

## CSC 360 Mid-Term Exam 2

*Exam carries 20% of grade. Weight of each question is indicated against them.*

*Time Limit: 50 min*

**Name:**

1. (4 points) For the following grammar, construct an equivalent grammar without  $\lambda$ -rules. Your answer must include the NULL set for the grammar.

$$S \rightarrow AB \mid BCS$$

$$A \rightarrow aA \mid C$$

$$B \rightarrow bbB \mid b$$

$$C \rightarrow cC \mid \lambda$$

2. (4 points) Construct an equivalent grammar  $G_C$  that **does not contain chain rules**. Your answer must include the sets CHAIN(S), CHAIN(A), CHAIN(B), CHAIN(C).

$$S \rightarrow AS \mid A$$

$$A \rightarrow aA \mid bB \mid C$$

$$B \rightarrow bB \mid b$$

$$C \rightarrow cC \mid B$$

3. (4 points) Construct a grammar that contains **no direct left recursive rules** and is equivalent to the following grammar.

$$S \rightarrow A \mid C$$

$$A \rightarrow AaB \mid AaC \mid B \mid a$$

$$B \rightarrow Bb \mid Cb$$

$$C \rightarrow cC \mid c$$

4. (4 points) Build a DFA which accepts strings over  $\{a, b\}$  that contain the substring 'abba'

5. (2+2 points) (i). Build a NFA for the following regular grammar:

$$\begin{aligned} S &\rightarrow aS \mid bB \mid a \\ B &\rightarrow Bb \mid \lambda \end{aligned}$$

- (ii). Write a regular expression representing the language of this grammar.