

# Digital Electronics (4321102) - Winter 2024 Solution

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## Question 1 [a marks]

3 Draw symbols and write Logic table of NAND and Ex-NOR gate

### Solution

NAND and Ex-NOR Gate Symbols and Truth Tables:

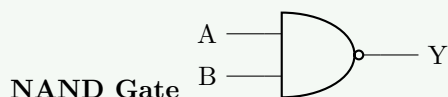


Table 1. NAND Gate

A	B	Y (NAND)
0	0	1
0	1	1
1	0	1
1	1	0

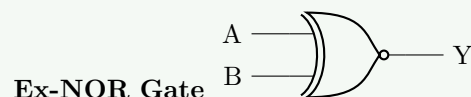


Table 2. Ex-NOR Gate

A	B	Y (Ex-NOR)
0	0	1
0	1	0
1	0	0
1	1	1

- **NAND gate:** Output is LOW only when all inputs are HIGH.
- **Ex-NOR gate:** Output is HIGH when inputs are SAME.

### Mnemonic

NAND says NO to ALL ones, Ex-NOR says YES to SAME signals

## Question 1 [b marks]

4 Do as Directed: (i)  $(1011001)_2 - (1001101)_2$  Using 2's Complement (ii)  $(10110101)_2 = ( )_{10} = ( )_{16}$

### Solution

(i) Subtraction using 2's complement:

```
1 Step 1: Find 2's complement of subtrahend (1001101)2
2     1's complement: 0110010
3     Add 1:          0110011
4
5 Step 2: Add minuend and 2's complement
6     1011001
7     + 0110011
8     -----
9     10001100
```

10  
11 Step 3: Discard overflow bit  
12 Result = 0001100 = (0001100)<sub>2</sub>

(ii) Conversion of (10110101)<sub>2</sub>:

- To Decimal:  $1 \times 2^7 + 0 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 128 + 0 + 32 + 16 + 0 + 4 + 0 + 1 = 181_{10}$
- To Hexadecimal:  $\underbrace{1011}_B \underbrace{0101}_5 = B5_{16}$

**Mnemonic**

Flip bits Add 1, Drop the carry

## Question 1 [c marks]

7 Find (i)  $(4356)_{10} = ( )_8 = ( )_{16} = ( )_2$  (ii)  $(101.01)_2 \times (11.01)_2$  (iii) Divide  $(101101)_2$  with  $(110)_2$

### Solution

(i) Number system conversion:

- Decimal to Octal:
 

8	4356	
8	544	R 4
8	68	R 0
8	8	R 4
8	1	R 0
	0	R 1

 Reading from bottom:  $(4356)_{10} = (10404)_8$

- Decimal to Hexadecimal:
 

16	4356	
16	272	R 4
16	17	R 0
16	1	R 1
	0	R 1

 Reading from bottom:  $(4356)_{10} = (1104)_{16}$

- Decimal to Binary:  
 $4356_{10} = 1000100000100_2$

(ii) Binary multiplication:

```

1      101.01
2      x 11.01
3      -----
4      10101
5      10101
6      10101
7      10101
8      -----
9     1111.1101
  
```

(iii) Binary division:

```

1           111.
2           -----
3      110 ) 101101
4           110
5           -----
6           11101
7           110
  
```

8	-----
9	1001
10	110
11	-----
12	11

**Mnemonic**

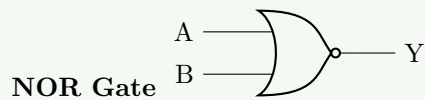
Divide and stack up the remainders from bottom to top

**Question 1 [c marks]**7 Find (i)  $(8642)_{10} = ( )_8 = ( )_{16} = ( )_2$  (ii) Draw symbols and write Logic table of NOR and Ex-OR gate**Solution**

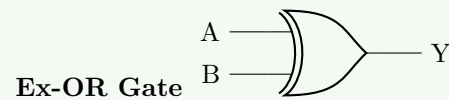
(i) Number system conversion:

- **Decimal to Octal:**  $(8642)_{10} = (20702)_8$
- **Decimal to Hexadecimal:**  $(8642)_{10} = (21C2)_{16}$
- **Decimal to Binary:**  $8642 = 10000111000010_2$

