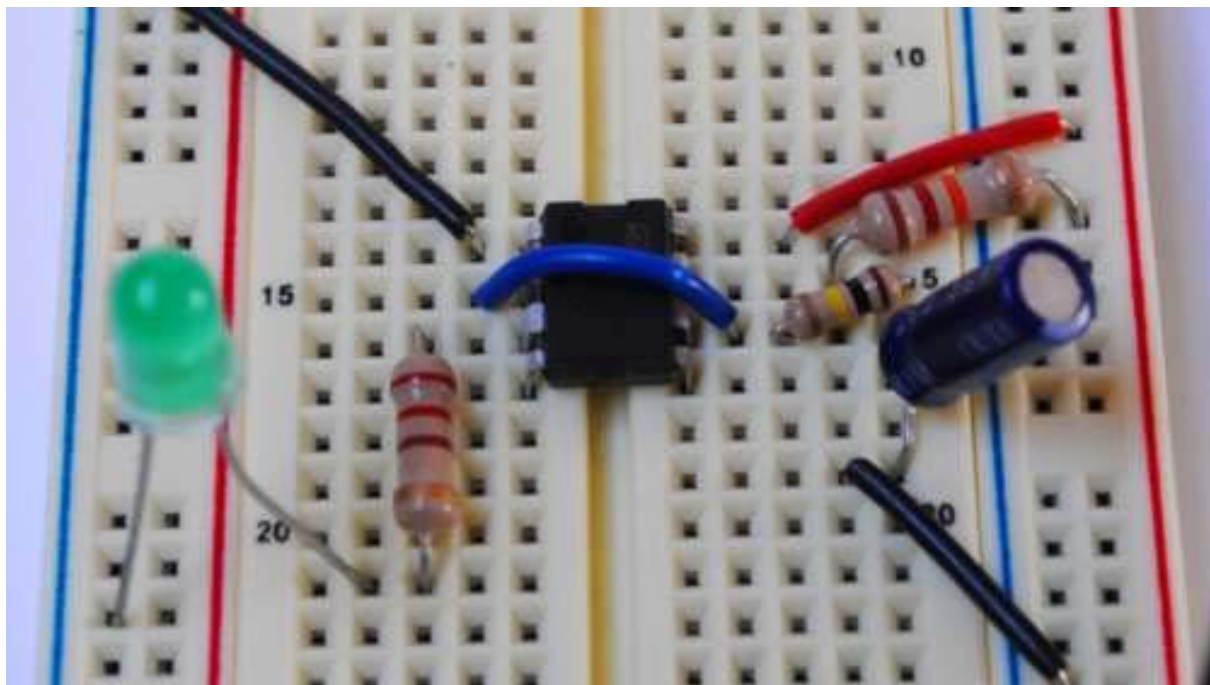
The curve above was done using PSpice for clarity.

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Question II: Practical Circuit Issues (20 points)

