COMPUTER SCIENCE & IT

DIGITAL LOGIC

Lecture No. 12

Combinational Circuit

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MUX & DEMUX

Question Practice

[NAT]

What is the minimum number of 2-input NOR gates required to implement a 4-variable function expressed in sum-of-minterms form as f = Σ(0, 2, 5, 7, 8, 10, 13, 15)? Assume that all the inputs and their complements are available. 3

[GATE-2019-CS: 2M]

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1			1
$\bar{A}B$		1	1	
AB		1	1	
$A\bar{B}$	1			1

$R \rightarrow \overline{B+D} \rightarrow 1$

$\overline{R+B} \rightarrow 1 \rightarrow P$

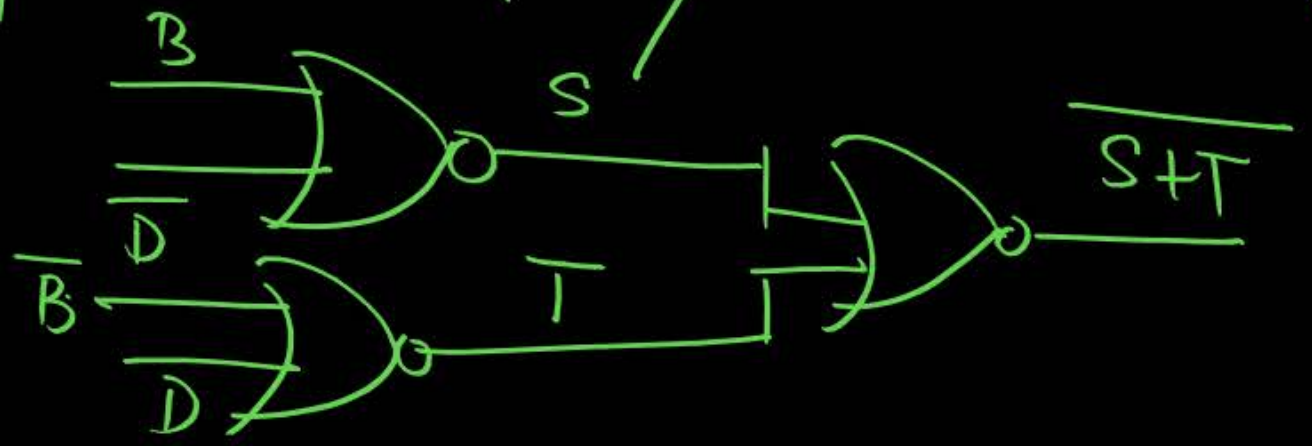
$\overline{R+D} \rightarrow 1 \rightarrow Q$

$\overline{P+Q} \rightarrow 1$

$\bar{f} = \overline{B+\bar{D}} + \overline{\bar{B}+D}$

$\bar{f} = S + T$

$f = \overline{S+T}$



$\boxed{A\bar{B}+\bar{A}B} = (\bar{A}+\bar{B})(A+B)$

$= BD + \bar{B}\bar{D} = B \odot D = (\bar{B}+D)(B+\bar{D})$

$= \bar{B}\bar{D} + BD = \overline{B+D} + BD$

$f = R + BD = (R+B)(R+D)$

$\bar{f} = \overline{R+B} + \overline{R+D}$

$f = \overline{\overline{R+B} + \overline{R+D}} \leftarrow \overline{P+Q}$

[MCQ]

Let $\oplus$ denote the Exclusive OR (XOR) operation. Let '1' and '0' denote the binary constants. Consider the following Boolean expression for F over two variables P and Q:

$$F(P, Q) = ((1 \oplus \underbrace{P) \oplus (P}_{} \oplus Q)) \oplus ((P \oplus Q) \oplus (Q \oplus 0))$$

The equivalent expression for F is

[GATE-2014-CS: 1M]

$\overline{Q} \oplus P = P \odot Q = \overline{P \oplus Q}$

(A) $P + Q$

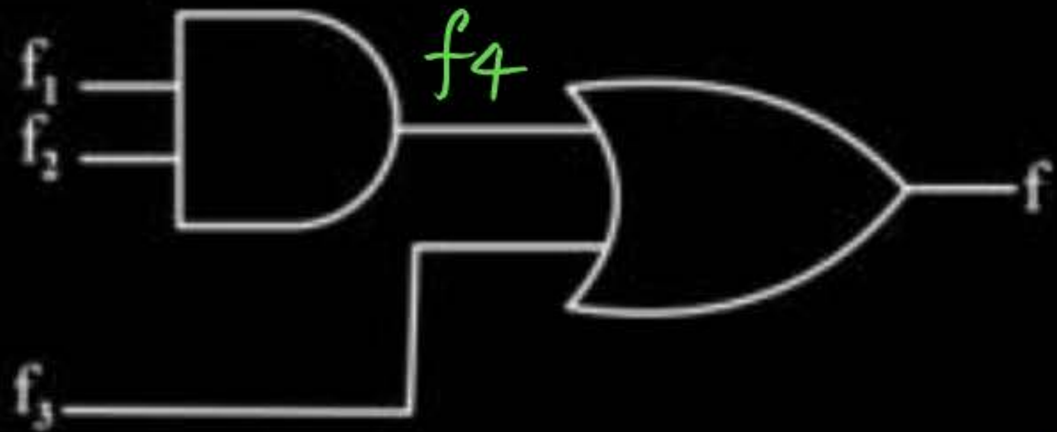
(B) $(P + Q)'$

(C) $P \oplus Q$

(D) $(P \oplus Q)'$

[MCQ]

Given f1,f3 and f in canonical sum of products from (in decimal) for the circuit.



[GATE-2008-CS: 1M]

$F_1 = \Sigma m\,(4,5,6,7,8)$

$F_3 = \Sigma m\,(1, 6, 15)$

$F = \Sigma m\,(1, 6, 8, 15)$

Then f_2 is

A. $\Sigma m\,(4, 6)$ ✗

B. $\Sigma m\,(4, 8)$ ✗

C. $\Sigma m\,(6, 8)$ ✓

D. $\Sigma m\,(4, 6, 8)$ ✗

$f = f_4 + f_3$

$f_4 = f_1 \cdot f_2$

$= \Sigma\, 1, 6, 15$

$f_2 = \Sigma\, \_\_ \;, 8\; \_\_$

$2^3 \rightarrow 8$

$\Sigma\, 1, 8$, $\Sigma\, 1, 6, 8$ $\Sigma(1, 8, 15)$

$f_4 \Rightarrow$

$1, 6, 15$

$8 \rightarrow$ compul

$f_2 \rightarrow$ 8 compuls

1, 6, 15 option

Question

A logical function f(x, y, z) is given as

$$f(x,y,z)=x\bar{y}+yz$$

H.W.

Another logical function

$f_1(x,y,z)=f[\bar{f},f,z]$ will be

a. $\bar{x}+y+z$

b. $\bar{x}y+yz$

c. $(x+\bar{y})(\bar{y}+\bar{z})$

d. $(x+\bar{y})(\bar{y}+\bar{z})(y+z)$

Question

A 3-input majority gate is defined by the logic function M (a, b, c) = ab + bc + ca. Which one of the following gate is $M\left(\overline{M(a,b,c)}, M(a,b,\overline{c}), c\right)$?

