

May/June 2024

1 (a) Describe the operation of each of the following logic gates:

NAND

.....

NOR

.....

XOR

.....

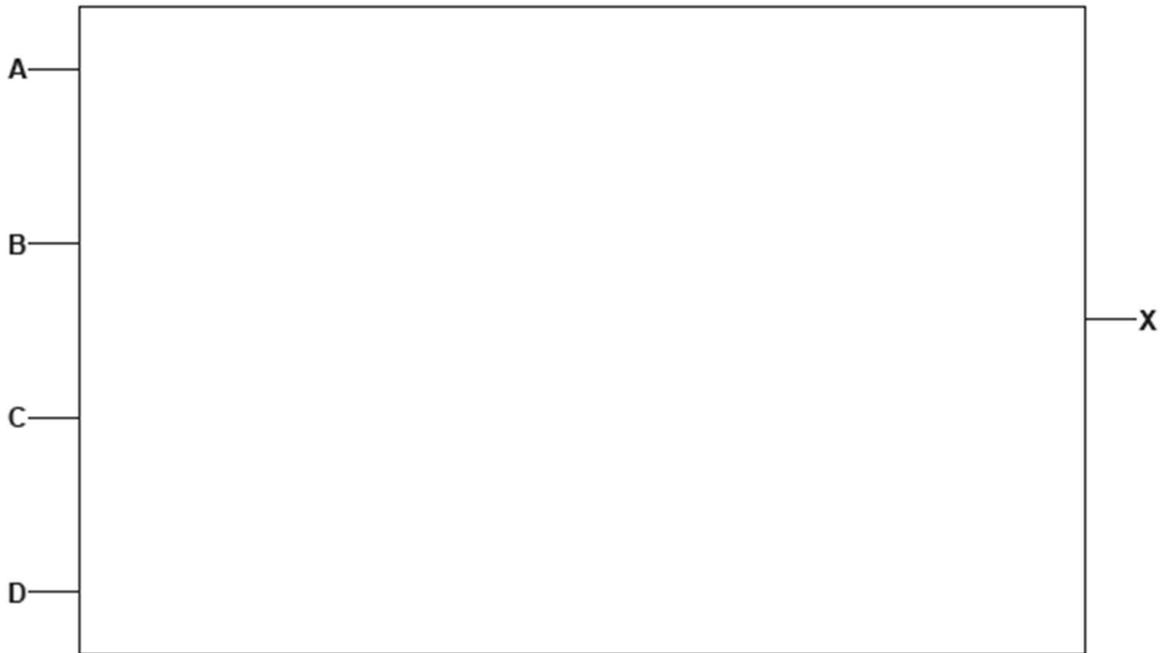
OR

.....

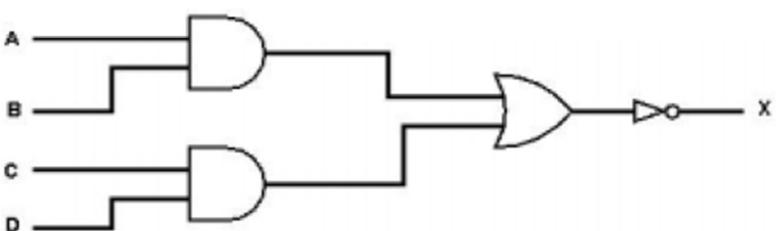
[4]

(b) Draw a logic circuit for this logic expression:

$$X = \text{NOT} ((A \text{ AND } B) \text{ OR } (C \text{ AND } D))$$



[2]

Question	Answer	Marks
1(a)	<p>1 mark for each correct answer:</p> <p><i>NAND</i></p> <ul style="list-style-type: none">• The output is 0 when both inputs are 1, otherwise the output is 1 <p><i>NOR</i></p> <ul style="list-style-type: none">• The output is 1 when both inputs are 0, otherwise the output is 0 <p><i>XOR</i></p> <ul style="list-style-type: none">• The output is 1 when one of the inputs is 1 and the other input is 0, otherwise the output is 0 <p><i>OR</i></p> <ul style="list-style-type: none">• The output is 0 when both inputs are 0, otherwise the output is 1	4
1(b)	<p>1 mark for both AND gates with correct inputs 1 mark for correct OR and NOT gates with correct inputs and no superfluous gates:</p>  <p>The diagram shows a logic circuit with four inputs labeled A, B, C, and D. Inputs A and B are connected to the first AND gate. Inputs C and D are connected to the second AND gate. The outputs of both AND gates are connected to the inputs of an OR gate. The output of the OR gate is connected to the input of a NOT gate, which produces the final output X.</p>	2

