

Homework 2

● Graded

Student

Aaryan Vinay Potdar

Total Points

100 / 100 pts

Question 1

Overview

0 / 0 pts

+ 0 pts Incorrect

✓ + 0 pts Correct

Question 2

Transistors

13 / 13 pts

2.1 (no title)

2 / 2 pts

✓ + 2 pts Correct (N-type)

+ 0 pts Incorrect

+ 2 pts Correct

2.2 (no title)

3 / 3 pts

✓ + 3 pts Correct (2 P-Type and 2 N-Type)

+ 0 pts Incorrect

+ 3 pts Correct

2.3 (no title)

5 / 5 pts

✓ + 5 pts Correct:

- › Gives formula $2n$
- › Explains reasoning correctly

+ 2.5 pts Gives formula $2n$, but does not explain reasoning correctly

+ 0 pts Incorrect

2.4 (no title)

3 / 3 pts

+ 0 pts Incorrect

+ 3 pts Correct

✓ + 3 pts Correct (A)

Question 3

Combinational Logic

18 / 18 pts

3.1 (no title) 8 / 8 pts

✓ + 8 pts Correct: $A'B'C' + A'BC' + AB'C$ (or equivalent terms in different order)

+ 8 pts Correct

+ 5 pts provides 2 out of 3 terms correctly

+ 3 pts provides 1 out of 3 terms correctly

+ 0 pts Incorrect

3.2 (no title) 10 / 10 pts

✓ + 10 pts Correct

+ 8 pts Partial credit - Correct AND gates, does not use OR gate to combine outputs of AND gates (or logical equivalent)

+ 6 pts Partial credit - two correct AND gate representations of terms out of 3

+ 3 pts Partial credit - one correct AND gate representation of term out of 3

+ 0 pts Incorrect

Question 4

NOR3

16 / 16 pts

4.1 Transistors

6 / 6 pts

✓ + 6 pts Correct

+ 0 pts Incorrect

+ 5 pts Minor mistake such as:

- › missing inputs
- › missing output
- › missing power/ground
- › missing line above transistor

4.2 Cascading

6 / 6 pts

✓ + 6 pts Correct

+ 3 pts Partial credit:

- (1) only uses two cascading NOR gates and a NOT gate (bubble or actual gate both count)
- (2) Unclear gate drawings

+ 0 pts Incorrect

- (1) Just 2 cascading NORs
- (2) Uses other gates
- (3) Drawn with transistors
- (4) Not equivalent to NOR3

4.3 Comparison

4 / 4 pts

✓ + 4 pts Correct, provides at least one of the facts below:

- › NOR3 has 6 transistors, which is less than NOR3 with cascading NOR2 gates.
- › NOR3 built with cascading NOR2 gates has 12 transistors.
- › More efficient to build NOR3 itself with transistors instead of cascading NOR2 gates as it requires less transistors. (Wiring is negligible compared to transistors).

+ 1.5 pts Correct conclusion (build w/ transistors), but does not explain reasoning

+ 0 pts Incorrect

Question 5

Multiplexers and Decoders	14 / 14 pts
5.1 (no title)	2 / 2 pts
+ 2 pts Correct	
✓ + 2 pts Correct (4)	
+ 0 pts Incorrect	
5.2 (no title)	2 / 2 pts
+ 2 pts Correct	
✓ + 2 pts Correct (32)	
+ 0 pts Incorrect	
5.3 (no title)	2 / 2 pts
+ 2 pts Correct	
✓ + 2 pts Correct (1)	
+ 0 pts Incorrect	
5.4 (no title)	2 / 2 pts
+ 2 pts Correct	
✓ + 2 pts Correct (8)	
+ 0 pts Incorrect	
5.5 (no title)	6 / 6 pts
✓ + 6 pts Correct	
+ 2 pts Partial credit - incorrect, but ATTEMPTS to use decoder and AND gates to select between inputs	
+ 0 pts Incorrect	