(a) 3-input NAND gate

(b) 3-input XOR gate

(c) 3-input NOR gate

(d) 3-input XNOR gate

$M(a,b,c) = ab + bc + ca = \sum(3,5,6,7)$

2 4 7 6

$f_1 = \overline{M(a,b,c)}$, $f_2 = M(a,b,\bar{c})$

$M(f_1, f_2, c) = f_1 \cdot f_2 + f_2 c + f_1 \cdot c$

$f_1(a,b,c) = \sum(0,1,2,4)$ $f_2(a,b,c) = M(a,b,\bar{c}) = \sum(2,4,6,7)$

$a b \bar{c} + \bar{a} b c + a b \bar{c} = f(a,b,c)$

$f(a,b,\bar{c}) = f(a,b,d) =$

$d = \bar{c}$

$\bar{d} = c$

$$M(f_1, f_2, c) = f_1 f_2 + f_1 \cdot c + f_2 \cdot c$$

$$= \sum(2,4) + \sum(1) + \sum(7) = \sum(1,2,4,7) = a \oplus b \oplus c$$

$$f_1 = \sum(0,1,2,4) \quad \cdot c = \sum(1)$$

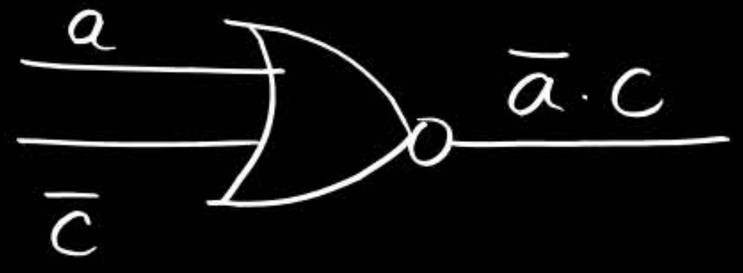
$$f_2 = \sum(2,4,6,7) \cdot c = \sum(7)$$

[NAT]

Consider the Karnaugh map given below, where X represents "don't care" and blank represents 0.

dc \ ba	00	01	11	10
00		x	x	
01	1			x
11	1			1
10		x	x	

$$c\bar{a} = \bar{a}\cdot c = \overline{a+\bar{c}}$$



Assume for all inputs(a, b, c, d) , the respective complements $(\bar{a}, \bar{b}, \bar{c}, \bar{d})$ are also available. The above logic is implemented using 2-input NOR gates only. The minimum number of gates required is 1.

[GATE-2017-CS: 1M]

[MCQ]

Consider the following Boolean expression for F: $F(P, Q, R, S) = PQ + P'QR + P'QR'S$

The minimal sum-of-products form of F is

[GATE-2014-CS: 1M]

(A) $PQ + QR + QS$

(B) $P + Q + R + S$

(C) $\overline{P} + \overline{Q} + \overline{R} + \overline{S}$

(D) $\overline{P}R + \overline{P}\,\overline{R}S + P$

	$\bar{R}\bar{S}$	$\bar{R}S$	RS	$R\bar{S}$
$\bar{P}\bar{Q}$				
$\bar{P}Q$		1	1	1
PQ	1	1	1	1
$P\bar{Q}$				

$PQ + QR + RS$

[MCQ]

Consider the following minterm expression for

F: F (P,Q,R,S) = $\sum$ 0, 2, 5, 7, 8,10,13,15

The minterms 2, 7, 8 and 13 are 'do not care' terms.

The minimal sum-of-products form for F is

[GATE-2014-CS: 1M]

	$\bar{R}\bar{S}$	$\bar{R}S$	RS	$R\bar{S}$
$\bar{P}\bar{Q}$	1			X
$\bar{P}Q$		1	X	
PQ		X	1	
$P\bar{Q}$	X			1

$= \bar{Q}\bar{S} + QS$

(A) $Q\bar{S} + \bar{Q}S$

(B) $\bar{Q}\bar{S} + QS$ ✓

(C) $\bar{Q}\bar{R}\bar{S} + \bar{Q}R\bar{S} + Q\bar{R}S + QRS$ ✗

(D) $\bar{P}\bar{Q}\bar{S} + \bar{P}QS + PQS + P\bar{Q}\bar{S}$ ✗

[MCQ]

What is the minimal form of the karnaugh map shown below? Assume that X denotes a don't care term

[GATE-2012-CS: M]

cd \ ab	00	01	11	10
00	1	×	×	1
01	×			1
11				
10	1			×

H.W

(A) $\bar{b}\bar{d}$

(B) $\bar{b}\bar{d} + \bar{b}\bar{c}$

(C) $\bar{b}\bar{d} + a\bar{b}\bar{c}d$

(D) $\bar{b}\bar{d} + \bar{b}\bar{c} + \bar{c}\bar{d}$

[MCQ]

In the Karnaugh map shown below, X denotes a don't care term. What is the minimal form of the function represented by the Karnaugh map?

[GATE-2008-CS: M]

(A) $\bar{b}.\bar{d} + \bar{a}.\bar{d}$

(B) $\bar{a}.\bar{b} + \bar{b}.\bar{d} + \bar{a}.b.\bar{d}$

(C) $\bar{b}.\bar{d} + \bar{a}.b.\bar{d}$

(D) $\bar{a}.\bar{b} + \bar{b}.\bar{d} + \bar{a}.\bar{d}$

cd \ ab	00	01	11	10
00	1	1		1
01	X			
11	X			
10	1	1		X

H.W.

[MCQ]

Consider the following Boolean function of four variables $f(A, B, C, D) = \Sigma(2, 3, 6, 7, 8, 9, 10, 11, 12, 13)$ The function is

[GATE-2008-CS: 1M]

(A) independent of one variable

(B) Independent of two variables

(C) Independent of three variables

(D) Dependent on all the variables

H.W.

[MCQ]

Given $f(w, x, y, z) = \Sigma m(0, 1, 2, 3, 7, 8, 10) + \Sigma d(5, 6, 11, 15)$, where d represents the don't-care condition in Karnaugh maps. Which of the following is a minimum product-of-sums (POS) form of $f(w, x, y, z)$? [GATE-2017-CS: 1M]

(A) $f = (\bar{w} + \bar{z})(\bar{x} + z)$

(B) $f = (\bar{w} + z)(x + z)$ $\quad z + \bar{w}x$

(C) $f = (w + z)(\bar{x} + z)$ $\quad z + w\bar{x}$

(D) $f = (w + \bar{z})(\bar{x} + z)$

	$\bar{y}\bar{z}$	$\bar{y}z$	yz	$y\bar{z}$
$\bar{w}\bar{x}$	1	1	1	1
$\bar{w}x$	0	X	1	X
wx	0	0	X	0
$w\bar{x}$	1	0	X	1

$(\bar{w}z + \bar{x}\bar{z})$

$(\bar{x} + \bar{y})(x + z)$

$= \bar{x}z + x\bar{y}$

$(\bar{w} + \bar{z})(\bar{x} + z) = \bar{w}\bar{x} + \bar{w}z + \bar{x}\bar{z}$

redundant

[MCQ]

A Boolean digital circuit is composed using two 4-input multiplexers (M1 and M2) and one 2-input multiplexer (M3) as shown in the figure. X0-X7 are the inputs of the multiplexers M1 and M2 and could be connected to either 0 or 1. The select lines of the multiplexers are connected to Boolean variables A, B and C as shown.

