MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 305: DIGITAL ELECTRONICS I

DATE: **TIME:**

INSTRUCTIONS

1. *This paper contains 5 questions.*
2. *Attempt **Question One** and **Any Other Two questions***
3. *Show calculations where applicable*

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Perform the following operation using 9's complement subtraction: $52_{10} - 89_{10}$ (3 marks)

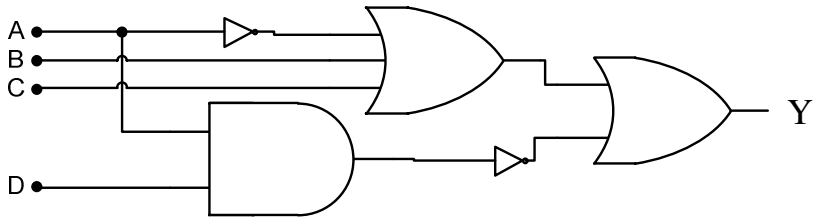
b) Simplify the following expression using Boolean algebra laws and rules and implement the simplified expression using logic gates.

$$F = xy + xyz + xy\bar{z} + \bar{x}yz$$ (5 marks)

c) A 4-bit binary number is applied to a circuit on four lines A, B, C, D. The circuit has a single output, F, which is true if the number is in the range three to twelve, inclusive.
   (i) Draw a truth table to represent the problem (3 marks)
   (ii) Use the K-map to obtain a simplified expression for the function (4 marks)
   (iii) Construct a circuit to implement the simplified expression in (ii) above using NAND gate only. (3 marks)

d) Draw a circuit diagram and a truth table of a J-K flip-flop and explain its operation. (6 marks)

e) Write the Boolean expression for output Y for logic circuit shown in the figure below and draw its truth table. (6 marks)



QUESTION TWO (20 MARKS)

a) Simplify the following expression function using Quine-McCluskey method and implement the minimum expression using only NOR gates.

$$f(A,B,C,D)=\prod_{M}(2,7,8,9,10,12)$$ (10 marks)

b) Construct the logic circuits that can implement the Boolean expressions:

$$y=\overline{\left(\overline{\overline{A\overline{B}}+\overline{C\oplus D}}\right)\left(\overline{A+\overline{B}+C}\right)}$$ (4 marks)

c) State and explain three advantages of a multiplexer. (3 marks)

d) Convert 871.84375_{10} to its binary equivalent: (3 marks)

QUESTION THREE (20 MARKS)

a) Design a full-subtractor and implement it using basic logic gates and an EX-OR gate. (11 marks)

b) Use 1's complement to perform the following operation:

$$12\frac{1}{2}_{10}-22\frac{3}{4}_{10}$$ (4 marks)

c) Perform the following operations using BCD addition:

$$257_8+AE_{16}+10111011.11_2$$ (5 marks)

QUESTION FOUR (20 MARKS)

a) Using a truth table, K-map, and logic expressions, design a full adder. (7 marks)

b) Minimize the Boolean function given below using a K-map and implement the minimized expression using logic gates. (7 marks)

$$f(A,B,C,D)=\sum(1,\ 2,6,7,8,13,14,15)+\sum_{x}(3,5,12)$$

c) With the aid of logic symbols and truth tables, explain the operation of the following two-input gates.
   (i) NOR
   (ii) XOR (6 marks)

QUESTION FIVE (20 MARKS)

a) Find the canonical sum of products (SOP) and product of sums (POS) form for the expression given below (6 marks)

$$f(A,B,C) = AB + \bar{A}\bar{B} + AC + \bar{A}\bar{C}$$

b) Using appropriate truth table and Boolean expressions design and implement a 1:4 demultiplexer (7 marks)

c) Prove the following identity using Boolean algebra and De Morgan's theorems:

$$AB + \overline{AC} + A\bar{B}C(AB + C) = 1$$

(3 marks)

d) Perform $22_{10} - 54_{10}$ using 10's complement method. (4 marks)