DFA
Spring25 set A

MIDTERM EXAM SPRING 2025

CSE331
Automata and Computability

TOTAL MARKS: 50
DURATION: 90 MINUTES

A

There are a total of five problems. You have to solve all the problems.

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{a, b\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{length of } w \text{ is three more than multiple of four}\}$$
$$L_2 = \{w : \text{every even position letter in } w \text{ is the same as the first letter of } w\}$$
$$L_3 = \{w : \text{every } 2k+1 \text{ position in } w \text{ is } a\text{, where } k \geq 0\}$$
$$L_4 = \{w : \text{every } 2k+1 \text{ position in } w \text{ is } b\text{, where } k \geq 0\}$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) **Give** the state diagram for a DFA that recognizes L_3. (3 points)

(d) If you were to use the "cross product" construction to obtain a DFA for the language $L_2 \cap (L_3 \cup L_4)$, how many states would it have? (1 point)

(e) **Find** all four-letter strings in $L_2 \cap (L_3 \cup L_4)$. (1 point)

(f) **Give** the state diagram for a DFA that recognizes $L_2 \cap (L_3 \cup L_4)$ using only four states. (2 points)

(g) **Find** a four-letter string in $\overline{L_3} \circ L_4$. [Recall: $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$] (1 point)

(h) Is $\overline{L_3} \circ L_4 = \overline{L_3}$? **Give** justification for your answer. (1 point)

Spring23 set 1

There are a total of five problems. You have to solve the first four. Problem 5 is optional.

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ. Note that we define 0^m to be the string $\overbrace{000\ldots000}^{m \text{ times}}$. 1^n is defined analogously.

$$L_1 = \{w : w \text{ does not contain } 01 \text{ as a substring}\}$$
$$L_2 = \{0^m : m \text{ is even}\}$$
$$L_3 = \{1^n : n \geq 0\}$$
$$L_4 = L_2 \circ L_3$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (4 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (4 points)

(c) **Find** all the four and five-letter strings in L_4. (1 point)

(d) **Give** the state diagram for a DFA that recognizes L_4. (2 points)

(e) If you were to use the "cross product" construction shown in class to obtain a DFA for the language $L_1 \cap L_4$, how many states would it have? (1 point)

(f) **Find** all five-letter strings in $L_1 \cap L_4$. (1 point)

(g) **Give** the state diagram for a DFA that recognizes $L_1 \cap L_4$ using only five states. (2 points)

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A

There are a total of five problems. You have to solve all the problems.

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{\mathtt{a}, \mathtt{b}\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{length of } w \text{ is three more than multiple of four}\}$$
$$L_2 = \{w : \text{every even position letter in } w \text{ is the same as the first letter of } w\}$$
$$L_3 = \{w : \text{every } 2k+1 \text{ position in } w \text{ is } \mathtt{a}, \text{ where } k \geq 0\ \}$$
$$L_4 = \{w : \text{every } 2k+1 \text{ position in } w \text{ is } \mathtt{b}, \text{ where } k \geq 0\ \}$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) **Give** the state diagram for a DFA that recognizes L_3. (3 points)

(d) If you were to use the "cross product" construction to obtain a DFA for the language $L_2 \cap (L_3 \cup L_4)$, how many states would it have? (1 point)

(e) **Find** all four-letter strings in $L_2 \cap (L_3 \cup L_4)$. (1 point)

(f) **Give** the state diagram for a DFA that recognizes $L_2 \cap (L_3 \cup L_4)$ using only four states. (2 points)

(g) **Find** a four-letter string in $\overline{L_3} \circ L_4$. [Recall: $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$] (1 point)

(h) Is $\overline{L_3} \circ L_4 = \overline{L_3}$? **Give** justification for your answer. (1 point)