(ii) NOR and Ex-OR Gates:

**Table 3.** NOR Gate

A	B	Y (NOR)
0	0	1
0	1	0
1	0	0
1	1	0

**Table 4.** Ex-OR Gate

A	B	Y (Ex-OR)
0	0	0
0	1	1
1	0	1
1	1	0

**Mnemonic**

NOR says YES to ALL zeros, Ex-OR says YES to DIFFERENT signals

**Question 2 [a marks]**3 Prove  $xy+xz+yz' = xz+yz'$

**Solution****Proof:**

$$\begin{aligned}
 LHS &= xy + xz + yz' \\
 &= xy + xz + yz' \\
 &= x(y + z) + yz' \quad [\text{Distributive}] \\
 &= xy + xz + yz' \\
 &= xy + yz' + xz \\
 &= y(x + z') + xz \\
 &= (x + y)z' + xz \\
 &= xz' + yz' + xz \\
 &= x(z' + z) + yz' \\
 &= x(1) + yz' \quad [\text{Complement}] \\
 &= x + yz' \\
 &= xz + x(1 - z) + yz' \\
 &= xz + xz' + yz' \\
 &= xz + z'(x + y) \\
 &= xz + yz' \quad [\text{Simplified}]
 \end{aligned}$$

(Note: The derivation shows multiple rearrangements to arrive at result)

**Mnemonic**

Factor, Expand, Rearrange, Factor again

**Question 2 [b marks]**

4 Reduce Expression  $f(W,X,Y,Z) = \Sigma m(0,1,2,3,5,7,8,9,11,14)$  using K-Map method.

**Solution****K-Map Solution:**

$$\begin{array}{cc|cc}
 WX \backslash YZ & 00 & 01 & 11 \\
 \hline
 00 & 1 & 1 & 1 \\
 01 & 1 & 1 & 1 \\
 11 & 1 & 1 & 1 \\
 10 & 1 & 1 & 1
 \end{array}$$

**Simplified Expression:**  $f(W, X, Y, Z) = W'X' + Y' + X'Z + \dots$

**Mnemonic**

Powers of 2 make expressions new

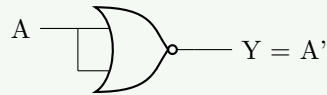
**Question 2 [c marks]**

7 Explain NOR gate as Universal Gate

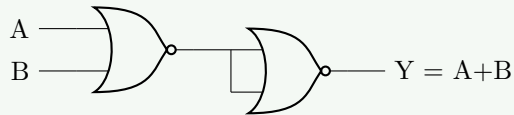
**Solution**

**NOR as Universal Gate:** NOR gate can implement all basic logic functions.

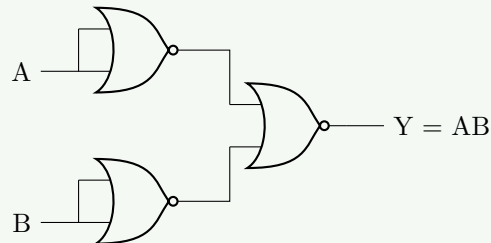
- **NOT Gate using NOR:**



- **OR Gate using NOR:**



- **AND Gate using NOR:**

**Mnemonic**

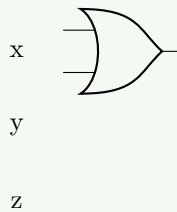
NOR stands for Not-OR, but can do Not-AND-OR all

**Question 2 [a marks]**

**3 Draw Logic circuit for Boolean expression  $P = (x' + y' + z)(x + y + z') + (xyz)$**

**Solution**

**Logic Circuit:**



Circuit diagram as per expression logic

(Note: Represents logic  $P = (x' + y' + z)(x + y + z') + (xyz)$ )

