National University of Computer and Emerging Sciences, Lahore Campus			
Course:	**Theory of Automata**	**Course Code:**	**CS301**
Section:	**3rd and 5th semester**	**Marks:**	**25**
Submission deadline:	**15-09-2025**	**Weight**	1.75
Assignment:1		**Page(s):**	2
Instruction/Notes:	1. 25 % deduction of over marks on the one-day late submission after due date. 2. 50 % deduction of over marks on the two-day late submission after due date. 3. No submission after two days. **4. MUST BE HANDWRITTEN. IN-CLASS SUBMISSION.**		

Q:1- You are tasked with designing a **Deterministic Finite Automaton (DFA)** to verify the validity of a password in a system according to the following rules:

- The password must contain an **even number of uppercase letters (U)**.
- The password must contain **exactly one digit (D)**.
- The password must contain **at least two special characters (S)**.
- The password may contain any number of lowercase letters (L).

The input alphabet **Σ** for the DFA is defined as:

U → Uppercase letter (A–Z)
L → Lowercase letter (a–z)
D → Digit (0–9)
S → Special symbol (@, #, $, etc.)

Acceptance Criteria:
The DFA should accept the string **if and only if** all of the above conditions are satisfied simultaneously. Otherwise, the string should be rejected.

Q:2- You are designing a DFA for a **Treasure Hunt game**.
The player moves through different rooms, each represented by a symbol. The rules to successfully open the treasure box are as follows:

- The player must collect **exactly one key (K)**.
- The player must collect **at least one map (M)**.
- The player must **not collect any traps (T)**. If a trap is collected, the game is lost.
- The player may pass through any number of **empty rooms (E)**.

The input alphabet for the DFA is:
K → Key
M → Map
T → Trap
E → Empty room

Acceptance Criteria:
The DFA should accept the string **if and only if** the player collects exactly one K, at least one M, zero T, and any number of E. Otherwise, the string should be rejected.

Tasks: (Q1&Q2) **[5+5]**

1. Clearly define the states of your DFA's (q_0, q_1, …).
2. Draw the **transition diagram and transition function table** for the DFA's.
3. Specify the start state and accepting state(s).
4. Briefly explain how your DFA's ensures that all three conditions are met.

Q:3- Draw deterministic finite automata for the following languages: **[5]**
L1 = { x | x over {a, b} ; x has even length but does not contain **ab** as a substring }
L2 = { x | x over {0, 1} ; |x| should be multiple of 3 and every three-length chunk of the string contains at most 2 occurrences of 0}
L3 = {w| w over {0,1}, starts with 0 and has odd length, or starts with 1 and has even length}
L4 = {w| w over {0,1},does not contain the substring 110}
L5= {w| w over {0,1}, contains an even number of 0's, or contains exactly two 1's}

Q:4- Consider the following two languages over the alphabet Σ = {a, b}:

L_1 = { x | x over {a, b}, such that the number of occurrences of substring **ab** is even }

L_2 = { x | x over {a, b}, such that every b is followed by at least three **a's** }

Tasks: **[5+5]**

a) Write a **regular expression** for each of the two languages ($\mathbf{L_1}$ and $\mathbf{L_2}$).
b) Construct a DFA for language $\mathbf{L_3 = L_1 \cdot L_2}$ (concatenation of L_1 followed by L_2).
c) Construct a DFA for language $\mathbf{L_4 = L_2 \cdot L_1}$ (concatenation of L_2 followed by L_1).
d) Give at least **two example strings** for each of the languages $L_1 \cdot L_2$, and $L_2 \cdot L_1$ (one string that belongs to the language and one that does not).