Spring 24 set1

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w \text{ starts with } 10\}$$
$$L_2 = \{w \text{ doesn't contain } 11\}$$
$$L_3 = \{w \text{ doesn't contain } 00\}$$
$$L_4 = \{w = 10\}$$
$$L_5 = L_2 \cap L_3$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) If you were to use the "cross product" construction shown in class to obtain a DFA for the language L_5, how many states would it have? (1 point)

(d) **Find** all four-letter strings in L_5. (1 point)

(e) **Give** the state diagram for a DFA that recognizes L_5 using only four states. (2 points)

(f) **Find** one six-letter string in $L_4{}^*$. (1 point)

(g) **Give** the state diagram for a DFA that recognizes $L_4{}^*$. (2 points)

(h) Is $L_4{}^*$ and $L_1 \cap L_5$ same? **Give** justification for your answer. (2 points)

Spring 23 set 2

Problem 1 (CO1): DFA and Regular Languages (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : w = 1^m 0^n, \text{ where } m, n \geq 0\}$$
$$L_2 = \{w : 1 \text{ does not appear at any even position in } w\}$$
$$L_3 = L_1 \cap L_2$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) If you were to use the "cross product" construction shown in class to obtain a DFA for the language L_3, how many states would it have? (1 point)

(d) **Find** all four-letter strings in L_3. (1 point)

(e) **Give** the state diagram for a DFA that recognizes L_3 using only three states. (2 points)

Spring 23 set 2

Problem 2: Constructing a DFA (10 points)
Consider the following language.

$$L = \{w \in \{0,1\}^* : w = 0^m1^n \text{ where } m \text{ and } n \text{ are either both even or both odd}\}$$

(a) Write down the strings $w \in L$ such that the length of w is six. (2 points)

(b) Consider the following pair of languages.

$$L_1 = \{w \in \{0,1\}^* : w = 0^m1^n \text{ where } m \text{ and } n \text{ are both even}\},$$

$$L_2 = \{w \in \{0,1\}^* : w = 0^m1^n \text{ where } m \text{ and } n \text{ are both odd}\}.$$

Notice that $L = L_1 \cup L_2$. So, one way of designing a DFA for L would be to construct DFA for L_1 and L_2 and combine them using the "cross-product" construction shown in class.

Construct a DFA for L_1. (5 points)

(c) If you were to construct a DFA for L using the method described in (b), how many states would it have? Your answer should only be a number. (1 point)

(d) However, there is a DFA for L using at most seven states. Find that DFA. (2 points)

Spring 24 set1

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w \text{ starts with } 01\}$$
$$L_2 = \{w \text{ doesn't contain } 00\}$$
$$L_3 = \{w \text{ doesn't contain } 11\}$$
$$L_4 = \{w = 01\}$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) If you were to use the "cross product" construction shown in class to obtain a DFA for the language $L_2 \cap L_3$, how many states would it have? (1 point)

(d) **Find** all four-letter strings in $L_2 \cap L_3$. (1 point)

(e) **Give** the state diagram for a DFA that recognizes $L_2 \cap L_3$ using only four states. (2 points)

(f) **Find** one six-letter string in $L_4{}^*$. (1 point)

(g) **Give** the state diagram for a DFA that recognizes $L_4{}^*$. (2 points)

(h) Is $L_4{}^*$ and $L_1 \cap L_2 \cap L_3$ same? **Give** justification for your answer. (2 points)

Spring 24 set2

Problem 1 (CO1): DFA and Regular Languages (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : w = 1^m 0^n, \text{ where } m, n \geq 0\}$$
$$L_2 = \{w : 1 \text{ does not appear at any even position in } w\}$$
$$L_3 = L_1 \cap L_2$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) If you were to use the "cross product" construction shown in class to obtain a DFA for the language L_3, how many states would it have? (1 point)

(d) **Find** all four-letter strings in L_3. (1 point)

(e) **Give** the state diagram for a DFA that recognizes L_3 using only three states. (2 points)

