INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH MOHALI

Second Mid Semester Examination(March 15, 2019, Academic Session 2018-19)

IDC204(Theory of Computation) **Maximum Marks: 20**

Instructions

This booklet contains 8 printed pages, including this cover page, and 4 problems. **Check if there are missing pages.** Write your initials on the top of every page, in case the pages become separated. Attempt **ALL** problems. Read the problems carefully. Write all arguments precisely and do not leave **anything** to the instructor's[1] imagination. You need to sign the following ***Academic Honour Code***, else **your answers will not be evaluated.**

"I affirm, on my honour, that I shall maintain my integrity and uphold the highest standards of academic conduct. I shall not receive or provide and shall not make any attempt to receive or provide an unlawful aid during this examination. I shall not tolerate any action that does not adhere to these words."

Signature Abhigyan W. Medhi

Name Abhigyan W. Medhi

Reg. No. MS17108

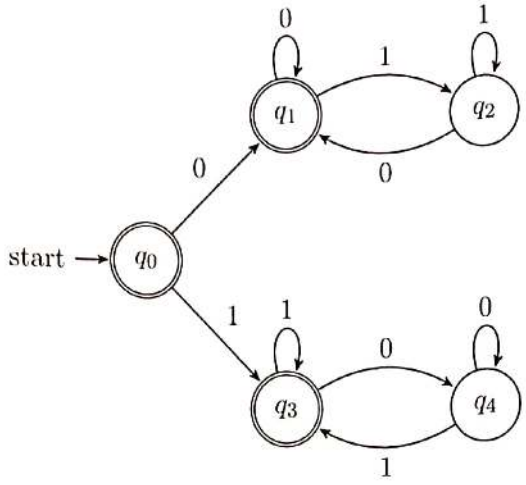
The following rules apply:

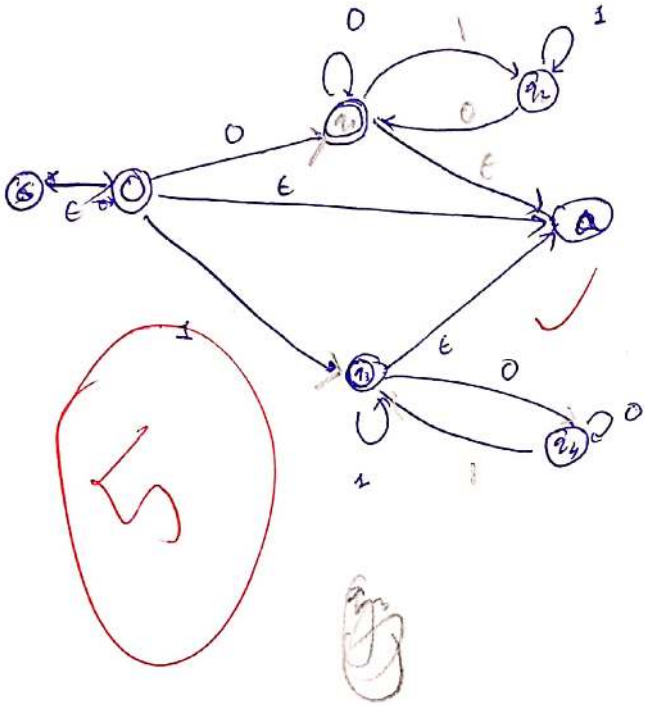
- **Organize your work**, in a reasonably neat and coherent way, in the space provided. Work scattered all over the page without a clear ordering will receive very little credit. Illegible work will not receive credit.
- **Mysterious or unsupported answers will not receive credit.** A correct answer, unsupported by calculations, explanation, or algebraic work will receive no credit; an incorrect answer supported by substantially correct calculations and explanations *might* still receive partial credit.
- **Do your rough work in the blank pages attached at the end of this booklet. No other space will be provided for the rough work.**

