## Midterm

There are 5 problems each worth 6 points for a total of 30 points. Show all your work, partial credit will be awarded. Space is provided on the test for your work; if you use a blue book for additional workspace, sign it and return it with the test. No notes, no collaboration.

Name: _____

| Problem | Credit |
|---------|--------|
| 1       |        |
| 2       |        |
| 3       |        |
| 4       |        |
| 5       |        |
| Total   |        |

1. Give an NFA that accepts exactly the strings over the alphabet $\{0, 1\}$ such that the number of 01 substrings equals the number of 10 substrings. (Exactly means, those string and only those strings. The empty string happens to be such a string, by the way.)

   Next, give a machine with the fewest number of states. *Do not worry if you believe your first answer had the minimum number of states. This is just a problem to come back to later, to see if you can improve your otherwise correct solution.*

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2. Write a Regular Expression that expresses the same language as the following FSA.
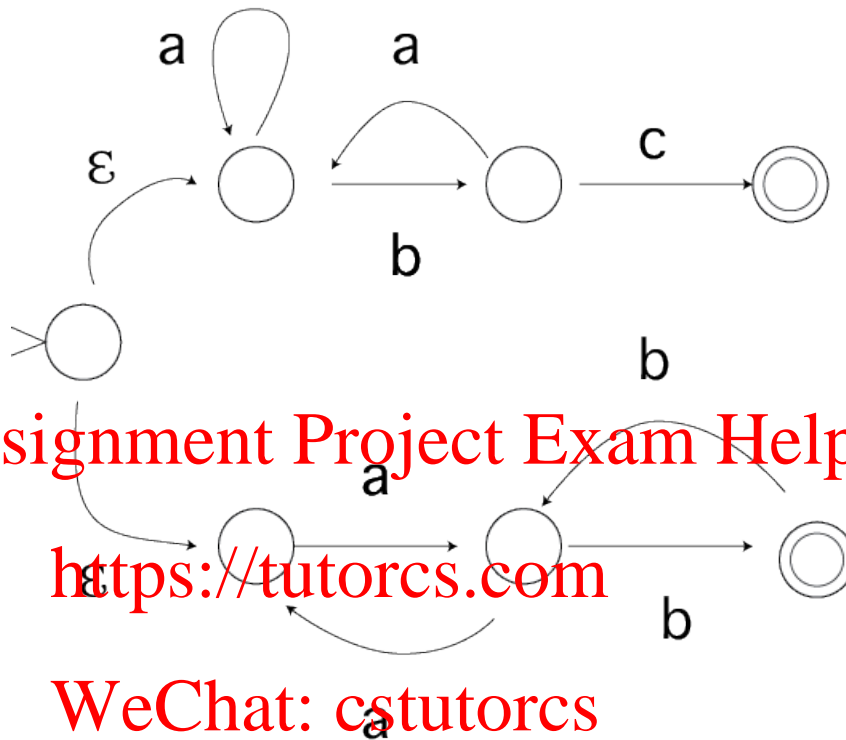
3. Show that the language

$$\{\, a^i \# b^j \# c^k \# d^n \mid \text{ where } i, j, k \geq 0 \text{ and } i + j + k = n \,\}$$

is not regular.

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4. Give a Context Free Grammar for the language,

$$\{\, a^i b^j c^k \,|\, i = j \text{ or } i = k \,\}$$

Then show that the CFG is ambiguous by giving two parse trees in you grammar of the string *aaabbbccc*.

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5. Give a Context Free Grammar for the Regular Expression:

$$ab^*(a|b)(c(a|b))^*$$

Give a Regular Expression for the following Context Free Grammar, or give a proof or a concise logical argument why an equivalent Regular Expression does not exist,

$$
\begin{aligned}
S &\longrightarrow AX \\
A &\longrightarrow aA \,|\, a \\
X &\longrightarrow \epsilon \,|\, abXc
\end{aligned}
$$

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