

CPS 104

Homework 4

Due: October 26 in class.

1. (10 pts.) Construct the truth table for the Boolean function:

$$F(A,B,C) = A*(\sim B + C*B) + C*\sim B.$$

2. (10 pts.) Draw a circuit diagram for a digital circuit that realizes the function **F(A,B,C)** of question number 1.

3. (30 pts.) Show that the **NAND(A, B)** (**NOT-AND**) and **NOR(A, B)** (**NOT-OR**) functions are universal, that is any other Boolean function can be constructed only with the **NAND** function, or only with the **NOR** function.

Hints:

a. We know that one only needs the functions **AND(A, B)**, **OR(A, B)** and **NOT(A)** to construct any Boolean function. So, construct these functions using only the **NAND** function, or only the **NOR** function.

b. Use De Morgan laws: $\sim(A*B) = \sim A + \sim B$ $\sim(A+B) = \sim A * \sim B$

4. (30 pts.) A 2 to 1 multiplexor (2-1 MUX) is a circuit with two inputs **A** and **B**, one output **Q** and one control input **S**. If **S** = 0 output of the multiplexor **Q** is equal to the value of **A**, otherwise **Q** is equal to the value of **B**.

a. Write down the truth table for the 2-1 MUX.

b. Design a digital circuit for the 2-1 MUX using **AND**, **OR** and **NOT** gates.

c. A 2^n to 1 MUX is a circuit with 2^n inputs n control lines and one output. By setting the n control lines to one of the possible 2^n binary values the output of the MUX is equal to the unique input associated with that binary value. Show that any 2^n to 1 MUX can be implemented using 2^n-1 (2 to 1) MUXs.

Hint : Use induction.

5. (20 pts.) You are given an 8 to 1 MUX and you are asked to implement the following Boolean function **Q**:

A	B	C	Q
0	0	0	1
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	0

Explain how it can be done. You can connect any input to a logical high (**V_{cc}**) or a logical low (**GND**).

6. (Extra credit)

a: (20 pts) Show how you can implement the above function using only a 4 to 1 MUX and an inverter.

b: (25 pts) Explain how any Boolean function of three variables can be implemented with at most one 4-1 MUX, an inverter, **Vcc** (5V, logical high, 1) and **GND** (0V, logical low, 0).