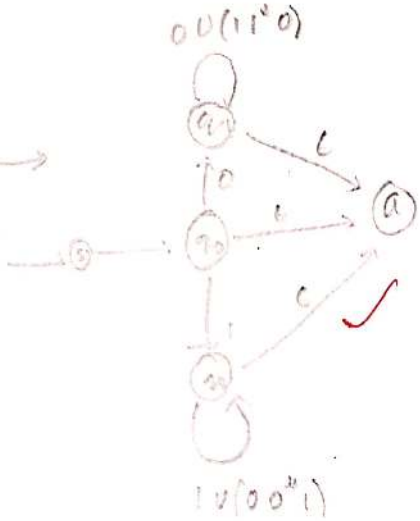
Problem	Points	Score
1	5	5
2	5	5
3	5	5
4	5	5
Total:	20	20

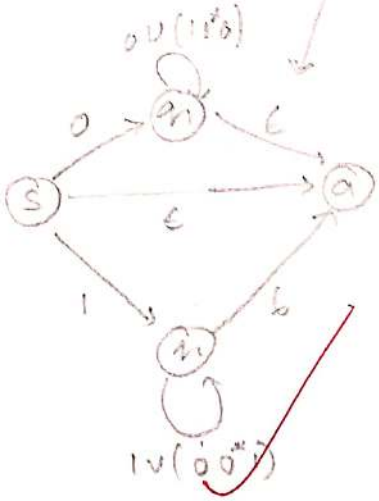
[1] Instructor: *Amit Kulshrestha*

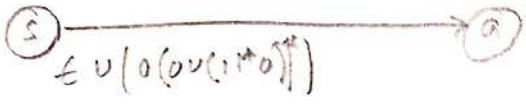
1. (5 points) Find a regular expression that evaluates to the language recognized by the following DFA.

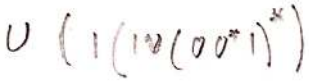


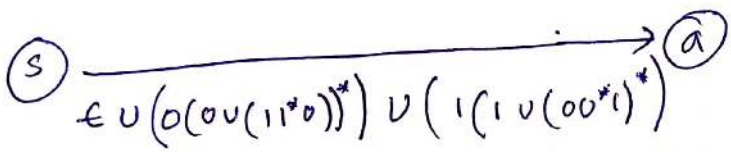






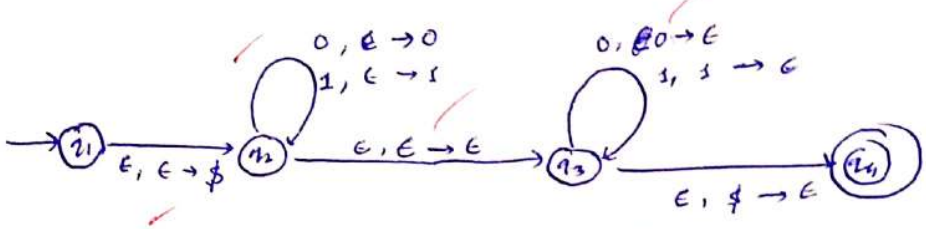






2. (5 points) Construct a pushdown automaton that recognizes *palindromes of even length*, i.e. the language $\{ww^R : w \in \{0,1\}^*\}$. Here w^R denotes the reverse of the string w.

$PD = \{ Q , \Sigma , \tau , \delta , q_1 , q_4 \}$



$Q = \{ q_1 , q_2 , q_3 , q_4 \}$

$\Sigma = \{0, 1\}$

$\tau = \{ 0, 1, \$ \}$

$$\delta(r,p,q) = \begin{cases} (q_1, \epsilon, \epsilon) \rightarrow (q_2, \$) \\ (q_2, 0, \epsilon) \rightarrow (q_2, 0) \\ (q_2, 1, \epsilon) \rightarrow (q_2, 1) \\ (q_2, \epsilon, \epsilon) \rightarrow (q_3, \epsilon) \\ (q_3, 0, 0) \rightarrow (q_3, \epsilon) \\ (q_4, 1, 1) \rightarrow (q_4, \epsilon) \\ (q_3, \epsilon, \$) \rightarrow (q_4, \epsilon) \end{cases} \qquad \begin{array}{l} r \in Q \\ p \in \Sigma \\ q \in \tau \end{array}$$

5

3. (5 points) Consider the language $A = \{0^n 1^n 2^n : n \geq 0, n \in \mathbb{N}\} \subseteq \{0,1,2\}^*$. Determine if A is regular.

