Ma2201/CS2022 **Foundations of C.S.** Spring, 2017

Double Down Quiz 1100

PRINT NAME: _____

$\mathcal{SIGN}$: _____

☐ - Ordinary ☐ - Replace ☐ - Double Down

1. (4 pts) Given a grammar G:

$$\begin{aligned} G: S &\rightarrow AB \mid C \\ A &\rightarrow AC \mid AB \mid BC \mid BD \\ B &\rightarrow BC \mid BD \mid a \mid bb \\ C &\rightarrow CC \mid aa \mid bbb \\ D &\rightarrow aa \mid bb \end{aligned}$$

Express as an equivalent grammar with no left recursion.

♣ A, B and C have left recursion, so we introduce R_A, R_B, and R_C.

$$\begin{aligned} G': S &\rightarrow AB \mid C \\ A &\rightarrow BC \mid BD \mid BCR_A \mid BDR_A \\ R_A &\rightarrow C \mid B \mid CR_A \mid BR_A \\ B &\rightarrow a \mid bb \mid aR_B \mid bbR_B \\ R_B &\rightarrow C \mid D \mid CR_B \mid DR_B \\ C &\rightarrow aa \mid bbb \mid aaR_C \mid bbbR_C \\ R_C &\rightarrow C \mid CR_C \\ D &\rightarrow aa \mid bb \end{aligned}$$

2. (4 pts) Give a regular expression for the language $L \subseteq \{a, b, c\}^*$ consisting of all strings which contain the substring *abab* as well as the substring *baba*.

♣ There are many ways to do this. The two subwords to be included can occur in either order and can intersect in either 1 or 3 characters, in which case the string contains *ababa* or *babab* which is sufficient to insure the string is in the language. So

$$(a \cup b \cup c)^*[ababa \cup babab \cup abab(a \cup b \cup c)^*baba \cup baba(a \cup b \cup c)^*abab](a \cup b \cup c)^*$$

3. (2 pts) On the back of this page, draw the state diagram of an automaton, deterministic, or non-deterministic, which expresses the language in problem 2.

♣ Is much easier to use a non-deterministic machine following the idea of problem 2.