initial configuration to be ⊳⊔w (if the input is ⊳⊔w, the output should be ⊳⊔w′, where w′ is the one's complement of w). Show the trace of above turing machine M on the string ⊳⊔0110. (5)

(b) Prove that if a language is recursive, it is also recursively enumerable. (2)

(c) Consider the Turing Machine M = (K, Σ, δ, s, {h}), where K = {s,q,h}, Σ = {⊔, ⊳, a} and δ is given in the following table :

state,	symbol	δ
s	a	$(q, \sqcup)$
s	$\sqcup$	$(h, \sqcup)$
s	$\triangleright$	$(s, \rightarrow)$
q	a	(s, a)
q	$\sqcup$	$(s, \rightarrow)$
q	$\triangleright$	$(q, \rightarrow)$

Give the representation of Universal Turing machine for M. (3)

[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1042 **C**

Unique Paper Code : 32341502

Name of the Paper : Theory of Computation

Name of the Course : **B.Sc. (Hons.) Computer Science**

Semester : V (Admissions 2019-2021)

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1 (Section A)** is compulsory.
3. Attempt any **four** Questions from Nos. **2** to **7** **(Section B)**.
4. Parts of a question must be answered together.
5. Consider Σ = {a, b} for all the questions unless specified otherwise.

SECTION A

1. (a) Let **s** = **{aa, bb}** and **T** = **{aa, bb, bbaa}**. Show that **S*=T***. Does the string **aaa** belong to the language **S***? Justify. (3)

(b) Consider the following Context Free Grammar (CFG) :

S -> SAbAbAbA | λ

A -> aA | λ

Describe the language generated by given CFG. List any two words of the language. (3)

(c) Construct a regular expression defining each of the following languages :

(i) L1= {words in which a appears tripled (in clumps of 3) if at all}

(ii) L2= {ends with a and does not contain the substring bb} (4)

(d) Describe the language defined by each of the following regular expressions:

(i) bba*b

(ii) ((a+b) a) *

Also, determine the shortest word in the language. (4)

(e) Build a finite automaton that accepts the language of words having exactly four letters. (4)

(b) Construct a PDA for the language $a^n b^q a^m$ where m, n>=1 and q=m+n. (6)

6. (a) Consider the following context free grammar :

S -> AbB

A -> aA| λ

B -> aB | bB| λ

Construct an equivalent CFG by eliminating all λ productions and convert the resultant grammar into chomsky normal form (CNF). (4)

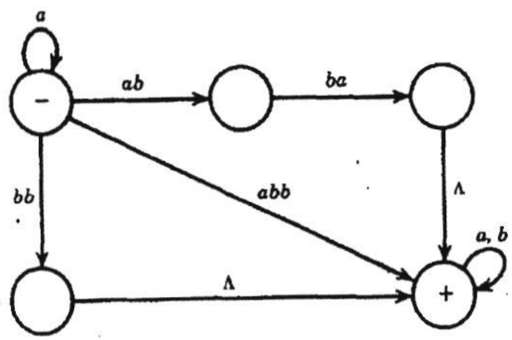
(b) Write the CFG for the language containing all words which are palindromes excluding the null string. Create a parse tree for the word abaaba. (4)

(c) Show that the following CFG is ambiguous: (2)

S -> XaXaX

X -> aX | bX | λ

7. (a) Assume Σ = {0, 1}. Design a standard turing machine M that computes one's complement of the binary number on the input tape. Assume the

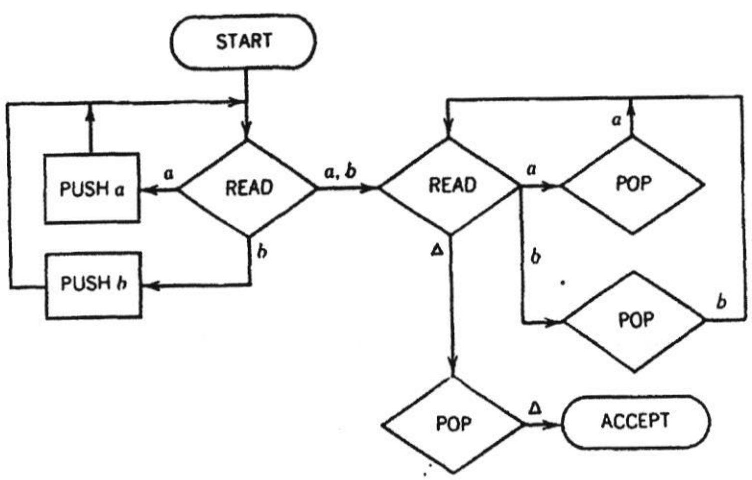


(b) Use pumping lemma to prove that the language $\{a^n b^n c^n$ where $n=1, 2, 3, 4, 5....\}$ is non-context free language. (4)