Fall 24 Set B

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{length of } w \text{ is exactly three}\}$$
$$L_2 = \{w : \text{every even position in } w \text{ is } 1\}$$
$$L_3 = \{w : 10 \text{ appears even number of times in } w \text{ as a substring}\}$$
$$L_4 = L_1 \cap L_2 \cap L_3$$
$$L_5 = \{w : 1^m 0^n, \text{where } m, n \geq 0\}$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) **Give** the state diagram for a DFA that recognizes L_3. (3 points)

(d) If you were to use the "cross product" construction shown in class to obtain a DFA for the language L_4, how many states would it have? (1 point)

(e) **Find** all the strings in L_4. (1 point)

(f) **Give** the state diagram for a DFA that recognizes L_4 using only five states. (2 points)

(g) Is L_4 is a subset of L_5? **Give** justification for your answer. (2 points)

Fall 24 Set A

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{length of } w \text{ is exactly three}\}$$

$$L_2 = \{w : \text{every even position in } w \text{ is } 0\}$$

$$L_3 = \{w : 01 \text{ appears even number of times in } w \text{ as a substring}\}$$

$$L_4 = L_1 \cap L_2 \cap L_3$$

$$L_5 = \{w : 0^m 1^n, \text{where } m, n \geq 0\}$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(c) **Give** the state diagram for a DFA that recognizes L_3. (3 points)

(d) If you were to use the "cross product" construction shown in class to obtain a DFA for the language L_4, how many states would it have? (1 point)

(e) **Find** all the strings in L_4. (1 point)

(f) **Give** the state diagram for a DFA that recognizes L_4 using only five states. (2 points)

(g) Is L_4 is a subset of L_5? **Give** justification for your answer. (2 points)

Fall 23 Set K

DFA Set A

Problem 1 (CO1): DFA and Regular Languages (15 points)

We define the last two digits of your Student ID to be AB [e.g: If your Student ID is 2102895, then A = 9, B = 5] Given, $\Sigma = \{\mathtt{A}, \mathtt{B}, \#\}$. Consider the following languages over Σ.

$$L_1 = \{w : w \text{ starts with } \mathtt{A}\}$$
$$L_2 = \{w : w \text{ contains } \mathtt{AB\#} \text{ as a substring}\}$$
$$L_3 = L_1 \circ L_2$$

Now solve the following problems. For questions (a)-(f), you must use your specific Σ to answer.

(a) If $\Sigma = \{\mathtt{A}, \mathtt{B}, \#\}$, then **define** Σ according to your Student ID. (1 point)

(b) **Give** the state diagram for a DFA that recognizes L_1. (3 points)

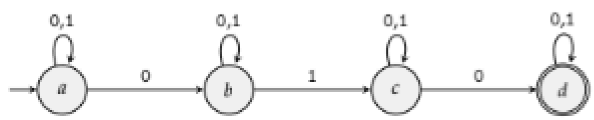
(c) **Give** the state diagram for a DFA that recognizes L_2. (3 points)

(d) **Find** all the four-letter strings in $L_1 \cap L_2$. (2 points)

(e) If you were to use the "cross product" construction shown in class to obtain a DFA for the language $L_1 \cap L_2$, how many states would it have? (1 point)

(f) **Prove** L_3 is a regular language by giving the state diagram for a DFA or an NFA that recognizes L_3. (2 points)

Now, let $\Sigma = \{0, 1\}$. Consider the following diagram of the NFA to answer the questions (g)-(h) defined for Σ.