Shown below are two pictures for an Instructables project based on the circuit you have just analyzed in Question I. In the top picture are the components (all found in your parts kits).
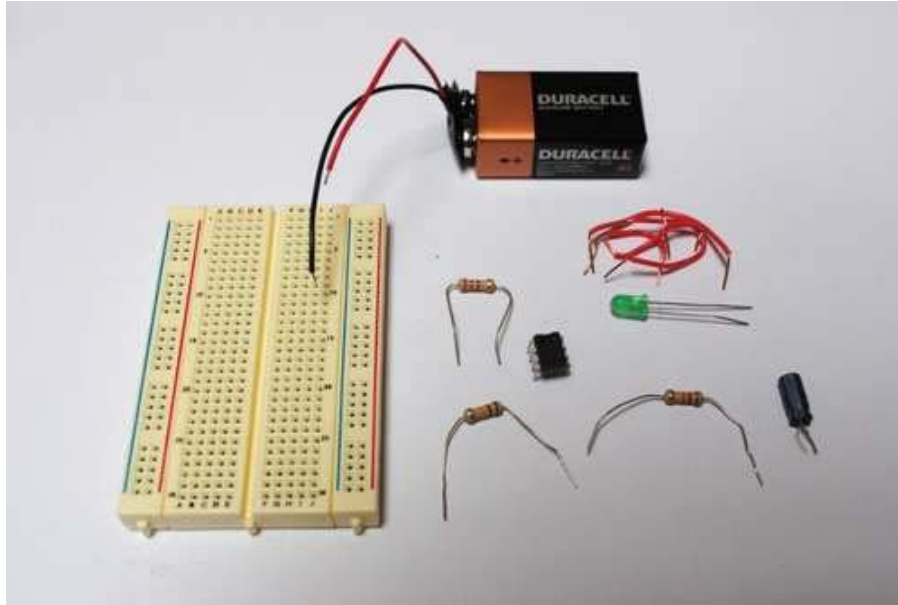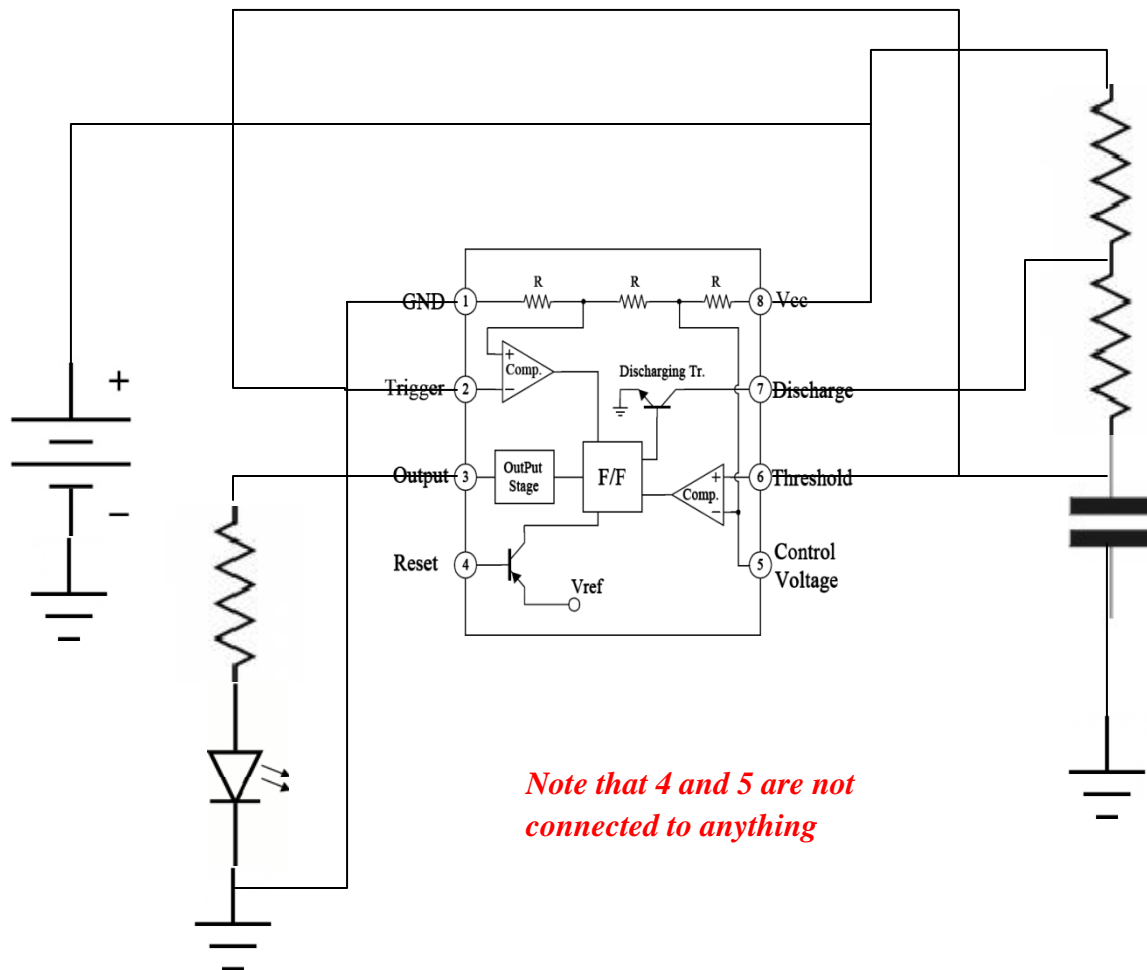

The bottom picture shows the completed circuit.

