Instructions:
- ALLOWED: pens and drawing tools (no red color).
- NOT ALLOWED: Papers, calculators, literatures and any handouts. Otherwise, it will lead to the non-approval of your examination.
- Shut down Telephones, and other communication devices.

Please note:
- This exam paper contains 6 questions totaling 40 marks
- Write your name and your matriculation number on every page of the solution sheets.
- All solutions together with solution methods (explanatory statement) must be inserted in the labelled position on the solution sheets.
- You can submit your exam after the first hour.

Basic notions: The aims of the questions in this part are to evaluate the required minimal student knowledge and skills. Answers in the pass category represent the minimum understanding of basic concepts: Digital Systems, Binary Number Systems, Boolean Algebra, Basic Logic Gates, Boolean Expression Simplification, Karnaugh Maps, Combinational and Sequential Circuits.

Question 1  Multiple Choice  (10 marks)

Identify the choice that best completes the statement or answers the question.

1) The binary number 11101011000111010 can be written in hexadecimal as ________.
   a) DD63A_{16}  
   b) 1D63A_{16}  
   c) 1D631_{16}  
   d) 1D33A_{16}

2) Refer to the following figure. If A = 0 and B = 1, what will be the logic states at X, Y and Z?

   ![Logic Circuit Diagram]

   a) X=1, Y=1, Z=0  
   b) X=1, Y=0, Z=0  
   c) X=0, Y=0, Z=1  
   d) X=0, Y=1, Z=0

3) The simplification of the Boolean expression \( \bar{A}BC + A\bar{B}C \) is
   a) 0  
   b) 1  
   c) A  
   d) BC

4) The equivalent canonical (standard) form for the following logical expression \( F = AB + \bar{C} \) is
   a) \( F = ABC + \bar{ABC} + \bar{ABC} + \bar{ABC} \)  
   b) \( F = ABC + \bar{ABC} + \bar{ABC} + \bar{ABC} \)  
   c) \( F = ABC + \bar{ABC} + \bar{ABC} + \bar{ABC} + \bar{ABC} \)  
   d) None of the above
5) The function \( F(A, B, C) = \sum(1, 2, 3, 5, 7) \) is equivalent to
   a) \( C + \overline{AB} \) b) \( C + AB \)
   c) \( C + \overline{A} \overline{B} \) d) \( C + A\overline{B} \)

6) Which of the following circuits come under the class of combinational logic circuits?
   1. Full adder 2. Full subtracter

   Select the correct answer from the codes given below:
   a) 1 only b) 3 and 4
c) 4 and 5 d) 1, 2, and 3

7) The Boolean function realized by the logic circuit shown is

   ![Logic Circuit Diagram]

   a) \( F = \sum m(0, 1, 3, 5, 9, 10, 14) \) b) \( F = \sum m(2, 3, 5, 7, 8, 12, 13) \)
c) \( F = \sum m(1, 2, 4, 5, 11, 14, 15) \) d) \( F = \sum m(2, 3, 5, 7, 8, 9, 12) \)

8) The circuit shown here is most likely a ________.

   ![Circuit Diagram]

   a) Adder b) Multiplexer
c) Demultiplexer d) Parity generator

9) If the input combination \( A=0, B=1 \) is applied to this circuit, the (steady state) output will be:

   ![Logic Circuit Diagram]

   a) \( X=0, Y=0 \) b) \( X=0, Y=1 \)
c) \( X=1, Y=0 \) d) \( X=1, Y=1 \)

10) The characteristic equation for the T-Flip Flop is:
    a) \( Q(t + 1) = T \overline{Q} + \overline{T}Q \) b) \( Q(t + 1) = \overline{T} \overline{Q} + TQ \)
Familiar and Unfamiliar Problems Solving: The aim of the questions in this part is to evaluate that the student has some basic knowledge of the key aspects of the lecture material and can attempt to solve familiar and unfamiliar problems of Combinational and Sequential Circuits and Analysis of Sequential Circuits.

**Question 2**

a) List three weighted Binary codes. (1.5 marks)

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b) For the following logic circuit, find $D = f(A, B, C)$, that is, express the output $D$ in terms of the inputs $A$, $B$ and $C$, simplify the Boolean expression obtained, and draw the circuit. (2.5 marks)

![Logic Circuit Diagram]

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c) Express the function in a sum of minterms form. (2 marks)

$D = f(A, B, C) = A + \overline{B}C$

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Question 3  

a) Construct the **full adder** using **two half adders** (use **XOR** gates) and one **OR** gate (you must prove your answer with the help of equations).  

\[ (4 \text{ marks}) \]

**Solution**

b) Give the **Characteristic equations** and the **Excitation tables** for the **SR** and **JK** flip-flops.  

\[ (3 \text{ marks}) \]

**Solution**
Question 4

a) A combinatorial circuit is defined by the following three Boolean functions:

\[ F_1 = (X + Z) + XYZ \]
\[ F_2 = (X + Z) + \overline{XYZ} \]
\[ F_3 = XYZ + (X + Z) \]

Design a circuit with a single decoder and external OR gates.

Solution

b) Design a 32-to-1 multiplexer using only 8-to-1 multiplexer. Use block diagram for the components.

Solution
c) Complete the **timing diagram**, showing the state of the $Q$ output over time as (SR Latch) the **Set** and **Reset** switches are actuated. Assume that $Q$ begins in the **low state**:  

![Timing Diagram](image)
Question 5 (5 marks)
A sequential circuit with two D Flip-Flops, A and B; two inputs, x and y; and one output, z, is specified by the following next-state and output equations:

\[
A(t + 1) = \overline{xy} + xA \\
B(t + 1) = \overline{x}B + xA \\
z = B
\]

a) Draw the circuit. (1.5 marks)
b) List the state table for the sequential circuit. (2 marks)
c) Draw the corresponding state diagram. (1.5 marks)

Solution
Question 6
Design a **clocked sequential** circuit that operates according to the following **state diagram** (use **JK Flip-Flops**).

**Solution**

GOOD LUCK