# CS2100 Computer Organization
**AY2023/24 Semester 2**
**Assignment 3**
**(Deadline: 8 April 2024, Monday, 1pm)**

## Instructions

1. There are NINE (9) questions in this assignment, totaling TWENTY (20) marks.

2. This assignment is due on **Monday, 8 April 2024, 1 pm.** The submission folder will be closed at 1:10 pm, **after which no submission will be accepted and you will receive ZERO for this assignment.**

3. Answer these questions on Canvas → Assignments.

4. You should do these assignments on your own. Do not discuss the assignment questions with others.

5. Please post on QnA "Assignments" topic if you have any queries.

**Note that unless otherwise stated, complemented literals are not available. Constants 1 (true) and 0 (false) are always available. This instruction applies to the final exam and it may not be repeated there.**

**Question 1.** (2 marks)

The diagram below shows a 2×4 decoder with one-enable and active-high outputs. Fill in the list of minterms for *F1(A,B,C,D)* in the $\Sigma m$ **notation** (sum-of-minterms), i.e. *F1(A,B,C,D)* = $\Sigma m(...)$.
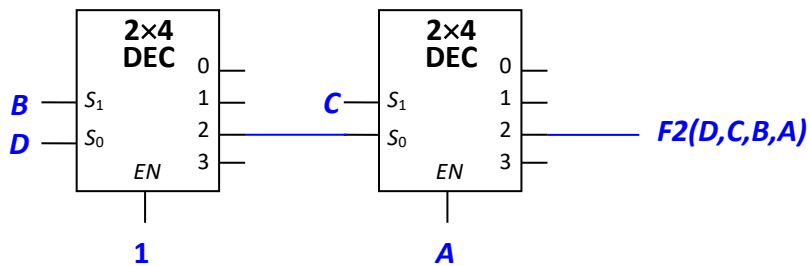
For example, if the answer is $\Sigma m(1, 3, 6)$, enter **1,3,6** (in increasing order of the minterm numbers, separated by comma, no other punctuation besides commas, and without any space). Pay attention to the order of the variables in the given function.

**2×4 DEC** — $S_1$, $S_0$, EN; outputs 0, 1, 2, 3. Inputs A, B (OR gate), C, D (NAND gate). Output F1(A,B,C,D).
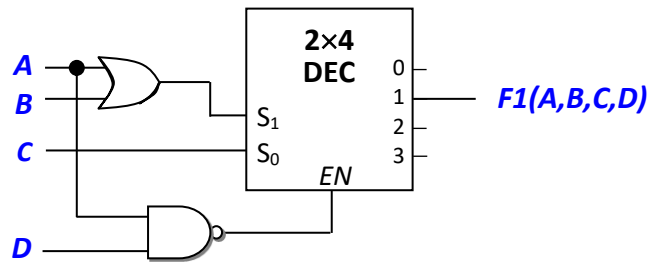
**Question 2.** (2 marks)

The diagram below shows a 2×4 decoder with one-enable and active-high outputs. Fill in the list of minterms for *F2(D,C,B,A)* in the $\Sigma m$ **notation** (sum-of-minterms), i.e. *F2(D,C,B,A)* = $\Sigma m(...)$.
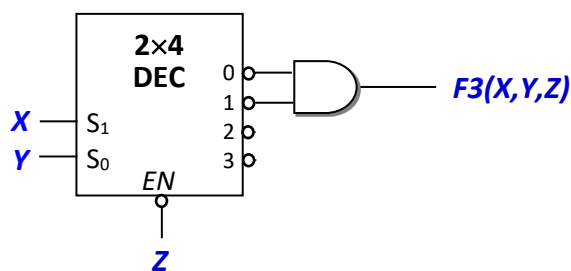
For example, if the answer is $\Sigma m(1, 3, 6)$, enter **1,3,6** (in increasing order of the minterm numbers, separated by comma, no other punctuation besides commas, and without any space). Pay attention to the order of the variables in the given function.

First **2×4 DEC**: inputs B ($S_1$), D ($S_0$), EN = 1; outputs 0, 1, 2, 3. Output 2 connects to second decoder.
Second **2×4 DEC**: inputs C ($S_1$), $S_0$, EN = A; outputs 0, 1, 2, 3. Output 2 = F2(D,C,B,A).