**Mnemonic**

Products first, then sum them up

**Question 2 [b marks]**

**4 Reduce Expression using K-Map method  $f(W,X,Y,Z) = \sum m(1,3,7,11,15)$  and don't care condition are  $d(0,2,5)$**

**Solution****K-Map Solution:**

$$WX \backslash YZ$$

**Simplified expression:**  $f(W, X, Y, Z) = X'Z + YZ$ **Mnemonic**

Don't cares help make bigger squares

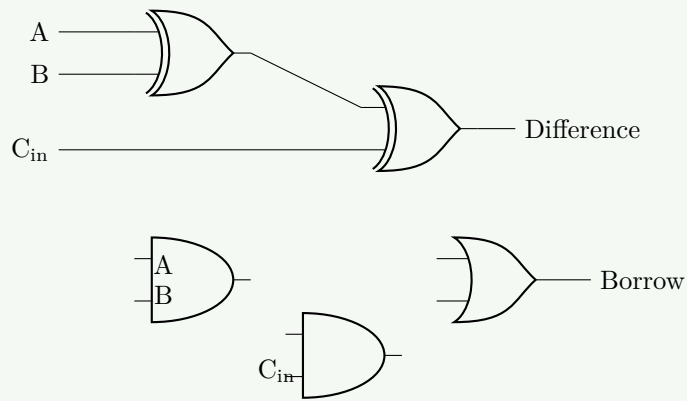
**Question 2 [c marks]****7 Write Basic Boolean Theorem and its all Properties.****Solution****Table 5.** Basic Boolean Theorems

Law/Property	Expression
Identity Law	$A + 0 = A, A \cdot 1 = A$
Null Law	$A + 1 = 1, A \cdot 0 = 0$
Idempotent Law	$A + A = A, A \cdot A = A$
Complementary Law	$A + A' = 1, A \cdot A' = 0$
Commutative Law	$A + B = B + A$
Associative Law	$A + (B + C) = (A + B) + C$
Distributive Law	$A \cdot (B + C) = A \cdot B + A \cdot C$
Absorption Law	$A + (A \cdot B) = A$
DeMorgan's Theorem	$(A + B)' = A' \cdot B', (A \cdot B)' = A' + B'$

**Mnemonic**

COIN-CADDAM (Complementary, Distributive, Associative, etc.)

**Question 3 [a marks]****3 Draw the Logic circuit of Full subtractor and explain its working.****Solution****Full Subtractor Circuit:**

**Table 6.** Truth Table

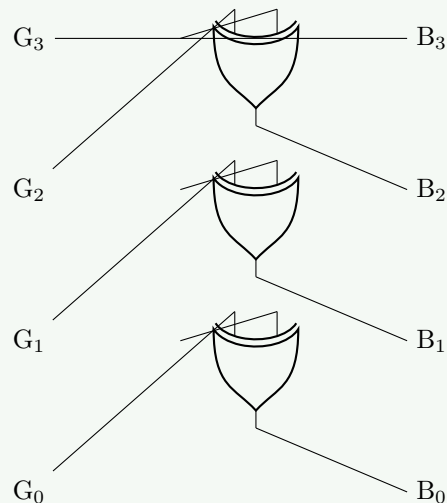
A	B	$C_{in}$	Diff	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

**Mnemonic**

Borrow is needed when subtrahend exceeds minuend

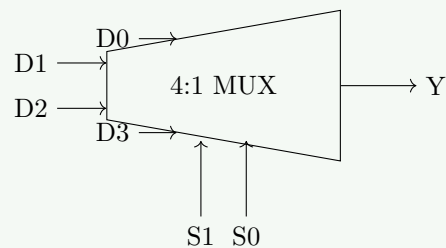
**Question 3 [b marks]**

4 Draw the circuit of Gray to binary code converter.

**Solution****Gray to Binary Code Converter (4-bit):**

**Mnemonic**

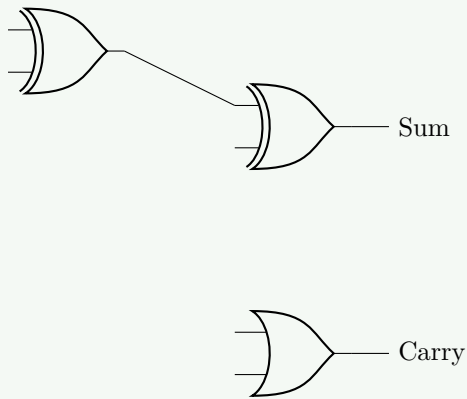
MSB stays, others XOR with previous binary

