

① Consider the grammar below

$$S \rightarrow A$$

$$A \rightarrow A + A \mid \text{id}$$

$$\text{id} \rightarrow a \mid b \mid c$$

(a) show that the language is ambiguous (5pts)

(b) Find an equivalent unambiguous grammar (3pts)

② Consider the grammar below

$$S \rightarrow SS \mid bS \mid a$$

(a) show that the language is ambiguous (5pts)

(b) Find an equivalent unambiguous grammar (3pts)

③ In each case, state what language is generated by the context free grammar with the indicated productions.

(a) $S \rightarrow aSa \mid bSb \mid \Lambda$ (2pts)

(b) $S \rightarrow aSa \mid bSb \mid a/b$ (2pts)

(c) $S \rightarrow aSb \mid bSa \mid \Lambda$ (4pts)

④ For each of the following regular expressions over $\{0,1\}$, draw an NFA-E recognizing the corresponding language.

(a) $(0+1)^*(011+01010)(0+1)^*$ (4pts)

(b) $(0+1)(01)^*(011)^*$ (3pts)

(c) $010^* + 0(01+10)^*11$ (3pts)

5 Construct DFAs for each of the following regular languages. In all cases the alphabet is $\{a, b\}$

- (a) The set of strings that has exactly 3 bs (and any number of as) (3pts)
- (b) The set of strings where the number of bs is a multiple of 3 (and there can be any number of as) (5pts)