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Question II: Practical Circuit Issues (continued)

a) Draw the circuit diagram for the Instructables project. A symbol for the 555 time chip is
    provided, but none of the other components. (8 points) *A larger version of this diagram is
    shown on page 2.*

*Note that 4 and 5 are not
connected to anything*

b) Identify and label the differences between the circuit as built for the Instructable project
    and the one analyzed in Question I. (4 points) What does this circuit do? (2 points)

*The biggest difference is that 4 and 5 are not connected to anything. The LED is also an added
compoenent.*

Question II: Practical Circuit Issues (continued)
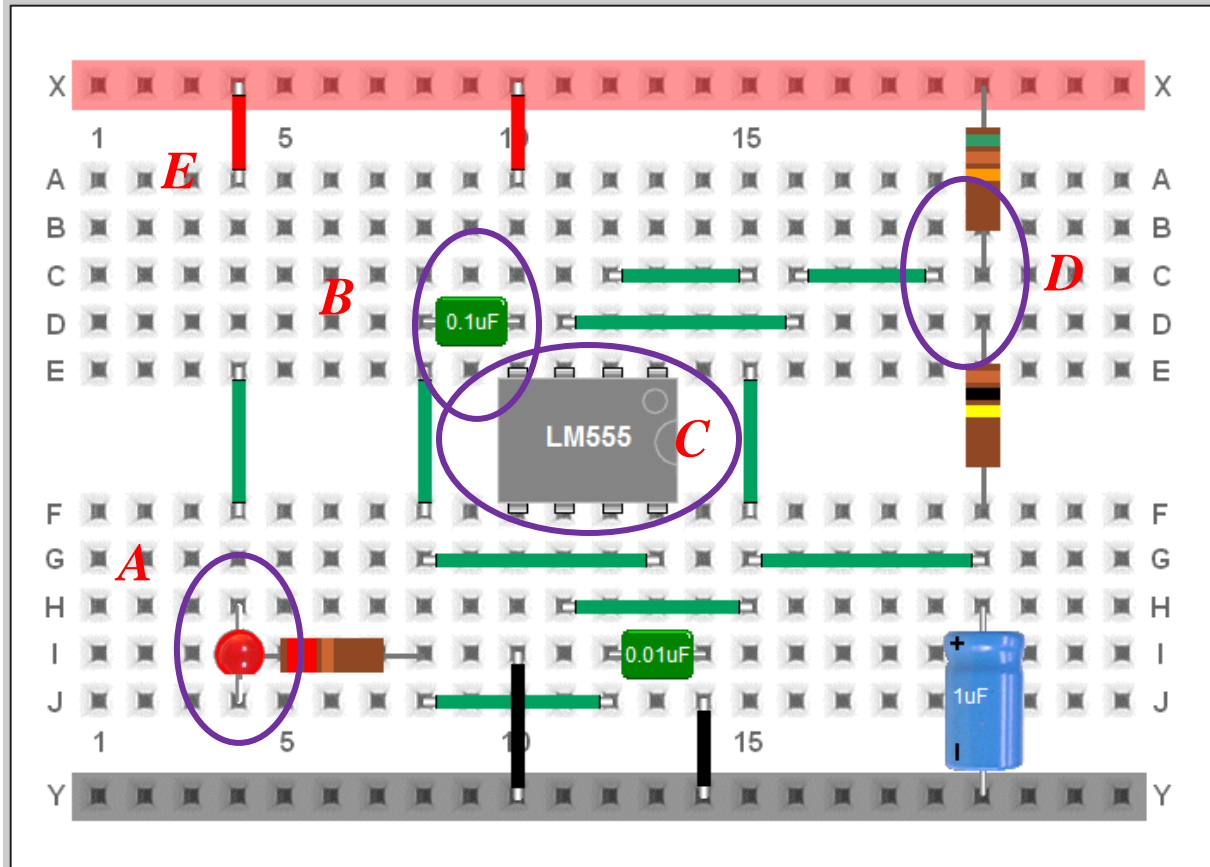
c) Shown above is a protoboard layout for a very similar 555 timer circuit. There are at least three errors in the layout that will keep the circuit from working. Circle each error and label them with a letter (e.g. A, B, C, D …). Describe each error in the space below. (3 points) *All answers, except the one on the chip orientation, assume the chip is in correctly.*

A Both LED wires are connected to the same row of 5 holes so it is not connected to the circuit.

