Mode of Examination: Online

M.Sc. (Computer Science) Semester – III Examination, 2020

2020

Subject: Computer Science

Paper Code & Name: CSM303 (CBCS A) : Theory of Computation

Full Marks: 70

Date: 15.03.2021 **Time and Duration: 12.00 PM – 3:00 PM (3:00 Hours)**

Please note the following instructions carefully:
Promise not to commit any academic dishonesty.
Marks will be deducted if the same/similar answers are found in different answer-scripts.
Candidates are required to answer in their own words as far as applicable.
Each page of the answer scripts should have your University Roll # on the right-top corner.

The name of the scanned copy of the answer script will be of the following format:
(Example: CSM-303A-TOC-My Roll Number.pdf)
The subject of the mail should be the file name only.
The name of the scanned answer-script is to be sent to cucse2020@gmail.com
The report should have the top page (Page #1) as an index page; mention page number(s) against the answer of each question number.
The answer-script may not be accepted after the scheduled time.

Answer Question No. **1, 2**, and **any Four** from the rest.

1. Answer ***any*** 5 questions [2 X 5 = 10]

a. Test the *ambiguity* of the given grammar:
   a. $S \rightarrow aSa \mid bSb \mid a \mid b \mid \varepsilon$

b. How do NP problems differ from NP-Completes?

c. What do you mean by the Boolean Satisfiability problem?

d. What are alternative normal forms of CFG and their significances?

e. What are the differences between recursive language and recursively enumerable language?

f. What do you understand by a halting problem in Turing Machine?

g. Consider the set of all strings of odd length on the alphabet {0,1}. Express this set in the form of a regular expression.

h. Let R_1 be a regular set on the alphabet {0,1} and let R_2 = { 00, 101, 110, 011 }.
   Is the difference set $R = R_1 - R_2$ necessarily a regular set?

2. Answer ***any*** 5 questions [4 X 5 = 20]

a. If L and $\bar{L}$ are both recursively enumerable, show that L and $\bar{L}$ are recursive.

b. "If L is a context-free language and R is a regular language, then $L \cap R$ is context-free language.". Prove or disprove

c. Why is non-deterministic PDA more powerful than deterministic? Justify your answer.

d. Eliminate the Null production from the given set of production rules: P={$S \rightarrow ABCd$, $A \rightarrow BC$, $B \rightarrow bB$, $B \rightarrow \lambda$, $C \rightarrow cC$, $C \rightarrow \lambda$}. Here, "λ" is Null. Show all the steps.

e. State the rule to convert left recursive to right recursive grammar. Show the steps with a suitable example.

f. Prove by example that regular languages are closed under union and intersection.

g. Give the regular expressions generating the following languages. In all cases the alphabet is { 0 , 1 }

i. L_1 = { w | w does not contain 100 as a substring }
ii. L_2 = { w starts with 0 and has odd length or starts with 1 and has even length }

h. Convert the following regular expression into an equivalent NFA

$$(((00)^* (11) + (01))$$

i. Let L be any language. Define DROPOUT(L) to be the language consisting of all strings that can be obtained by removing one symbol from strings of L. Thus

$$\text{DROPOUT}(L) = \{ xz \mid xyz \in L \text{ where } x , z \in \Sigma^* , y \in \Sigma \}$$

Show that the class of regular languages is closed under DROPOUT operation.

j. Design the regular expression for palindromes and draw the corresponding DFA to accept it.

3. a. Prove or disprove the following for regular expressions a, b, c.

$$1(01 + 1)^*0 = 00^*1(00^*1)^*$$
$$(a + b)^* = a^* + b^*$$

b. Construct a deterministic finite automaton M on the input alphabet {0,1,2} that accepts a string α if and only if α is contained in all regular expression 0^*1^*.

[5+5]

4. a. State and prove the pumping lemma for context-free languages..

b. Use pumping lemma to show that the language $L = \{a^n b^n c^n ; n \geq 0\}$ is not context-free.

[3 + 7]

5. a. Critically comment on the closure properties of context-free language.

b. Use *CYK algorithm* to test the membership of the string ***aabba*** for the given grammar:

$S \rightarrow AB \mid BC$
$A \rightarrow BA \mid a$
$B \rightarrow CC \mid b$
$C \rightarrow AB \mid a$

[4+6]

6. a. "Every language accepted by a *multi-tape* Turing machine is accepted by some *single-tape* Turing machine ", Comment critically. What is a Universal Turing machine?

b. Design a Turing machine capable of computing proper subtraction, i.e., $p \dot{-} q$, where p and q are positive integers and represented in unary formats..

[5 + 5]

7. a. How are ‘Intractable problems’ related to computing theory?

   b. Illustrate P- Class and NP- Class problems with the help of a Venn diagram. Cite an example of each type.

   c. Prove that Clique Decision Problem is NP-Complete.

[2 + 3 + 5]

8. a. Construct a PDA for the given CFG:

$S \rightarrow aAA$
$A \rightarrow aS \mid 1S \mid 0$

   b. Convert the given grammar to its corresponding CNF and GNF:

$S \rightarrow ASA \mid 0B$
$A \rightarrow B \mid S$
$B \rightarrow 1 \mid \varepsilon$

[5+5]

9. a. What are the alternatives forms of Push Down Automata (PDA). How will you justify the equivalence of alternative forms of PDA?

   b. Design a PDA to accept the following context-free language

$L = \{ \alpha \mid$ the string α contains more 0’s that 1’s $\}$

[4+6]