$8:1 \xrightarrow{4:1} 2(4:1) + 1(2:1)$

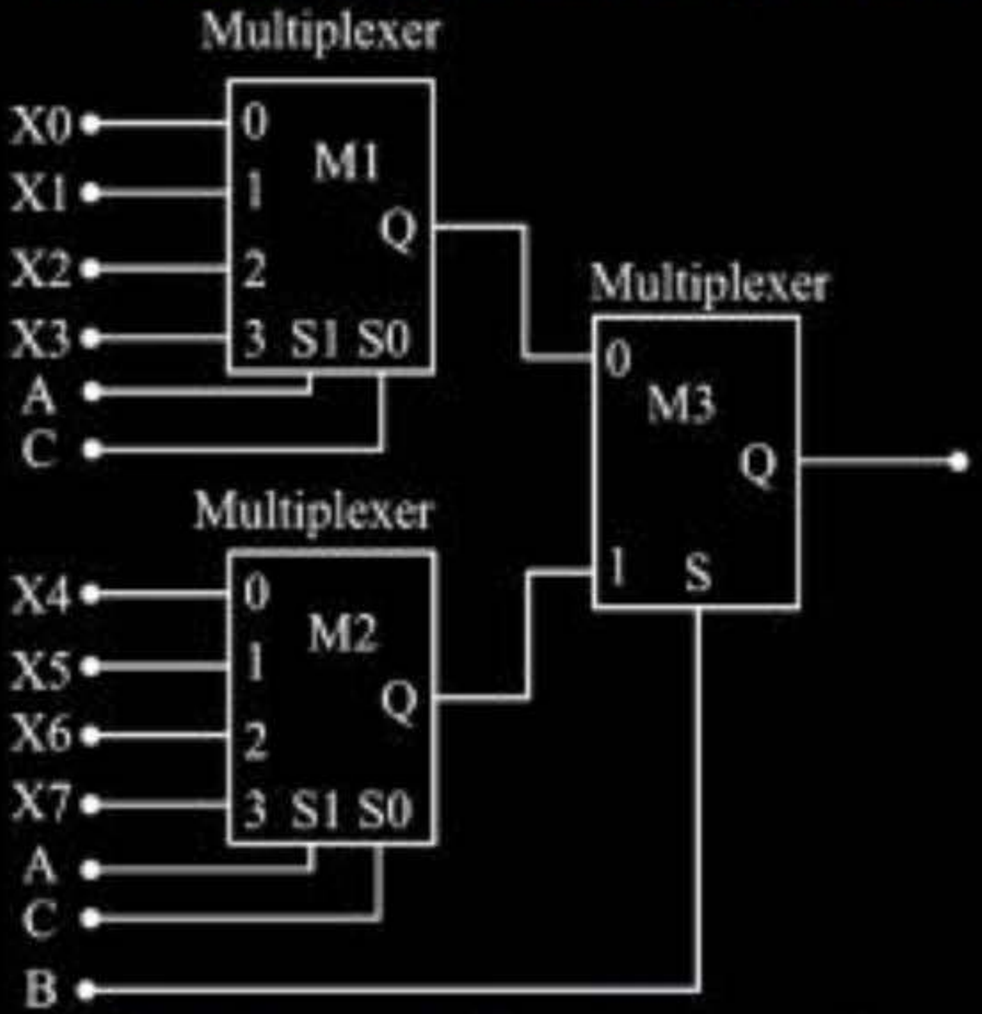
$\downarrow$

$S_2 S_1 S_0$

A B C

1

1



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

$f(0,0,0) = 1$, $X_0 = 1$

$f(1,0,1) = 1$, $X_3 = 1$

Which one of the following set of values of (X0, X1, X2, X3, X4, X5, X6, X7) will realise the Boolean function $\bar{A} + \bar{A}\bar{C} + A\bar{B}C$.

[GATE-2023-CS: 2M]

$x_1 = 1$

$x_3 = 1$

A (1, 1, 0, 0, 1, 1, 1, 0) ✗

B (1, 1, 0, 0, 1, 1, 0, 1) ✗

C (1, 1, 0, 1, 1, 1, 0, 0) ✓

D (0, 0, 1, 1, 0, 1, 1, 1) ✗

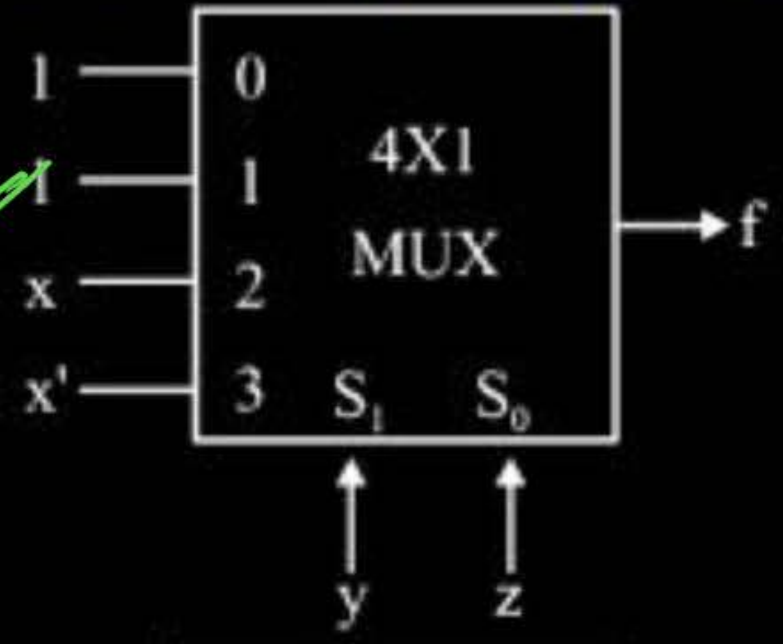
[MCQ]

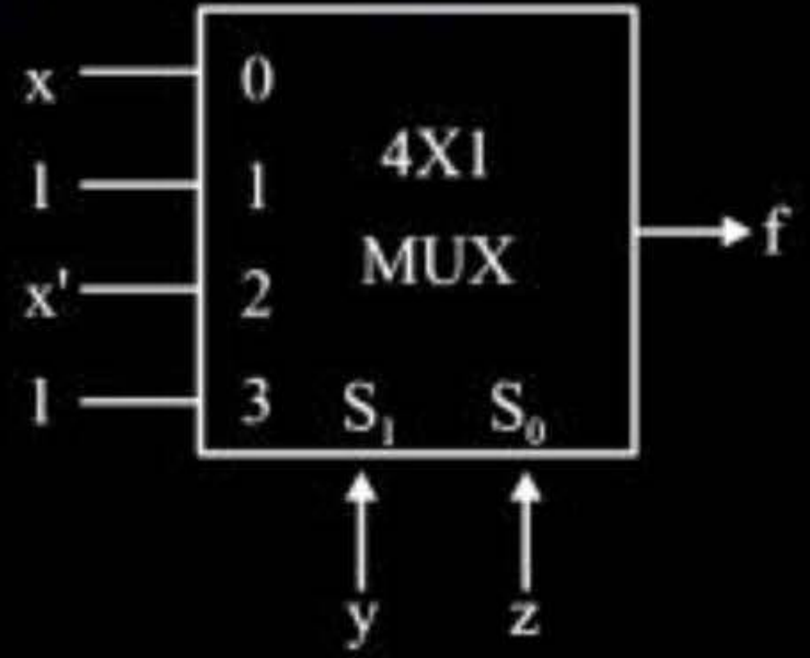
Which one of the following circuits implements the Boolean function given below?

