

# Formal Languages and Automata Theory (CS303)

End-Semester Examination  
Indian Institute of Technology, Patna  
November 21, 2017  
Full marks- 100, Duration- 180 min

1. Answer all the questions: (8+8+4)

- (a) Is  $f(x) = 3x$  computable? If true then design the Turing Machine for that function. [1+7]
- (b) Provide a "high-level" description for Turing machines that accept the following languages on  $\{a, b\}$ :  $\{a^n b^n\}$  and  $\{ww^R\}$ . [4+4]
- (c) What is polynomial time reduction? How is it used for proving some language in NPC and some other language in P? [2+2+2]

2. Answer all the questions: (8+8+4)

- (a) Prove Savitch's theorem for log-space complexity only.
- (b) Prove that CONN is NL-complete.
- (c) What are the differences between space complexity and time complexity?

3. Answer all the questions: (8+8+4)

- (a) Show that Deterministic Turing Machines have the same power as the Nondeterministic Turing Machines.
- (b) Using reduction show that CLIQUE problem is NP-complete.
- (c) Write a brief outline on the proof of Cook-Levin theorem?

4. Answer all the questions: (8+8+4)

- (a) How to design an enumerator for a Turing acceptable language? Give an example of Turing acceptable but undecidable language and prove it. [3+5]
- (b) Show that  $EMPTY_{TM}$  is undecidable.
- (c) What is Universal Turing Machine? Show that the set of rational numbers is countable. [2+2]

5. Answer all the questions: (4+6+8+2)

- (a) State Pumping Lemma theorem for regular language and context free language.
- (b) Is the following language  $L = \{0^n 1^n \mid n \geq 1\}$  regular? Justify your answer with respect to pumping lemma theorem of regular language.
- (c) Prove using pumping lemma theorem that  $L = \{SS \mid S \text{ is a string defined over the alphabet set consisting of } a \text{ and } b \text{ only}\}$  is not context free language. Explain each step and assumption with proper justification.
- (d) State the necessary and sufficient condition for converting a non-deterministic PDA to deterministic PDA.