CSci 435: Formal Languages and Automata

Instructor: Dr. M. E. Kim Name: Pedro Schmidt \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Home Assignment 4: 150 points + 10 points (optional)**

Q1. [20] For a given language L = {*anb****2n*** | *n* ≥ 0 is even}.

1. [8] Give a CFG that accepts L.

S->A, A->aaAbbbb| ∈

1. [6] Show the sequence of derivations for the acceptance of *aaaabbbbbbbb* by G in (1).

S->A -> aaAbbbb -> aabbbb

1. [6] Draw a derivation tree for *aaaabbbbbbbb*.

Diagram, schematic

Description automatically generated

Q2. [30] Construct a CFG for the following languages where *n*, *m, k* ≥ 0.

1. [10] L1 = { *anbn* | *n* is a multiple of *3* }

S→ aaaSbbb | E

1. [10] L2= { *anbmck* | *k* = *n+m* }

S → aSc | A

1. [10] L3 = { *anbm* | *n =* *m –*1 }

S→ aSB | b

1. [10, optional] L4 = { *anbmck* | *n=m* or *m* ≤ *k* }

Q3. [10] Give the language L that is generated by the given grammar, in a formal expression.

S → *aa*S*bb* | SS |λ.

e.g.) L = { *w* ∈ {*a, b*}\* | *na*(*w*) = 2*nb*(*w*) }

L = {*w* ∈ {*a, b*}\* | *na*(*w*) = Nb(w), where na(w) and nb(w)}

L = (w| *na*(*w*) = Nb(w))

Q4. [10] Find an s-grammar for L = {*anb****2n*** | *n* ≥ 2}.

L = {*anb****2n*** | *n* ≥ 2}

S → S1, S2, S3, S1 → aa, S2 → a S2 bb | *λ ,* S3 → bbbb

Q5. [20] For a grammar G with the productions where G = ( {S, A, B}, {*a, b*}, S, P ) with productions

S → AB | *bbbB*, A → *b* | A*b*, B → *a..*

1. [8] Show that the grammar G is ambiguous.

A picture containing chart

Description automatically generated

1. [6] Give language L that is generated by G, L = L(G), in a formal expression (including a regular expression).

b*+*

(b *+* + bbb) a..

1. [6] Can you construct an unambiguous grammar that is equivalent to G? Otherwise, show that G is inherently ambiguous.

s→ b *+* | bbb N

B → a

Q6. [35] In the given grammar G, generate the simplified equivalent grammar by eliminating the following productions through (1) – (3).

G = ( {S, A, B, C}, {*a, b*}, S, P ) with productions

S →*b*AA | *b*B, A → *a*A| *aaC* , B → *bb*B | *λ,* C → A

1. [10] Eliminate the λ-productions

We substitute b to remove λ-productions

S → bAA | b | bB

A → aA | aaC

B → bbB | bb

C → A

1. [10] Eliminate the Unit-productions from (1)

C→ A

S → bAA |b| bB

A → aA| aaA

B→ bbB | bb

1. [10] Eliminate the useless productions (2), so that give the simplified equivalent grammar.

A→ b | bB

B → bbB | bb

1. [5] Give the language L that is generated by this grammar, L = L(G), in a formal expression (including a regular expression).

(bb)\*b

Q7. [15] Convert the given grammar into Chomsky Normal Form (CNF).

S → AB | *a*B, A → *abb* | *λ* , B → *bb*A

Hint: Eliminate the λ-productions and/or any unit-production prior to their conversion into CNF.

Eliminate λ-productions

S → AB | *a*B | B|

A → aab

B → bbA|bb

Next,

S → AB | *a*B | bba|bb

A → aab

B → bbA|bb

Two production variables

S → AB | CB | DDA|DD

A → CCD

C → a

D→ b

Final making it to a CNF

S → AB | CB | DDA|DD

A → CF

B → DE| DD

C → a

D→ b

Q8. [10] Convert the given grammar into Greibach normal form.

S → *a*S*b* | *ab* | *bb*

S → aS | *ab* | *bb*

A → aS

B → bb