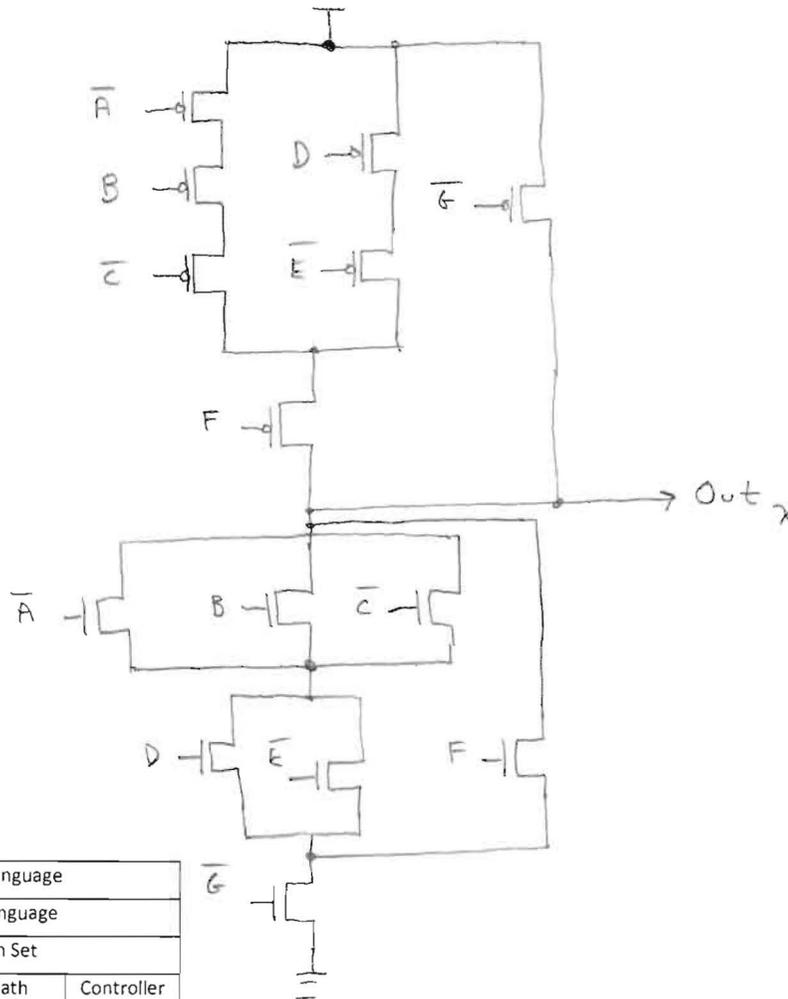


6 pages, 100 possible points. **Show your work for any possible partial credit.** No calculators, no cell phones allowed.

Switch Level Circuits:

1) (15 total point) For the expression below, create a switch level implementation using N and P type switches. Assume both inputs and their complements are available. Your design should contain no shorts or floats. Implement the equations exactly as they are (no simplifying).

$$Out_x = (A \cdot \overline{B} \cdot C + \overline{D} \cdot E) \overline{F} + G$$



High Level Language		
Assembly Language		
Instruction Set		
Memory	Data Path	Controller
Storage	Functional Units	State Machines
Building Blocks		
Gates		
Switches and Wires		

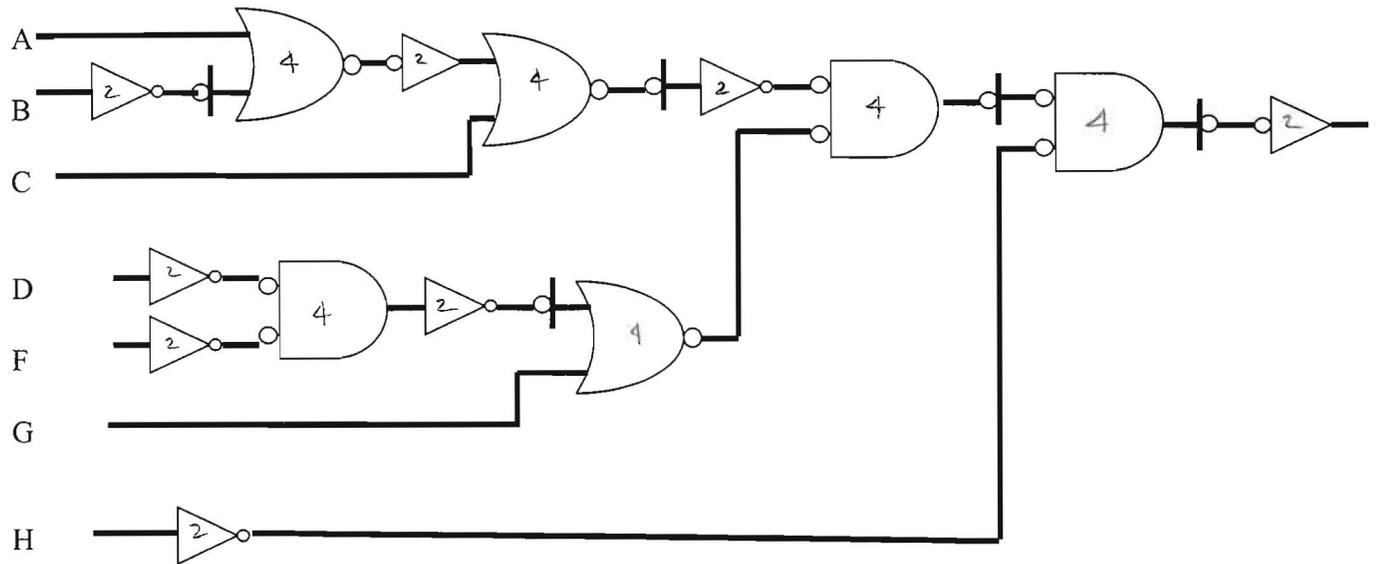
Switch-Ready Expressions:

