



Final term Exam (May 2015)
Duration : Three Hours

Theory of Computation
Dep. : Computer science

Question NO. 1

a) Given a grammar $G = \{ \{A, B, S\}, \{a, b\}, S, P \}$ and P:

$$S \rightarrow AB$$

$$A \rightarrow aaA$$

$$A \rightarrow \varepsilon$$

$$B \rightarrow Bb$$

$$B \rightarrow \varepsilon$$

- i. What type of language is this (prove your claim)?
 - ii. Write an expression for $L(G)$
 - iii. Convert this grammar to Chomsky Normal Form
 - iv. Show the derivation for string "aabbb"
- b) Draw a Venn diagram that shows the classification of languages and show where the language L should be located such that:

$$L = \{w \mid w \text{ is a palaindrome}\} \text{ (prove your claim)}$$

Question NO. 2

For each of the following languages, mention the most restrictive class to which the language must belong (prove your claim)

a) $L_1 = \{(w, G_1, G_2) \mid G_1, G_2 \text{ are CFGs and } w \in L(G_1) \text{ or } w \in L(G_2)\}$

(TM- Decidable, TM- Recognizable , not TM- Recognizable)

b) $L_2 = \{w^2 \mid w \in \{a, b\}^*\}$

(Regular , Context-free, Decidable)

c) $L_3 = \{w w^R w \mid w \in \{0,1\}^*\}$ (w^R describes the string w in reverse order)

(Regular, Context-free, non Context-free)

d) $L_4 = \{1^n 2^m 3^{n+m} \mid \text{where } n, m \geq 0\}$

(Regular, Context-free, Decidable)

e) $L_5 = \{w \in \{a,b\}^* \mid w \text{ contains 2 } bs \text{ at least}\}$

(Regular, Context-free, Decidable)

Question NO.3

a) For the language L over the alphabet $\{a,b\}$ such that:

$$L = \{a^{3n} b^n \mid n \geq 0\}$$

- i. Show whether or not L is a regular language.
- ii. Design a Pushdown automaton that accepts L
- iii. Design a Turing machine that accepts L

b) According to complexity theory

- i. Show the differences between the classes P and NP
- ii. Mention the most restrictive class to which S with $O(N!)$ belongs.
- iii. What are the benefits from solving S in polynomial time

Question NO. 4

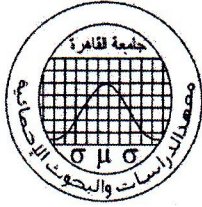
a) $A = \{w \mid w \in \{0,1\}^* \text{ and } w \text{ includes a 1 but not as its third character}\}$

- i. Give NFA that accepts language A .
- ii. Convert NFA to DFA that accepts language A .
- iii. Create a regular expression for language A
- iv. Represent DFA or NFA for language A in Turing machine

b) For $L = \{a^n b^n a^n b^n \mid \text{where } n \geq 0\}$

- i. Prove that language L is not a context free language.
- ii. Design a Turing machine that accepts L
- iii. Simulate its action on the input string aabbaabb.

(Best wishes)



Final term Exam (Jan. 2016)
Duration : Three Hours
Dr. Assem A. Alsawy

CS 600
Theory of Computation
Dep. : Computer Science

Question NO. 1 (20 marks)

a) Given a grammar $G = \{ \{A, B, S\}, \{a, b\}, S, P \}$ and P:

$S \rightarrow AB$

$A \rightarrow aaA$

$A \rightarrow \varepsilon$

$B \rightarrow Bb$

$B \rightarrow \varepsilon$

1. What type of language is this (prove your claim)?
2. Write an expression for $L(G)$
3. Convert this grammar to Chomsky Normal Form
4. Show the derivation for string "aabb"

b) Draw a Venn diagram that shows the classification of languages and show where the language L_1 should be located such that:

$$L_1 = \{ a^n b^m \mid n \leq m \leq 2n, \text{ where } n, m \geq 0 \} \text{ (prove your claim)}$$

Question NO. 2 (15 marks)

a) $A = \{ w \in \{a, b\}^* : w \text{ has 'a' in the } 2^{\text{nd}} \text{ end position from the right} \}$

1. Give DFA that accepts language A
2. Convert DFA to a regular expression for language A

b) For $L = \{ a^n b^n a^n b^n \mid \text{where } n \geq 0 \}$

1. Prove that language L is not a context free language.
2. Design a Turing machine that accepts L
3. Simulate its action on the input string aabbaabb.

Question NO. 3 (20 marks)

For each of the following languages, mention the most restrictive class to which the language must belong (prove your claim)

a) $L_1 = \{a^i b^j c^k d^m \mid i + j + k + m \text{ is multiple of } 13\}$

(Regular, Context-free, Decidable)

b) $L_2 = \{w^2 \mid w \in \{a, b\}^*\}$

(Regular, Context-free, Decidable)

c) $L_3 = \{ww^R \mid w \in \{0, 1\}^*\}$ (w^R describes the string w in reverse order)

(Regular, Context-free, non Context-free)

d) $L_4 = \{1^n 2^m 3^{n+m} \mid \text{where } n, m \geq 0\}$

(Regular, Context-free, non Context-free)

e) $L_5 = \{w \in \{a, b\}^* \mid w \text{ contains 2 bs at least}\}$

(Regular, Context-free, non Context-free)

Question NO.4 (20 marks)

a) Consider the following regular expression

$$(0/\epsilon)(0/1)^*0$$

1. Construct an NFA for the regular expression above using Thomson's construction.
2. Convert the NFA to a DFA using the subset construction algorithm
3. Use the algorithm for state minimization to construct a minimized DFA.

b) For the language L over the alphabet $\{a, b\}$ such that: $L = \{a^{3n}b^n \mid n \geq 0\}$

1. Design a Pushdown automaton that accepts L
2. Design a Turing machine that accepts L

(Best wishes)