Question 6

Circuit Tracing	10 / 10 pts
✓ + 10 pts Correct (0, 1, 1, 1)	
+ 10 pts Correct	
+ 6 pts 3 out of 4 correct	
+ 4 pts 2 out of 4 correct	
+ 2 pts 1 out of 4 correct	
+ 0 pts Incorrect	

Question 7

DeMorgan's Law/Bubble Theorem

11 / 11 pts

7.1 (no title)

Resolved 6 / 6 pts

+ 6 pts Correct: $\sim A \mid (B \mid C) \mid \sim(\sim A \mid \sim C)$

✓ + 6 pts Correct

+ 0 pts Incorrect

C Regrade Request

Submitted on: Sep 24

7.2

- My solution is logically equivalent, does that count as partial points at least?
Thank you.

Yep. Sorry about that.

Reviewed on: Sep 25

7.2 (no title)

Resolved 5 / 5 pts

✓ + 5 pts Correct

+ 0 pts Incorrect

C Regrade Request

Submitted on: Sep 25

7.2- My solution is logically equivalent, does that count as partial points at least?
Thank you.

I sent the regrade request on the wrong question earlier. Sorry for the inconvenience.

This is correct, all fixed.

Reviewed on: Sep 25

Question 8

K-Maps

18 / 18 pts

8.1 (no title)

6 / 6 pts

+ 6 pts Correct: $BD + BC + A'CD + B'C'D'$

✓ + 6 pts Correct

+ 4.5 pts 3 out of 4 terms correct

+ 3 pts 2 out of 4 terms correct

+ 1.5 pts 1 out of 4 terms correct

+ 0 pts Incorrect

8.2 (no title)

6 / 6 pts

+ 6 pts Correct: $AC + A'B'C'$

✓ + 6 pts Correct

+ 3 pts provides 1 out of 2 correct terms

+ 0 pts Incorrect

8.3 (no title)

6 / 6 pts

+ 6 pts Correct: $A'BC'D$ (or equivalent)

✓ + 6 pts Correct

+ 0 pts Incorrect

+ 2 pts Typo

Q1 Overview**0 Points**

Please complete the following problems.

The collaboration policy for the course still applies. Refer to the syllabus for details regarding this policy.

Q2 Transistors

13 Points

Q2.1

2 Points

This type of transistor is closed when a 1 is applied to the gate and connects to ground.

P-type

N-type

Q2.2

3 Points

In CMOS design, what is the **minimum** number of each transistor required to build a **2-input NAND gate**?

P-type:

2

N-type:

2

Q2.3

5 Points

Write a general formula for the **total** (N-type and P-type) **minimum** number of transistors required to build a **NAND_n** gate where **n** is the number of **inputs** to the **NAND** gate.

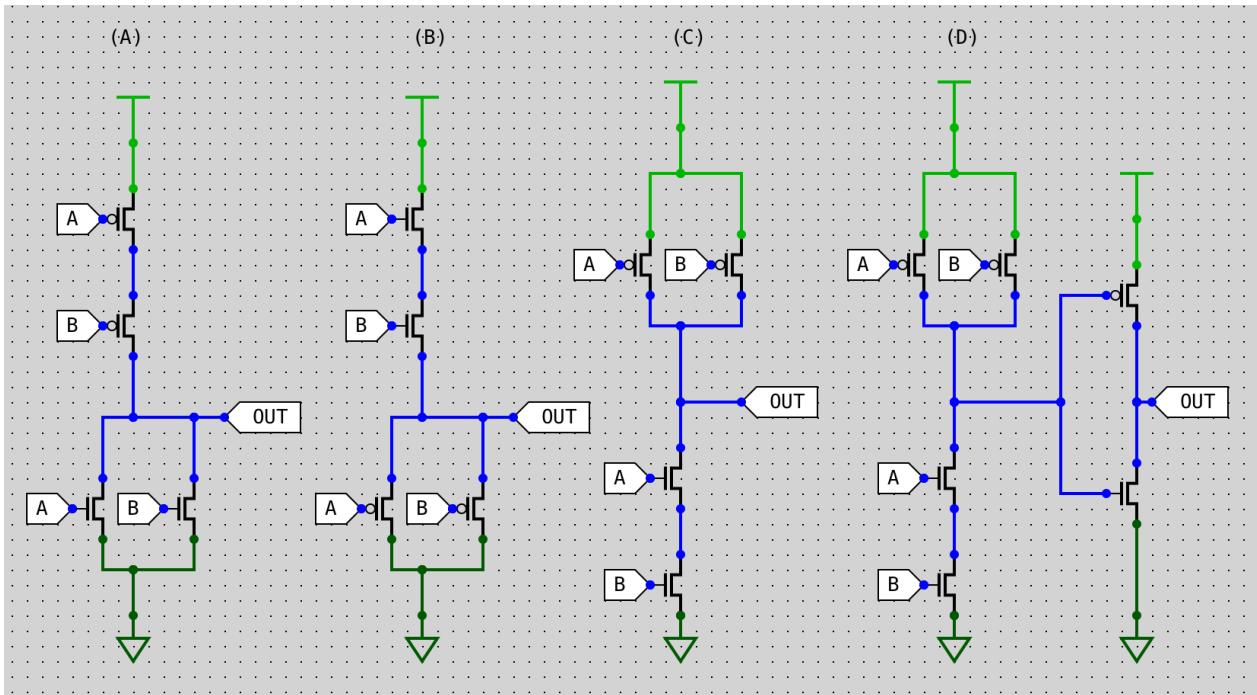
Explain your answer in 1-2 sentences.

