University of Delaware
CISC260 Homework 2 Solution

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1 Notation

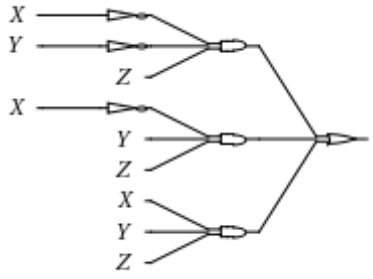
Here, let me use the following notations for logic:
$\bar{X}$: NOT X .
$X + Y$: X or Y.
$X * Y$: X and Y.

2 Question 1.

[25 points] Given the following truth table, where X, Y, and Z are input and W is output, write the canonical expression and generate gate-level logical circuit.

X	Y	Z	W
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Answer: $W = \bar{X} * \bar{Y} * Z + \bar{X} * Y * Z + X * Y * Z$ The circuit is shown as following.



3 Question 2.

[25 points] Write the Boolean expression and fill out the truth table for following logical circuit.

Answer
The expression is:
$F = A * (B + \bar{C}) + B * (C + \bar{D}) + BD$
The truth table is:

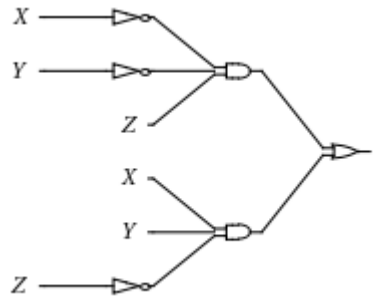
A	B	C	D	E	F
0	0	0	0		0
0	0	0	1		0
0	0	1	0		0
0	0	1	1		0
0	1	0	0		1
0	1	0	1		1
0	1	1	0		1
0	1	1	1		1
1	0	0	0		1
1	0	0	1		1
1	0	1	0		0
1	0	1	1		0
1	1	0	0		1
1	1	0	1		1
1	1	1	0		1
1	1	1	1		1

4 Question 3.

[25 points] You are asked to design a circuit to detect if an overflow occurs when adding two integers represented in two's complement: Z= X + Y. Let Sz, Sx, and Sy be the sign bit for Z, X, and Y respectively, and they are fed as input to the circuit. Let O be the output bit of the circuit, whose value is 1 if an overflow happens, and 0 if otherwise.
Answer
The truth table is:

Sx	Sy	Sz	O
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

From the above truth table, the expression is:
$O = \bar{Sx} * \bar{Sy} * Sz + Sx * Sy * \bar{Sz}$
Then, from the expression, the circuit is the following:



5 Question 4.

[25 points] Prove that NOR gate is universal, by showing how AND, OR, and NOT gates can be built by wiring a bunch of NOR gates. Draw the wire diagram for each case.

Answer

NOR to NOT:
$NOT(x) = (\bar{x}) = \overline{(x + x)} = NOR(x, x)$

NOR to OR:
$OR(x, y) = x + y = NOT(\overline{(x + y)}) = NOR(NOR(x, y), NOR(x, y))$

NOR to AND:
$AND(x, y) = x * y = NOT(\bar{x} + \bar{y}) = NOR(NOR(x, x), NOR(y, y))$
Then, Wire diagram is trivial.