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- 6 (a) Draw the logic circuit for this logic expression:

$$Z = (R \text{ XOR } S) \text{ AND } (\text{NOT } T \text{ NOR } P)$$



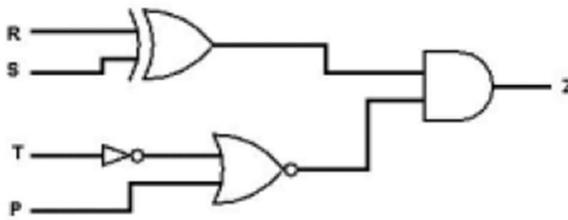
[2]

- (b) Complete the truth table for this logic expression:

$$Z = (\text{NOT } P \text{ OR } Q) \text{ XOR } (R \text{ NOR } Q)$$

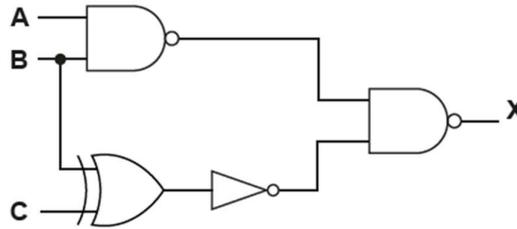
P	Q	R	Working space	Z
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

6(a)	<p>1 mark for correct XOR and AND gates, with correct inputs 1 mark for correct NOT and NOR gates with correct inputs</p> 	2																																													
6(b)	<p>1 mark for first 4 rows 1 mark for last 4 rows</p> <table border="1"> <thead> <tr> <th>P</th> <th>Q</th> <th>R</th> <th>Working space</th> <th>Z</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td></td> <td>1</td> </tr> </tbody> </table>	P	Q	R	Working space	Z	0	0	0		0	0	0	1		1	0	1	0		1	0	1	1		1	1	0	0		1	1	0	1		0	1	1	0		1	1	1	1		1	2
P	Q	R	Working space	Z																																											
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- 4 (a) Write the Boolean expression that corresponds to the following logic circuit.



.....
 [3]

- (b) Complete the truth table for the logic expression:

$$X = A \text{ XOR } (B \text{ AND } (A \text{ NAND } B) \text{ AND NOT } C)$$

A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

Question	Answer	Marks																																				
4(a)	<p>1 mark for each bullet point</p> <ul style="list-style-type: none"> A NAND B NOT(B XOR C) Final NAND <p>$X = A \text{ NAND } B \text{ NAND } (\text{NOT}(B \text{ XOR } C))$</p>	3																																				
4(b)	<p>1 mark for each set of rows (shaded)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>X</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>1</td></tr> </tbody> </table>	A	B	C	X	0	0	0	0	0	0	1	0	0	1	0	1	0	1	1	0	1	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1	2
A	B	C	X																																			
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1	0	1	1																																			
1	1	0	1																																			
1	1	1	1																																			

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- 7 Complete the truth table for the following logic expression:

$$X = (A \text{ XOR } B) \text{ AND NOT } C$$

A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

Question	Answer	Marks																																													
7	<p>1 mark for first 4 rows, 1 mark for second 4 rows (shaded)</p> <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>Working space</th> <th>X</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td></td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td></td> <td>0</td> </tr> </tbody> </table>	A	B	C	Working space	X	0	0	0		0	0	0	1		0	0	1	0		1	0	1	1		0	1	0	0		1	1	0	1		0	1	1	0		0	1	1	1		0	2
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- 3 (a) A greenhouse has an automatic window.