B Pin 4 is not connected to the high voltage (9V) because of the extra capacitor. Technically, this is not really a problem because the circuit works whether or not 4 is connected to anything.

C The 555 chip is in backwards

D Pin 7 is not connected to the two resistors because it is in the wrong row of 5 holes

E The output (pin 3) connects to the high voltage rather than the ground, but this is OK because the LED will turn on when there is voltage across it. One end does not have to be at ground. The flat end of the LED is at the lower voltage, so this works.
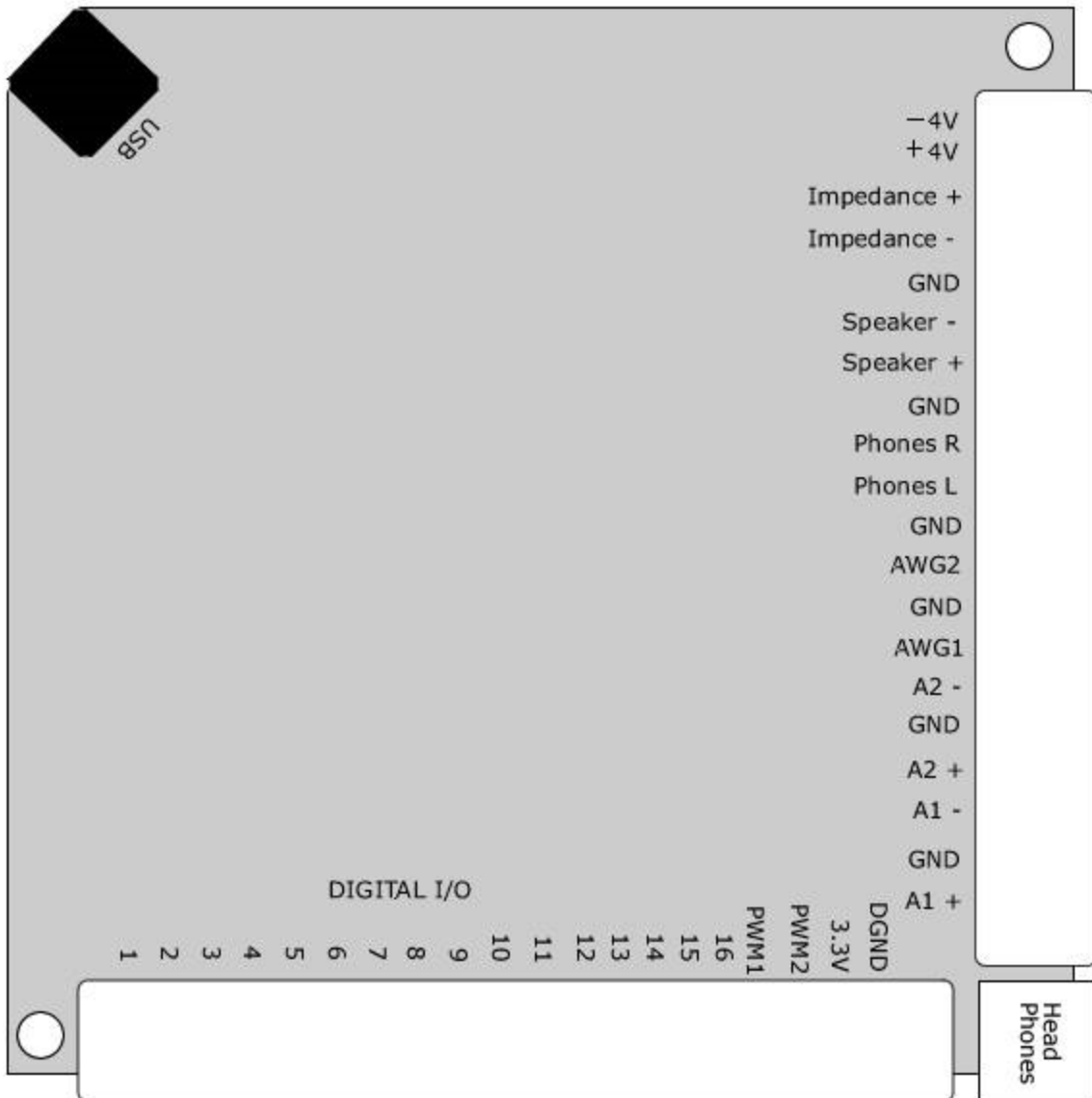
d) After building a circuit like this, it is useful to monitor the voltages on pins 3 and 6 to confirm that it is working correctly. To make these two measurements and display them on the two Mobile Studio oscilloscope channels, you will need to connect some wires between the circuit and some Mobile Studio inputs. Where should you make the connections to the Mobile Studio? (3 points)