2) (15 points) Transform each of the following Boolean expressions to a form where they are ready for switch level implementation (i.e., there should only be bars over input variables, not over operations). The behavior of the expression should remain unchanged. **Do not implement**, just show the new Boolean equation without any "big bars". (Note: The line above the boolean equation is a bar and is not a blank for you to write an answer in).

$$\begin{aligned} \text{Outx} &= \overline{(D \cdot E + F \cdot G) \cdot H} + \overline{I \cdot J} \\ &= \overline{\overline{((D \cdot E) + (F \cdot G)) + H}} + \overline{\overline{I + J}} \\ &= \overline{(D \cdot E) + (F \cdot G) + H} + \overline{I + J} \\ &= \overline{(D \cdot E) \cdot (F \cdot G) + H} + \overline{I + J} \\ &= \overline{(D \cdot E)(F \cdot G) + H} + \overline{I + J} \\ &= \overline{(\overline{D + E})(\overline{F + G}) + H} + \overline{I + J} \\ &= (\overline{D + E})(\overline{F + G}) + H + \overline{I + J} \end{aligned}$$

High Level Language		
Assembly Language		
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Gates		
Switches and Wires		

3) (15 points) Write the boolean output expression for the gate design shown below. Also determine the number of switches used in its implementation.



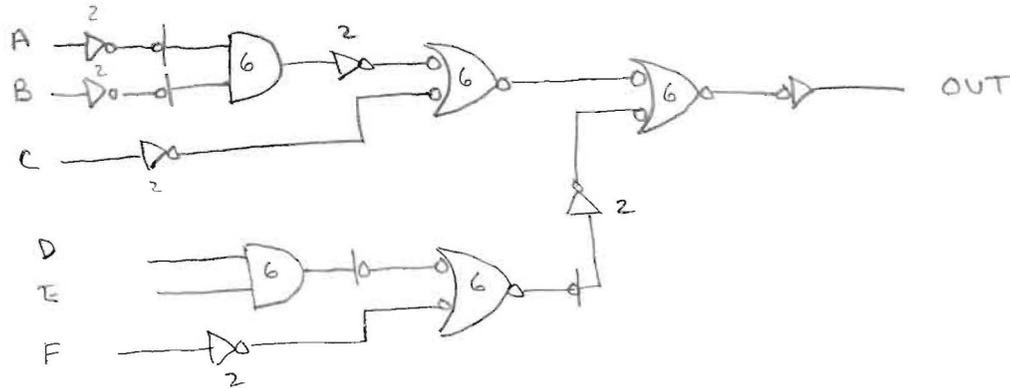
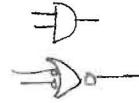
Out $(A + \overline{B} + C)(\overline{D \cdot F} + G) \cdot H$

number of switches $6 \times 4 + 8 \times 2 = 40$

High Level Language		
Assembly Language		
Instruction Set		
Memory	Data Path	Controller
Storage	Functional Units	State Machines
Building Blocks		
Gates		
Switches and Wires		

4) (15 points) Implement the following expression using only two input AND gates and inverters so as to minimize the number of switches required. Then determine the number of switches required. Use proper mixed logic notation. Do not modify the expression, do not simplify the expression. Do not assume complements of inputs are available.

$$\text{Out} = (\overline{A} \cdot \overline{B} + C) + \overline{(\overline{D} \cdot \overline{E} + F)}$$



Number of switches 5x6 + 7x2 = 44

High Level Language		
Assembly Language		
Instruction Set		
Memory	Data Path	Controller
Storage	Functional Units	State Machines
Building Blocks		
Gates		
Switches and Wires		