The window (X) operates according to the following criteria:

Parameter	Description of parameter	Binary value	Condition
T	Temperature	1	Too high
		0	Acceptable
W	Wind speed	1	Too high
		0	Acceptable
R	Rain	1	Detected
		0	Not detected
M	Manual override	1	On
		0	Off

The window opens ($X = 1$) if:

- the temperature is too high **and** the wind speed is acceptable
- **and**
- rain is not detected, **or** the manual override is off.

Draw a logic circuit to represent the operation of the window.



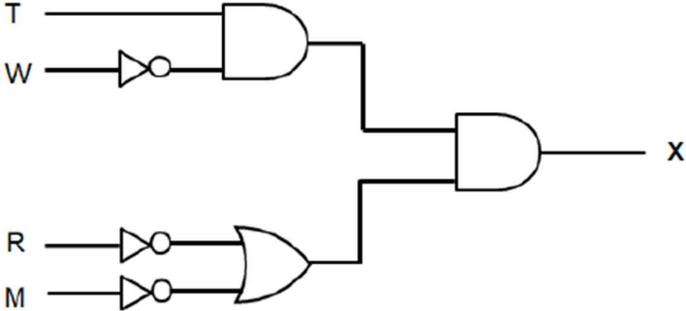
[3]

(b) Complete the truth table for the logic expression:

$$X = \text{NOT (A OR B OR C) AND (B NOR C)}$$

A	B	C	Working space	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

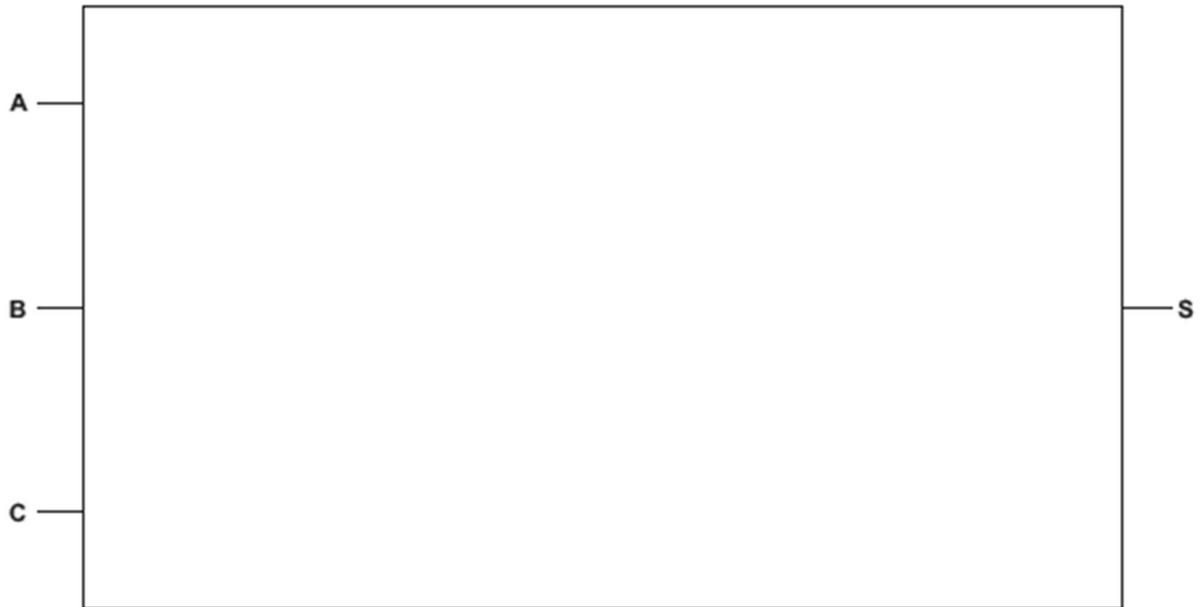
Question	Answer	Marks																																				
3(a)	<p>1 mark for T AND NOT W 1 mark for NOT R OR NOT M 1 mark for final AND</p> 	3																																				
3(b)	<p>1 mark for each set of rows as highlighted:</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>X</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	A	B	C	X	0	0	0	1	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	1	0	1	1	0	0	1	1	1	0	2
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- 3 A logic expression is given:

$$S = (A \text{ AND } B \text{ AND } C) \text{ OR } (B \text{ XOR } C)$$

- (a) Draw the logic circuit for the given expression.