(g) **Choose** the language recognized by this NFA? (1 point)

(i) $\{w : w$ has a length equal to or more than three.$\}$
(ii) $\{w : w = (010)^n, n \geq 0\}$
(iii) $\{w : w$ contains 010 as a subsequence$\}$
(iv) $\{w : w$ contains 010 as a substring$\}$

(h) **Select** the paths that accepts 010110 in the given NFA? There can be more than one path that accepts the string. (2 points)

(i) a → b → b → b → b → c → d
(ii) a → b → c → d → d → d → d
(iii) a → b → b → b → b → b → b
(iv) a → a → b → b → c → c → d
(v) a → a → a → b → c → c → d

Fall22 Set 2

Problem 1 (CO1): DFA and Regular Languages (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : w \text{ starts with either } 01 \text{ or } 10\}$$
$$L_2 = \{w : w \text{ does not start with } 11\}$$
$$L_3 = \{w : \text{the length of } w \text{ is at least two}\}$$

Now solve the following problems.

(a) Give the state diagram for a DFA that recognizes L_1. (3 points)

(b) Give the state diagram for a DFA that recognizes L_2. (3 points)

(c) Give the state diagram for a DFA that recognizes L_3. (2 points)

(d) Give the state diagram for a DFA that recognizes $\overline{L_1} \cap L_2 \cap L_3$ using only four states. Here $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$. (2 points)

Fall 22 Set 1

Problem 1 (CO1): DFA and Regular Languages (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{the length of } w \text{ is at most three}\}$$
$$L_2 = \{w : w \text{ starts and ends with different letters}\}$$
$$L_3 = \{w : \text{the length of } w \text{ is at least two}\}$$

Now solve the following problems.

(a) Give the state diagram for a DFA that recognizes L_1. (2 points)

(b) Give the state diagram for a DFA that recognizes L_2. (3 points)

(c) Give the state diagram for a DFA that recognizes L_3. (2 points)

(d) Find a shortest string in $\overline{L_1} \cap L_3$. Here $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$. (1 point)

(e) If you were to use the "cross product" construction shown in class to obtain a DFA for the language $L_2 \cap L_3$, how many states would it have? (1 point)

(f) How many states does the smallest DFA for $L_2 \cap L_3$ have? (1 point)

Summer 22

Problem 1: Finite Automata and the Regular Operations (10 points)

Let $\Sigma = \{0, 1, \#\}$. Consider the following two languages.

$$L_1 = \{w \in \Sigma^* : w \text{ does not contain } \# \text{ and the number of 0s in } w \text{ is not a multiple of } 3\}$$
$$L_2 = \{w \in \Sigma^* : \text{the substring between any two successive occurrences of \#s in } w \text{ is in } L_1\}$$

Now solve the following problems.

(a) Write down a string $w \in L_2$ such that the length of w is ten. (1 point)

(b) Give the state diagram for a DFA that recognizes L_1. (4 points)

(c) Give the state diagram for a DFA that recognizes L_2. (3 points)

(d) If you use the "cross product" construction shown in class to obtain a DFA for $L_1 \cap L_2$, how many states will it have? (1 point)

(e) Give an upper bound on the number of states in the smallest DFA that recognizes $L_1 \cap L_2$. (1 point)

Summer 23

Problem 1 (CO1): DFA and Regular Languages (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ. Note that we define 0^m to be the string $\overbrace{000\ldots000}^{m \text{ times}}$. 1^n is defined analogously.

$$L_1 = \{w : w \text{ does not contain 01 as a substring}\}$$
$$L_2 = \{0^m : m \text{ is even}\}$$
$$L_3 = \{1^n : n \geq 0\}$$
$$L_4 = L_2 \circ L_3$$

Now solve the following problems.

(a) **Give** the state diagram for a DFA that recognizes L_1. (4 points)

(b) **Give** the state diagram for a DFA that recognizes L_2. (4 points)

(c) **Find** all the four and five-letter strings in L_4. (1 point)

(d) **Give** the state diagram for a DFA that recognizes L_4. (2 points)

(e) If you were to use the "cross product" construction shown in class to obtain a DFA for the language $L_1 \cap L_4$, how many states would it have? (1 point)

(f) **Find** all five-letter strings in $L_1 \cap L_4$. (1 point)

(g) **Give** the state diagram for a DFA that recognizes $L_1 \cap L_4$ using only five states. (2 points)

RE

Spring 25Set A

Automata and Computability DURATION: 90 MINUTES

Problem 4 (CO1): Regular Expressions (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w : \text{length of } w \text{ is exactly } 4\}$$
$$L_2 = \{w : \text{the third last digit of } w \text{ is } 0\}$$
$$L_3 = \{w : w \text{ contains at most two } 11\}$$
$$L_4 = \overline{L_1^* \cap L_2}$$

Now solve the following problems.

