

YOUR NAME: _____

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Read each problem **very carefully** before starting to solve it. Each problem is worth 5 points. It is necessary to show **all** your work. Correct answers without explanations are worth 0 points. GOOD LUCK!!

1. In this quiz, you are asked to design three Turing Machines of increasing complexity.
 - (a) Design a Turing Machine M_1 that does the following: On input $x_0x_1 \cdots x_n \in \{a, b, c\}^*$ it replaces all occurrences of c by a and halts with its head scanning the first symbol of the output.

- (b) Design a Turing Machine M_2 that does the following: On input $x_0x_1 \cdots x_{n-1}x_n \in \{a, b\}^*$, it leaves on its tape the output $x_nx_0x_1 \cdots x_{n-1}$ and halts with its head scanning x_n .

- (c) Design a Turing Machine M_3 that on input $x_0x_1 \cdots x_n \in \{(,)\}^*$ balances left and right parentheses, i.e., halts accepting if the input expression of parentheses is syntactically sound (e.g. “ $((()))$ ”) and rejects otherwise (e.g. “ $()$ ” or “ $((() ())$ ”).