

## EECE 2322 – Embedded Design, Enabling Robotics

## Homework #1

Assigned Wednesday, Sept. 4, 2024. Due: Monday, Sept. 16 by 11:59pm on Canvas

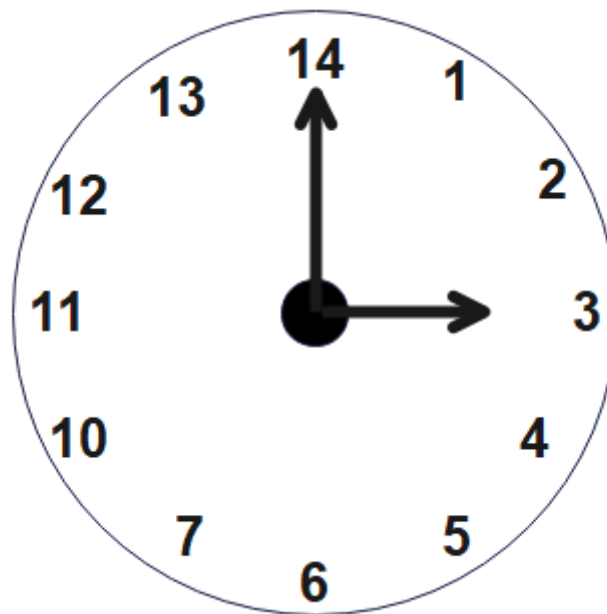
4 Problems, 100 points Total

*Show your work!*

**Problem 1** (8 points)

The Mars rover Perseverance just discovered an ancient clock partially sticking out of the sand near its landing site – definitive proof that a technologically advanced civilization once existed on the Red Planet. Scientists have concluded that it is a 12-hour clock remarkably similar to clocks on Earth. The clock is shown in the figure below with the clock hands in the position corresponding to 3 o'clock on an Earth clock.

Question for you to answer: From the numbers on the clock determine how many fingers were on each hand of the ancient Martians. (Other evidence showed that they possessed two arms with hands at the ends of each arm).



The ancient Martians have four fingers on each hand. They use a base eight system which suggests that they have eight total fingers.

**Problem 2** (32 points total, 8 points each)

Translate each pair of numbers into 8-bit two's complement binary numbers and add them. The sum will be an 8-bit two's complement number. Indicate:

- Whether or not the answer is correct
- If a carry occurred
- If an overflow occurred

a.  $44 + 8$

b.  $20 + -70$

c.  $50 + 86$

d.  $0xA0 + 0xBE$

A.  $44 \Rightarrow 00101100$   $8 \Rightarrow 00001000$   
 $\text{comp} \Rightarrow 11010011$   $\text{comp} \Rightarrow 11110111$   

$$\begin{array}{r} 11010011 \\ + \quad 1 \\ \hline 11010100 \end{array}$$
  

$$\begin{array}{r} 11010100 \\ + 11110111 \\ \hline 11001100 \end{array}$$
  

$$\begin{array}{r} 44 \\ + 8 \\ \hline 52 \end{array} \Rightarrow \begin{array}{r} 11010100 \\ + 11110111 \\ \hline 11001100 \end{array} \Rightarrow \begin{array}{r} 00011001 \\ + 1 \\ \hline 00110100 \end{array} = 52$$
  
 i. Answer is correct.  
 ii. A carry occurred.  
 iii. An overflow didn't occur.

B.  $20 \Rightarrow 00010100$   $\text{Two's comp of } -70 \Rightarrow 01000110$   
 $\text{comp} \Rightarrow 11101011$   

$$\begin{array}{r} 11101011 \\ + \quad 1 \\ \hline 11101100 \end{array}$$
  

$$\begin{array}{r} 01000110 \\ + 11101100 \\ \hline 10011010 \end{array} = -50$$
  
 i. yes the answer is correct  
 ii. a carry occurred  
 iii. an overflow didn't occur

C.  $50 \Rightarrow 00110010$   $86 \Rightarrow 01010110$   
 $\text{comp} \Rightarrow 11001101$   $\text{comp} \Rightarrow 10101001$   

$$\begin{array}{r} 11001101 \\ + \quad 1 \\ \hline 11001110 \end{array}$$
  

$$\begin{array}{r} 11001110 \\ + 10101001 \\ \hline 10111000 \end{array} \Rightarrow \begin{array}{r} 01000111 \\ + \quad 1 \\ \hline 01001000 \end{array} = 136$$
  
 i. the answer is correct  
 ii. a carry did occur.  
 iii. an overflow did not occur