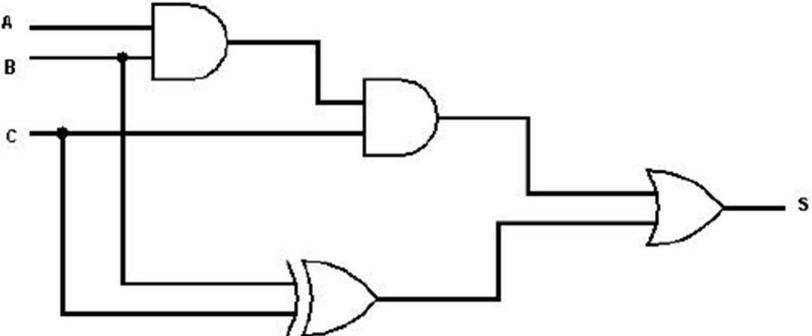
[4]

- (b) Complete the truth table for the logic expression:

$$S = (A \text{ AND } B \text{ AND } C) \text{ OR } (B \text{ XOR } C)$$

A	B	C	Working space	S
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

[2]

Question	Answer	Marks																																													
<p>3(a)</p>	<p>1 mark for each correct gate, with correct inputs</p> 	<p>4</p>																																													
<p>3(b)</p>	<p>1 mark for each half (shaded)</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>Working space</th> <th>S</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td></td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td></td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td></td> <td>1</td> </tr> </tbody> </table>	A	B	C	Working space	S	0	0	0		0	0	0	1		1	0	1	0		1	0	1	1		0	1	0	0		0	1	0	1		1	1	1	0		1	1	1	1		1	<p>2</p>
A	B	C	Working space	S																																											
0	0	0		0																																											
0	0	1		1																																											
0	1	0		1																																											
0	1	1		0																																											
1	0	0		0																																											
1	0	1		1																																											
1	1	0		1																																											
1	1	1		1																																											

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- 2 (a) Complete the truth table for each of the following two logic gates.



A	B	Output
0	0	
0	1	
1	0	
1	1	



A	B	Output
0	0	
0	1	
1	0	
1	1	

[2]

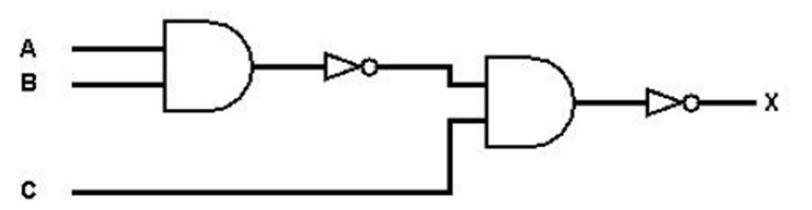
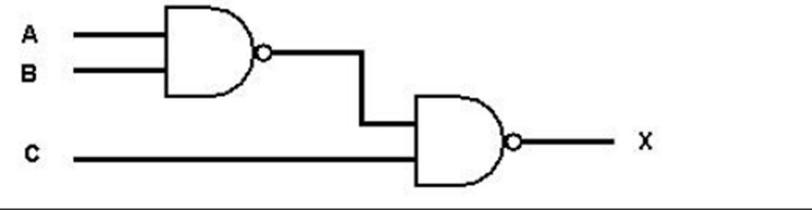
- (b) Draw a logic circuit for the following logic expression.

$$X = \text{NOT}(\text{NOT}(A \text{ AND } B) \text{ AND } C)$$



[2]

Question	Answer	Marks																														
2(a)	<p>1 mark for each completely correct truth table</p> <p>NOR</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table> <p>NAND</p> <table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	A	B	Output	0	0	1	0	1	0	1	0	0	1	1	0	A	B	Output	0	0	1	0	1	1	1	0	1	1	1	0	2
A	B	Output																														
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0	1	0																														
1	0	0																														
1	1	0																														
A	B	Output																														
0	0	1																														
0	1	1																														
1	0	1																														
1	1	0																														

Question	Answer	Marks
2(b)	<p>1 mark for each correct bullet point</p> <ul style="list-style-type: none"> • NOT (A AND B) // A NAND B • NOT the result AND C // the result NAND C  <p>OR</p> 	2