5) (15 points) Determine the canonical sum of products (using minterms) expressions for the truth table below:

A	B	C	OUT
0	0	0	1
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

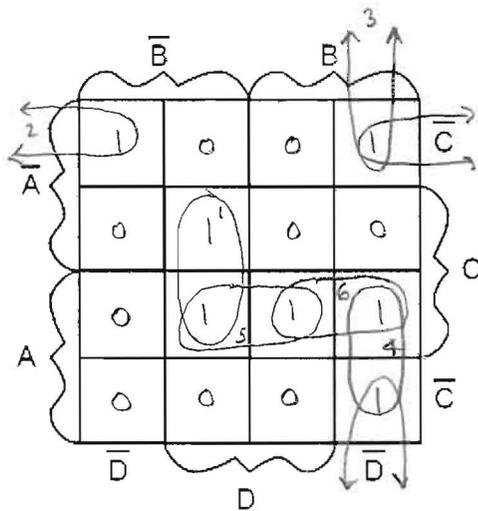
SOP (minterms) = $\bar{A} \cdot \bar{B} \cdot \bar{C} + \bar{A} B \bar{C} + A \bar{B} \bar{C}$

High Level Language		
Assembly Language		
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Gates		
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Karnaugh Maps:

6) (15 points) Part A: For the following expression, derive a simplified *sum of products* expression using a Karnaugh Map. Circle and list **ALL** the prime implicants, indicating which are essential.

$$\overline{A} \overline{B} \overline{C} \overline{D} + \overline{A} \overline{B} C \overline{D} + \overline{A} B \overline{C} D + A \overline{B} C D + A B C D + A B C \overline{D} + A B \overline{C} \overline{D}$$

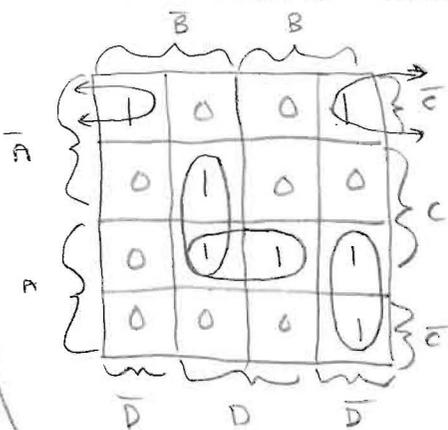


	prime implicants	essential?	
		yes	no
1	$\overline{B} \overline{C} \overline{D}$	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	$\overline{A} \overline{C} \overline{D}$	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	$B \overline{C} \overline{D}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4	$A B \overline{D}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
5	$A C D$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6	$A B C$	<input type="checkbox"/>	<input checked="" type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>

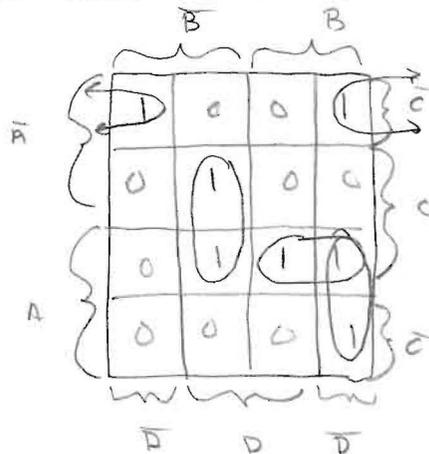
Simplified sum of products

Part B: (10 points) There may be more than one correct answer. For full credit, show **ALL** additional possible correct simplified sum of products answers (if there are any). Show your work!

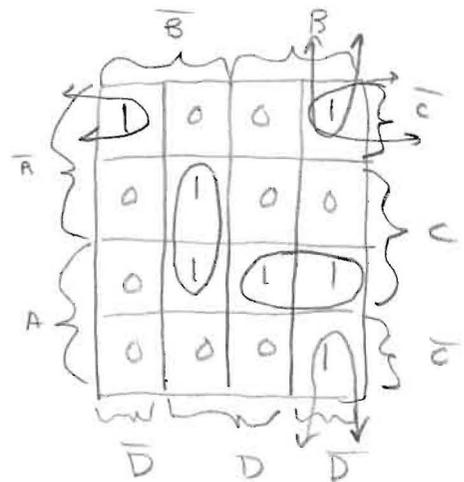
ALL POSSIBLE CORRECT ANSWERS ARE:



$$\overline{B} \overline{C} \overline{D} + \overline{A} \overline{C} \overline{D} + A B \overline{D} + A C D$$



$$\overline{B} \overline{C} \overline{D} + \overline{A} \overline{C} \overline{D} + A B \overline{D} + A B C$$



$$\overline{B} \overline{C} \overline{D} + \overline{A} \overline{C} \overline{D} + B \overline{C} \overline{D} + A B C$$