2020-2021 resit

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1 Given alphabet A = {a, b, c} answer the following questions.

a) Let L be the set of words over A, in which the letters are in alphabetical order, for example abc, aabbbc, ac, bbbc. Write down a regular expression for L. **4**

b) Which of the following regular expressions are equivalent to each other? Justify your answer. **6**

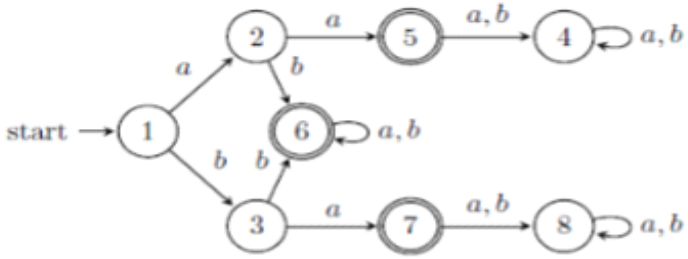
1. cab(ab)*
2. c(aba)*b
3. ca(ba)*b

2 Convert the nondeterministic automaton given below to an equivalent deterministic one using the subset construction. Omit inaccessible states. Draw the graph of the resulting DFA. **8**

	a	b
→ q1 (initial state)	{q2}	{}
q2 → (accepting state)	{}	{q1, q3}
q3 → (accepting state)	{q2, q3}	{q1}

3 For the language $\{0^n10^n \mid n \geq 1\}$, use the Pumping Lemma to prove it is not regular. **10**

4 A DFA is given below.



a) Are there any inaccessible states? If yes, list all inaccessible states. **6**

b) List all pair(s) of equivalent states in the DFA. **6**

c) Minimise the DFA by merging the equivalent states. **8**

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5 Consider a context-free grammar G = ({S, A, B}, {a, b, c}, S, P), where P is the set of productions:

$$S \rightarrow SAS \mid bB$$
$$A \rightarrow \varepsilon \mid a \mid c$$
$$B \rightarrow aB \mid \varepsilon$$

a) Give a left-most derivation for the string bcb. **4**

b) Give two different left-most derivations for the string baaba. Write down also the associated derivation trees. **6**

c) Can the string abaaba be derived from the grammar G? **4**

d) Is the grammar G ambiguous? If yes, justify your answer. **4**

6 Convert the following grammar to Chomsky Normal Form. (You can do this by first substituting variables for the constants and then breaking apart rules the length of whose right hand side is more than 2.) **10**

$$S \rightarrow aAS \mid a$$
$$A \rightarrow SbA \mid SS \mid ba$$

8 A three-phase algorithm performed by a Turing machine is listed below. The input alphabet of the machine is {a, #}, the tape alphabet is {a, A, #, -|}, and its initial input on the tape takes the form of $a^n\#a^n$.

Preparatory phase: scan right to first blank symbol and replace it with a -|.

Main phase: repeat in rounds, in each round performing:
Repeatedly scan from right to left, matching the rightmost a on the right of # with the rightmost a on the left of #. The matching is done by replacing the corresponding a with A.

A round terminates in one of two possible ways:
(a) If there are no more a on the right of #, then delete (that is, replace with the blank symbol) all A on the left of #, and restore all A on the right of # to a. Start new round.
(b) If there is no matching a on the left of #, then go to the next phase.

Finalising phase:
Replace all A by a on the left of #, and delete all other symbols on the tape.

For each of the following initial inputs on the tape given below what will be left on the tape after the machine halts?

a) aaaaa#aa **4**

b) aaaaaaaa#aaa **4**

c) What arithmetic operation does this machine perform? **4**

9 a) What are recursive and recursively enumerable languages? Which one of the two sets stands for decidable problems? 4

b) Describe a language which is recursively enumerable but not recursive. 4

c) Describe a language which is not recursively enumerable. 4

The end