A total of $2n$ transistors will be required. Each input corresponds to a gate in one N-type and one P-type transistor. For NAND_n gate, we will need n N-type transistors in series and n P-type transistors in parallel.

Q2.4

3 Points

Which of the following transistor diagrams represents a valid, functioning **NOR2** gate? The inputs are represented by A and B and the output is represented by OUT.



A

B

C

D

Q3 Combinational Logic

18 Points

Q3.1

8 Points

Given the following truth table, please generate a boolean expression which describes the variable O using A, B, and C. Write your answer in the sum of products format. Do not simplify your answer.

You should use `'` for **NOT** (no spaces) and `+` for **OR** (use spaces in between).

For **AND**, put the inputs together with no space.

Example (NOT THE ANSWER): $AB + A'B'C'$

A	B	C	O
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

`A'B'C' + A'BC' + AB'C`

Q3.2

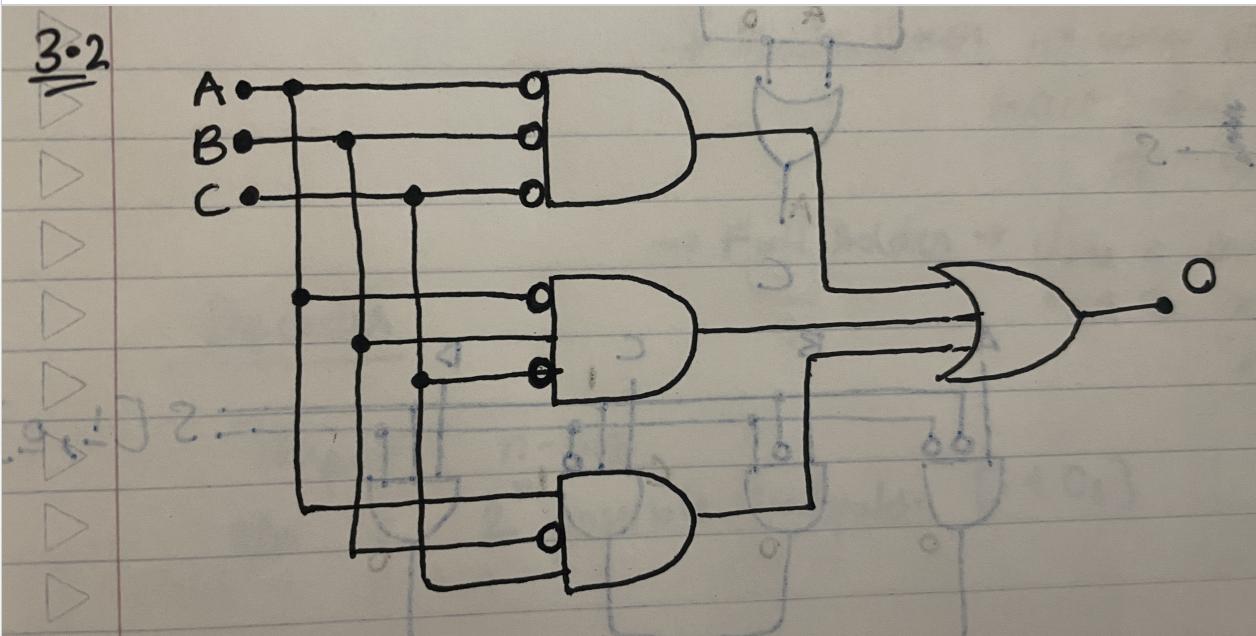
10 Points

Create a circuit representation of the boolean expression created in 3.1. You do **not** need to draw the gates with transistors.

Please draw the circuit clearly on a piece of paper and upload it below.

▼ IMG_4464.jpg

 Download



Q4 NOR3

16 Points

Q4.1 Transistors

6 Points

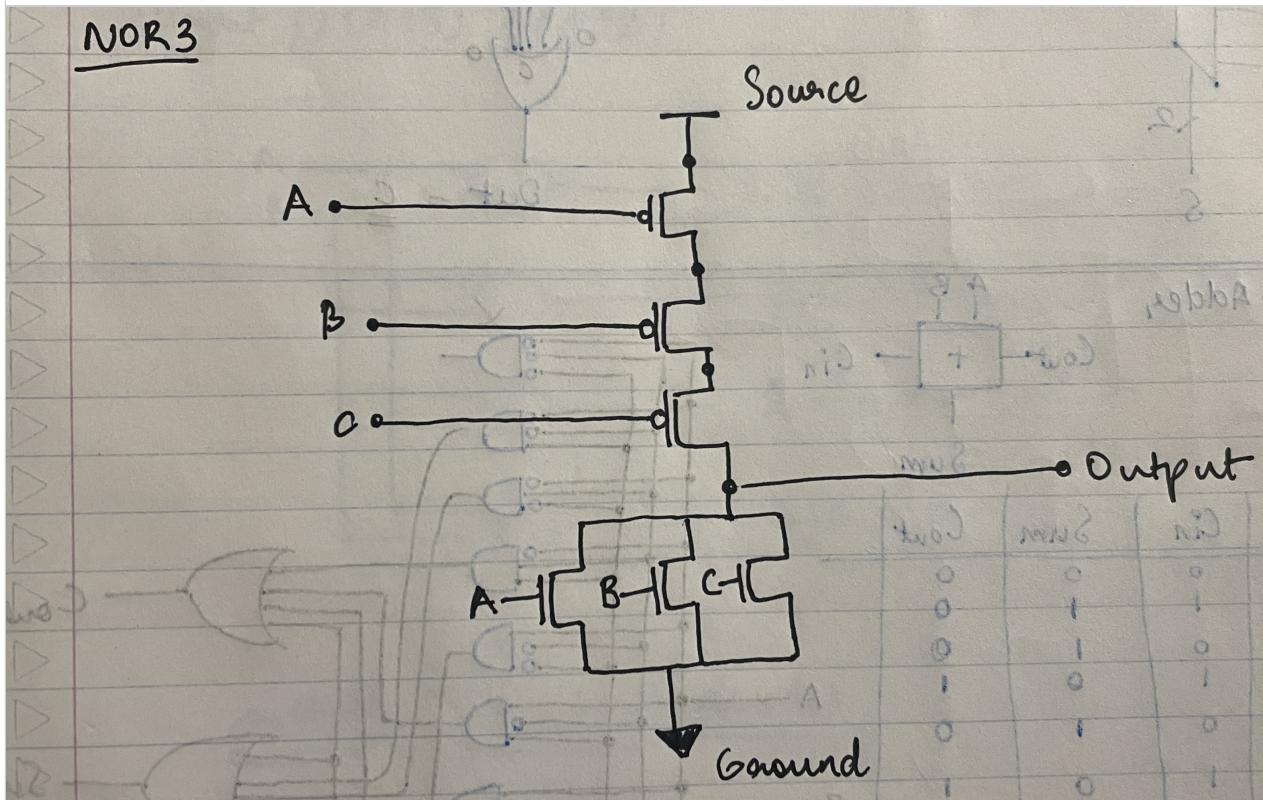
Using only P-type and N-type transistors, 3 inputs, and basic wiring, create an **NOR3** gate.

