



1. (4 pts) Write a regular expression for all strings on $\{a, b, c\}$ which contain a^2 , b^2 and c^2 as substrings.

Give a short explanation why your solution is correct.

♣ *The string has contain all three substrings, together with other letters. The variation we have to allow for is that the required substrings can come in any order. There are 6 ways to order the substrings, our regular expression seems to require six terms.*

$$\begin{aligned} &[(a \cup b \cup c)^*aa(a \cup b \cup c)^*bb(a \cup b \cup c)^*cc(a \cup b \cup c)^*] \cup \\ &[(a \cup b \cup c)^*aa(a \cup b \cup c)^*cc(a \cup b \cup c)^*bb(a \cup b \cup c)^*] \cup \\ &[(a \cup b \cup c)^*bb(a \cup b \cup c)^*aa(a \cup b \cup c)^*cc(a \cup b \cup c)^*] \cup \\ &[(a \cup b \cup c)^*bb(a \cup b \cup c)^*cc(a \cup b \cup c)^*aa(a \cup b \cup c)^*] \cup \\ &[(a \cup b \cup c)^*cc(a \cup b \cup c)^*aa(a \cup b \cup c)^*bb(a \cup b \cup c)^*] \cup \\ &[(a \cup b \cup c)^*cc(a \cup b \cup c)^*bb(a \cup b \cup c)^*aa(a \cup b \cup c)^*] \end{aligned}$$



2. (6 pts) Consider the grammar given by

$$\begin{aligned} G : S &\rightarrow ABC \mid BCA \mid CAB \mid CBA \mid BAC \mid ACB \\ A &\rightarrow DaaD \\ B &\rightarrow DbbD \\ C &\rightarrow DccD \\ D &\rightarrow DD \mid ab \mid ac \mid ba \mid bc \mid ca \mid cb \mid aa \mid bb \mid cc \mid \lambda \end{aligned}$$

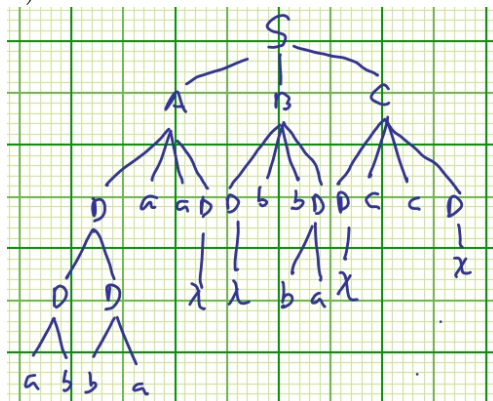
- a) Find a derivation of $abbaaabbbacc$.

♣ *Noticing that all occurrences of alphabet elements are in pairs, it helps to pair the desired string: $(ab)(ba)(aa)(bb)(ba)(cc)$ and that gives us the start.*

$$S \Rightarrow ABC \Rightarrow DaaDDbbDDccD \Rightarrow DDaa\lambda\lambda bbD\lambda cc\lambda \Rightarrow (ab)(ba)aabb(ba)cc$$



- b) Draw the derivation tree of $abbaaabbbacc$.



c) Give your best description of the language $L(G)$ and specify, according to your description, the role played by variable D .

♣ *The language is the strings of even length containing at least one occurrence of each alphabet letter squared in an even position. The role of D is produce any string of even length on the alphabet, and it is used as a separator between the desired strings.*

Naturally I am expecting a variety of different descriptions. ♣