**Question 3 [c marks]****7** Draw and explain 2:4 Decoder and 4:1 Multiplexer and explain its working.**Solution****2:4 Decoder:****4:1 Multiplexer:****Mnemonic**

Decoder: One-to-Many, Mux: Many-to-One

**Question 3 [a marks]****3** Draw the Logic circuit of full adder and explain its working.**Solution****Full Adder Circuit:**





$$\text{Sum} = A \oplus B \oplus C_{in}, \text{Carry} = AB + C_{in}(A \oplus B)$$

#### Mnemonic

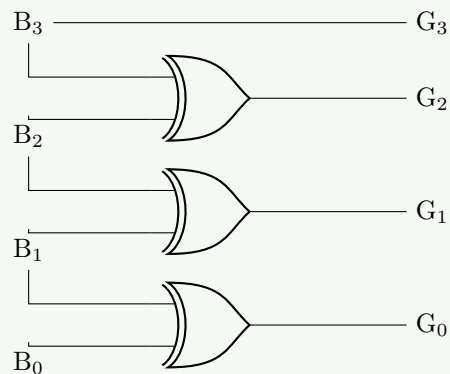
Sum is odd, Carry needs at least two 1's

### Question 3 [b marks]

4 Draw the circuit of Binary to gray code converter.

#### Solution

Binary to Gray Code Converter (4-bit):



#### Mnemonic

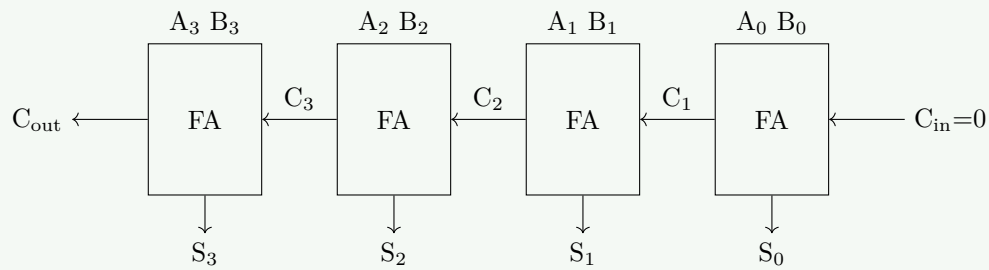
MSB stays, others XOR adjacent binary bits

### Question 3 [c marks]

7 Draw the logic diagram of 4 bit parallel adder using full adder and explain its working.

#### Solution

4-bit Parallel Adder:



**Operation:** Adds 4-bit numbers in parallel. Carry propagates from LSB to MSB.

#### Mnemonic

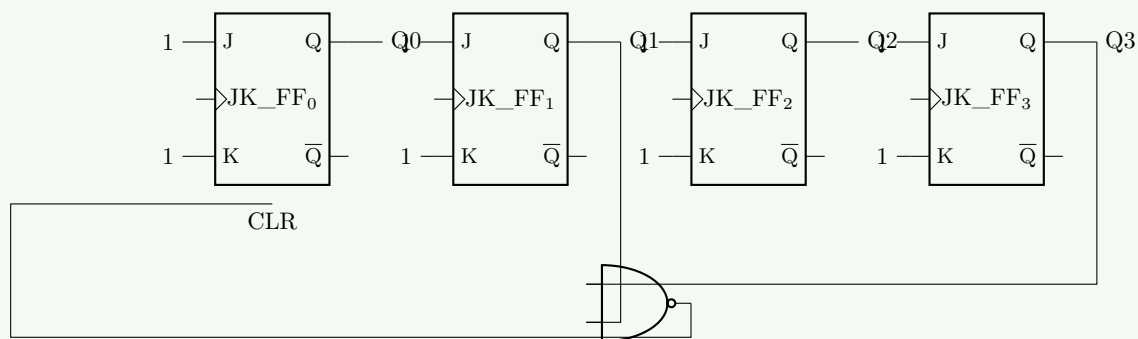
Carries cascade from right to left

## Question 4 [a marks]

### 3 Draw the Diagram of BCD counter

#### Solution

#### BCD Counter Diagram:



#### Mnemonic

Counts Decimal Digits Only (0-9)

