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QUESTION 1:

a) G1 represents the language which includes strings in the form 0^m1^m or 1^m0^m such that m ≥0.

b) Yes this grammar is ambigious because for empty string there is actually two different leftmost derivation (which also means 2 different parse trees):

S =>A=>e

S=>B=>e

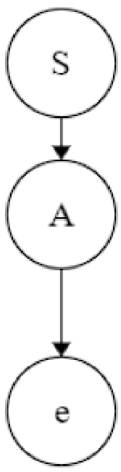

Figure 1: Parse tree for given derivation

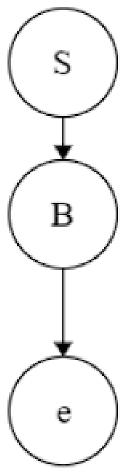

Figure 2: Parse tree for given derivation

QUESTION 2:

a) To show that this grammar is ambigous, I will use this string: ab. Because for the string ab there exists 2 different left-most derivation(which also means 2 different parse trees):

Derivation 1) S =>AB=>aAB=>aB=>abB=>ab

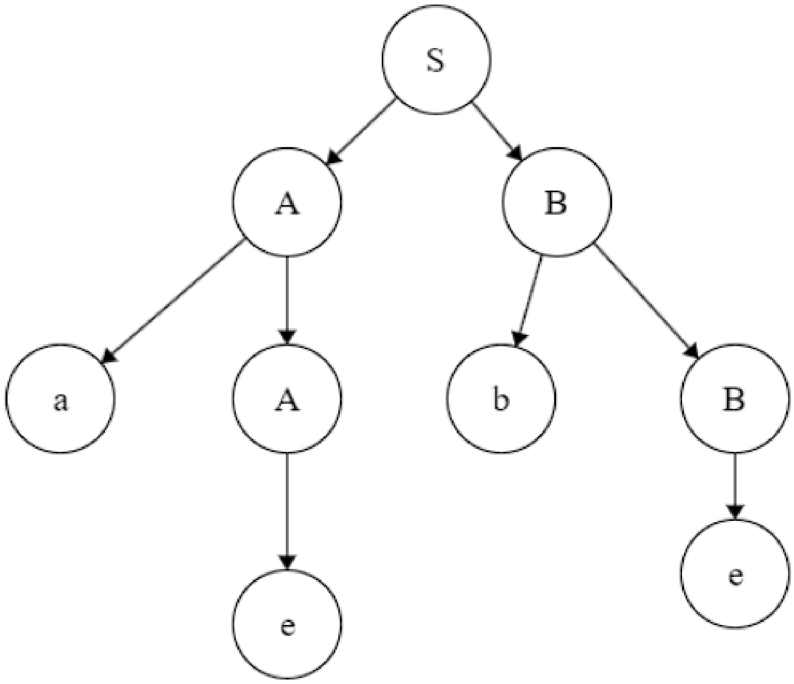

Figure 3: Parse tree for given derivation

Derivation 2) S =>AB=>aB=>ab

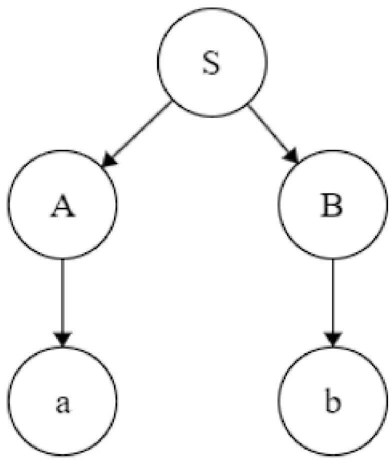

Figure 4: Parse tree for given derivation

b) Lets call the unambigious version of G2 is called G3. And G3 will be like this:

G3 = {V, Σ, R, S} where V = {a, b, S, A, B}, Σ = {a, b} and R={

S → AB,

A → aA|e,

B → bB|e

c)

