7. (a) Design an NPDA that accepts the language [4]

$$L = \{ w : w \in \{a+b\}^* \text{ and } n_a(w) \geq n_b(w) \}$$

(b) For your constructed PDA, give a sequence of instantaneous descriptions leading to acceptance of the string *baaba*. [4]

8. (a) Design a Turing machine that accepts the language [4]

$$L = \{ w \in a^n b a^n : n \geq 1 \}$$

(b) Consider the context-free grammar G over $\{x, y\}$ with start symbol S, and with the following productions [4]

$$S \rightarrow xxB \mid Ayy$$

$$A \rightarrow x \mid xA$$

$$B \rightarrow y \mid By$$

a. Show that the grammar G is ambiguous.

b. Find an unambiguous grammar equivalent to G.

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KIIT

AUTUMN END SEMESTER EXAMINATION-2018

5th Semester B.Tech & B.Tech Dual Degree

FORMAL LANGUAGES AND AUTOMATA THEORY

CS3003

[For 2017(L.E.) & 2016 Admitted Batches]

Time: 3 Hours — Full Marks: 60

Answer any SIX questions including question No.1 which is compulsory.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable and all parts of a question should be answered at one place only.

1. Answer all the questions with proper justification. [2× 10]

(a) Let N be an NFA with k states. Let p be the number of states in a minimal DFA equivalent to N. What will be the minimum and maximum value of p? Justify your answer.

(b) Design a minimal DFA that accepts a string over $\{0,1\}$ iff either it starts and ends with the same symbol or starts and ends with different symbols.

(c) Give example of two context-free languages whose union is context-free. However, their intersection is not context-free.

(d) Give a regular grammar that generates the language of the regular expression $(0 + 10 + 01)^*$.

(e) Let $\Sigma_1 = \{0,1\}$ and $\Sigma_2 = \{a,b\}$ and $h : \Sigma_1^* \rightarrow \Sigma_2^*$ be a homomorphism such that $h(10) = aba$, $h(1011) = bbab$.
Find $h(L)$ for the language $L = \{1011101011, 101011\}$

(f) Find the language of the Turing machine with transitions $\delta(q_0, a) = (q_0, a, R), \delta(q_0, B) = (q_1, B, L)$, where q_0, q_1 and B represent initial state, final state and blank symbol, respectively.

(g) Find an equivalent grammar in GNF for the grammar $A \rightarrow BC, B \rightarrow a \mid CD, C \rightarrow bD \mid b, D \rightarrow k$

(h) State Pumping Lemma for context free languages.

(i) Find the language of the grammar $S \rightarrow 0S \mid A,\ A \rightarrow 1 \mid A1$.

(j) Consider the context-free grammar $S \rightarrow AS \mid d, A \rightarrow CA, A \rightarrow b, C \rightarrow a$. Find the number of derivation steps needed to derive abbbbdddd.

2. (a) What do you mean by indistinguishable pair of states in a finite automaton? Prove that indistinguishability is an equivalence relation. [4]

(b) Design a DFA for the language, $L = \{ w \in (0+1)^* :$ w contains an equal number of ocurrences of 01 and 10 $\}$. For example, the string 01010 is in the language whereas 11010 is not in the language. [4]

3. (a) Consider the context-free grammar $S \rightarrow n \mid S \times S \mid S + S$. Draw four different derivation trees for the string $n + n \times n + n$. [4]

(b) Show that context free languages are closed under concatenation and kleene closure operation. [4]

4. (a) State pumping lemma for regular languages. Show that $L = \{a^n : \text{n is a perfect square}\}$ is not regular. [4]

(b) Find context-free grammars for the following languages: [4]

a. $L = \{ a^m b^n a^n b^m : m > 0 \text{ and } n \geq 0 \}$

b. $L = \{ a^m : m = 2 \times i + 5 \times j \text{ for } i, j \geq 0 \}$

5. (a) Differentiate between a recursively enumerable language and a recursive language. Explain chomksy hierarchy for class of formal languages. [4]

(b) Construct a non-deterministic pushdown automaton equivalent to the following CFG: [4]

$S \rightarrow aABc \mid aAd$

$A \rightarrow aBB \mid b$

$B \rightarrow bBd \mid A$

6. (a) Transform the following grammar into Chomsky Normal Form [4]

$S \rightarrow AB \mid aB$

$A \rightarrow abb \mid \lambda$

$B \rightarrow bbA \mid \lambda$

(b) Consider the following transition table of an NFA N [4]

q	$\delta(q,a)$	$\delta(q,b)$	$\delta(q,\lambda)$
1	ϕ	ϕ	{2}
2	{3}	ϕ	{5}
3	ϕ	{4}	ϕ
4	{4}	ϕ	{1}
5	ϕ	{6,7}	ϕ
6	{5}	ϕ	ϕ
7	ϕ	ϕ	{1}

For the subsets S = {1, 2, 3} and T = {1, 3, 4} of the set of states of N, find

a. λ-closure (λ-closure (S))

b. λ-closure (S) ∪ λ-closure (T)