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Answer 1

a.

(i) G = (V, Σ, R, S)
V= {a,b,S,K }
Σ = { a,b }
R= { $S \rightarrow aSa|bK$
$K \rightarrow aKa|b$
}

(ii) G = (V, Σ, R, S)
V= {a,b,S,K_1, L_1, K_2, L_2}
Σ = { a,b }
R= { $S \rightarrow aK_1a|bL_1b$
$K_1 \rightarrow bK_1a|bK_1b|aK_1a|aK_1b$
$K_1 \rightarrow bK_2a|bK_2b|aK_2a|aK_2b$
$K_2 \rightarrow a$
$L_1 \rightarrow bL_1a|bL_1b|aL_1a|aL_1b$
$L_1 \rightarrow bL_2a|bL_2b|aL_2a|aL_2b$
$L_2 \rightarrow b$
}

(iii) G = (V, Σ, R, S)
V= {a,b,S,$S_1, S_2, R_1, C_1, R_4, A_1, R_2, R_3$}
Σ = { a,b }
R= { $S \rightarrow S_1|S_2$
$S_1 \rightarrow aR_1C_1|R_4bC_1$
$R_1 \rightarrow aR_1b|e|aR_1$
$R_4 \rightarrow aR_4b|e|aR_4$
$C_1 \rightarrow C_1c|e$

$S_2 \rightarrow A_1bR_2|R_4bC_1$
$R_2 \rightarrow bR_2c|e|bR_2$
$R_3 \rightarrow bR_3c|e|R_3c$
$A_1 \rightarrow aA_1|e$
}

(iv)

b.

Answer 2

a.

G = (V, Σ, R, K_1)
V= {a,b,K_1, A, B}
Σ = { a,b }
R= { $K_1 \rightarrow Ab|aaB$
$A \rightarrow a|Aa$
$B \rightarrow b$
}

Left most and right most derivations of the string ""aab" are given above respetively.

$S \rightarrow Ab \rightarrow Aab \rightarrow aab$ (left)
$S \rightarrow aaB \rightarrow Aabaab$ (right)

b.

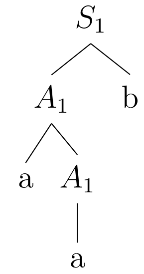
$S_1 \rightarrow A_1 b$
$A_1 \rightarrow aA_1|a$
$G^{'}(V_1, \Sigma_1, R_1, S_1$ } where
V_1 = { a, b, S_1, A_1 },
Σ_1={a,b},
R_1= { $S_1 \rightarrow A_1 b, A_1 \rightarrow aA_1|a$ }
S_1= initial symbol

c.

String s="aab"

unique left most derivation of string s:

$S_1 \to A_1 b \to aA_1 b \to aab$



Answer 3

a.

In the Push Down Automaton ,
of aa's which are in the string is equal to # of x's which are in the stack . Also when there is bbb , x's are poped from stack. To accept the string , all x's should be poped from stack, that means # of aa's and # of bbb's are the same in the string.
Also empty string is accepted by Push Down Automaton.

L(M)={ $(aa)^m$ $(bbb)^m$, $m \geq 0$ }

b.

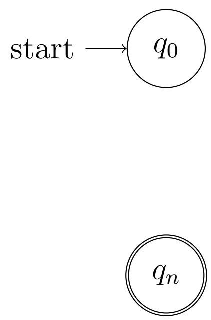
G = (V,Σ, R, S_1)
V ={ a, b S_1, K, L,} ,
Σ = { a,b },

R ={
$S_1 \to K|L|KL|LK$,
$K \to a|aKb|aKa|bKb|bKa$,
$L \to b|aLa|aLb|bLa|bLb|bLa$ }
the push down automaton=
M = (Σ, Γ, Δ, p, { f },{ p,f })
Σ ={ a,b }
Γ = { S_1, K, L ,e,a,b}

Δ = { ((p,e,e),(f,S_1)),
((f,e,S_1),(f,K)),
((f,e,S_1),(f,L)),
((f,e,S_1),(f,KL)), ((f,e,S_1),(f,LK)),
((f,e,K),(f,a)), ((f,e,K),
(f,aKa)),((f,e,K),(f,bKa)), ((f,e,K),(f,aKb)), ((f,e,K),(f,bKb)),
((f,e,L),(f,b)),((f,a,a),(f,e)),
((f,e,L),(f,aLa)),

((f,e,L),(f,aLb)), ((f,e,L),(f,bLb)),
((f,e,L),(f,bLa)),
((f,b,b),(f,e)) }

c.



