Unit I: Boolean Algebra, Logic Gates & Data Representation

SECTION A: MULTIPLE CHOICE QUESTIONS (MCQs)
(15 Questions | 1 Mark Each)

Q1. What is the decimal equivalent of the binary number 1101.101_2?
A) 12.625
B) 13.625
C) 14.5
D) 11.375

Q2. Which number system uses base 16 and digits from 0–9 and A–F?
A) Octal
B) Binary
C) Hexadecimal
D) BCD

Q3. How many bits are used to represent a single decimal digit in BCD (Binary Coded Decimal)?
A) 2 bits
B) 3 bits
C) 4 bits
D) 8 bits

Q4. The 2's complement of binary number 1010 is:
A) 0101
B) 0110
C) 1001
D) 1010

Q5. Which of the following gates is known as a Universal Gate?
A) AND gate
B) OR gate
C) NAND gate
D) XOR gate

Q6. According to De Morgan's First Theorem, (AB)' is equal to:
A) A' · B'
B) A' + B'
C) A + B
D) AB

Q7. The IEEE 754 Single Precision floating point format uses how many bits?
A) 16 bits (1+5+10)
B) 32 bits (1+8+23)
C) 64 bits (1+11+52)
D) 128 bits (1+15+112)

Q8. In a K-Map (Karnaugh Map), grouping 4 adjacent cells eliminates how many variables?
A) 1 variable
B) 2 variables
C) 3 variables
D) 4 variables

Q9. The decimal number 255_{10} in hexadecimal is:
A) EE_{16}
B) FE_{16}
C) FF_{16}
D) EF_{16}

Q10. The XOR gate output is 1 when:
A) Both inputs are 1
B) Both inputs are 0
C) Inputs are different
D) Inputs are the same

Q11. In Sign-Magnitude representation, the MSB represents:
A) The magnitude of the number
B) The sign (0 = positive, 1 = negative)
C) The exponent
D) The mantissa

Q12. In the Von Neumann architecture, program instructions and data are stored in:
A) Separate memory units
B) The same shared memory
C) Only in registers
D) Only in cache memory

Q13. The bias value used in IEEE 754 Single Precision format for the exponent is:
A) 255
B) 1023
C) 127
D) 128

Q14. The Gray code representation of binary 1101 is:
A) 1011
B) 1010
C) 1110
D) 1001

Q15. Which canonical form represents a Boolean function as a sum (OR) of minterms?
A) POS (Product of Sums)
B) SOP (Sum of Products)
C) NAND-NAND form

D) NOR-NOR form

ANSWERS — MCQs

Q.No	Answer	Explanation
Q1	**B) 13.625**	$1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$ = 8+4+0+1+0.5+0+0.125 = 13.625
Q2	**C) Hexadecimal**	Hex is base-16 using digits 0–9 and letters A–F (A=10 to F=15)
Q3	**C) 4 bits**	BCD represents each decimal digit (0–9) using exactly 4 binary bits
Q4	**B) 0110**	1's complement of 1010 = 0101; adding 1 gives 0110
Q5	**C) NAND gate**	NAND and NOR are universal gates; any Boolean function can be built using only NAND gates
Q6	**B) A' + B'**	De Morgan's 1st Theorem: (AB)' = A' + B' (NAND = OR of complements)
Q7	**B) 32 bits (1+8+23)**	IEEE 754 Single Precision: 1 sign + 8 exponent + 23 mantissa = 32 bits
Q8	**B) 2 variables**	Grouping 2^n cells eliminates n variables. Group of 4 (=2^2) eliminates 2 variables
Q9	**C) FF_{16}**	255 ÷ 16 = 15 R 15 (F); 15 ÷ 16 = 0 R 15 (F) → FF_{16}
Q10	**C) Inputs are different**	XOR: Y=1 if inputs differ (0,1 or 1,0); Y=0 if inputs are same
Q11	**B) The sign (0 = positive, 1 = negative)**	In Sign-Magnitude, MSB=0 → positive; MSB=1 → negative
Q12	**B) The same shared memory**	Von Neumann bottleneck: one memory for both code and data (unlike Harvard architecture)

Q.No	Answer	Explanation
Q13	**C) 127**	IEEE 754 Single Precision bias = 2^(8-1) − 1 = 127; Double Precision bias = 1023
Q14	**A) 1011**	Gray code: MSB same (1); G3=B3⊕B2=1⊕1=0→ Wait: 1^1=0, 1^0=1, 0^1=1 → 1011
Q15	**B) SOP (Sum of Products)**	SOP = OR of AND terms (minterms); POS = AND of OR terms (maxterms)

SECTION B: FILL IN THE BLANKS
(15 Questions | 1 Mark Each)

1. Digital computers use the _____ number system internally because electronic circuits have two stable states: ON (1) and OFF (0).