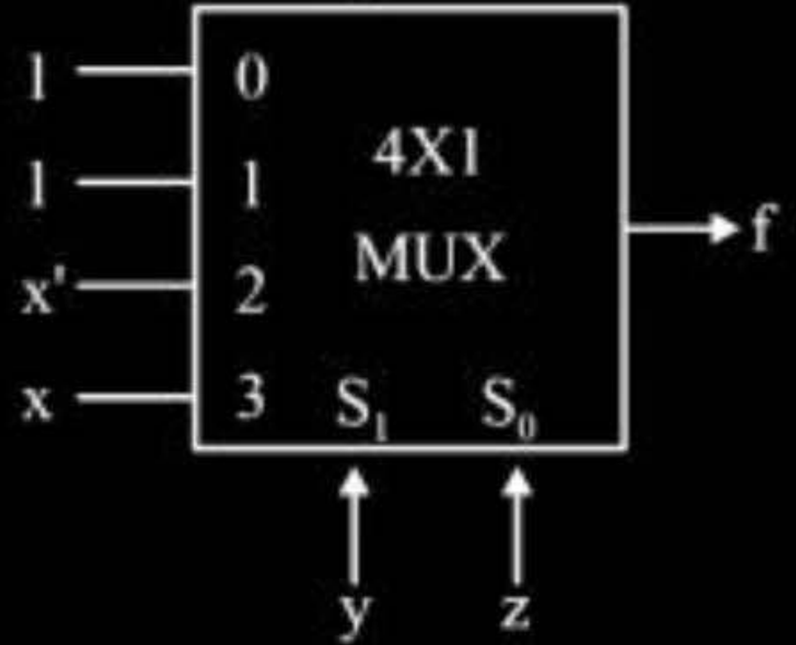
$2^2 \quad 2^1 \quad 2^0$

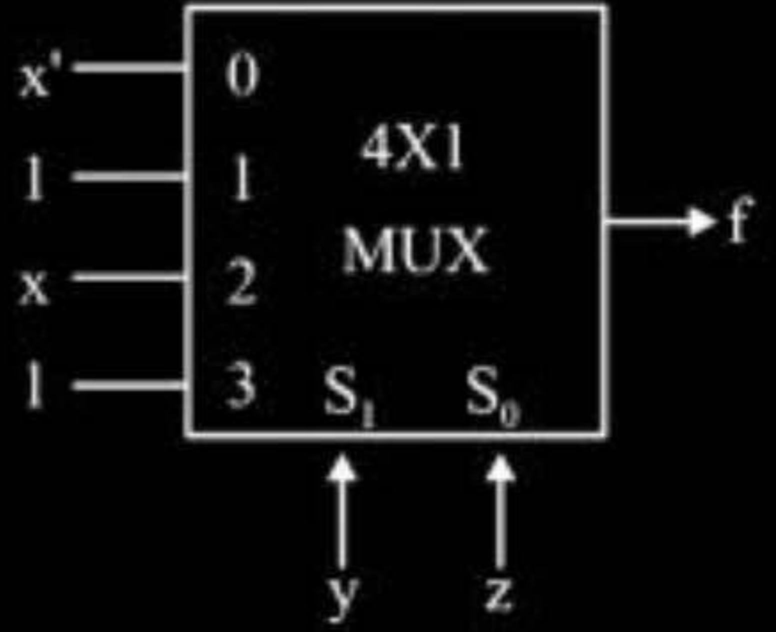
$f(x, y, z,) = m_0 + m_1 + m_3 + m_4 + m_5 + m_6$ where m_t is the i^{th} minterm.

[GATE-2021-CS: 1M]

A


B


C


D


		I_0	I_1	I_2	I_3
0	$\bar{x}$	0	1	2	3
1	x	4	5	6	7
		1	1	x	$\bar{x}$

[**Question**]

A digital circuit is as shown below:

When f_1 (A, B) = Σ(0, 1) f_2 (A, B) = Σ 1 = f_3 (A, B) = Σ(0,2,3),

f_4 (A, B) = Σ(1,2,3) then f(A, B, C) will be

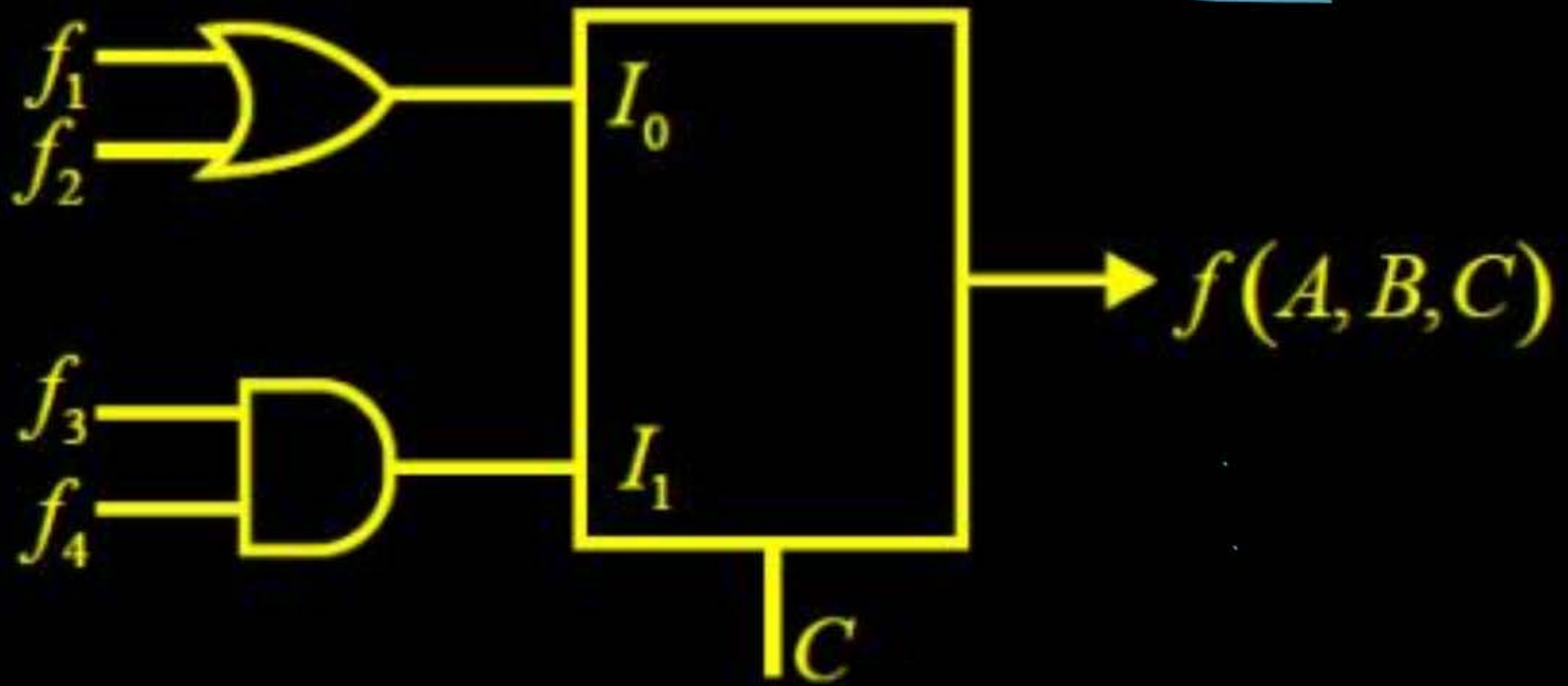
H.W.

(a) $A \oplus C$

(b) $A \odot C$

(c) $A \oplus B \oplus C$

(d) $A \odot B \oplus C$



[NAT]

A multiplexer is placed between a group of 32 registers and an accumulator to regulate data movement such that at any given point in time the content of only one register will move to the accumulator. The number of select lines needed for the multiplexer is ____. [GATE-2020-CS: 1M]