**Question 3.** (2 marks)

The diagram below shows a 2×4 decoder with zero-enable and active-low outputs. Fill in the list of minterms for *F3(X,Y,Z)* in the $\Sigma m$ **notation** (sum-of-minterms), i.e. *F3(X,Y,Z)* = $\Sigma m(...)$.

For example, if the answer is $\Sigma m(1, 3, 6)$, enter **1,3,6** (in increasing order of the minterm numbers, separated by comma, no other punctuation besides commas, and without any space). Pay attention to the order of the variables in the given function.

**2×4 DEC**: inputs X ($S_1$), Y ($S_0$), EN = Z; active-low outputs 0, 1, 2, 3. Outputs 0 and 1 feed an AND gate producing F3(X,Y,Z).

# Question 4. (2 marks)

The diagram below shows a 4:1 multiplexer. Fill in the list of maxterms for *F4(A,B,C)* in the $\Pi M$ **notation** (product-of-maxterms), i.e. *F4(A,B,C)* = $\Pi M(\dots)$.

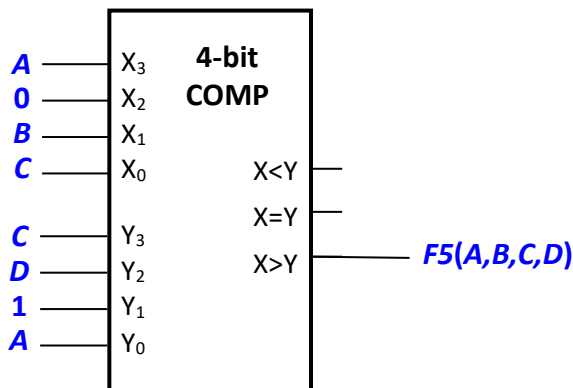For example, if the answer is $\Pi M(2,5,7)$, enter **2,5,7** (in increasing order of the maxterm numbers, separated by comma, no other punctuation besides commas, and without any space). Pay attention to the order of the variables in the given function.
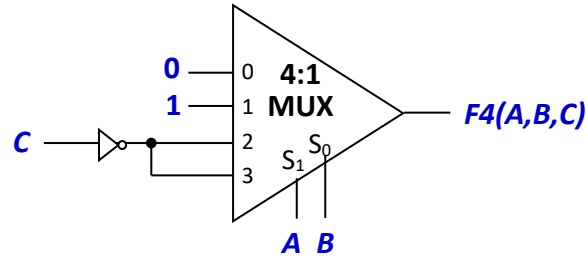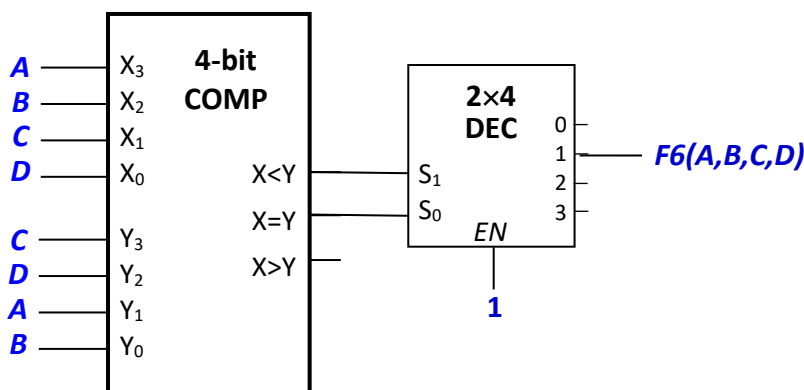


# Question 5. (2 marks)

The diagram below shows a 4-bit magnitude comparator. What is the simplified SOP expression of *F5(A,B,C,D)*?

If your product term contains more than one literal, you must have the dot (AND) symbol, or your answer will be considered wrong. Within a product term, the literals should be in alphabetical order. Literals should be in upper-case letters, and there should be no space and no symbols other than the dot, plus and single quote in your answer.