Connect pin 3 to A1+, pin 6 to A2+ (these can be reversed) and connect the ground in the 555 circuit to one of the ground connections on the board.

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Question III: Combinational Logic Circuits (20 points)
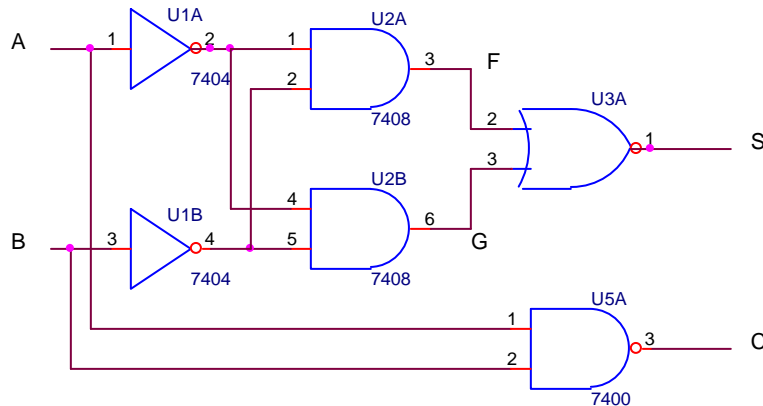
a) Complete the table below for the circuit above. (6 pts)

A	B	F	G	C	S
0	0	1	1	1	0
0	1	0	0	1	1
1	0	0	0	1	1
1	1	0	0	0	1

b) What type of gate is output S above, if any? (circle one) (1 pt)

AND   NAND   OR   NOR   XOR   NOT   None of the others.

c) A logic circuit similar to that in a) (but NOT the same) has the following truth table. Combining CS as a 2-bit binary number, fill in the decimal value in the table. (4 pts)

A	B	C	S	CS as Decimal Number
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	0	2

d) If A and B are treated as binary number inputs, what Arithmetical operation is being performed in creating the output CS? (4 pts)

Addition

K. A. Connor

Question 2 – Combinational Logic Circuits (continued)

e) Of the basic 2-input logic gates, which could be used for the Arithmetic multiply operation of 1-bit binary numbers A and B. (4 pts)

AND

f) Show that the multiply and logic operations are equivalent by filling in the table below. The symbol '♦' represents the logic operation chosen in e). (1 pt)
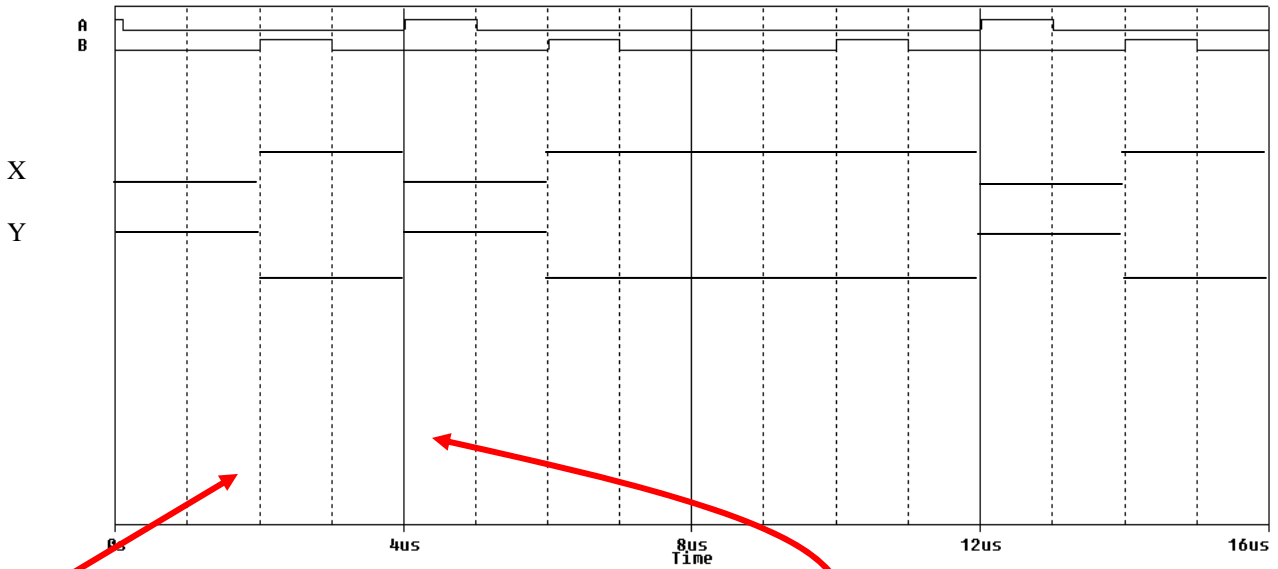
A	B	AxB	A♦B
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