H. W.

Question

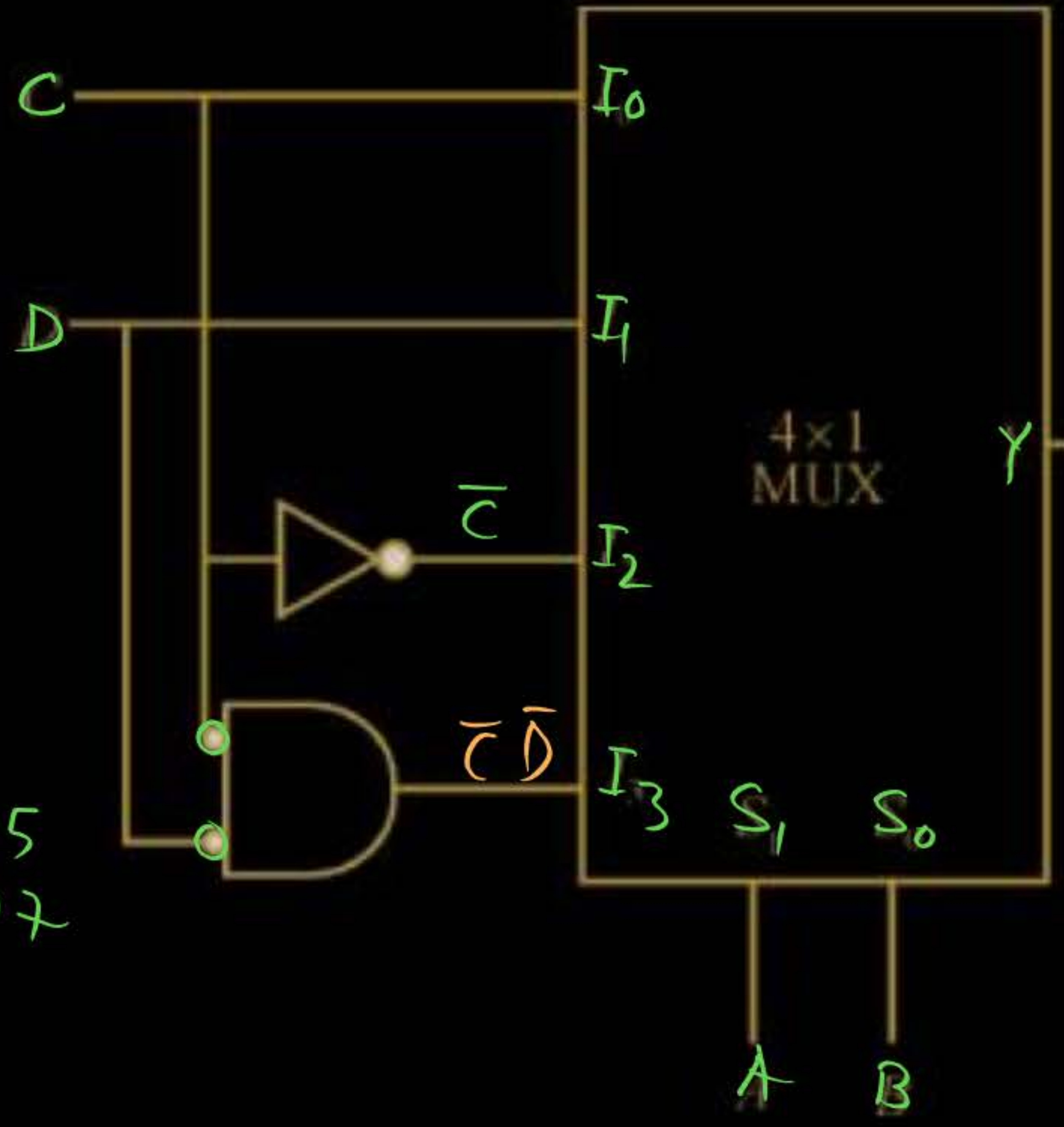
The Boolean function realized by the logic circuit shown is

(a) $F = \Sigma m(0,1,3,5,9,10,14)$

(b) $F = \Sigma m(2,3,5,7,8,12,13)$

(c) $F = \Sigma m(1,2,4,5,11,14,15)$

(d) $F = \Sigma m(2,3,5,7,8,9,12)$



$F(A,B,C,D)$

$= \bar{A}\bar{B}\cdot C + \bar{A}BD + A\bar{B}\bar{C}$

$\bar{A}\bar{B}C$

0 0 1 0 → 2

0 0 1 1 → 3

$\bar{A}B\ D$

0 1 0 1 → 5

0 1 1 1 → 7

$A\bar{B}\bar{C}$

1 0 0 0 → 8

1 0 0 1 → 9

[MCQ]

Consider the 4 – to – 1 multiplexer with two select S_1 and S_0 given below. The minimal sum of products from the Boolean expression for the output F of the multiplexer is -

[GATE-2014-CS: 2M]

partially minimised solution

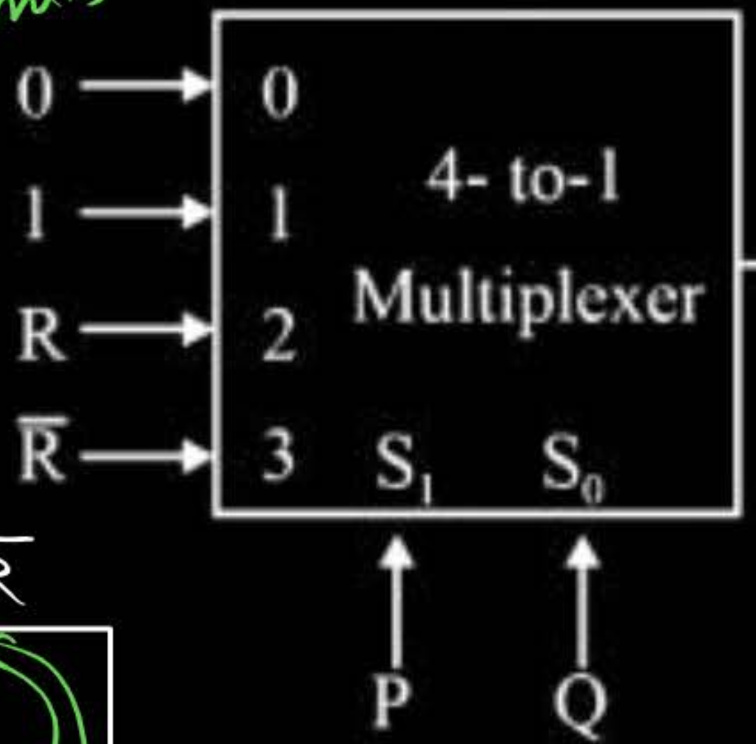
(A) $\bar{P}Q + Q\bar{R} + P\bar{Q}R$

(B) $\bar{P}Q + \bar{P}Q\bar{R} + PQ\bar{R} + P\bar{Q}R$

(C) $\bar{P}QR + \bar{P}Q\bar{R} + Q\bar{R} + P\bar{Q}R$

(D) $PQ\bar{R}$

10



$f = \bar{P}\bar{Q}\cdot 0 + \bar{P}Q\,1 + P\bar{Q}\cdot R + PQ\cdot\bar{R}$

$\bar{P}Q + P(Q \oplus R)$

$= \Sigma(2, 3, 5, 6)$

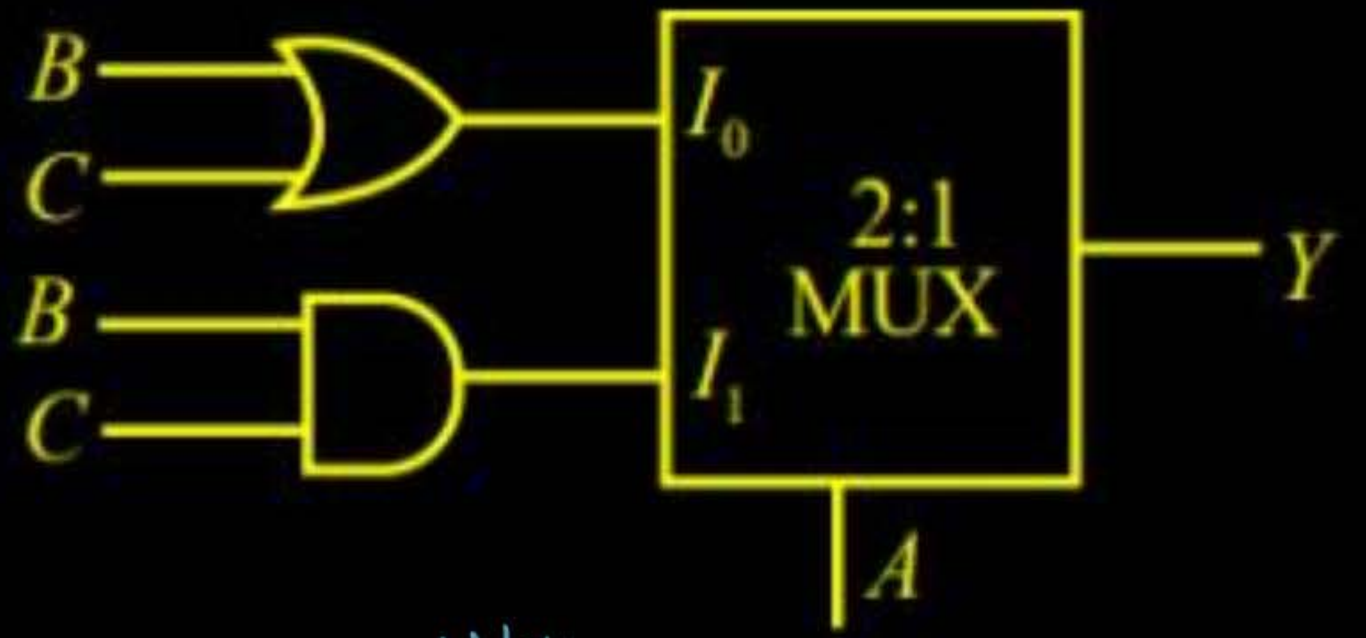
	$\bar{Q}\bar{R}$	$\bar{Q}R$	QR	$Q\bar{R}$
$\bar{P}$			1	1
P		1		1