# Question 6. (2 marks)

The diagram below shows a 4-bit magnitude comparator and a 2×4 decoder with 1-enable and active-high outputs. What is *F6(A,B,C,D)* in $\Sigma m$ **notation** (sum-of-minterms)? List out the minterms. For example, if the answer is $\Sigma m(1,3,6)$, enter **1,3,6** (in increasing order of the minterm numbers, separated by comma, no other punctuation besides commas, and without any space).
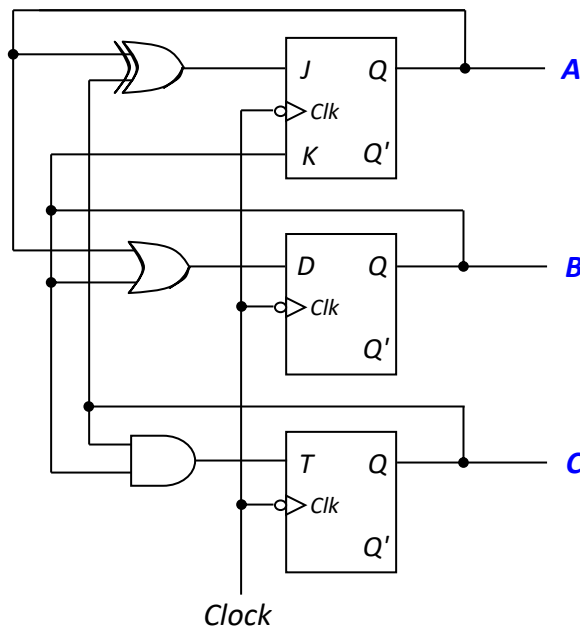
## Question 7. (2 marks)

The diagram below shows the 74LS83 chip (4-bit parallel adder). Suppose *AB* is a 2-bit unsigned binary number, how is the output *UVWXYZ* related to *AB*?
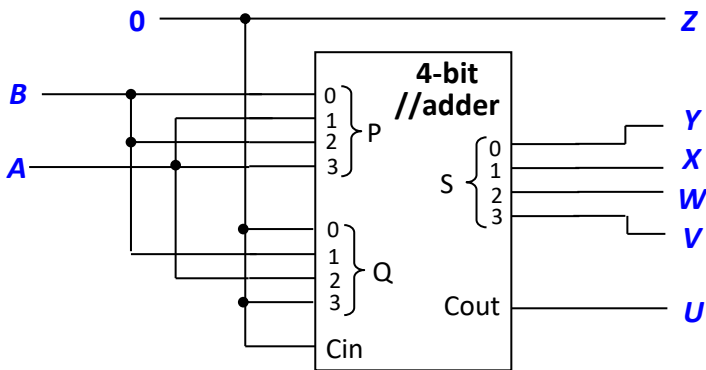


## Question 8. (Total: 3 marks)

A sequential circuit with state *ABC* is shown below.



**All answers should be in decimal, not binary.**

(a) If the initial state is 0 (*ABC* = 000), what state is the circuit in after 2 clock cycles?          [1 mark]

(b) If the initial state is 1 (*ABC* = 001), what state is the circuit in after 2 clock cycles?          [1 mark]

(c) Identify all the sink states in this circuit. If there are more than one sink state, write them in ascending order, separated by comma, without any space. There should be no punctuation other than comma.          [1 mark]

**Question 9.** (Total: 3 marks)

A sequential circuit goes through the following states, whose state values are shown in decimal:
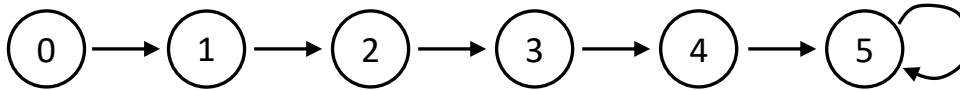


The states are represented by 3-bit values *ABC*. Implement the sequential circuit using a *JK* flip-flop for *A*, a *T* flip-flop for *B*, and a *D* flip-flop for *C*.

Write the simplified SOP expression for each of the following flip-flop inputs. For each product term in your SOP expression, write the literals in alphabetical order. Literals should be in upper-case letters, and there should be no space and no symbols other than the dot, plus and single quote in your answer.

(a) Flip-flop input *JA*.                                                                                         [1 mark]

(b) Flip-flop input *TB*.                                                                                         [1 mark]

(c) Flip-flop input *DC*.                                                                                         [1 mark]

**=== END OF PAPER ===**