Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

Total Marks: 35

Notes:

1. For the written questions show all of your work and submit either a PDF or text file.
2. For programming questions hand in your source program (.asm file).
3. Name you programs LastnameFirstnameAxQy.asm, replace x with the assignment number and y with the question number.
4. Please comment appropriately for programming question. Please read the "programming standards" for COMP 2280. Marks are allocated for good documentation.
5. Hand in your assignment through UMLearn

Written Part

Question 1 [4 marks]

Construct a symbol table for the following program.

```
    .ORIG X3000
    AND R1,R1,#0
    ADD R2,R1,#0
    LD R3,ZERO
    LD R1,X

LOOP1
    BRZ DONE1
    LD R2,Y
LOOP2
    BRZ DONE2
    ADD R3,R3,#1
    ADD R2,R2,#-1
    BR LOOP2
DONE2
    ADD R1,R1,#-1
    BR LOOP1
DONE1
    ST R3, RESULT
    HALT

RESULT  .BLKW #1
ZERO     .FILL x0000
X       .FILL x0005
Y       .FILL x0800

.END
```

The headings in the table should be *Symbol* followed by *Address*.

List the symbols in ascending alphabetic order.

Symbol	Address

Answer: (0.5 per Symbol)

Symbol	Address
DONE1	0x300C
DONE2	0x300A
LOOP1	0x3004
LOOP2	0x3006
RESULT	0x300E
X	0x3010
Y	0x3011
ZERO	0x300F

Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

Total Marks: 35

Question 2 [6 marks]

Write out the assembly language instructions encoded by the following six words (That is, disassemble the machine language instructions):

Note: show the binary representations and other work underneath the table.

Note: If there are offsets, like from labels, just list them like this: "*LD R1, offset:#-10*"

Note: Remember that offsets are signed, so they can be negative

Hexadecimal	Binary	Equivalent Instruction
x1DE2		
x953F		
x7203		
xF021		
x5443		
xC140		

Answer: (1pt per instruction)

Hexadecimal	Binary	Equivalent Instruction
x1DE2	0001 1101 1110 0010	ADD R6, R7, #2
x953F	1001 0101 0011 1111	NOT R2, R4
x7203	0111 0010 0000 0011	STR R1, R0, #3
xF021	1111 0000 0010 0001	OUT / trap x21
x5443	0101 0100 0100 0011	AND R2, R1, R3
xC140	1100 0001 0100 0000	JMP R5

Assignment 2 for COMP 2280

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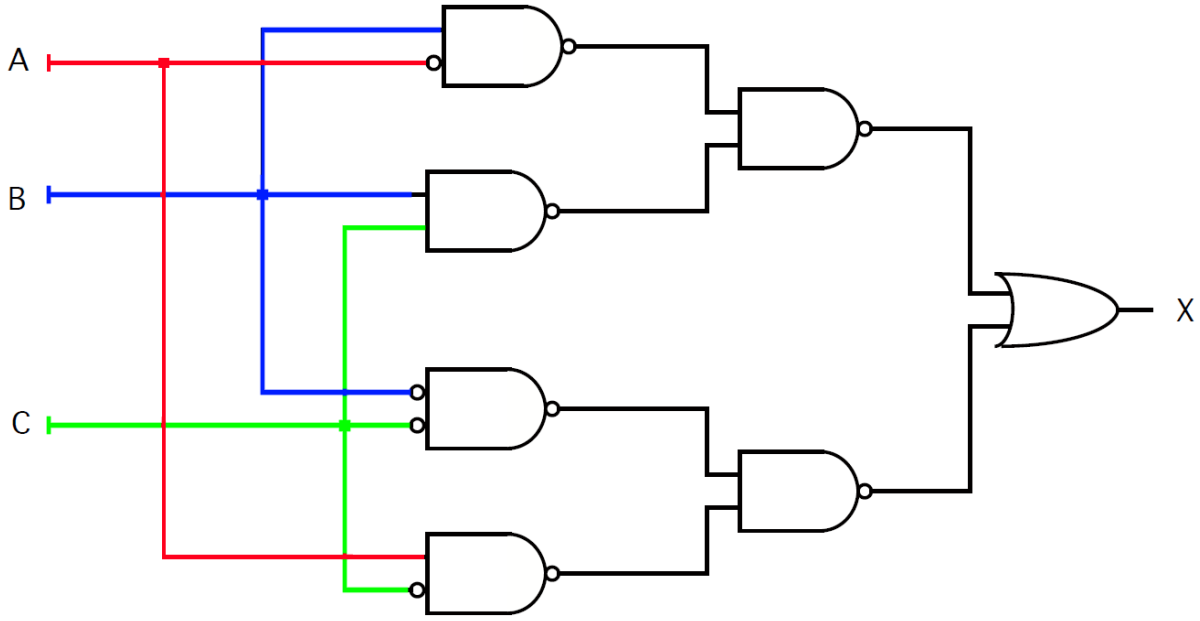
Question 3 [6 marks]