$= P\bar{Q}R + \bar{P}Q + Q\bar{R}$

Question

Logical circuit is implemented as

Y represents



H.W

(A)Borrow output of full subtractor

(B) Carry output of full adder

(C) 3-input XOR gate

(D) 3-input NOR gate

[MCQ]

Consider the two cascaded 2 to 1 multiplexers as shown in the figure.
The minimal sum of products form of the output X is : [GATE-2016-CS: 1M]

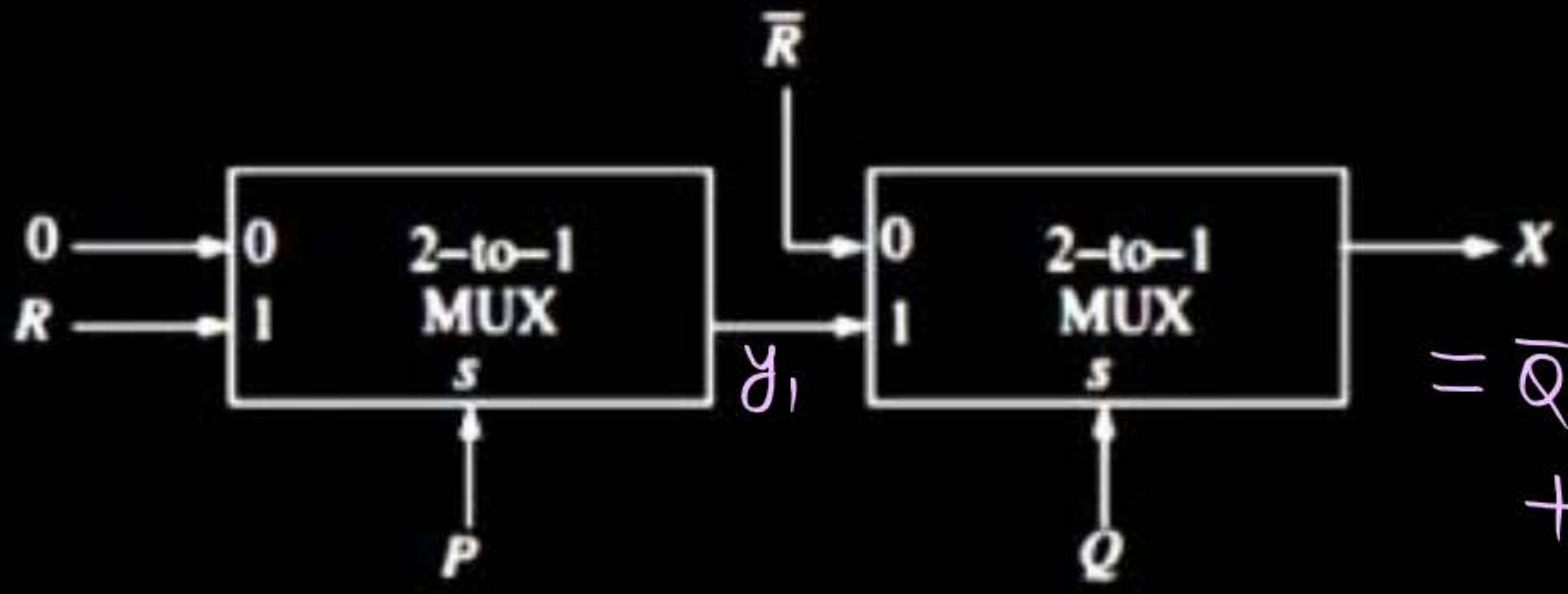
$y_1 = \bar{P}\cdot 0 + P\cdot R$

(A) $\bar{P}\bar{Q} + PQR$

(B) $\bar{P}Q + QR$

(C) $PQ + \bar{P}\bar{Q}R$

(D) $\bar{Q}\bar{R} + PQR$



$= \bar{Q}\cdot\bar{R} + Q\cdot PR$

$= \bar{Q}\bar{R} + PQR$

Question