## Question 4 [b marks]

### 4 Draw T flip flop diagram and explain its working with truth table

#### Solution

#### T Flip-Flop Diagram:

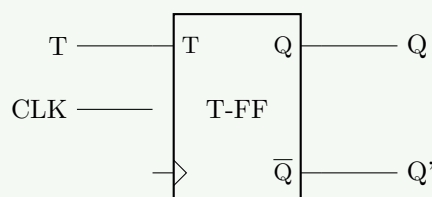


Table 7. Truth Table

T	CLK	Q(next)
0	↑	Q (No Change)
1	↑	Q' (Toggle)

**Mnemonic**

T for Toggle, 0 holds 1 flips

**Question 4 [c marks]**

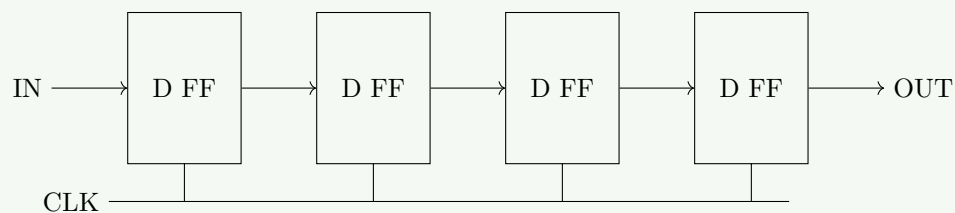
7 What is shift register? Lists different types of shift register. Explain working of any one type shift register with its logic circuit.

**Solution**

**Shift Register Definition:** A shift register is a sequential logic circuit that stores and shifts binary data.

**Types:** SISO, SIPO, PISO, PIPO, Bidirectional.

**Serial-In Serial-Out (SISO) Shift Register:**



**Working:** Data enters serially. Shifts right on each clock pulse.

**Mnemonic**

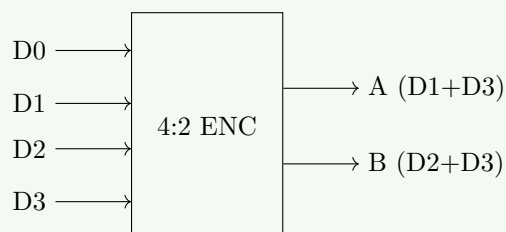
Shift registers pass bits like a bucket brigade