Given the truth table for the following circuit. write a **Sum of Products** expression for Z in terms of A, B, and C.

a) You can simplify the Sum of Products if you wish (not graded), but be sure to include the un-simplified expression before simplifying.
b) For reference, this Sum of Products can be simplified to a Sum of two Products.



Truth Table:

A	B	C	X	Minterms

Sum of Products Expression:

Simplified:

Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

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Marking:

- **Truth table: 4 marks, deduct ½ mark for each error in the truth table.**
- **Un-simplified Sum of Products expression: 2 mark, deduct ½ mark for each error in the expression.**

Truth Table:

A	B	C	X	Minterms
0	0	0	1	A'B'C'
0	0	1	0	A'B'C
0	1	0	1	A'BC'
0	1	1	1	A'BC
1	0	0	1	AB'C'
1	0	1	0	AB'C
1	1	0	1	ABC'
1	1	1	1	ABC

Sum of Products Expression: Z = A'B'C' + A'BC' + A'BC + AB'C' + ABC' + ABC

Simplified (ungraded):

= (A'B'C' + A'BC' + A'BC) + (AB'C' + ABC' + ABC) – T7 associativity
= A'(B'C' + BC' + BC) + A(B'C' + BC' + BC) – T8 Distributivity
= (B'C' + BC' + BC) – T10 Combining
= (B'C' + BC' + BC' + BC) – T3 Reverse Idempotency
= (B'C' + BC') + (BC' + BC) – T7 Associativity
= C'(B'+B) + B(C'+C) – T8 Distributivity
= C'(1) + B(1) – T5 Complements
= C' + B – T1 Identity

Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

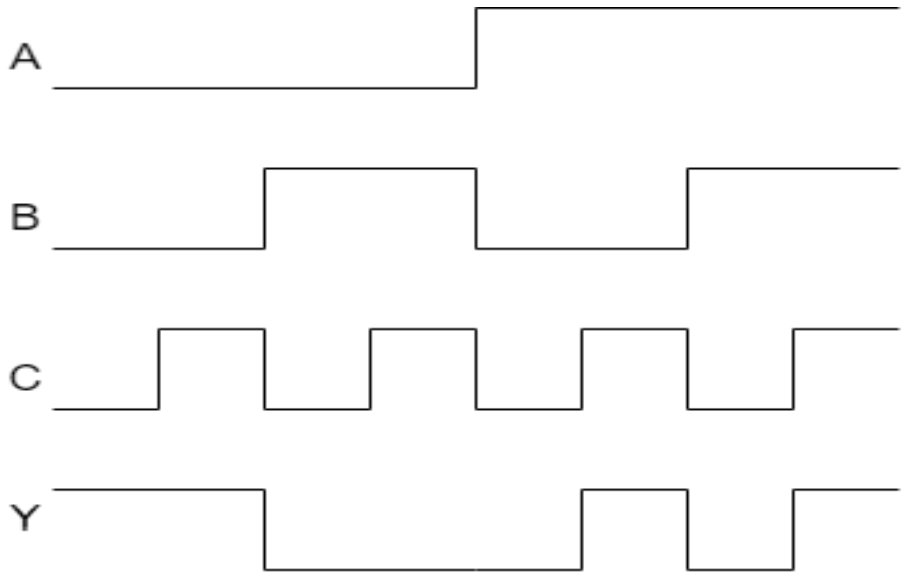
Total Marks: 35

Question 4 [4 marks]

Give a timing diagram for the truth table below, running through all possible inputs starting from ABC=000 and ending in ABC=111.