S =>AB=>aAB=>aB=>abB=>abbB=>abbbB=>abbb

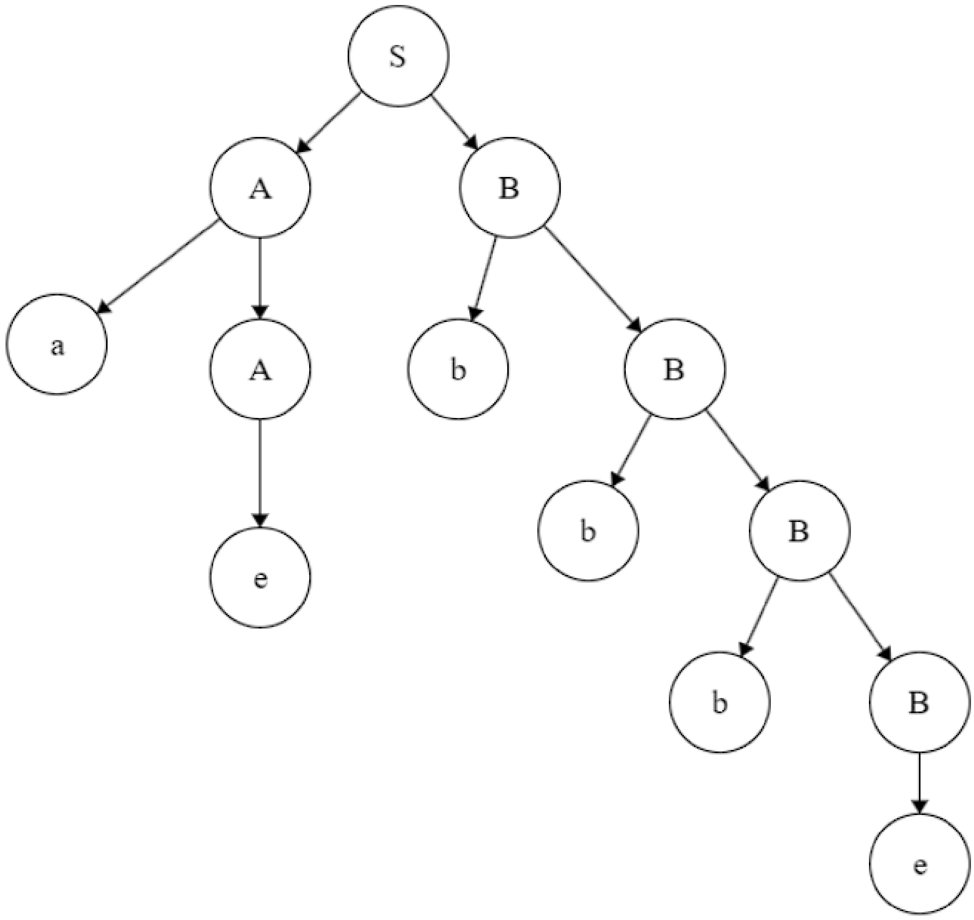

Figure 5: Parse tree for given derivation

QUESTION 3:

a)

a.1)

- $L_1 = \{ca^m b^n \mid m \neq n\} \cup \{da^m b^{2m} \mid m \geq 0\}$ is deterministic context free language because $L_1\$$ is accepted by this DPDA:
- For this DPDA, # represents the bottom of stack symbol and $ represents the end of input symbol.
- States q1, q3, q4, q5, q8 represents the $\{ca^m b^n \mid m \neq n\}$ part of the language L_1.

- States q2, q6, q7 represents the $\{da^mb^{2m} \mid m \geq 0\}$ part of the language L_1.
- We should accepts the strings for $\{ca^mb^n \mid m \neq n\}$ part of the language L_1, by using two different accepting states. Because either $m \geq n$ or $m \leq n$ can be true.
- Q5 accepts the strings that are in this form $\{ca^mb^n \mid m \geq n\}$.
- Q8 accepts the strings that are in this form $\{ca^mb^n \mid m \leq n\}$.
- Q7 accepts the strings that are in this form $\{da^mb^{2m} \mid m \geq 0\}$.
- Also it is guarenteed that there is no two transitions that are compatible. (I checked each pair of transitions.)