(a) **Give** a regular expression for the language L_1. (1 point)

(b) **Give** a regular expression for the language L_1^*. (1 point)

(c) **Give** a regular expression for the language $\overline{L_1^*}$. [Recall: $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$] (2 points)

(d) **Give** a regular expression for the language L_2. (2 points)

(e) **Give** a regular expression for the language $\overline{L_3}$. (2 points)

(f) **Give** a regular expression for the language L_4. (2 points)

Summe 23Set 2

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{a, b\}$. **Give** regular expressions generating each of the following languages over Σ.

(a) $\{w :$ the first and last letters of w are a and b respectively$\}$ (3 points)

(b) $\{w :$ the length of w is odd$\}$ (3 points)

(c) $\{w :$ every a in w is followed by an even number of bs$\}$ (3 points)

(d) $\{w : w$ does not contain ab$\}$ (3 points)

(e) $\{w :$ ab appears in w exactly once$\}$ (3 points)
(Hint: If $w = x\texttt{ab}y$, what can you say about x and y?)

Spring 24 Set 1

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w \text{ contains exactly two } 1\}$$
$$L_2 = \{w \text{ doesn't start with } 0\}$$
$$L_3 = \{\text{every third position in } w \text{ is } 1\}$$
$$L_4 = \{\text{every } 1 \text{ in } w \text{ is followed by at least two } 0\}$$
$$L_5 = L_3 \cap L_4$$

Now solve the following problems.

(a) **Give** a regular expression for the language L_1. (3 points)

(b) **Give** a regular expression for the language L_2. (3 points)

(c) **Give** a regular expression for the language L_3. (3 points)

(d) **Write** a five-letter string that belongs to L_5. (1 point)

(e) **Give** a regular expression for the language L_5. (2 points)

(f) **Give** a regular expression for the language $\overline{L_4}$. Here $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$. (3 points)

Spring 23 Set 2

Problem 2 (CO1): Regular Expressions (10 points)

Consider the following languages over $\Sigma = \{0, 1\}$.

$$L_1 = \{w : w \text{ does not contain } 00\}$$
$$L_2 = \{w : \text{every } 0 \text{ in } w \text{ is preceded by at least one } 1\}$$
$$L_3 = \{w : \text{the number of times } 0 \text{ appears in } w \text{ is even}\}$$

Now solve the following problems.

(a) **Give** a regular expression for the language L_1. (2 points)

(b) Your friend claims that $L_1 = L_2$. **Prove** him wrong by writing down a five-letter string in $L_1 \setminus L_2$. Recall that $L_1 \setminus L_2$ contains all strings that are in L_1 but not in L_2. (2 points)

(c) **Give** a regular expression for the language $L_1 \setminus L_2$. (2 points)

(d) **Give** a regular expression for the language L_3. (2 points)

(e) **Give** a regular expression for the language $L_2 \setminus L_3$. (2 points)

Spring 24 Set 1

(h) Is L_4^* and $L_1 \cap L_2 \cap L_3$ same? **Give** justification for your answer. (2 points)

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w \text{ contains exactly two } 1\}$$

$$L_2 = \{w \text{ doesn't start with } 0\}$$

$$L_3 = \{\text{every third position in } w \text{ is } 1\}$$

$$L_4 = \{\text{every } 1 \text{ in } w \text{ is followed by at least two } 0\}$$

$$L_5 = L_3 \cap L_4$$

Now solve the following problems.