Question IV: Sequential Logic Circuits (20 points)

In the circuit below, the timing traces at nodes A and B are displayed. You don't need to worry about the details of the clocks. Assume that node X starts low. Plot the time trace for nodes X and Y.
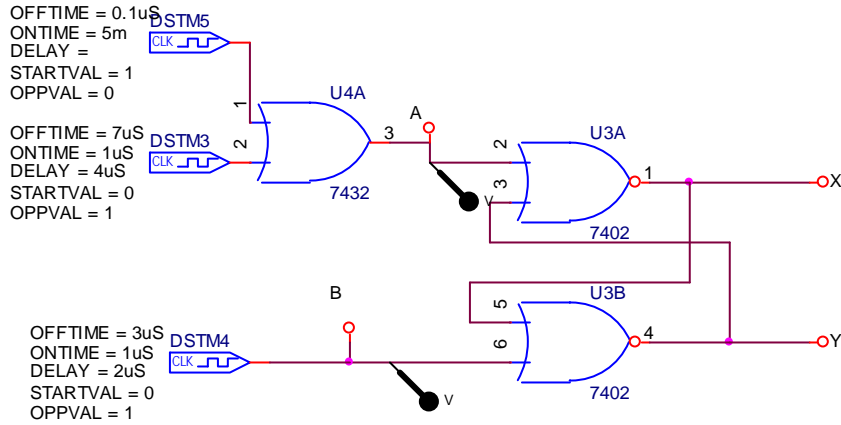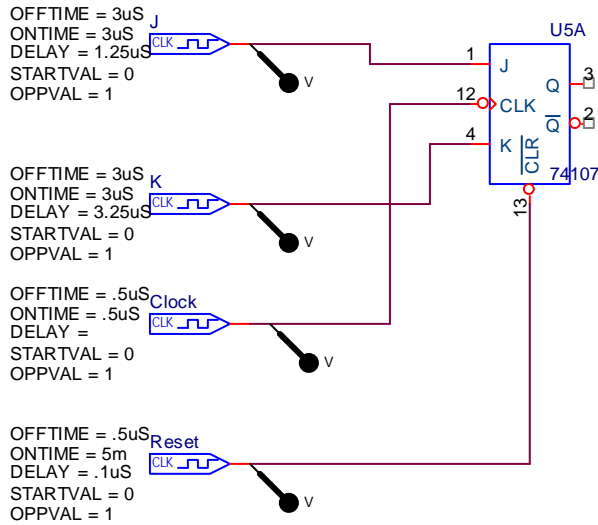

a) Fill in the timing diagram with the signals indicated. (8 pt)

B goes high, Y goes low, A+Ylow gives X goes high

A goes high, X goes low, with A and X both low, Y goes high

*K. A. Connor*

Question IV: Sequential Logic Circuits (continued)

