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PES UNIVERSITY, Bangalore

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IN SEMESTER ASSESSMENT (ISA-2)- B.TECH III SEMESTER
November, 2020

Scheme & Solution
Automata Formal Languages & Logic

Time: 1 $\frac{1}{2}$ Hrs **Answer All Questions** **Max Marks: 40**

1 a (5 marks)

Determine whether the following language is context free or not:

$$\{0^i 1^i 0^j 1^i \mid , i,j > 0\}$$

(Note : In case the language is not context free. Provide a formal proof and Clearly specify all the cases)

Solution:

The given language is not context-free. We provide the formal proof using Pumping Lemma:

The adversary claims the language is context free. Let's assume there are N non-terminals in the Adversary hypothetical grammar in CNF for the given language

We calculate the pumping constant, $p = 2^N$

Consider the string $z=0^p1^p01^p$, which is in the language.

If we decompose z into z=uvwxy, such that $|vwx| <= p$ and $|vx| >=1$

we will have the following cases :

Case	locn of vwx	i	n_0	n_1	n_0	n_1	Comment
1	only 0's in the start	>=2	↑	-	-	-	Too many 0's in the start
2	Few 0's and 1's	>=2	↑	↑	-	-	Too few 1's in the end
3	Only 1's in the start	>=2	-	↑	-	-	Too few 0's in the start and too few 1's in the end
4	Few1's in the start and few 1's at the end with 0 as the fixed center	>=2	-	↑	-	↑	Too few 0's in the start
5	if vwx is the l one zero	=0	-	-	↓	-	$0^p1^p1^p$ is not in the language
6	Only 1's in the end	>=2	-	-	-	↑	Too many 1's in the end

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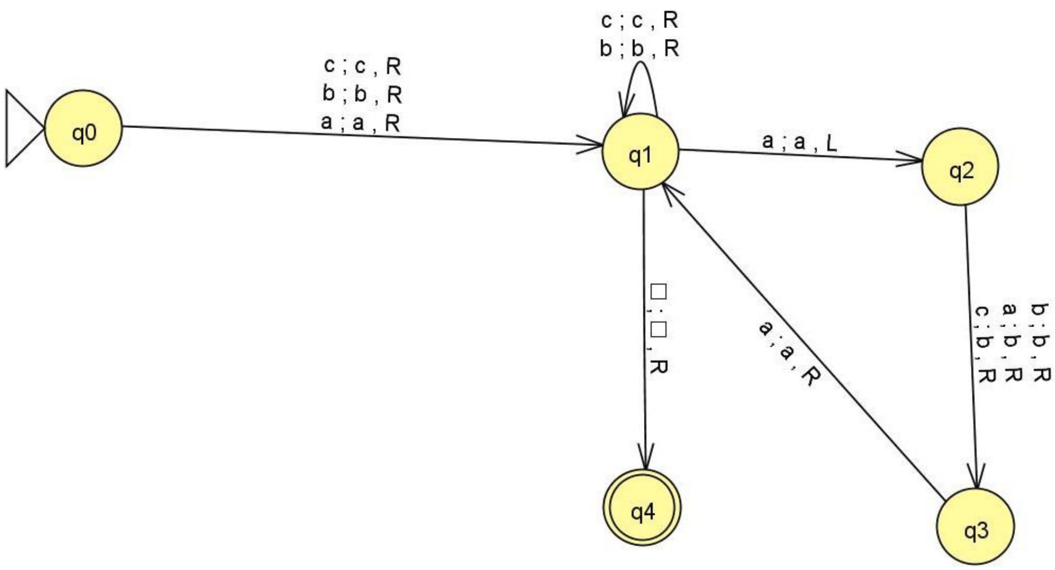
		We see as per the comments made in each case, the resultant string is not in the language. This contradicts the pumping lemma, so therefore the language is not context free.	
	b	Design a Turing machine that transforms a string containing only a's, b's, and c's by replacing each letter preceding an a to a b. (Do not worry about the case when the string begins with an a.) Thus, bccb would remain unchanged while caccaa would change to bacbba. The Turing Machine should always eventually enter an accepting state to terminate. **Solution:** 	5
2	a	Does the following instance of PCP have a solution? Justify your answer. Consider the lists A = <110, 0011, 0110> and B = <110110, 00, 110> **Solution:** Yes there exists a solution. There is a sequence i = 2, 3, 1 such that s 2 s 3 s 1 = t 2 t 3 t 1 , since s 2 s 3 s 1 = 00110110110 and t 2 t 3 t 1 = 00110110110	5
	b	Suppose there are four languages A, B, C, and D. Each of the languages may or may not be recursively enumerable. However, we know the following about them: ● There is a reduction from A to B. ● There is a reduction from B to C. ● There is a reduction from D to C. Below are three statements. Indicate whether each one is (a) **CERTAIN to be true**, regardless of what problems A through D are. (b) **MAYBE true**, depending on what A through D are.	3

