Each problem is weighted equally, and you will be evaluated on 2 out of 4 problems.

1. CMOS Logic:
Below is the CMOS diagram of a 2-input logic gate with A and B as inputs and Y as output.

(a) Complete the following table for all possible combinations of A and B. Note that N\textsubscript{X} and P\textsubscript{X} represent nMOS and pMOS respectively with input X. For each, write whether the transistor is ON/OFF. Finally, fill column Y (which shows the function implemented by the above diagram).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>P\textsubscript{A}</th>
<th>P\textsubscript{B}</th>
<th>N\textsubscript{A}</th>
<th>N\textsubscript{B}</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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<td>0</td>
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</tbody>
</table>

(b) Give the Boolean representation of the implemented function.

(c) Identify the type of logic gate implemented by the CMOS diagram.
2. Boolean Algebra:
Prove the boolean equations using the axioms and theorems of boolean algebra. Write down explicitly the theorems used in each step of the derivation.

(a) \((A+B+C).(A'+B'+C+D').(A'+C).(B+C).(A'+B') = (B+C).(A'+B')\)
(b) \((A + B).(A.C + A.C') + A.B + B = A+B\)

3. Universal Gates/De Morgan’s Theorem:
\[ (\overline{A + B} \cdot \overline{AC}) \]

(a) Implement the boolean logic with NOT and 2-input gates as shown, no simplification
(b) Implement the same circuit only using NOR and NOT gates.
(c) How many transistors do the circuits from parts A and B use?

4. Boolean Word Problem:
You have been tasked with designing a circuit for controlling an actuator. Two inputs \(X\) and \(Y\) control the actuator such that when \(X=1\) or \(Y=1\), but not both, the output of the circuit is 1. Otherwise, the output is 0. Additionally, due to safety concerns, a kill switch \(K\) must also be added such that regardless of the other inputs, if the kill switch is on \((K=1)\), the output of the circuit is 0. If kill switch is off \((K=0)\), then output depends on \(X\) and \(Y\) as described above.

(a) Represent this circuit in boolean algebra. Give solution in terms of \(X\), \(Y\), and \(K\).
(b) Design a circuit using AND, NAND, OR, NOR, and/or NOT gates that achieves the goals outlined above.