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

½ mark off for each wrong timing over the inputs 000 to 111.



Assignment 2 for COMP 2280
Due: 11:30 PM on Wednesday March 9th, 2022
Total Marks: 35

Question 5 [5 marks]
An art gallery has 3 three wings (call them wings 1, 2, 3) that contain very important collections.

- Each of these wings has a sensor. Let the three sensors be denoted w0,w1,w2 (for wings 1, 2 and 3, respectively) with binary output values (0 or 1).
- A sensor outputs 1 if and only if motion is detected in that room.
- At night, the only person in the art gallery is one security guard who walks from room to room.
- Design a circuit that sounds an alarm by setting the output (denoted by Z) to 1 if motion is detected in **more than** one wing at a time, meaning there must be intruders in the art gallery.

Give the truth table that characterizes this circuit and give an SOP implementation using a decoder and one or more OR gates to implement your circuit.

W0	W1	W2	Z

2 Marks for the symbol table taking off ½ mark for each wrong row in table.
3 marks for the circuit. 1 mark for using a decoder, 1 mark for the correct inputs into decoder, and one mark for the correct OR gate.

W0	W1	W2	Z
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

Total Marks: 35

The output is 1 if and only if at least two sensors are activated. So, the sensor will detect situations where the security guard is in one wing and one or more robbers are in another wing. Here is a circuit for this truth table.

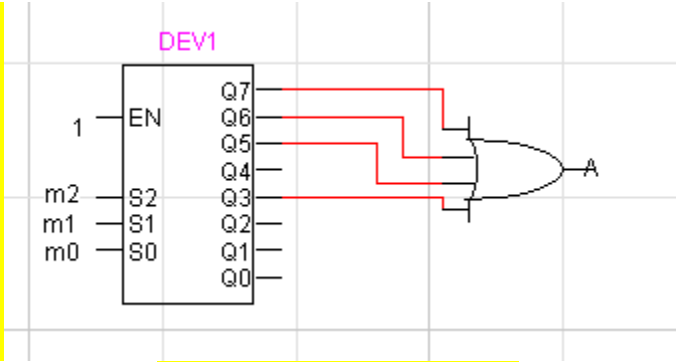


Figure 1 - Circuit for Q4a

Assignment 2 for COMP 2280
Due: 11:30 PM on Wednesday March 9th, 2022
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Programming Part

Question 6 [10 marks]

Write an LC-3 assembly language program that does the following:

1. Display the prompt "***Enter a character:*** "
    a. Note: The prompt "***Enter a character:*** " should be printed in each iteration of the loop detailed below
2. Reads in values from the keyboard using GETC (Trap x20)
3. The program will loop and process characters as detailed below until the user enters CTRL-D (x04).
    a. CTRL-D is the EoT character, which means "End of Transmission"
    b. You may have used in when working with the UNIX Terminal
    c. Once the character entered is EoT, the program will terminate.
4. Inside the loop, display the character to the console window using OUT (Trap x21).
5. Inside the loop, your program will compute and print the number of times the pattern '10' occurs in the ASCII code of that character.
6. Display a termination message that includes your name before halting the program.

A sample run of the program is shown below.

```
Enter a character: A
Number of 10s: 1
Enter a character: Z
Number of 10s: 3
Enter a character: z
Number of 10s: 2
Enter a character: 1
Number of 10s: 1
Enter a character: 2
Number of 10s: 2
Enter a character:
Programmed by Stew Dent
End of processing.
```

Note: The ASCII code for 'A' is 01000001_2

Note: The ASCII code for 'Z' is 01011010_2

Note: The sentinel value EoT was entered but not displayed

Marking:

- **5 marks for a working program. If you program doesn't work, you will not get any of these 5 marks.**

Regardless of whether program works or not, you will get:

- **1 mark for providing a register dictionary and adequate comments.**

Assignment 2 for COMP 2280

Due: 11:30 PM on Wednesday March 9th, 2022

Total Marks: 35

- **1 mark for code for correctly checking sentinel**
- **1 mark for correctly setting up looping**
- **1 mark for correctly checking value of current bit.**
- **1 mark for correctly code for printing answer**