Roll No								

NATIONAL INSTITUTE OF TECHNOLOGY GOA

Department of Computer Science and Engineering

B.Tech V Semester-End Examination

Course Name: **Theory of Computation** Course Code: **CS303**

Date: **December 9, 2021** Time: **02:00 PM**

Duration: **3 Hours** Max. Marks: **100**

Note:

- Be legible. Keep the rough work separate from the space you write the answer.
- The notations used should be consistent as mentioned in the class.
- Unnecessary details attracts penalty.
- The question paper is of *four* pages.
- Attach the rough work sheets at the end of the answer scripts clearing mentioning it as a rough work. All the necessary calculations to be shown. In multiple choice, write the complete answer with choice.

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1. State whether True or False. **Justify**.

a) If a CFG G has three productions, i.e. $S \to AA, A \to aa, A \to bb$, then $L(G)$ is finite. **(2)**

b) If a CFG G has productions $S \to aS|bS|a$, then $L(G)$ is the set of all strings over $\{a, b\}$ ending in a. **(2)**

c) The language $\{a^n bc^n | n \geq 1\}$ is regular. **(2)**

d) If the productions of G are $S \to aS|Sb|a|b$, then $abab \in L(G)$.**(2)**

e) If $G = (V, T, P, S)$ and $P \neq \phi$, then $L(G) \neq \phi$.**(2)**

2. Choose the correct answer for the following.

i) The CFG generating $\{a^n : n \geq 1\}$ is **(2)**

a) $(\{S\}, \{a\}, \{S \to aS, S \to a\}, S)$
b) $(\{S\}, \{a\}, \{S \to aS\}, S)$
c) $(\{S\}, \{a\}, \{S \to SS, S \to a\}, S)$
d) $(\{S\}, \{a\}, \{S \to aSS\}, S)$

ii) Which of the following regular expression represents the set of all binary strings with an odd number of $1's$? **(2)**

a) $((0+1)^*1(0+1)^*1)^*10^*$
b) $(0^*10^*10^*)^*10^*$
c) $10^*(0^*10^*10^*)^*$
d) $(0^*10^*10^*)^*0^*1$

iii) Consider the following languages over the alphabet $\{0,1\}$. Note that x^R is the reverse of the string x. **(3)**

$$L_1 = \{xx^R | x \in \{0,1\}^*\}$$
$$L_2 = \{xx | x \in \{0,1\}^*\}$$

Which of the following is true. **Justify.**

a) Both L_1 and L_2 are regular.
b) L_1 is context free but not regular whereas L_2 is regular.
c) Both L_1 and L_2 are context free and neither is regular.
d) L_1 is context free but L_2 is not context free.
e) Both L_1 and L_2 are not context-free.

iv) Let a, b, c be regular expressions.Which of the following identities is correct?**Justify. (3)**

a) $(a+b)^* = a^*b^*$
b) $a(b+c) = ab + c$
c) $(a+b)^* = a^* + b^*$
d) $(ab+a)^*a = a(ba+a)^*$
e) None of the above

3. Design a CFG to the generate the following languages. Also, show by deriving atleast one string that is in the language of the designed CFG.

a) $L = \{w | w$ is a string over $\{0,1\}$ ending in $0\}$.**(4)**

b) $L = \{w | w$ is a string over $\{0,1\}$ beginning with $0\}$.**(4)**

4. Write the regular expression for the following languages.

a) The set of all strings of $0's$ and $1's$ ending in 00.**(2)**

b) The set of all strings of $0's$ and $1's$ beginning with 11 and ending with 0.**(2)**

c) $L = \{\epsilon, 11, 1111, 111111, \ldots\}$ **(2)**

5. **a)** Convert the following NFA to DFA.**(5)**

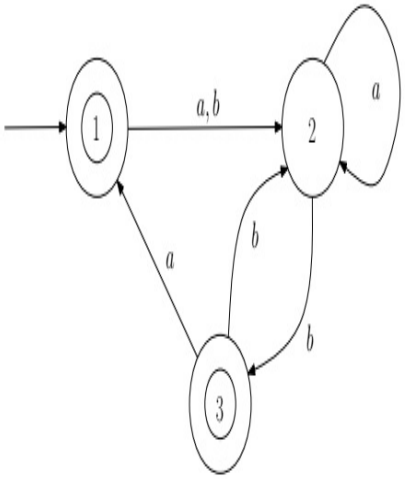
	0	1
$\rightarrow p$	$\{q, s\}$	$\{q\}$
$*q$	$\{r\}$	$\{q, r\}$
r	$\{s\}$	$\{p\}$
$*s$	ϕ	$\{p\}$

b) Convert the following $\epsilon-$NFA to DFA.**(5)**

	ϵ	a	b	c
$\rightarrow p$	ϕ	$\{p\}$	$\{q\}$	$\{r\}$
q	$\{p\}$	$\{q\}$	$\{r\}$	ϕ
$*r$	$\{q\}$	$\{r\}$	ϕ	$\{p\}$

c) Convert the Regular expression $(0+1)^*(0+1)1$ to $\epsilon-$NFA.**(5)**

d) Convert the DFA to Regular expression. **(5)**



e) Construct a **DFA with minimum number of states** to accept all strings over $\{0, 1\}$ ending in 010 or 0010.**(5)**

6. **a)** Prove that the language $L = \{a^n b^{2n} | n > 1\}$ is not regular.**(4)**

b) Show that the grammar $S \rightarrow a|abSb|aAb, A \rightarrow bS|aAAb$ is ambiguous.**(4)**

c) Design a PDA to accept the set of all strings of $0's$ and $1's$ with an equal number of $0's$ and $1's$. Show for atleast one string in the Language how the designed PDA accepts. In addition, you have to briefly explain the approach in few sentences. **(4)**

7. **a)** Consider the following CFG.

$S \rightarrow AB|CA$
$A \rightarrow a$
$B \rightarrow BC|AB$
$C \rightarrow aB|b$

Find the equivalent CFG with no useless symbols.**(4)**

b) Put the following CFG in Chomsky Normal Form.**(10)**

$S \rightarrow ASB|\epsilon$
$A \rightarrow aAS|a$
$B \rightarrow SbS|A|bb$

8. **a)** Prove that the language $L = \{0^n 1^n 2^n | n \geq 1\}$ is not a context-free language.**(5)**

b) Design a Turing machine to recognize the language $L = \{w|w$ is string over $\{0, 1\}$ that ends with $010\}$. Show how Turing machine processes the input 0101010 using instantaneous descriptions. In addition, you have to briefly explain the approach in few sentences.**(10)**

**********All the Best**********