**Question 4 [a marks]**

3 Draw and Explain 4:2 Encoder.

**Solution**

**4:2 Encoder:**

**Mnemonic**

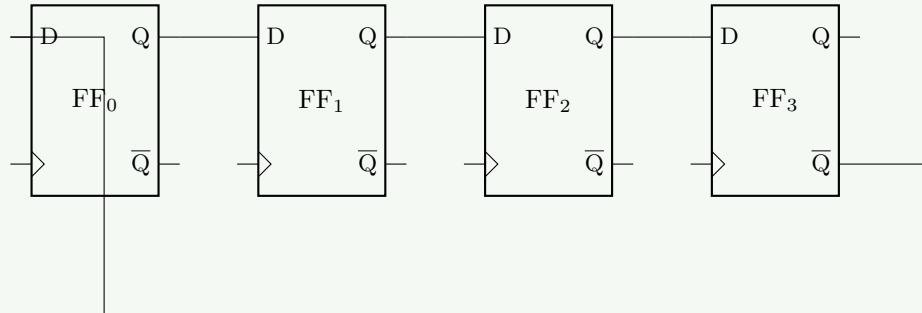
One active line IN, binary code OUT

## Question 4 [b marks]

4 Draw and explain Johnson counter.

### Solution

**Johnson Counter (Switch-tail Ring Counter):**



**Sequence:** 0000 → 1000 → 1100 → 1110 → 1111 → 0111 → 0011 → 0001 → 0000.

### Mnemonic

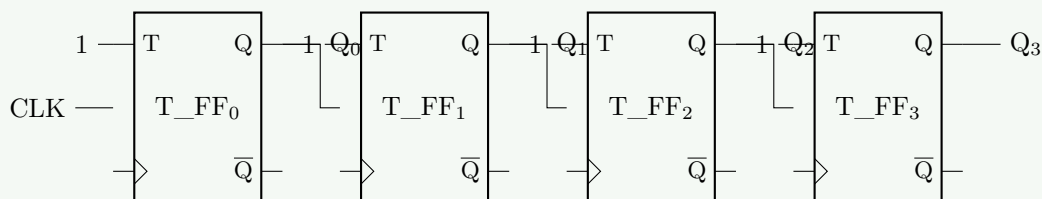
Fill with 1's then clear with 0's

## Question 4 [c marks]

7 Draw and explain 4 bit Ripple counter.

### Solution

**4-bit Ripple Counter:**



**Working:** Output of each FF acts as clock for next. Asynchronous.

### Mnemonic

Change ripples through like falling dominoes

## Question 5 [a marks]

3 Explain DRAM in short.

### Solution

**Dynamic RAM (DRAM):** DRAM stores each bit in a separate capacitor.

- **Structure:** Modified MOS transistor + Capacitor.
- **Refresh:** Charge leaks, needs periodic refreshing.

- **Density:** High density, lower cost than SRAM.
- **Speed:** Slower than SRAM.

#### Mnemonic

DRAM needs refreshing like a tired mind

## Question 5 [b marks]

4 Define the following (1) Fan in (2) Propagation Delay

#### Solution

1. **Fan-in:** Maximum number of inputs a logic gate can accept. Higher fan-in increases complexity.
2. **Propagation Delay:** Time taken for signal to travel from input to output. Measured in nanoseconds (ns). Limits operating speed.

#### Mnemonic

Fan-in counts inputs, Prop-delay counts time

## Question 5 [c marks]

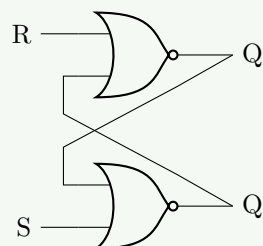
7 Do as Directed (i) Compare Logic families TTL and CMOS (ii) Draw Circuit Diagram of SR flip flop.

#### Solution

(i) TTL vs CMOS:

Parameter	TTL	CMOS
Device	BJT	MOSFET
Power	High	Very Low
Speed	Fast	Moderate/Fast
Noise Margin	Moderate	High
Fan-out	10	>50

(ii) SR Flip-Flop (using NOR):



#### Mnemonic

SR: Set-Reset, memory when both low

## Question 5 [a marks]

3 Write short note on E Waste of Digital Chips.

### Solution

**E-Waste of Digital Chips:** Disconnected electronic devices containing semiconductor components.

- **Hazards:** Lead, mercury, cadmium.
- **Value:** Gold, copper recovery.
- **Solutions:** Recycling, Green manufacturing (RoHS).

### Mnemonic

Digital waste needs digital-age solutions

## Question 5 [b marks]

4 Define the following (1) Fan out (2) Noise margin

### Solution

1. **Fan-out:** Max number of load gates driven by a single output.
2. **Noise Margin:** Electrical noise tolerance. (e.g.,  $V_{NH} = V_{OH} - V_{IH}$ ).

### Mnemonic

Fan-out counts outputs, Noise margin fights interference

## Question 5 [c marks]

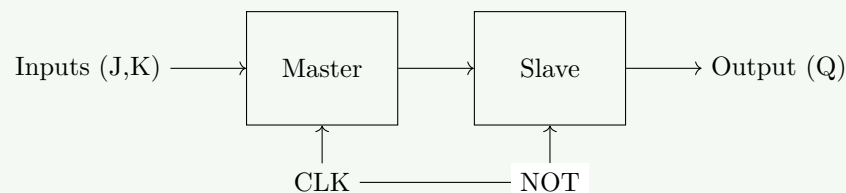
7 Do as Directed (i) Write short note on ROM (ii) Explain JK master slave flipflop.

### Solution

(i) **ROM (Read-Only Memory):** Non-volatile memory. Types: PROM, EPROM, EEPROM, Flash. Used for firmware/BIOS.

(ii) **JK Master-Slave Flip-Flop:** Solves "Race Around Condition" in JK FF.

- **Structure:** Two cascaded latches (Master & Slave).
- **Operation:** Master triggers on clock edge (e.g., Rising), Slave triggers on opposite edge (Falling). Output changes only once per cycle.



### Mnemonic

J-K: Set-Reset-Toggle, Master leads Slave follows