K={q0,q1,q2,q3,q4,q5,q6,q7,q8}

∑={a,b,c,d,$}

Γ={a,#}

S=q0

F={q5,q7,q8}

Δ={((q0,c,e),(q1,#)), ((q0,d,e),(q2,#)),

((q1,a,e),(q1,a)), ((q1,b,a),(q3,e)),

((q1,b,#),(q4,e)), ((q1,$,a),(q5,e)),

((q3,b,a),(q3,e)), ((q3,b,#),(q4,e)),

((q4,b,e),(q4,e)), ((q4,$,e),(q8,e)),

((q3,$,a),(q5,e)), ((q5,e,a),(q5,e)),

((q2,a,e),(q2,aa)), ((q2,$,#),(q7,e)),

((q2,b,a),(q6,e)), ((q6,b,a),(q6,e)),

((q6,$,#),(q7,e)), ((q5,e,#),(q5,e))}

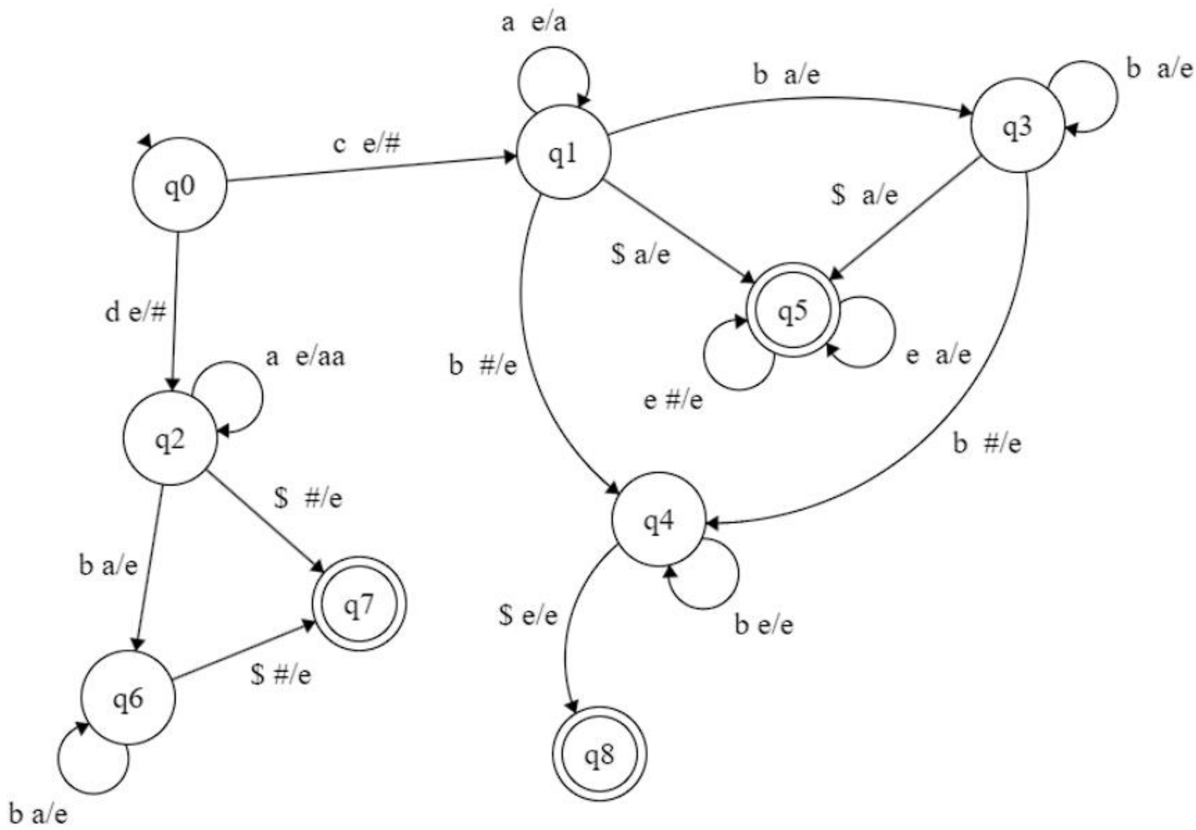

Figure 6: DPDA for L_1

a.2)

- $L_2 = \{a^m cb^n \mid m \neq n\} \cup \{a^m db^{2m} \mid m \geq 0\}$ is deterministic context free language because $L_2\$$ is accepted by this DPDA:
- For this DPDA, # represents the bottom of stack symbol and $ represents the end of input symbol.
- In this question since the strings do not start with the identifier symbols as we see on the L_1 like “c” and “d”. We should push the bottom of stack symbol before recognizing them.
- States q1, q3, q7 represents the $\{a^m db^{2m} \mid m \geq 0\}$ part of the language L_2.
- States q1, q2, q4, q5 q6 represents the $\{a^m cb^n \mid m \neq n\}$ part of the language L_2.