A **NOR3** gate is an **NOR** gate with 3 inputs.

Please draw the circuit clearly on a piece of paper and upload it below.

▼ IMG_4465.jpg

 Download



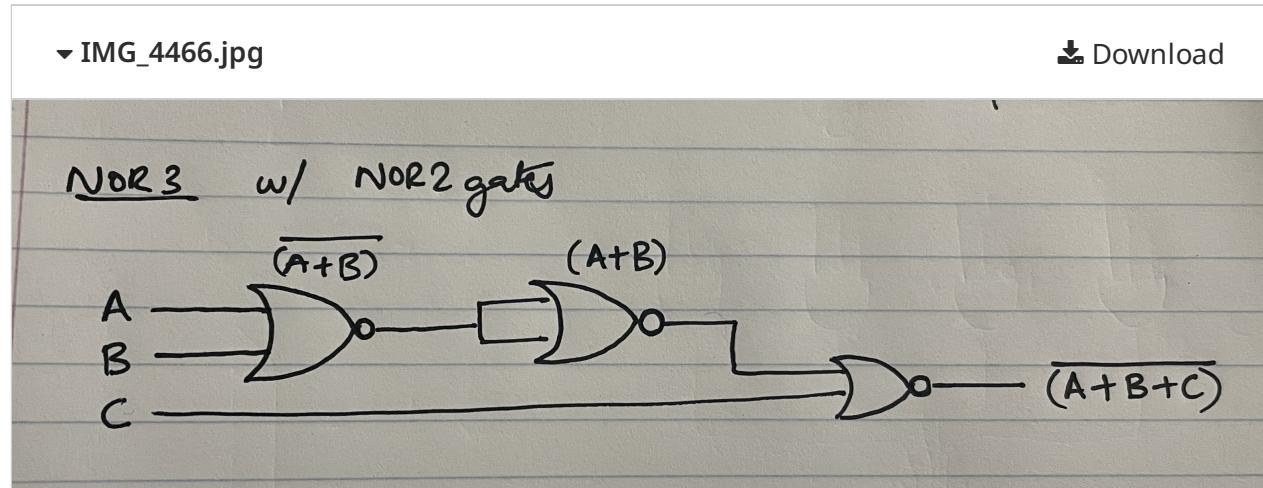
Q4.2 Cascading

6 Points

Using **only** NOR2 gates, the 3 inputs, and basic wiring, create an NOR3 gate.

A NOR2 gate is an NOR gate with 2 inputs. You do **not** need to draw the NOR2 gates out of transistors.

Please draw the circuit clearly on a piece of paper and upload it below.



Q4.3 Comparison

4 Points

Compare your implementation of the NOR3 gate with transistors and with NOR2 gates. If you were deciding which to use, which would be the better choice? Think about the total hardware (transistors and wires) cost of the circuit.

I would choose NOR3 gate with transistors as each input has a dedicated gate. In terms of hardware cost, we require 3 NMOS and 3 PMOS transistors, which is a fixed number. Depending on the arrangement for cascading NOR3, we will need more as each NOR2 gate requires 4 transistors each. Having multiple NOR2 will also require more wires increasing the hardware cost. Overall, the NOR3 with transistors would be a better choice due to lesser transistors actively switching.

Q5 Multiplexers and Decoders

14 Points

Please give all answers as **integers**, not as an expression (eg. 1024 instead of 2^{10}).

Q5.1

2 Points

Given a decoder with 16 outputs, what is the **minimum** number of input/selector bits it must have?