3/ Let A be a regular language and p be its pumping length

Let $s = 0^p 1^p 2^p$ $|s| > p$ ✓

$\therefore \exists\ xyz$ s.t $xy^i z \in A$ for all i

Case I y has only 1's ✓

Then $xy^i z \notin A$ as no. of 1's will be greater

Case II y has only 0's ✓

Then $xy^i z \notin A$ as no. of 0's will be greater

Case III ~~Then $xy^i z \in$~~ y has only 2's 5

Then also, $xy^i z \notin A$ as no. of 2's will be greater

Case IV y has both 1's and 2's

Then $xy^i z \notin A$ as order will not be maintained

Similarly, y cannot have both 2's & 0's and 0's & 1's ✓

Case V y has all 1's, 2's and 3's

$xy^i z \notin A$ as the order will not be maintained

$\therefore$ A is not a regular language. ✓

4. (5 points) Consider the following grammer.

⟨Sentence⟩ → ⟨Noun-Phrase⟩⟨Verb-Phrase⟩

⟨Noun-Phrase⟩ → ⟨Complex-Noun⟩ | ⟨Complex-Noun⟩⟨Preposition-Phrase⟩

⟨Verb-Phrase⟩ → ⟨Complex-Verb⟩ | ⟨Complex-Verb⟩⟨Preposition-Phrase⟩

⟨Preposition-Phrase⟩ → ⟨Preposition⟩⟨Complex-Noun⟩

⟨Complex-Noun⟩ → ⟨Article⟩⟨Noun⟩

⟨Complex-Verb⟩ → ⟨Verb⟩ | ⟨Verb⟩⟨Noun-Phrase⟩

⟨Article⟩ → a | the

⟨Noun⟩ → boy | girl | Mohali | flower | spectacles | orange

⟨Verb⟩ → touches | eats | sees | talks | likes | reads

⟨Preposition⟩ → on | under | with | after

Show that the string w = "a girl touches a boy with the flower" is ambiguous by exhibiting two leftmost derivations of w. Draw parse trees for the two derivations.

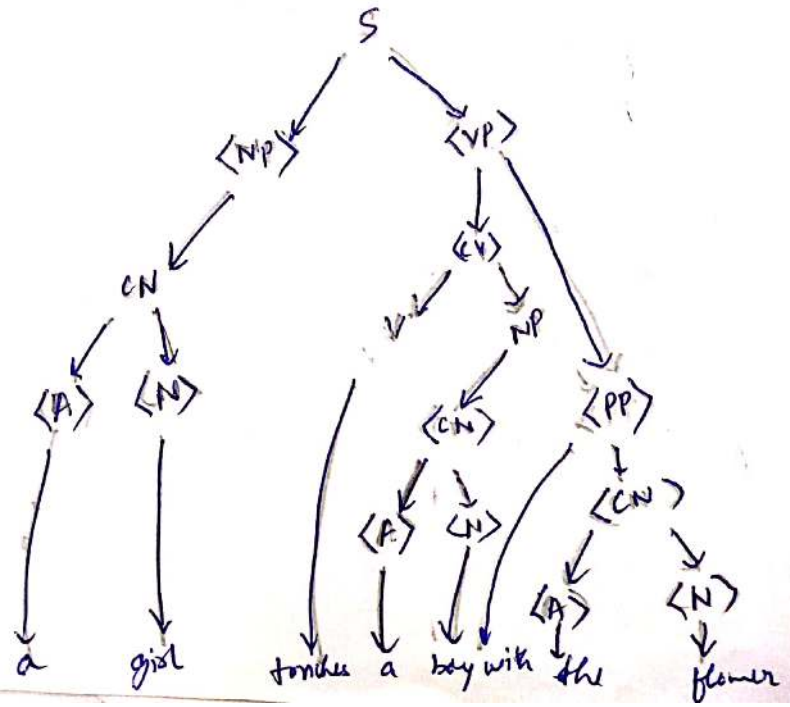
4/ S ⇒ ⟨NP⟩⟨VP⟩ ⇒ ⟨P⟩⟨CV⟩ ⇒ ⟨CN⟩⟨V⟩⟨NP⟩ ⇒ ⟨A⟩⟨N⟩⟨V⟩⟨NP⟩