(i)

(ii)

State	Input	Stack	Transition
q_0	aabcc	e	-
			Accepts/Rejects.

State	Input	Stack	Transition
q_0	bac	e	-
			Accepts/Rejects.

Answer 4

a.

$\Delta = \{$

((p,e,e),(q,E)),
((q,e,E),(q,E+T)),
((q,e,E),(q,T)),
((q,e,T),(q,TxF)),
((q,e,T),(q,F)),
((q,e,F),(q,(E))),
((q,e,F),(q,a)),
((q,a,a),(q,e)),
((q,+,+),(q,e)),
((q,x,x),(q,e)),
((q, (, ( ),(q,e)),
((q,),)),(q,e))
}
V= { $a, +, x, (,), E, T, F$ }
$E \to E + T|T$
$T \to TxF|F$
$F \to (E)|a$
M= { { p,q } , $\Sigma, V, \Delta, p,$ { q } }

$\Sigma = \{ a, +, x, (,) \}$

b.

Answer 5

a.

(i) Let $G_1 = (V_1, \Sigma_1, R_1, S_1)$ and Let $G_2 = (V_2, \Sigma_2, R_2, S_2)$
G = $(V_1 \cup V_2 \cup$ {S} , $\Sigma_1 \cup \Sigma_2$, $R_1 \cup R_2 \cup \{ S \to S_1S_2 \}$, S) where
V_1= {a,b,S_1} and V_2= {a,b,S_2}

Σ_1 = { a,b } and Σ_2 = { a,b }
$R_1 = \{ S_1 \to aS_1b|e$
}
$R_2 = \{ S_2 \to bS_2a|e$
}

(ii) This language is equal to
$\Sigma^*a \cup a\Sigma^* \cup \Sigma^*bb\Sigma^* \cup \Sigma^* \cup \Sigma^*$ { $ba^nba^m, n+1$ is not equal to m } Σ^*
Since each of these languagese above are CF, their union is also CF
CFG's for each language above, respectively:
$G_1 = (V_1, \Sigma_1, R_1, S_1)$
V_1= {a,b,S_1, K_1}
Σ_1 = { a,b }
$R_1 = \{ S_1 \to K_1a$
$K_1 \to e|aK_1|bK_1$
}

$G_2 = (V_2, \Sigma_2, R_2, S_2)$
V_2= {a,b,S_2, K_2}
Σ_2 = { a,b }
$R_2 = \{ S_2 \to aK_2$
$K_2 \to e|aK_2|bK_2$
}

$G_3 = (V_3, \Sigma_3, R_3, S_3)$
V_3= {a,b,S_3, K_3}
Σ_3 = { a,b }
$R_3 = \{ S_3 \to bbK_3bb$
$K_3 \to e|aK_3|bK_3$
}

b.

(i) choose pumping length m,
there are possible cases here.
First lets w=uvxyz where $|vxy| \leq m$ and $|vy| \geq 1$ and for every $i \geq 0$, $uv^i xy^i z \in L$
case1: $u = a^{m-j}$, $vxy = a^j b^{n-r}$ and $z = b^r$
for i=2 , string w becomes a^{m-j}

(ii)

Answer 6

(i) (T/F)?True because of from book theorem 3.5.4
From book

(ii) (T/F)?False since $L_1 == \{ \ a^n b^n c^m : m, n \geq 0 \ \}$ and $L_2 == \{ \ a^m b^n c^n : m, n \geq 0 \ \}$ are both CF but their intersection $\{ \ a^n b^n c^n : m, n \geq 0 \ \}$ is not CF.

(iii) (T/F)? True
$L_1 - L_= L_1 \cup L_2^-$
where L_1 is CFL andL_2 is a RL and also L_2^- is a RL. RLs are close under copmlementation and intersection of aRL with a CFL is also a CFL from book Theorem 3.5.2

(iv) (T/F)? False
For example $a^n b^n c^n$ is not a CFL but $a^n b^n$ is a CFL.