4

Q5.2

2 Points

Given a decoder with 5 input/selector bits, what is the **maximum** number of outputs it can have?

32

Q5.3

2 Points

Given a multiplexer with 8 selector bits, up to **how many outputs can it have?**

1

Q5.4

2 Points

Given a multiplexer with 3 selector bits, what is the **maximum** number of inputs it can have?

8

Q5.5

6 Points

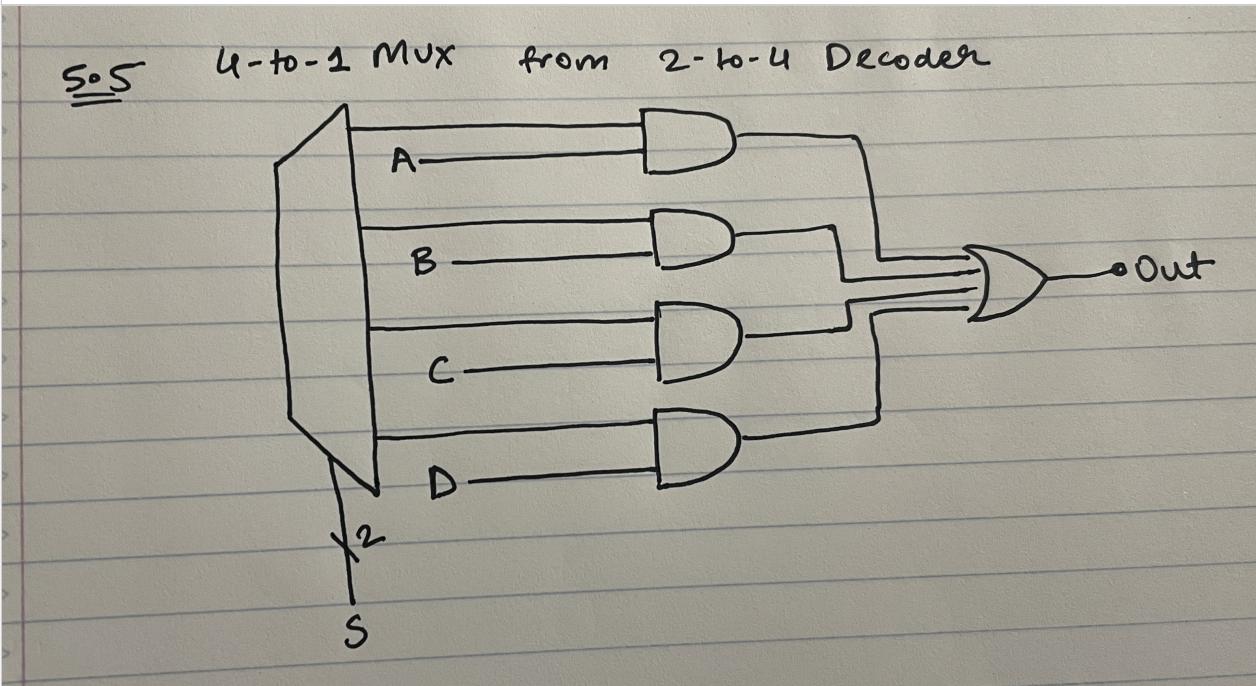
You want to build an **4-to-1 mux**, but all you have is a **2-to-4 decoder** plus a supply of **AND** and **ORs** of various fan-ins (e.g., AND2, AND3, etc.)!

Show how you can construct the **4-1 mux** out of the **decoder** using these **extra gates**. You **may** use the simplified symbol for a decoder in your drawing.

Please draw the circuit clearly on a piece of paper and upload it below.

