# 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= $\{a^i b^j c^k \mid\mid i*j = k \text{ and } i, j, k \geq 1\}$                    **(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= $\{\langle G \rangle \mid\mid$ G is the connected undirected graph$\}$ and also give TM Configuration for the given graph (Figure 1).                    **(5)**
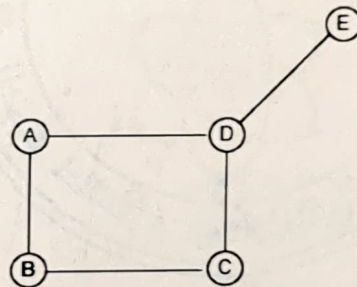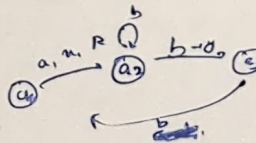


Figure 1:

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

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

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

11. Construct a SPACE(logn) Turing Machine which decides the language B=$\{0^k 1^k \mid\mid k \geq 0\}$.Show that language (B=$\{0^k 1^k \mid\mid k \geq 0\}$) 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 = $\{\langle x, y \rangle \mid\mid x$ 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.