D.  $A0 = 160 \Rightarrow 10100000$   $BE = 190 \Rightarrow 10111110$   
 $\text{comp} \Rightarrow 01011111$   $\text{comp} \Rightarrow 01000001$   

$$\begin{array}{r} 01011111 \\ + \quad 1 \\ \hline 01100000 \end{array}$$
  

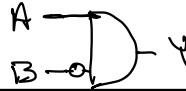
$$\begin{array}{r} 01100000 \\ + 01000001 \\ \hline 10100000 \end{array} \Rightarrow \begin{array}{r} 01011101 \\ + \quad 1 \\ \hline 01011110 \end{array} = 94$$
  
 i. the answer is not correct  
 ii. a carry did occur  
 iii. an overflow didn't occur

**Problem 3** (30 points, 10 points each)

Simplify each of the following Boolean equations (4 points). State the theorem(s) and axiom(s) used for each step of the simplification (3 points). Sketch a combinational logic circuit from each simplified equation (3 points).

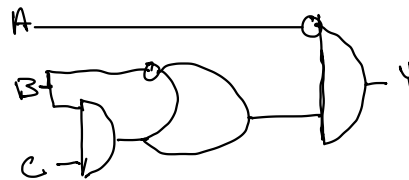
a.  $Y = A\bar{B}C + A\bar{B}\bar{C}$

A. 
$$\begin{aligned} Y &= A\bar{B}C + A\bar{B}\bar{C} \\ &= A\bar{B}(C + \bar{C}) \quad \text{Dist. theorem} \\ &= A\bar{B}(1) \quad \text{Complements law} \\ &= A\bar{B} \quad \text{Identity theorem} \end{aligned}$$



b.  $Y = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C}$

B. 
$$\begin{aligned} Y &= \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C} \\ &= \bar{A}(\bar{B}\bar{C} + \bar{B}C + B\bar{C}) \quad \text{Dist. theorem} \\ &= \bar{A}(\bar{B}(\bar{C} + C) + B\bar{C}) \quad \text{Dist. theorem} \\ &= \bar{A}(\bar{B}(1) + B\bar{C}) \quad \text{Comp. Dual} \\ &= \bar{A}(\bar{B} + B\bar{C}) \quad \text{Identity theorem} \end{aligned}$$



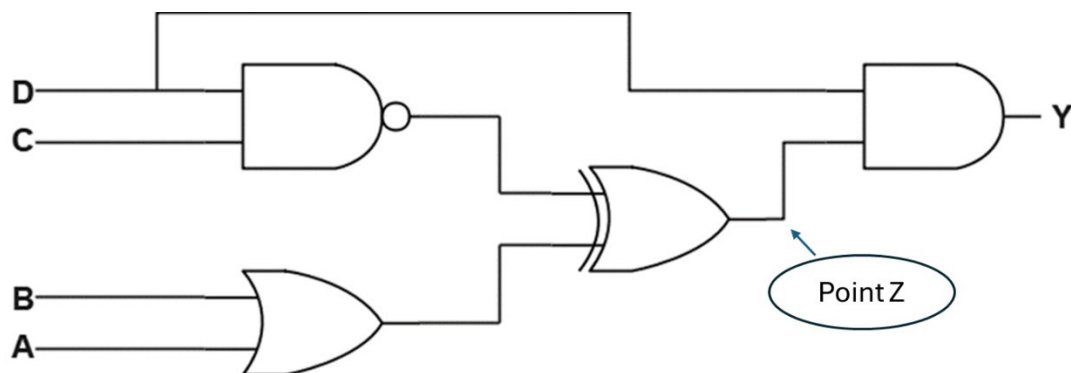
c.  $Y = \overline{(AB)} + A + B + C$

C. 
$$\begin{aligned} Y &= \overline{(AB)} + A + B + C \\ Y &= \bar{A} + \bar{B} + A + B + C \quad \text{Bubble Pushing} \\ &= 1 + 1 + C \quad \text{Ann. or Dual} \\ &= 1 \quad \text{Null Element Dual} \end{aligned}$$

$1 - Y$

**Problem 4** (30 points)

What is the output **Y** and the logic state at point **Z** of this circuit for each of the given inputs (A, B, C, and D).



Inputs				Point	Output
A	B	C	D	Z	Y
0	0	0	0	↓	0
0	1	1	1	↓	↓
0	0	1	0	↓	0
1	0	1	1	↓	↓