▼ IMG_4468.jpg

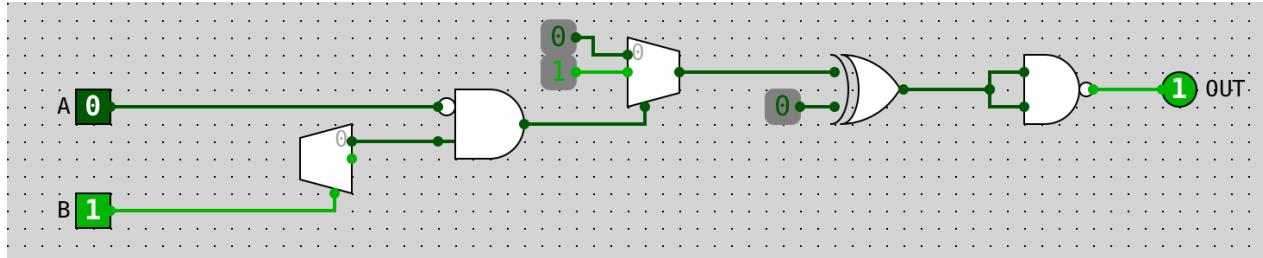
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Q6 Circuit Tracing

10 Points

Fill out the truth table below for the following circuit. The output should be either a **1** or a **0**. Fill in the corresponding short answer questions to the entries in the table below numbered 1-4.



A	B	OUT
0	0	(1)
0	1	(2)
1	0	(3)
1	1	(4)

(1)

(2)

(3)

(4)

1

Q7 DeMorgan's Law/Bubble Theorem

11 Points

Q7.1

6 Points

Convert the following Boolean expression to one that only uses ORs and NOTs

Do not simplify

$$\sim(A \ \& \ (\sim B \ \& \ \sim C) \ \& \ \sim(A \ \& \ C))$$

$$\sim A \mid (B \mid C) \mid \sim(\sim A \mid \sim C)$$

Q7.2

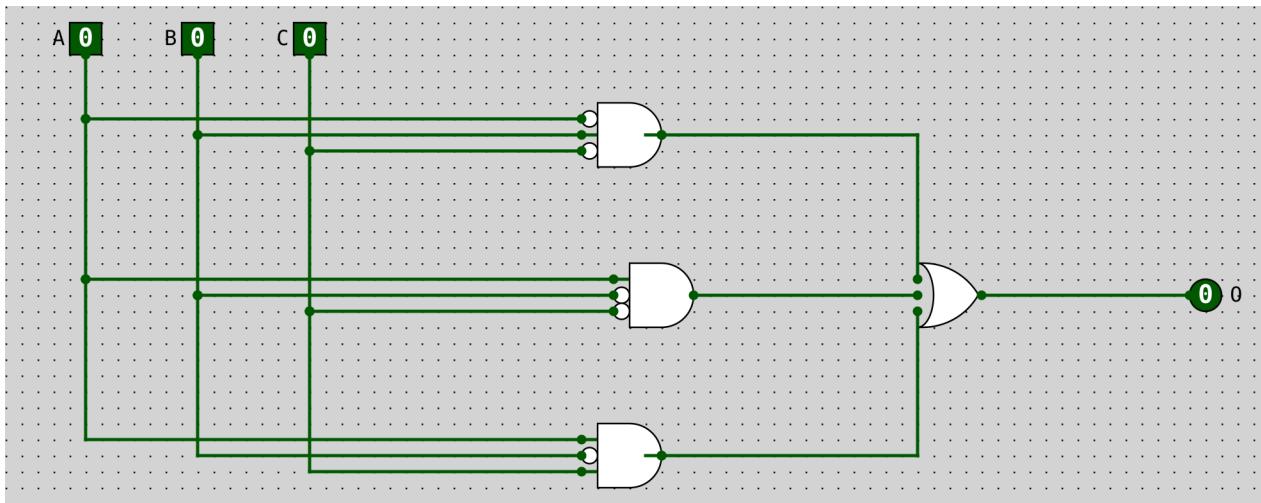
5 Points

The following sum of products circuit currently uses 3 AND3 gates, 1 OR3 gate, and 5 NOT gates.

Build a logically equivalent circuit with **only** NAND3 and NOT gates. Use the **minimum** number of gates as possible.