Combination circuit in designed as shown below:-

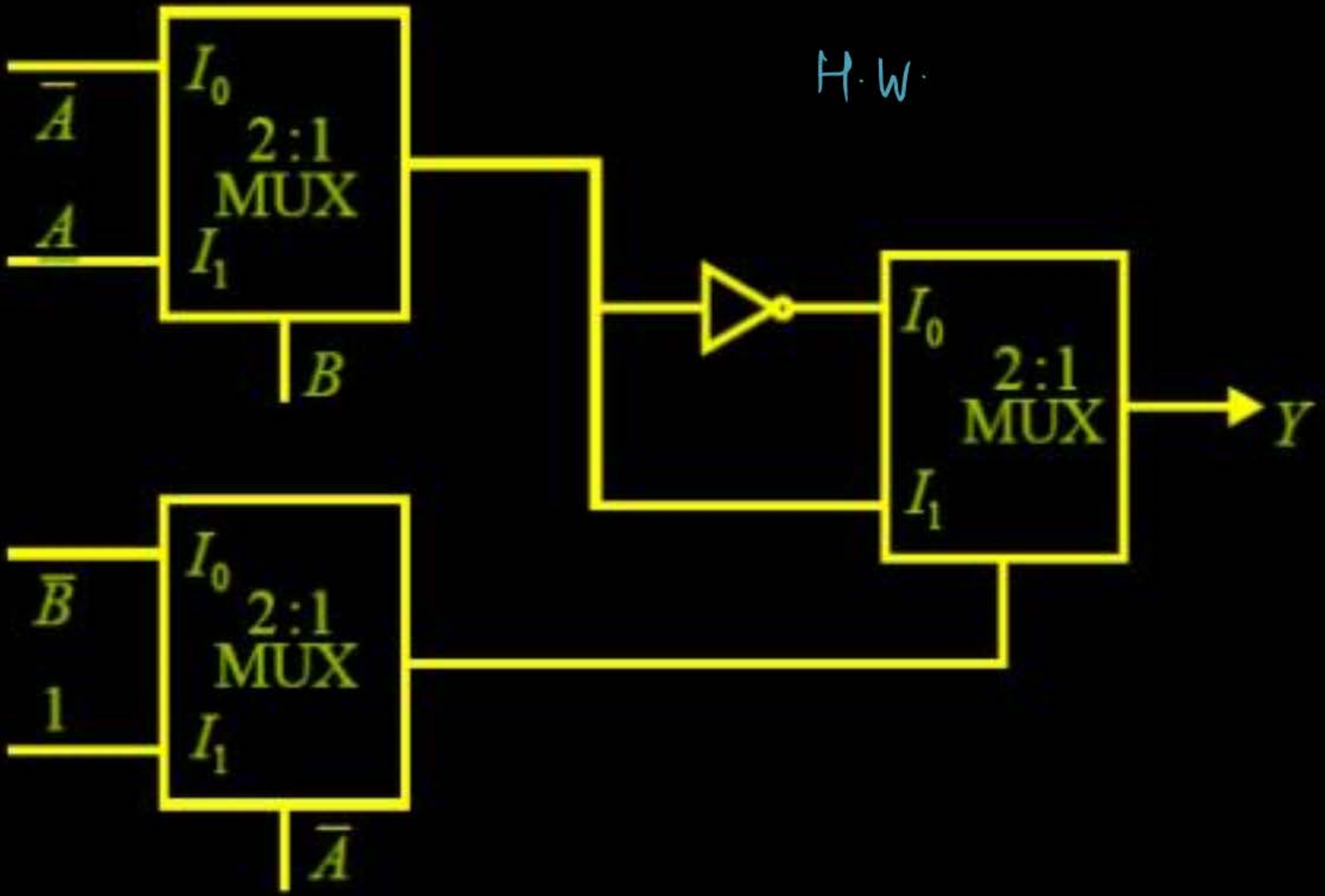
Output Y is

(a) 2 input NOR gate

(b) 2 input AND gate

(c) 2 input OR gate

(d) 2 input NAND gate



Question

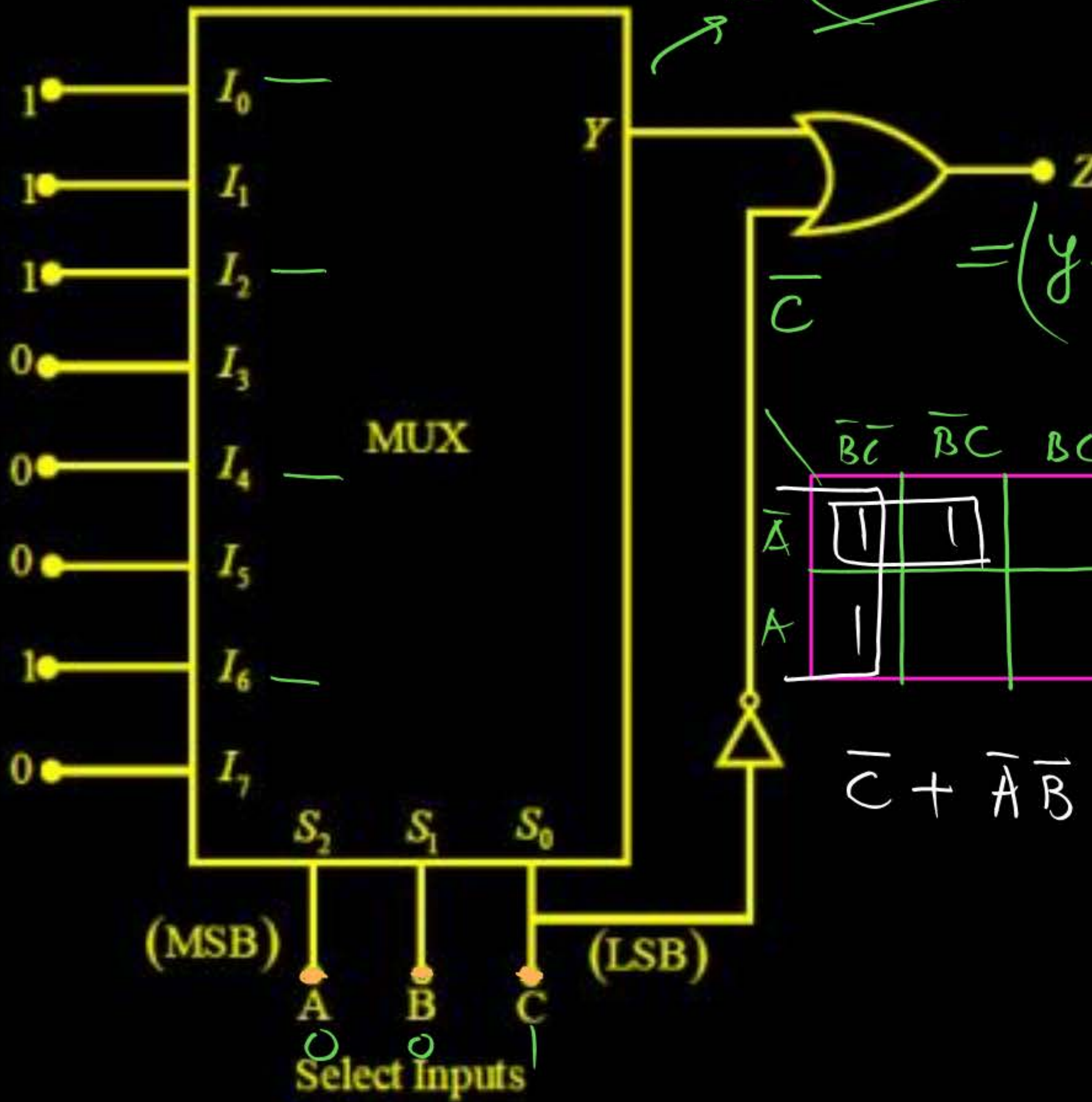
A combinational circuit using an 8 to 1 multiplexer is shown in the following figure. The minimized expression for the output (Z) is

(a) $C(\bar{A}+\bar{B})$ ✗ 0

(b) $C(A+B)$ ✗ 6

(c) $\bar{C}+\bar{A}\bar{B}$ ✓ 1 $0+1\cdot 1=1$

(d) $\bar{C}+AB$ ✓ 1 $0+0\cdot 0=0$



$\Sigma(0,1,2,6)$

$=(y+\bar{C}$

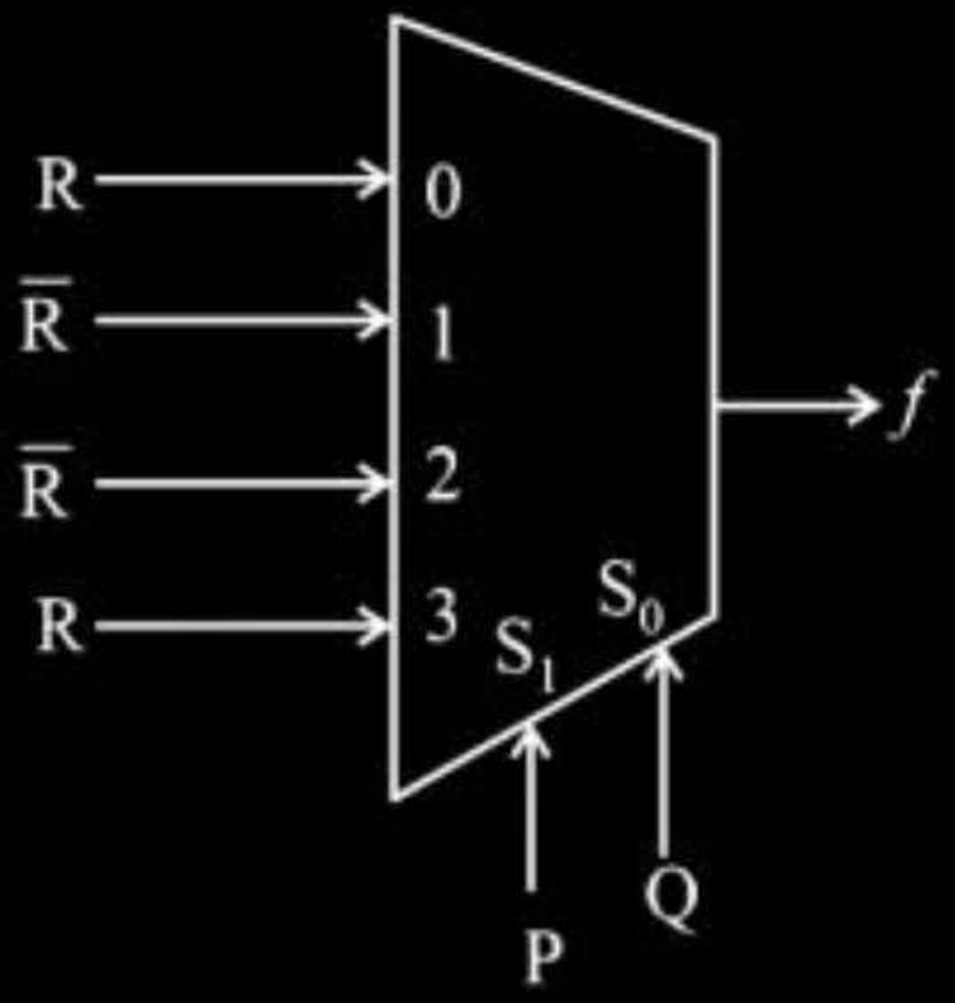
	$\bar{B}\bar{C}$	$\bar{B}C$	BC	
$\bar{A}$	1	1		
A	1			