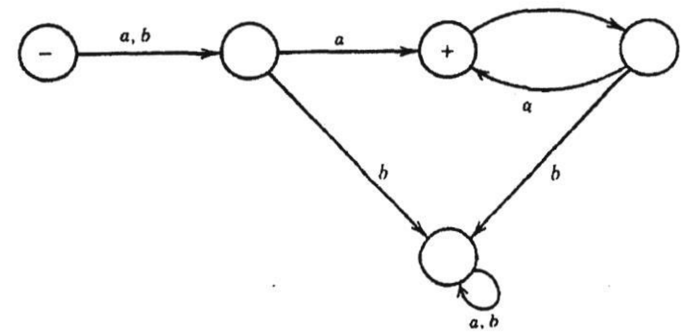
5. (a) For the Push Down Automata shown below :

(i) Describe the language accepted by it.

(ii) Is the given PDA deterministic or non-deterministic? (4)



(f) Describe the language accepted by following finite automaton : (2)

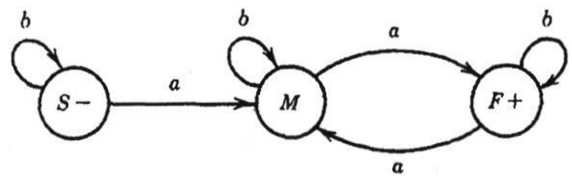


(h) Using pumping lemma, show that the following language is a non-regular language : (4)

$\{a^n b a^{2n}$ where $n \geq 1\}$ = {abaa, aabaaaa, aaabaaaaaa,...}

(i) Construct a deterministic PDA for the language $L_3 = \{a^n S$ where S starts with b and length (S) = n$\}$ (4)

(j) Construct the context free grammar (CFG) for the language accepted by following finite automaton : (3)

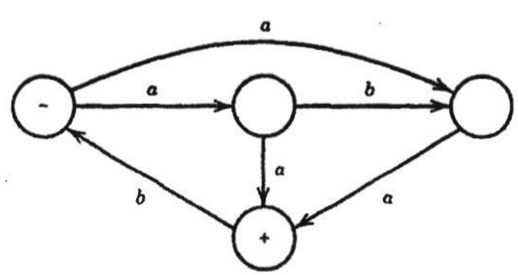


(k) Design a right shifting hiring machine. Assume the initial configuration to be ⊳⊔w⊔ and desired output configuration to be ⊳⊔⊔w⊔. (4)

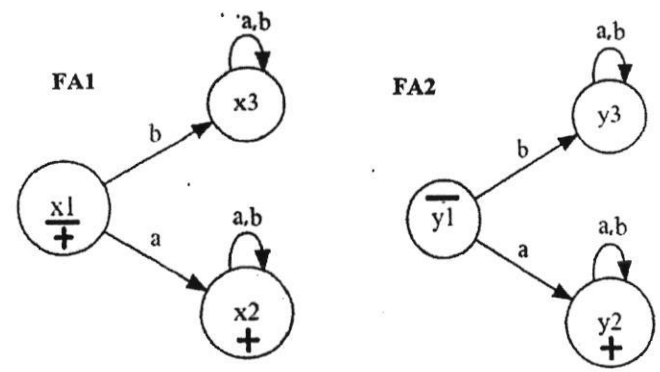
SECTION B

2. (a) Consider the following language of all the words defined over having Σ = {a, b} comprising only b's including empty string λ. Build a finite automaton FA that accepts the given language and find its kleene closure i.e. (FA) *. (6)

(b) Convert the following non-deterministic finite automaton to deterministic finite automaton: (4)



3. (a) For the following pairs of FAs, build a finite automaton that accepts the intersection of languages defined by FA1 and FA2. Also, build a finite automaton that accepts the complement of the language defined by FA1. (6)



(b) Show that the set of regular languages are closed under union and kleene closure using non-deterministic finite automata. (4)

4. (a) Using the bypass theorem, convert the following transition graph into a regular expression : (6)