OFFTIME = 3uS J
ONTIME = 3uS
DELAY = 1.25uS CLK
STARTVAL = 0
OPPVAL = 1

U5A

1 J
Q 3
12 CLK
Q̄ 2
4 K
CLR 74107
13

Q and Qbar only change on the falling edge of the CLK

OFFTIME = 3uS K
ONTIME = 3uS
DELAY = 3.25uS CLK
STARTVAL = 0
OPPVAL = 1

OFFTIME = .5uS Clock
ONTIME = .5uS
DELAY = CLK
STARTVAL = 0
OPPVAL = 1

OFFTIME = .5uS Reset
ONTIME = 5m
DELAY = .1uS CLK
STARTVAL = 0
OPPVAL = 1

Four cases are labeled below

Case 1: J, K low, no change
Case 2: J hi, K lo, Q=1
Case 3: J hi, K hi, toggle
Case 4: J lo, K hi, Q=0

b) Clock pulses are applied to a J-K flip-flop as shown above. Below is a timing diagram for the input signals. Assume that the flip-flop starts with Q low and Qbar high. Plot the timing trace for Q and Qbar. (8 pt)
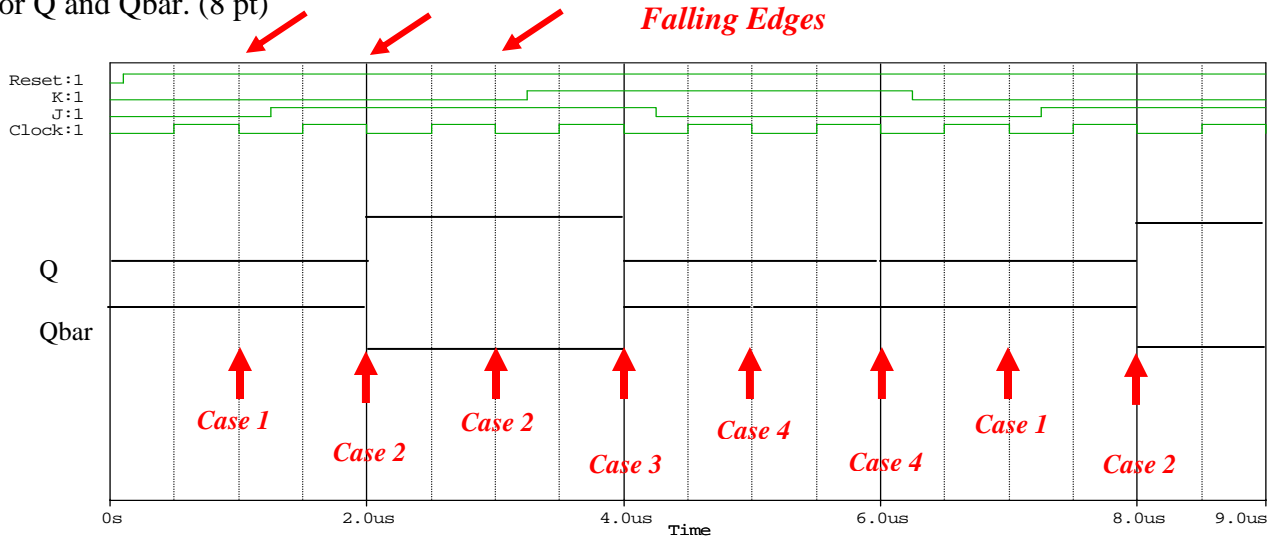
c) A 4-bit counter is cleared and then receives a string of clock pulses. (4 pt)

What are QA, QB, QC and QD after 7 clock pulses? Clearly indicate the state of each signal, don't just list some 1's and 0's without stating which is QA, which is QB, …

QA	QB	QC	QD
0	1	1	1

What are QA, QB, QC and QD after a total of 17 clock pulses? *16 counts goes to all zeros*

| QA	QB	QC	QD
0	0	0	1

K. A. Connor

Question V: Comparators and Schmitt Triggers (20 points)

You are to design a comparator circuit that takes a ±2.5V triangle wave and outputs a ±5V square wave that is positive when the triangle wave is negative and negative when the triangle wave is positive.

