



Name:

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**Problem 1: Regular Expression**

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

$$L1 = \{w \text{ contains exactly two } b\}$$

$$L2 = \{w \text{ contains } aa \text{ or } bb\}$$

$$L3 = \{w \text{ ends with even numbers of } b\}$$

$$L4 = \{\text{length of } w \text{ is two more than multiple of four}\}$$

$$L5 = \{\text{each } a \text{ in } w \text{ is followed by at least two } b\}$$

$$L6 = L1 \cap L5$$

$$L7 = \{\omega \text{ starts with even numbers of } a\}$$

- a) Give the regular expression for  $L1$ . (4 points)

$$a^* b a^* b a^*$$

- b) Give the regular expression for  $\overline{L2}$ . (3 points)

$$\overline{L2} = \omega \text{ contains neither } aa \text{ nor } bb$$

$$\text{sol1: } (ab)^* (a + \epsilon) + (ba)^* (b + \epsilon) \quad \text{sol2: } (a + \epsilon)(ba)^* (b + \epsilon)$$

- c) Write four four-letter strings that belongs to  $L3$ . (2 points)

$\overset{\curvearrowleft}{\text{choices}}$  aaaa, babb, aabb, bbbb (write any four)

- d) Give the regular expression for  $L3$ . (3 points)

$$(a+b)^* a (bb)^* + (bb)^*$$

- e) Give the regular expression for  $L4$ . (4 points)

$$\text{sol1: } ((a+b)(a+b)(a+b)(a+b))^* (aa+ab+ba+bb)$$

$$\text{sol2: } ((a+b)(a+b)(a+b)(a+b))^* (a+b)(a+b)$$

- f) Give the regular expression for  $L5$ . (2 points)

$$b^* (a b b b^*)^*$$

- g) Give the regular expression for  $L6$ . (2 points)

$$bb + abb$$

$L7 = \omega \text{ starts with even numbers of } a$   
 $(aa)^* b (a+b)^* + (aa)^*$



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## Problem 1: Regular Expression

Let  $\Sigma = \{a, b\}$ . Consider the following language over the  $\Sigma$ . 'Precede' means come before in order or position.

$$L1 = \{w \text{ contains at most two } a\}$$

$$L2 = \{w \text{ contains } ab \text{ or } ba\}$$

$$L3 = \{w \text{ starts and ends with different symbols}\}$$

$$L4 = \{\text{length of } w \text{ is not multiple of three}\}$$

$$L5 = \{\text{each } b \text{ in } w \text{ is preceded by even numbers of } a\}$$

$$L6 = L1 \cap L3$$

- a) Give the regular expression for  $L1$ . (4 points)

$$\text{Sol1: } b^* + b^*ab^* + b^*ab^*ab^*$$

$$\text{Sol2: } b^* (a + \epsilon) b^* (a + \epsilon) b^*$$

- b) Give the regular expression for  $\overline{L2}$ . (3 points)

$$\overline{L2} = w \text{ contains neither } ab \text{ nor } ba$$

$$a^* + b^*$$

- c) Give the regular expression for  $L3$ . (3 points)

$$a(a+b)^*b + b(a+b)^*a$$

- d) Give the regular expression for  $L4$ . (4 points)

$$\text{Sol1: } ((a+b)(a+b)(a+b))^* (a+b+ab+ba+aa+bb)$$

$$\text{Sol2: } ((a+b)(a+b)(a+b))^* (a+b+\epsilon)(a+b)$$

- e) Write four four-letter strings that belongs to  $L5$ . (2 points)

aaaa, baaa, ~~baab~~, aaba, baab, bbaa, aabb,  
bbbb (write any four)

- f) Give the regular expression for  $L5$ . (2 points)

$$((aa)^*b)^*a^*$$

- g) Give the regular expression for  $L6$ . (2 points)

$$\text{Sol1: } ab^*b + a b^* a b^* b + b b^* a b^* a + b b^* a$$

$$\text{Sol2: } ab^*(a+\epsilon)b^*b + b b^*(a+\epsilon)b^*a$$

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## Problem 1: Regular Expression

Let  $\Sigma = \{a, b\}$ . Consider the following language over the  $\Sigma$ . 'Precede' means come before in order or position.

$$L_1 = \{w \text{ contains at most two } b\}$$

$$L_2 = \{w \text{ contains } ab \text{ or } ba\}$$

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

$$L_4 = \{\text{length of } w \text{ is not multiple of three}\}$$

$$L_5 = \{\text{each } a \text{ in } w \text{ is preceded by odd numbers of } b\}$$

$$L_6 = L_1 \cap L_3$$

a) Give the regular expression for  $L_1$ . (4 points)

$$\text{Sol1: } a^* + a^*ba^* + a^*ba^*ba^*$$

$$\text{Sol2: } a^*(b+\epsilon)a^*(b+\epsilon)a^*$$

b) Give the regular expression for  $\overline{L_2}$ . (3 points)

$$\overline{L_2} = w \text{ contains neither } ab \text{ nor } ba$$

$$a^* + b^*$$

c) Give the regular expression for  $L_3$ . (3 points)

$$a(a+b)^*a + b(a+b)^*b + a + b$$

d) Give the regular expression for  $L_4$ . (4 points)

$$\text{Sol1: } ((a+b)(a+b)(a+b))^* (a+b+aa+ab+ba+bb)$$

$$\text{Sol2: } ((a+b)(a+b)(a+b))^* (a+b)(a+b+\epsilon)$$

e) Write four four-letter strings that belongs to  $L_5$ . (2 points)

bbbb, babb, bbba, baba

f) Give the regular expression for  $L_5$ . (2 points)

$$((bb)^*ba)^*b^*$$

g) Give the regular expression for  $L_6$ . (2 points)

$$\text{Sol1: } ba^*b + \cancel{ab}aa^*a + aa^*ba^*a + aa^*ba^*ba^*a$$

$$\text{Sol2: } ba^*b + a^*a^*(b+\epsilon)a^*(b+\epsilon)a^*a$$