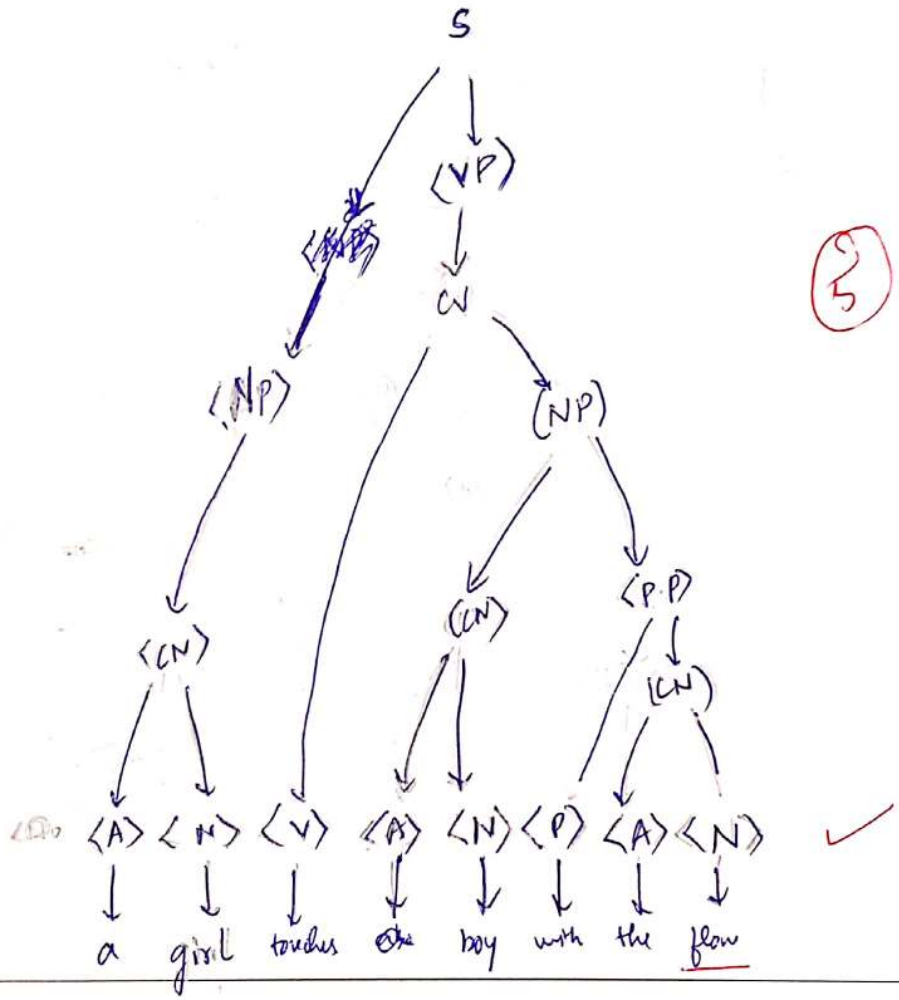
⇒ ⟨A⟩⟨N⟩⟨V⟩⟨CN⟩⟨PP⟩ ⇒ a ⟨N⟩⟨V⟩⟨A⟩⟨N⟩⟨P⟩⟨CN⟩

⇒ a girl ⟨V⟩⟨A⟩⟨N⟩⟨P⟩⟨A⟩⟨N⟩ ⇒ a girl touches ⟨A⟩⟨N⟩⟨P⟩⟨A⟩⟨N⟩

⇒ a girl touches a ⟨N⟩⟨P⟩⟨A⟩⟨N⟩ ⇒ a girl touches a boy ⟨P⟩⟨A⟩⟨N⟩

⇒ a girl touches a boy with the flower.





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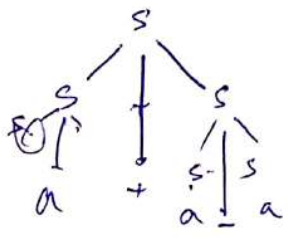

a+a-a

S → S+S | S-S | a .

S+S S+S-S

a+S-S a+a-S a+a-a