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In the regular expressions, '*' indicates that the preceding regular expression may appear zero or more times and '+' indicates that the preceding regular expression may appear one or more times.

a.

Consider the language $L=\{w \mid w \text{ begins with a 1 and ends with a } 0\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= 1\Sigma^*0 \\ &= 1(0+1)^*0 \end{aligned}$$

The strings accepted by the regular expression are $10,100,110,1010,1100,10100,\ldots$

Therefore, the regular expression is $1(0+1)^*0$.

b.

Consider the language $L=\{w \mid w \text{ contains at least three 1s}\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \Sigma^*1\Sigma^*1\Sigma^*1\Sigma^* \\ &= (0+1)^*1(0+1)^*1(0+1)^*1(0+1)^* \end{aligned}$$

The strings accepted by the regular expression are $111,010101,01101,00001111,\ldots$

Therefore, the regular expression is $(0+1)^*1(0+1)^*1(0+1)^*1(0+1)^*$.

c.

Consider the language $L=\{w \mid w \text{ contains the substring } 0101\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \Sigma^*0101\Sigma^* \\ &= (0+1)^*0101(0+1)^* \end{aligned}$$

The strings accepted by the regular expression are $0101,001011,101011,1101010,\ldots$

Therefore, the regular expression is $(0+1)^*0101(0+1)^*$.

d.

Consider the language $L=\{w \mid w \text{ has length at least 3 and its third symbol is a } 0\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \Sigma\Sigma 0\Sigma^* \\ &= (0+1)(0+1)0(0+1)^* \end{aligned}$$

The strings accepted by the regular expression are $000,1101,\ldots$

Therefore, the regular expression is $(0+1)(0+1)0(0+1)^*$.

e.

Consider the language,

$L=\{w \mid w \text{ starts with 0 and has odd length, or start with 1 and has even length}\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= 0(\Sigma\Sigma)^*+1\Sigma(\Sigma\Sigma)^* \\ &= 0((0+1)(0+1))^*+1(0+1)((0+1)(0+1))^* \end{aligned}$$

The strings accepted by the regular expression are $0,011,010,00101,10,11,1001,\ldots$

Therefore, the regular expression is $0((0+1)(0+1))^*+1(0+1)((0+1)(0+1))^*$.

f.

Consider the language $L=\{w \mid w \text{ doesn't contain the substring } 110\}$ over the alphabet $\Sigma=\{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$R = 0^*\left(10^+\right)^*1^*$

The strings accepted by the regular expression are $010, 011, 0101, \ldots$

Therefore, the regular expression is $0^*\left(10^+\right)^*1^*$ **.**

g.

Consider the language $L = \{w \mid \text{the length of } w \text{ is at most } 5\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \varepsilon + \Sigma + \Sigma\Sigma + \Sigma\Sigma\Sigma + \Sigma\Sigma\Sigma\Sigma + \Sigma\Sigma\Sigma\Sigma\Sigma \\ &= \varepsilon + (0+1) + (0+1)(0+1) + (0+1)(0+1)(0+1) + (0+1)(0+1)(0+1)(0+1) + (0+1)(0+1)(0+1)(0+1)(0+1) \\ &= \varepsilon + (0+1) + (0+1)^2 + (0+1)^3 + (0+1)^4 + (0+1)^5 \end{aligned}$$

The strings accepted by the regular expression are $\varepsilon, 0, 01, 101, 1010, 00000, \ldots$ The empty string is of length 0. The language accepts the strings of length from 0 to 5.

Therefore, the regular expression is $\varepsilon + (0+1) + (0+1)^2 + (0+1)^3 + (0+1)^4 + (0+1)^5$ **.**

h.

Consider the language $L = \{w \mid w \text{ is any string except } 11 \text{ and } 111\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \varepsilon + \Sigma + 0\Sigma + 10 + 0\Sigma\Sigma + 10\Sigma + 110 + \Sigma^3\Sigma^+ \\ &= \varepsilon + (0+1) + 0(0+1) + 10 + 0(0+1)(0+1) + 10(0+1) + 110 + (0+1)^3(0+1)^+ \end{aligned}$$

The strings accepted by the regular expression are $\varepsilon, 101, 110, 1010, \ldots$

Therefore, the regular expression is,

$$\varepsilon + (0+1) + 0(0+1) + 10 + 0(0+1)(0+1) + 10(0+1) + 110 + (0+1)^3(0+1)^+ .$$

i.

Consider the language $L = \{w \mid \text{every odd position of } w \text{ is a } 1\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= (1\Sigma)^*(\varepsilon + 1) \\ &= (1(0+1))^*(\varepsilon + 1) \end{aligned}$$

The strings accepted by the regular expression are $\varepsilon, 101, 111, 1010, \ldots$

Therefore, the regular expression is $(1(0+1))^*(\varepsilon + 1)$ **.**

j.

Consider the language $L = \{w \mid w \text{ contains at least two 0s and at most one } 1\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$R = 00^*00^*(\varepsilon + 1) + 00^*(\varepsilon + 1)00^* + (\varepsilon + 1)00^*00^*$$

The strings accepted by the regular expression are $001, 010, 100, \ldots$ In the first part of the regular expression $00^*00^*(\varepsilon + 1)$, there are two mandatory zeros and at most one 1. The optional 1 may appear at the start or middle or at the end. There are three parts in the regular expression to accept such strings.

Therefore, the regular expression is $00^*00^*(\varepsilon + 1) + 00^*(\varepsilon + 1)00^* + (\varepsilon + 1)00^*00^*$ **.**

k.

Consider the language $L = \{\varepsilon, 0\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$R = 0 + \varepsilon$$

Therefore, the regular expression is $0 + \varepsilon$ **.**

l.

Consider the language,

$L = \{w \mid w \text{ contains an even number of 0s, or contains exactly two 1s}\}$ over the alphabet $\Sigma = \{0,1\}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$R = 1^*(01^*01^*)^* + 0^*10^*10^*$$

The strings accepted by the regular expression are $\varepsilon, 00, 11, 0101, 010100, \ldots$

Therefore, the regular expression is $1^*(01^*01^*)^* + 0^*10^*10^*$.

m.

Consider the language $L = \text{The empty set}$. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$R = \phi$$

Therefore, the regular expression is ϕ .

n.

Consider the language *L* accepts all the strings except the empty string. Let *R* be the regular expression that generates the language *L*. The regular expression is as follows:

$$\begin{aligned} R &= \Sigma^+ \\ &= (0+1)^+ \end{aligned}$$

The language accepts all the strings except ε.

Therefore, the regular expression is $(0+1)^+$.