(a) **Give** a regular expression for the language L_1. (3 points)

(b) **Give** a regular expression for the language L_2. (3 points)

(c) **Give** a regular expression for the language L_3. (3 points)

(d) **Write** a five-letter string that belongs to L_5. (1 point)

(e) **Give** a regular expression for the language L_5. (2 points)

(f) **Give** a regular expression for the language $\overline{L}_4$. Here $\overline{L}$ denotes the complement of the language L i.e., $\overline{L} = \Sigma^* - L$. (3 points)

Spring 22

Problem 1: Regular Expressions (10 points)

Write down regular expressions for each of the following languages. Assume that $\Sigma = \{0, 1\}$.

(a) The language containing strings where 0s and 1s alternate. (3 points)

(b) The language containing strings in which the number of 1s is divisible by 4. (3 points)

(c) The language containing strings in which the number of 0s between every pair of consecutive 1s is even. (4 points)

Fall 24 set 1

Problem 3 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. Consider the following languages over Σ.

$$L_1 = \{w \text{ does not contain consecutive } 1\}$$

$$L_2 = \{w \text{ starts with } 0\}$$

$$L_3 = \{w \text{ starts and ends with the same character}\}$$

$$L_4 = L_2 \setminus L_3$$

Now solve the following problems.

(a) **Give** a regular expression for the language L_1. (3 points)

(b) **Give** a regular expression for the language $\overline{L_2}$. [Recall: $\overline{L}_2$ denotes the complement of the language L_2 i.e., $\overline{L}_2 = \Sigma^* - L_2$] (3 points)

(c) **Give** a regular expression for the language L_3. (3 points)

(d) **Write** four four-letter strings in L_4. (2 point)

(e) **Give** a regular expression for the language L_4. [Recall: $L_2 \setminus L_3$ contains all strings that are in L_2 but not in L_3] (2 points)

(f) **Give** a regular expression for the language $\overline{L_4}$. (2 points)

Fall 22 set 2

Problem 2 (CO1): Regular Expressions (10 points)

Let $\Sigma = \{0, 1\}$. Consider the following pair of languages over Σ.

$$L_1 = \{w : w \text{ contains } 11 \text{ as a substring}\}$$

$$L_2 = \{w : w \text{ contains } 10 \text{ as a substring}\}$$

Now solve the following problems.

(a) Write down a regular expression for the language L_1. (2 points)

(b) Write down a regular expression for the language L_2. (2 points)

(c) Your friend wants a regular expression for the language $\overline{L_1 \cap L_2}$ where $\overline{L}$ denotes the complement of the languag L i.e., $\overline{L} = \Sigma^* - L$. He wants your help. You tell him to make use of the fact $\overline{L_1 \cap L_2} = \overline{L_1} \cup \overline{L_2}$.

(i) Write down a regular expression for the language $\overline{L_1}$. (2 points)

(ii) Write down a regular expression for the language $\overline{L_2}$. (2 points)

(iii) Using the fact above, write down a regular expression for the language $\overline{L_1 \cap L_2}$. (2 points)

Fall 23 set k

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. **Give** regular expressions for each of the languages (a)-(f) over Σ.

(a) $\{w : w$ contains 11 or 101 as a substring.$\}$ (2 points)

(b) $\{w : w$ contains exactly four 1s.$\}$ (2 points)

(c) $\{w :$ The length of w is two more than multiple of five.$\}$ (2 points)

(d) $\{w : w$ consists of any combination of 01 and 110.$\}$ (2 points)

(e) $\{w : w$ doesn't end with 01$\}$ (2 points)

(f) $\{w :$ Number of 01 substring is more than number of 10 substrings in $w\}$ (2 points)

(g) You write a regular expression $0(0+1)^*1^*0^*0$. Your friends write another regular expression $01^*0^*(0+1)^*0$. Are they the same? **Write** Yes or No only. (1 point)

(h) You write a regular expression $(1+01)^*$. Your friends write another regular expression $1^*(011^*)^*$. Are they the same? **Give** justification for your answer. (2 points)

RE Set B

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. **Give** regular expressions for each of the languages (a)-(f) over Σ.