$\bar{C}+\bar{A}\bar{B}$

[MCQ]

The Boolean expression of the output f of the multiplexer shown below is :

[GATE-2010-CS: 1M]



H.W.

(A) $\overline{P \oplus Q \oplus R}$

(B) $P \oplus Q \oplus R$

(C) $P + Q + R$

(D) $\overline{P + Q + R}$

[**Question**] ***

logical function f (A, B, C) is given as

$$f(A,B,C)=\overline{AB+BC+CA}$$

H.W.

Then $f_1(A,B,C)=f[AB,BC,CA]$

f_1 implemented using 2 : 1 MUX with C as select input then input I_0 & I_1 of 2: 1 MUX will be

(a) $I_0=1, I_1=\bar{A}$

(b) $I_0=0, I_1=\bar{A}+\bar{B}$

(c) $I_0=1, I_1=\bar{A}+\bar{B}$

(d) $I_0=0, I_1=\bar{A}+B$

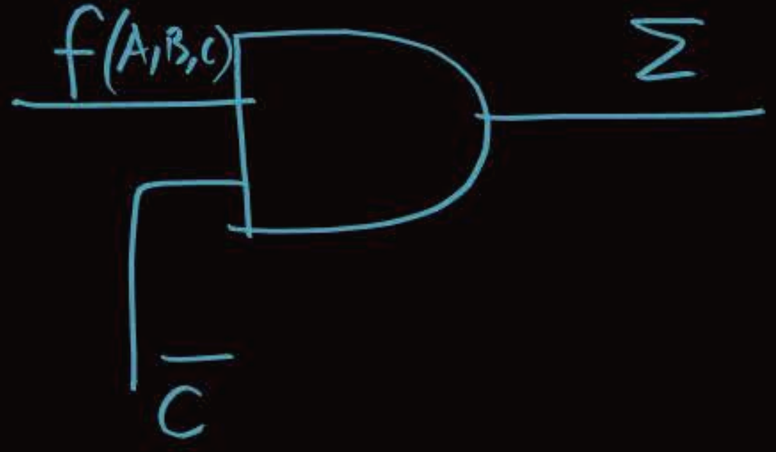
Q. $f(A,B,C) = \Sigma(1,2,3,5,7)$

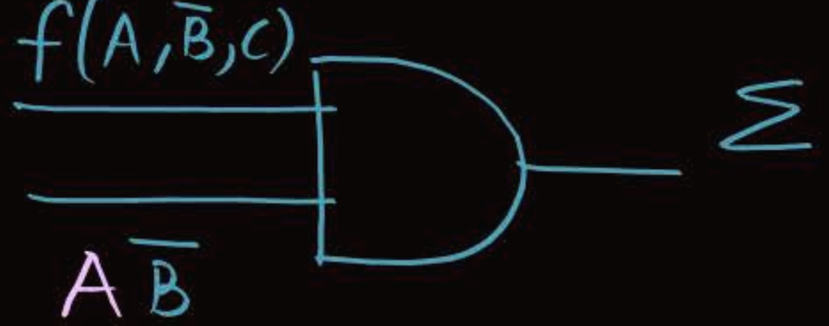
(i) $f(\bar{A},B,C) = ?$

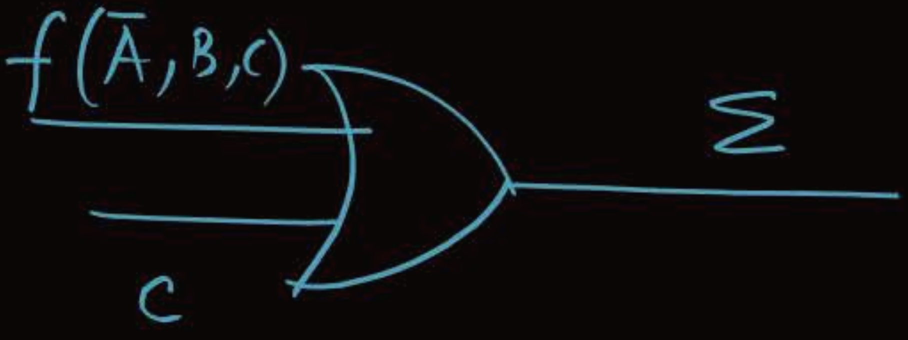
(ii) $f(\bar{A},\bar{B},C) = ?$

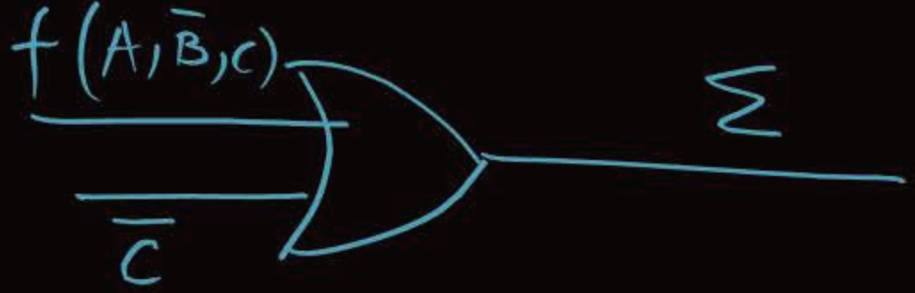
(iii) $f(A,\bar{B},C) = ?$

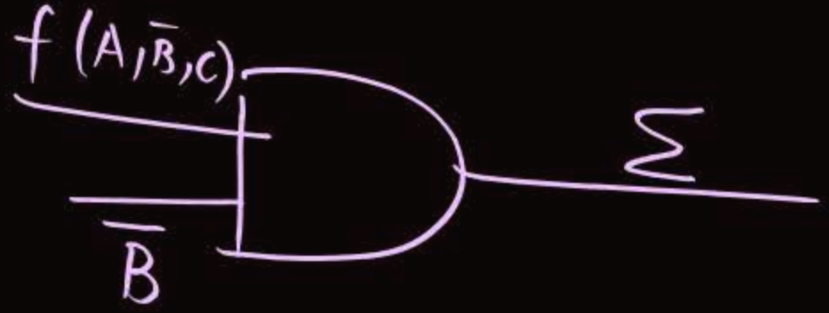
(iv) $f(A,\bar{B},\bar{C}) = ?$

(v) 

(vi) 

(vii) 

(viii) 

(ix) 

2 Minute Summary

Questions Practice

Thank you

GW

Soldiers !