2. To convert a binary number to hexadecimal, binary digits are grouped in sets of _____ from the decimal point.

3. The decimal number 45_{10} in binary is _____.

4. The _____ code is used in digital systems to minimize errors during transitions between successive values, as only one bit changes at a time.

5. The Boolean identity A + A' = _____ is an example of the Complement Law.

6. The 1's complement of the binary number 1010 is _____.

7. In the IEEE 754 Double Precision format, the exponent field uses _____ bits and the bias value is _____.

8. The _____ gate produces an output of 1 only when all inputs are 1, and is represented by the Boolean expression Y = A · B.

9. A K-Map group must always contain cells that are a power of 2 in number: 1, 2, 4, 8, _____.

10. In Sign-Magnitude representation, the range of an 8-bit number is from _____ to +127.

11. The process of representing data using a fixed binary point position in memory is called _____ representation.

12. The ASCII code for the decimal digit '5' is _____ in decimal.

13. The Excess-3 code is obtained by adding _____ to the BCD representation of each decimal digit.

14. In the Von Neumann architecture, the concept of having a single shared memory for both data and instructions leads to a bottleneck known as the _____.

15. A NOR gate is the complement of the _____ gate and is also considered a Universal Gate.

ANSWERS — Fill in the Blanks

Q.No	Answer	Explanation
1	**Binary (base 2)**	Circuits have two states (ON/OFF) → naturally map to binary 1 and 0
2	**4 bits**	Binary → Hex: group 4 bits from decimal point (e.g., 1010 1111 = AF)
3	**101101_2**	45 ÷ 2 repeated division gives remainders: 1,0,1,1,0,1 (read bottom to top)
4	**Gray code**	Gray code ensures only 1 bit changes between consecutive values; reduces conversion errors
5	**1**	Complement Law: A + A' = 1 (a variable OR'd with its complement always gives 1)
6	**0101**	1's complement: invert all bits → 1010 becomes 0101
7	**11 bits; 1023**	Double Precision: 1+11+52 bits; bias = 2^(11-1)−1 = 1023
8	**AND**	AND gate: output = 1 only if ALL inputs are 1; Y = A · B
9	**16**	Valid K-Map group sizes are powers of 2: 1, 2, 4, 8, 16
10	**−127**	8-bit Sign-Magnitude range: −127 to +127 (two representations of zero: +0 and −0)

Q.No	Answer	Explanation
11	**Fixed Point**	Fixed point: binary point is at a predetermined, fixed position in the bit pattern
12	**53**	ASCII 0–9 maps to decimal 48–57; digit '5' = 48+5 = 53
13	**3 (0011_2)**	Excess-3: BCD code + 3 (binary 0011); e.g., decimal 7 → BCD 0111 + 0011 = 1010
14	**Von Neumann Bottleneck**	Single shared memory bus creates a speed bottleneck between CPU and memory
15	**OR**	NOR = (A+B)'; it is the complement/negation of the OR gate; universal like NAND

Short Questions

Q.No	Question	Answer
Q1	What is Boolean Algebra?	A mathematical system using binary variables (0 and 1) with AND, OR, and NOT operations to analyze and simplify digital logic circuits.
Q2	What is the base of hexadecimal?	**Base 16**, using digits 0–9 and letters A–F.
Q3	What is BCD and how many bits per digit?	BCD = **Binary Coded Decimal**; uses **4 bits** to represent each decimal digit (0–9).
Q4	State De Morgan's First Theorem.	**(A · B)' = A' + B'** — The complement of an AND is the OR of the individual complements.
Q5	What is a Universal Gate? Name both.	A gate that can implement any Boolean function by itself. The two universal gates are **NAND** and **NOR**.

Q.No	Question	Answer
Q6	2's complement of 1010?	1's complement of 1010 = 0101; adding 1 gives **0110**.
Q7	What does SOP stand for?	**Sum of Products** — a Boolean expression written as an OR of AND terms (minterms).
Q8	Bias value in IEEE 754 Single Precision?	**127** (Exponent bias = 2^(8−1) − 1 = 127).
Q9	What is Gray Code?	A binary code where **consecutive values differ by only one bit**, used to prevent errors in digital systems.
Q10	Five components of a Digital Computer?	**Input Unit, Output Unit, Memory Unit, ALU (Arithmetic Logic Unit), and Control Unit**.
Q11	What is Fixed Point Representation?	A number representation where the **binary point is fixed at a predetermined position** in the bit pattern.
Q12	XOR output when both inputs are same?	**0** — XOR outputs 1 only when inputs are different; it outputs 0 when both inputs are the same.
Q13	ASCII decimal value of 'A'?	**65** (ASCII uppercase letters A–Z map to decimal values 65–90).
Q14	How is binary converted to octal?	Group binary digits into sets of **3 bits** from the decimal point, then convert each group to its octal digit.
Q15	Range of 8-bit 2's complement?	**−128 to +127** (i.e., -2^7 to $2^7 - 1$).