Theory of Computation (CS267)

End-Semester Examination

Indian Institute of Technology, Patna

MAY 02, 2023

Duration: 3 hrs | Max mark: 100

Attempt All Questions

1. A language is Turing recognizable if and only if some _____ Enumerates it. **(1)**

2. Every t(n) time multi-tape Turing Machine has an equivalent _____ *time* single tape Turing Machine where t(n) be a function and t(n)$\geq$ n **(2)**

3. If G is a Context Free Grammar(CFG) in Chomsky Normal form, then any w $\in$ L(G) where $|w| = n$. Exactly _____ steps are required for any derivation of w. **(2)**

4. Give a high-level description(i.e., algorithms) of the Turing Machine that decides to perform some elementary arithmetic for the L= $\{a^i b^j c^k \parallel i*j = k$ and i, j, k$\geq$1$\}$ **(5)**

5. Consider the following language L: L= $\{< M >$: M is a TM, and M accepts some strings that end in '0'$\}$. Prove that L is not decidable **(5)**

6. Show that t(n) time Non-Deterministic single tape Turing machine has equivalent exponential time Deterministic Turing Machine. **(5)**

7. Give a high-level description of the Turing Machine that decides A= $\{\langle G \rangle \parallel$ G is the connected undirected graph$\}$ and also give TM Configuration for the given graph (Figure 1). **(5)**

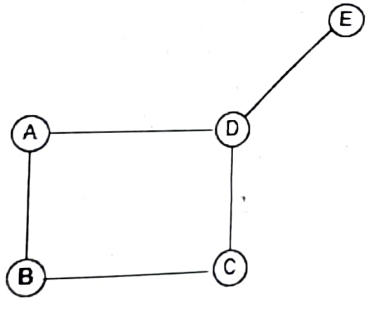

Figure 1:

8. Write down the formal description along with state diagrams of Turing Machine M which decide the language L = $\{a^n b^n a^{n+m} \parallel$ n,m$\geq$1$\}$ [Hints: Formal description is 7 tuples and state diagram for transition δ] **(8)**

9. Give the snapshot of Turing Machine tape while it is computing on input *aabbbaaaaa* is accepted by language L = $\{a^n b^n a^{n+m} \parallel n,m \geq 1\}$ **(5)**

10. Give the Formal description of the Turing Machine along with a state diagram which accepts the language L= $\{ww^R \parallel w \in (0,1)^*\}$ [Hints: Formal description is 7 tuples and state diagram for transition δ] **(8)**

11. Construct a SPACE(logn) Turing Machine which decides the language B=$\{0^k 1^k \parallel k \geq 0\}$.Show that language (B=$\{0^k 1^k \parallel k \geq 0\}$) is in L SPACE space complexity. **(8+7=15)**

12. Define Class P and deterministic time complexity class TIME (t(n)).Show that **(5+5=10)**

    1. *RELPRIME* = $\{\langle x, y\rangle \parallel$ x and y are relatively prime$\} \in$ P
    2. Every context-free language is a member of P.

13. Define NP-complete (NPC) Problem. Show that Clique problem$\in$ NPC. **(5+10=15)**

14. Define Class P SPACE. Establish the relationship of P SPACE with P, NP, and EXPTIME, and also define The classes L and NL. **(2+2+2=6)**

15. Write down the details notes on following theorem :- **(4x2=8)**

    1. *The Cook-Levin Theorem:*
    2. *Savitch's Theorem.*