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		(c) **NEVER true**, regardless of what A through D are. The statements are as follows: **Solution:** **(a) A is recursively enumerable but not recursive, and C is recursive.** NEVER TRUE. reductions are transitive, and since A reduces to B, and B reduces to C, we conclude that A reduces to C. Hence, it can't be that C ∈ R. **(b) A is not recursive, and D is not recursively enumerable.** MAYBE TRUE. **(c) If C is recursive, then the complement of D is recursive.** CERTAIN to be TRUE. If C is in R, and since D reduces to C, then by the reduction theorem, it follows that D is in R. Since R is closed under complement, then the complement of D is also in R.	
	c	Is the following problem about Turing machines solvable, or undecidable. Justify your answer carefully. To determine, given a Turing machine M , a state q, and a string w whether M ever reaches state q when started with input w from its initial state. **Solution:** This problem is undecidable. Suppose it were solvable; then some machine G would solve it. But given M and w, we could feed (M, w, h) ot G, where h is the halting state of M ; if more than one, we can simply repeat our query several times, and return G's answer, and this would constitute an effective procedure for deciding the halting problem.	2
3	a	Given the following premises 1. ~ R 2. ~ (P ∧ ~ Q) 3. ~ P → (R ∧ S) Prove Q by resolution refutation. **Solution:** Clauses: 1 ~ R (C1) 2 ~ P ∨ Q (C2) 3 P ∨ R (C3a) P ∨ S (C3b) 4 ~ Q (C4) [negated conclusion] Resolutions: C1, C3a → P (C5) C5, C2 → Q (C6) C4, C6 → ∅ (null, 'box')	6
	b	Suppose that KB for an agent trying to thrive in the wumpus world contains the following 10 facts: **K1 :** $\neg S_{1,1}$ **K2 :** $\neg S_{2,1}$ **K3 :** $S_{1,2}$ **K4 :** $\neg B_{1,1}$ **K5 :** $B_{2,1}$ **K6 :** $\neg B_{1,2}$	4 (2+2)

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		K7 : $\neg S_{1,1} \rightarrow (\neg W_{1,1} \land \neg W_{1,1} \land \neg W_{2,1})$ **K8 :** $\neg S_{2,1} \rightarrow (\neg W_{1,1} \land \neg W_{2,1} \land \neg W_{2,2} \land \neg W_{3,1})$ **K9 :** $\neg S_{1,2} \rightarrow (\neg W_{1,1} \land \neg W_{1,2} \land \neg W_{2,2} \land \neg W_{1,3})$ **K10 :** $S_{1,2} \rightarrow (W_{1,3} \lor W_{1,2} \lor W_{2,2} \lor W_{1,1})$ I. If we use model checking as a technique to find out whether our KB is satisfiable. What will be the size of the truth table? **Solution : 2^12, since there are 12 propositions involved.** II. Does the KB $\vDash B_{2,1}$? Prove using Resolution Refutation. **Solution: Using K5 and negating the Conclusion we get False. Hence $B_{2,1}$ logically entails from the KB.**	
4	a	Consider the following Predicates : Child(x) : x is a child Loves(x,y) : x loves y Student(x) : x is a student Convert the following Natural language sentences to statements in Predicate Logic : **Solution:** a) John is a student. *STUDENT(John)* *b) Scrooge is not a child.* *¬ Child(Scrooge)* c) Every child loves Santa. *∀ x (Child(x) → Loves(x,Santa))*	5 (1 + 2 + 2)
	b	Assuming Predicate logic as the knowledge representation language. Consider the domain as a particular Department in a University (for example Department of Computer Science in PES University) Answer the following : 1. Determine and specify a minimum of 4 objects in the domain. 2. Specify a minimum of 3 relations among the objects identified. 3. Specify a minimum of 2 functions. Note : Specify the relations and functions in proper syntax. The input and output of each function must be clearly mentioned. **Solution :** 1. Objects could be : Department, Teacher, Student, Classroom, Course, Semester, Lab, SRN 2. Relations are: a. Teaches_Course(Teacher, Course1, Course2) b. Teaches_Student(Teacher, Student) c. Studies(Student, Course1, course 2, course 3, ...) d. isTopper(Student, Semester) e. isSRN(Student, SRN) 3. Functions could be:	5 (2+2+1)

		a. Chairperson(Department) [there is only one Chairperson, returns the name of the Department Chairperson] b. SRN(Student) [returns SRN of the Student] c. CGPA(Student) [returns CGPA of a Student]	