a) Specify V+ (V_s^+) & V- (V_s^-) and connections to the + & - inputs and show where the input signal is connected. (Ignore OS1 and OS2) (4 pts)
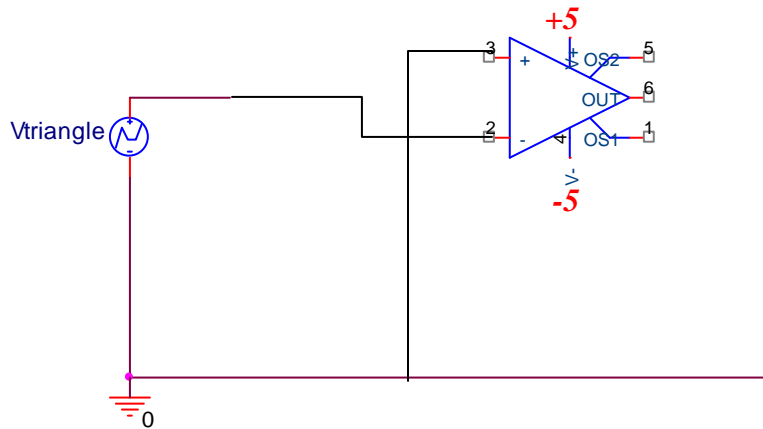
b) Modify the circuit in a) to be a Schmitt Trigger with hysteresis that switches at +1V and -1V by adding 2 resistors to the comparator. The smaller resistor value (R2) is 1k. Find the values of R1 and Vref, assuming that V+ and V- are unchanged from a). Show where the input signal is connected. (6 pts)
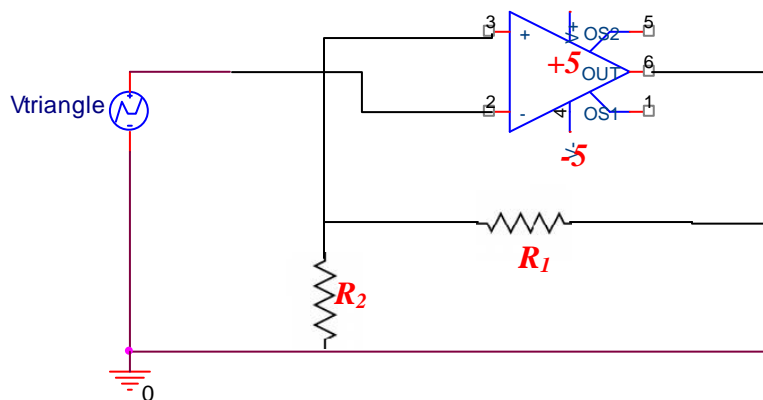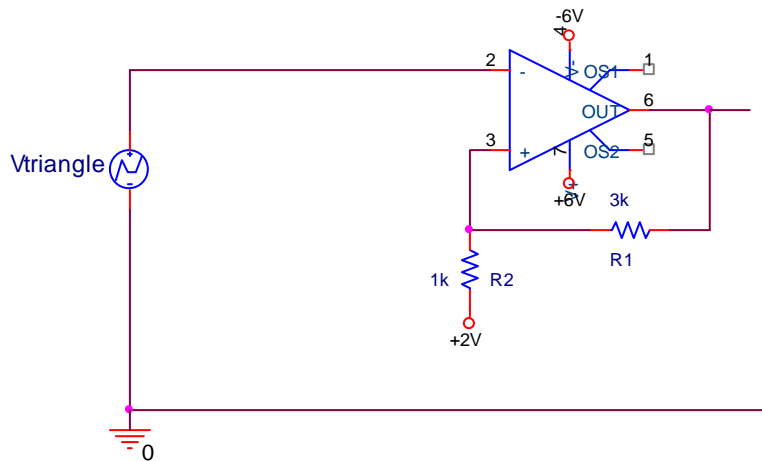

V+=(R₂/(R₁+R₂))(5-0)+0 or R₁=4k

V+=($R_2/(R_1+R_2)$)(5-0)+0 or R_1=4k

Hysteresis: -1V to +1V centered at 0V so that Vref=0V

Question V: Comparators and Schmitt Triggers (continued)

c) Given the circuit below, find the input voltage switch points for the Schmitt Trigger. Note that the supply voltages in the circuit are flipped when compared to the crib sheet drawing. (7 pts)

$V_{TH}^{+}=(1k/(1k+3k))(6-2)+2=1+2=3V$

$V_{TH}^{-}=(1k/(1k+3k))(-6-2)+2=-2+2=0V$

d) Can the circuit in c) be used to create a square wave from the original triangle wave in a)? Explain why or why not. (3 pts)

No, the signal input threshold never exceeds the high threshold (2.5V < 3V)

K. A. Connor