(a) $\{w : w$ starts with 00 or 010.$\}$ (2 points)

(b) $\{w : w$ contains at least three 1s.$\}$ (2 points)

(c) $\{w :$ The length of w is three more than multiple of five.$\}$ (2 points)

(d) $\{w : w$ consists of any combination of 10 and 001.$\}$ (2 points)

(e) $\{w : w$ doesn't end with 11$\}$ (2 points)

(f) $\{w :$ Number of 01 substring is less than number of 10 substrings in $w\}$ (2 points)

(g) You write a regular expression $11^*(0+1)^*0^*1$. Your friends write another regular expression $10^*1^*(0+1)^*1$. Are they the same? **Write** Yes or No only. (1 point)

(h) You write a regular expression $(0+10)^*$. Your friends write another regular expression $0^*(100^*)^*$. Are they the same? **Give** justification for your answer. (2 points)

Summer 22

Problem 2: Regular Expressions (10 points)

Mike and Willy recently learned how to write regular expressions. Mike wrote the regular expression `10*1*` for a language L_1 on the board and Willy wrote the regular expression `1*01*` for another language L_2 below that.

(a) Write down a string that is present in the language L_1 but not in the language L_2. (2 points)

(b) Write down a string that is not present in the language L_1 but present in the language L_2. (2 points)

(c) Write down a string that is neither present in the language L_1 nor in the language L_2. (2 points)

(d) Mike and Willy asked their friend Dustin to write a regular expression for the language $L_1 \cap L_2$. Dustin came up with `1*0*1*`. Is Dustin's regular expression correct? If you think it's not correct, then write down a correct regular expression for $L_1 \cap L_2$. (4 points)

Summer 23 Set 1

Problem 2 (CO1): Regular Expressions (15 points)

Let $\Sigma = \{0, 1\}$. **Give** regular expressions generating each of the following languages over Σ.

(a) $\{w : w$ starts with a 1 and ends in a 0$\}$ (3 points)

(b) $\{w :$ the length of w is even$\}$ (3 points)

(c) $\{w :$ every 1 in w is followed by an even number of 0s$\}$ (3 points)

(d) $\{w : w$ does not contain 10$\}$ (3 points)

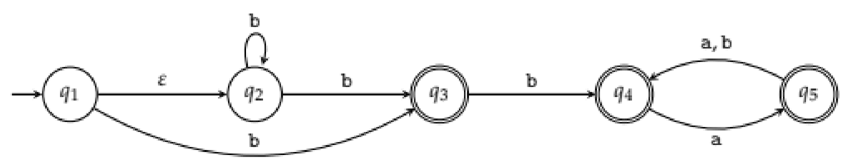
(e) $\{w :$ 10 appears in w exactly once$\}$ (3 points)
(Hint: If $w = x10y$, what can you say about x and y?)

NFA

Spring 25 Set A

Problem 5 (CO2): Subset Construction Method (5 points)

Consider the following NFA:



Now answer the following questions. [Note: You do not need to convert the given NFA into its equivalent DFA to answer the questions.]

(a) If you convert the given NFA into an equivalent DFA using the subset construction method, what is the maximum number of states that the DFA can have? (1 point)

(b) what is the maximum number of accepting states that the equivalent DFA can have? (1 point)

(c) **Write** the ε-closure of state q_1 in the given NFA. (1 point)

(d) **Write** the subset of states of the given NFA that will be the starting state in its equivalent DFA. (1 point)

(e) What is $\delta(\{q_1, q_3\}, \texttt{b})$ in the given NFA? [Recall: $\delta(\{q\}, \texttt{a})$ is the set of states in which the NFA transitions when it is in state q and receives input a.] (1 point)