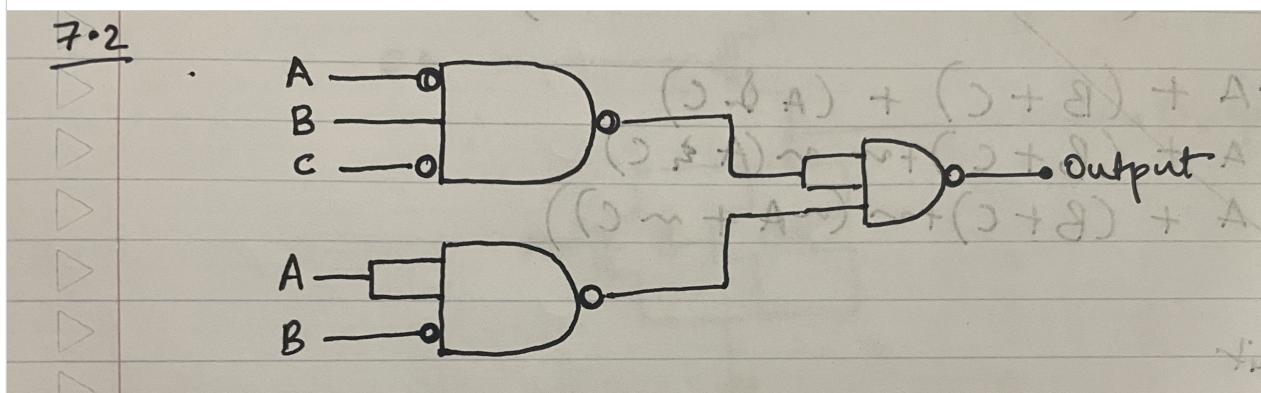
You can assume that the 3-input gates are built in the most efficient transistor implementation.

Please draw the circuit clearly on a piece of paper and upload it below.



▼ IMG_4467.jpg

Download



Q8 K-Maps

18 Points

Simplify the following K-Maps. Write the corresponding boolean expression with
as few terms as possible.

Q8.1
6 Points

	CD	C'D	C'D'	CD'
AB	1	1	0	1
A'B	1	1	0	1
A'B'	1	0	X	0
AB'	0	0	1	0

Simplify the K-Map above. Write the corresponding boolean expression with **as few terms as possible.**

- Use a single quote ' to denote the complement of a variable.
- Only use the variables A, B, C and D.
- Do not include spaces for AND (e.g. use AB, instead of A AND B, A * B, or A • B)
- Use + for OR (e.g. C+D)
- Within terms that are AND-ed together, place variables alphabetically (e.g. use ACD + BC, not CAD+CB)
- Example of an answer in the correct format: A'B+CD'
- **Do not use spaces in your answer.**

BD+A'CD+B'C'D'+BC

Q8.2

6 Points

	CD	C'D	C'D'	CD'
AB	1	0	0	1
A'B	0	0	0	0
A'B'	0	1	X	0
AB'	1	0	0	1

Simplify the K-Map above. Write the corresponding boolean expression with **as few terms as possible.**

- Use a single quote ' to denote the complement of a variable.
- Only use the variables A, B, C and D.
- Do not include spaces for AND (e.g. use AB, instead of A AND B, A * B, or A • B)
- Use + for OR (e.g. C+D)
- Within terms that are AND-ed together, place variables alphabetically (e.g. use ACD + BC, not CAD+CB)
- Example of an answer in the correct format: A'B+CD'
- **Do not use spaces in your answer.**

AC+A'B'C'

Q8.3

6 Points

	CD	C'D	C'D'	CD'
AB	0	0	0	0
A'B	0	1	0	0
A'B'	0	0	X	0
AB'	0	0	0	0

Simplify the K-Map above. Write the corresponding boolean expression with **as few terms as possible.**

- Use a single quote ' to denote the complement of a variable.
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- Do not include spaces for AND (e.g. use AB, instead of A AND B, A * B, or A • B)
- Use + for OR (e.g. C+D)
- Within terms that are AND-ed together, place variables alphabetically (e.g. use ACD + BC, not CAD+CB)
- Example of an answer in the correct format: A'B+CD'
- **Do not use spaces in your answer.**

A'BC'D