- We should accepts the strings for $\{a^m cb^n \mid m \neq n\}$ part of the language L_2, by using two different accepting states. Because either $m \geq n$ or $m \leq n$ can be true.
- Q4 accepts the strings that are in this form $\{a^m cb^n \mid m \geq n\}$.
- Q6 accepts the strings that are in this form $\{a^m cb^n \mid m \leq n\}$.
- Q7 accepts the strings that are in this form $\{a^m db^{2m} \mid m \geq 0\}$.
- Also it is guarenteed that there is no two transitions that are compatible. (I checked each pair of transitions.)

K={q0,q1,q2,q3,q4,q5,q6,q7 }

∑={a,b,c,d,$}

Γ={a,#}

S=q0

F={q4,q6,q7}

K={q0,q1,q2,q3,q4,q5,q6,q7 }

Δ={((q0,e,e),(q1,#)), ((q1,a,e),(q1,aa)),

((q1,c,e),(q2,e)), ((q1,d,e),(q3,e)),

((q2,b,aa),(q2,e)), ((q2,$,aa),(q4,e)),

((q4,e,aa),(q4,e)), ((q2,b,#),(q5,e)),

((q5,b,e),(q5,e)), ((q5,$,e),(q6,e)),

((q3,b,a),(q3,e)), ((q3,$,#),(q7,e)),

((q4,e,#),(q4,e)) }

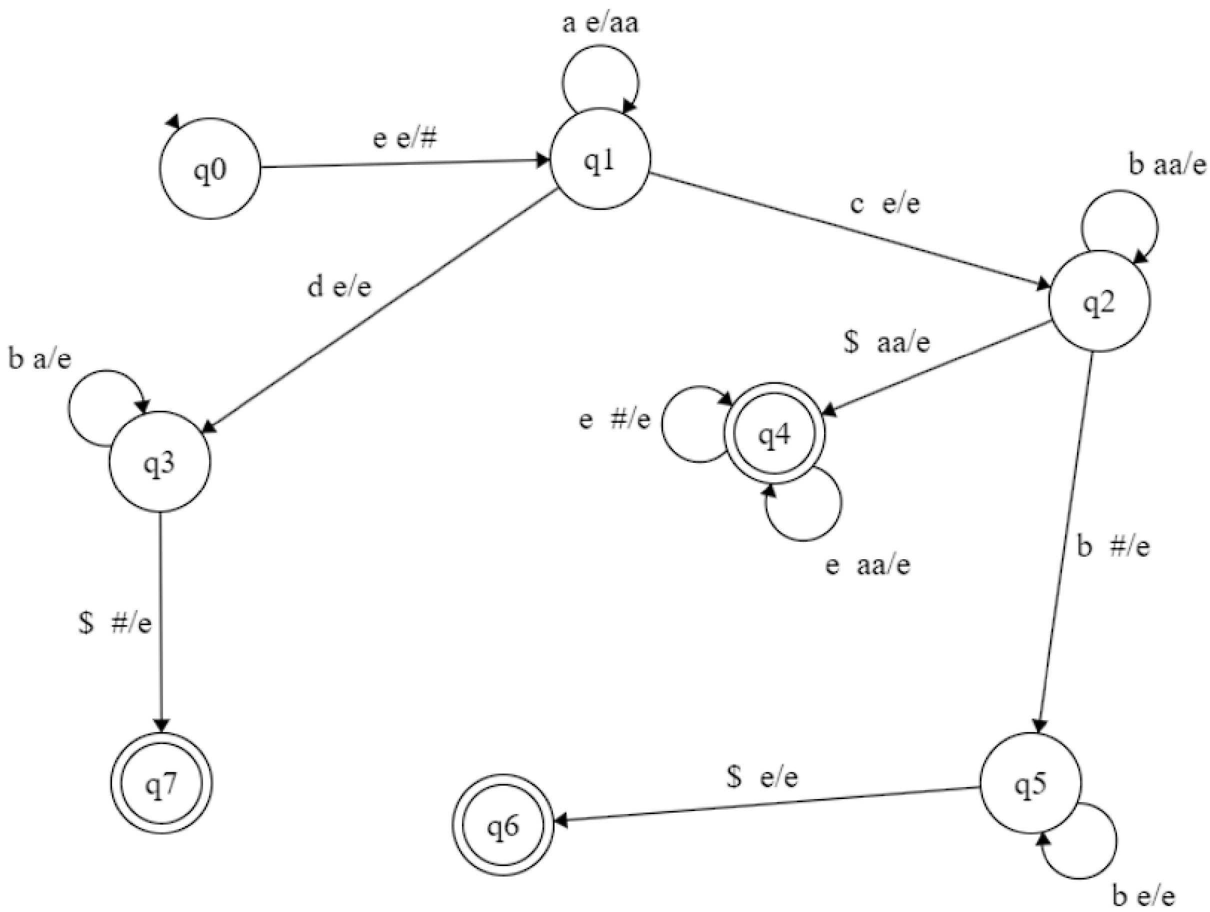

Figure 7: DPDA for L_2

b)

1) Regular

2) Context-free

3) The class of the complements of context-free languages

4) Deterministic context-free

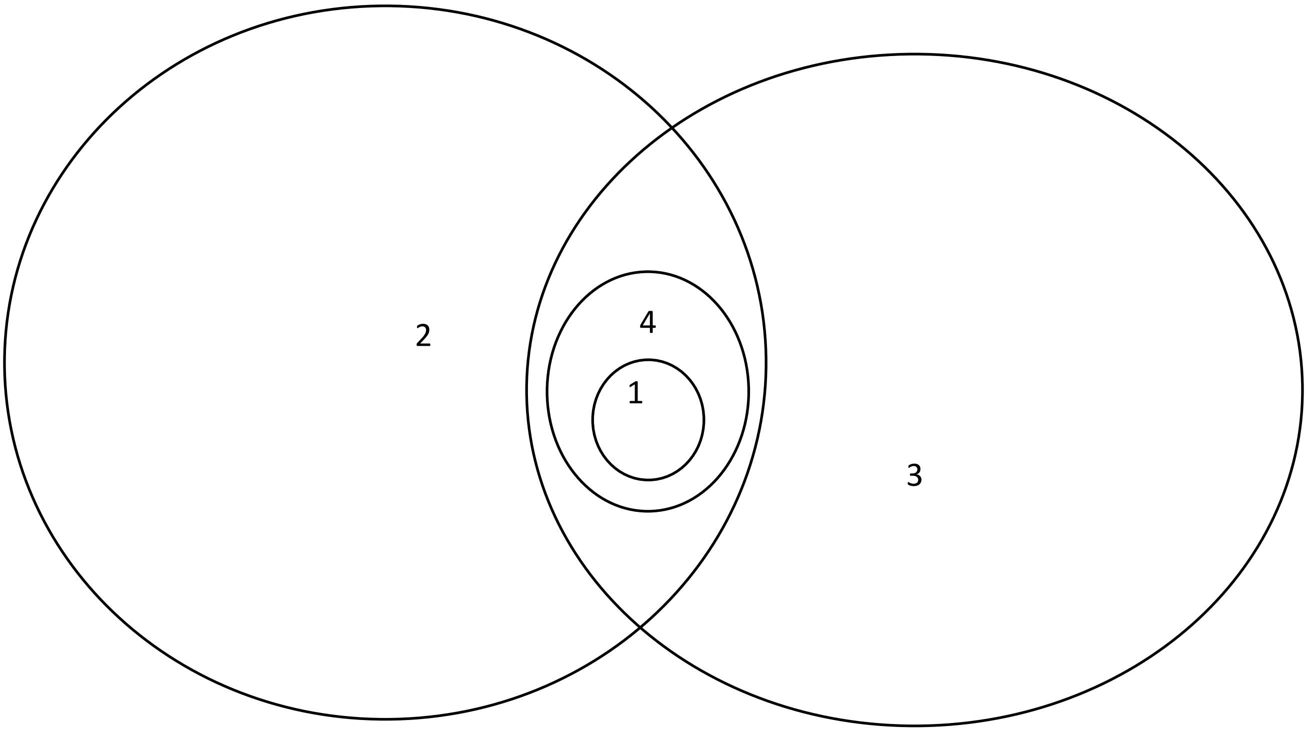

Figure 8: Venn diagram