# OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

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**Second Science**

**CS2502: Logic Design**

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Answer all questions.

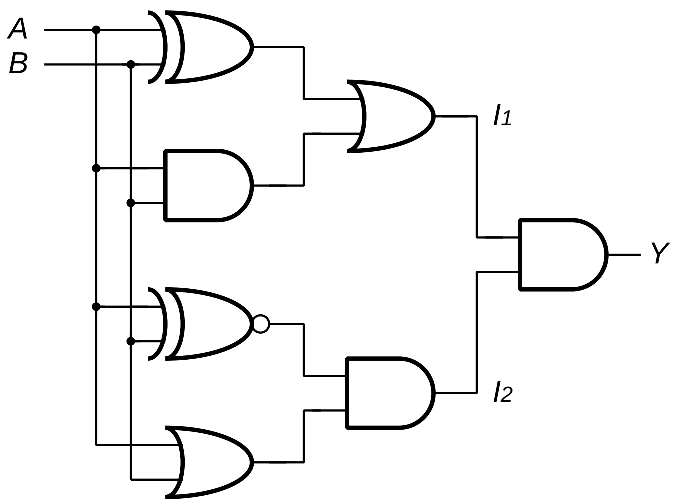
90 minutes

1. Recall the two canonical forms for switching functions, i.e. the *canonical sum of products* (CSOP) and the *canonical product of sums* (CPOS). These questions deal with general properties of these two forms and their components.

   a) Consider some switching function $f$ about which only the following is known: Its notation in CPOS form is shorter than its notation in CSOP form (i.e. the CPOS contains fewer literals).
   Which general conclusion about $f$ can be made from the assertion above?
   Hint: Consider the truth table of $f$. (*3 marks*)

   b) Recall that *minterms* as well as *simplified products* are both *AND-combinations* of direct or inverted input variables.
   Explain the general difference between these two expressions. (*3 marks*)

2. Consider the combinational circuit given in the diagram below. The circuit contains *AND*, *OR*, *XOR* and *Equivalence* (inverted XOR) gates.




   a) Determine the shortest notation of the switching function $Y = f(A, B)$ of this circuit.
   Hint: It is helpful if you first develop short notations for the two intermediate signals $I_1$ and $I_2$. (*4 marks*)

   b) Could a circuit as shown in the diagram above ever be a part of a real technical device? Justify your answer. (*2 marks*)

3. Recall that a typical *majority decoder* is a combinational circuit with an *odd number of inputs*. The single output $Y$ always follows the *predominant input value*, i.e. $Y$ assumes that value (0 or 1) that occurs on *more than half* of all input lines.

   In this question, however, we consider a majority decoder with *4 inputs* $A, B, C, D$ and one output $Y = f(A, B, C, D)$. As usual, $Y$ should follow the predominant input value, if there is any. In case of a tie, i.e. if two input lines assume 1 and two input lines assume 0, we *do not care* which value the output $Y$ assumes.

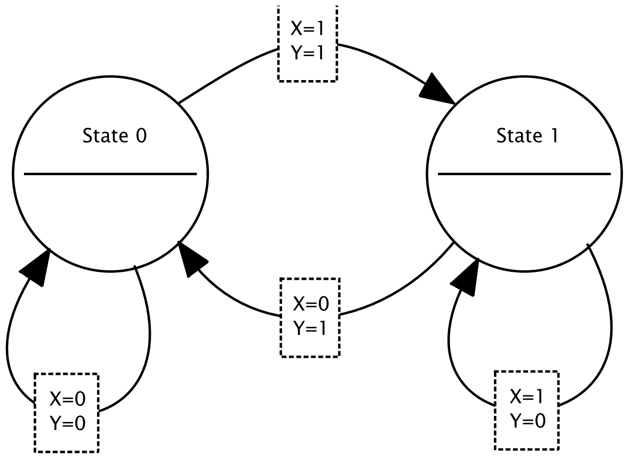
   a) Use the a Karnaugh-map to develop an optimal SSOP form (*simplified sum of products*) of $f$. There are several correct solutions. (*3 marks*)

   b) Use the a Karnaugh-map to develop an optimal SPOS form (*simplified product of sums*) of $f$. There are several correct solutions. (*3 marks*)

   c) Develop a circuit diagram of an implementation of $f$ that contains a *minimum number of NOR gates* and no other gates. (*3 marks*)

   d) Develop a circuit diagram of an implementation of $f$ that contains a *minimum number of NAND gates* and no other gates. (*3 marks*)

4. The following questions deal with the properties of a *sequential circuit* with one binary input $X$, one binary output $Y$ and two possible internal states. The state diagram of this circuit is given below.




a) Develop all necessary tables that completely describe this sequential circuit. (*4 marks*)

b) Describe the input/output behavior of this circuit in your own words. Do not use more than 3 sentences. (*4 marks*)

c) Is it possible that the output remains constantly at $Y = 0$ regardless of the clock pulses? If so, which sequence of input values $X$ causes this behavior?. (*3 marks*)

d) Is it possible that the output remains constantly at $Y = 1$ regardless of the clock pulses? If so, which sequence of input values $X$ causes this behavior?. (*3 marks*)

e) How many flip-flop circuits are needed in a implementation of this circuit? (*2 marks*)