CS & IT ENGINEERING

Theory of Computation

Finite Automata:

Practice on Regular Expressions

Lecture No. 4

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TOPICS TO BE COVERED

01 Practice Questions

02 GATE PYQs

03 Model GATE Questions

04 Important Regular Exps

05 Revision

Simplification

** (31) $(a+\varepsilon)^* = (a+\varepsilon)^0 + (a+\varepsilon)^1 + (a+\varepsilon)^2 + \cdots = \varepsilon + a + a^2 + a^3 + a^4 + \cdots$

$= a^*$

(32) $(a+\varepsilon)^+ = a^*$

(33) $(\phi+\varepsilon)^* = \varepsilon^* = \varepsilon$

(34) $(\phi+a)^* = a^*$

(35) $(a\cdot\phi)^* = \phi^* = \varepsilon$

$\boxed{\phi+\varepsilon=\varepsilon}$

$\boxed{\phi+a=a}$

$a\cdot\phi=\phi$

Simplification

I) $a + \varepsilon \neq a$

II) $(a+\varepsilon)^* = a^* = (a+\varepsilon)^+$

III) $(a+\varepsilon)^+ \neq a^+$

Simplification

$(aa)^3 = aa.aa.aa = a^6$

(36) $a.a^* = a^+$

(37) $a^*.a = a^+ = (36)$

(38) $a + a^* = a \cup a^* = a^*$

(39) $a^* + a^* = a^* \cup a^* = a^*$

(40) $a^+ + \varepsilon = a^*$

(41) $a^*.a^* = (a^*)^2 = a^*$

(42) $a^+.a^+ = a^2 + a^3 + a^4 + a^5 + \ldots$
$= aa^+ = aaa^* = a^*aa$

(43) $(aa)^* = \varepsilon + aa + a^4 + a^6 + \ldots$

Even no. of a's

(44) $a(aa)^* = a + a^3 + a^5 + a^7 + \ldots$

Odd no. of a's

*** (45) $(a+b)^* = \varepsilon + a + b + aa + ab + ba + bb + \ldots$
$= (b+a)^*$

$$a^{+} \cdot a^{+} = \cancel{a^0} + \cancel{a} + a^2 + a^3 + a^4 + a^5 + \dots$$

$$\underbrace{\checkmark \quad \checkmark \quad \checkmark \quad \dots}_{\text{min } 2a\text{'s}}$$

$$(a^1 + a^2 + a^3 + \dots) \cdot (a^1 + a^2 + a^3 + \dots)$$

$$a \cdot a = a^2$$

$$a \cdot a^2 = a^3$$

$$a^\dagger a^\dagger = \underbrace{\underbrace{a\,a}_{2\,a's}\;\underbrace{a^*}_{\geq 0\,a's}}_{\geq 2\,a's}$$

$$= a\,a^*\,a$$

$$= a^*\,a\,a$$

$$= a\,a^\dagger$$

$$= a^\dagger\,a$$

$$\underbrace{a}_{\text{one } a}\ \underbrace{(aa)^*}_{\text{even } a\text{'s}} = \underbrace{(aa)^*}_{\text{even}}\ \underbrace{a}_{\text{one}}$$

$$\{a^n \mid n = \text{odd}\}$$

$$\{a^1, a^3, a^5, a^7, \ldots\}$$

$a \cdot \varepsilon \longrightarrow a$

$a \cdot aa \longrightarrow a^3$

$a\ aaaa \longrightarrow a^5$

$a\ (aa)^3 \longrightarrow a^7$

$a\ (aa)^4 \longrightarrow a^9$

odd no. of a's

$$\underbrace{a^+ \cdot a^+}_{\text{min } 2\ a's} = a^2 + a^3 + a^4 + \ldots$$

$\boxed{aa}$

$$= a\,a^+$$

$$= a^+ a$$

$$= a\,a\,a^*$$

$$= a\,a^* a$$

$$= a^* a\,a$$

$$a^+ = a\,a^*$$

$$= a^* a$$

$$\underbrace{\underbrace{a}_{1} \cdot \underbrace{a}_{1} \cdot \underbrace{a^*}_{\geq 0}}_{\geq 2\ a's}$$

$$a^* \cdot a^* = a^*$$

$a\varepsilon = a$

$$\{\boxed{\varepsilon}, a, aa, \ldots\} \cdot \{\varepsilon, a, aa, \ldots\} = a^*$$

$\varepsilon a = a$ $\quad$ $\varepsilon \cdot a^2 = a^2$

$\varepsilon\varepsilon = \varepsilon$

Simplification

$$\Sigma^* = (a+b)^* = \overset{\varepsilon}{(a+b)^0} + \overset{a,b}{(a+b)^1} + \overset{aa,ab,ba,bb}{(a+b)^2} + \cdots$$

$\Sigma = \{a,b\}$ $\quad R^* = R^0 + R^1 + R^2 + \cdots$

$(a+b)^0 \longrightarrow$ zero length

$(a+b)^1 \longrightarrow$ one length strings

$(a+b)^2 \longrightarrow$ 2 length strings $\qquad (a+b)^2 = (a+b)^1 . (a+b)^1$

$\qquad = aa + ab + ba + bb$

$(a+b)^3 \longrightarrow$ 3 length string

$\Sigma = \{a\}$ $\qquad$ $\Sigma^* = a^*$ $\qquad$ $\Sigma^* \cup \text{Any} = \Sigma^*$

Dominator

$\Sigma = \{a, b\}$ $\qquad$ $\Sigma^* = (a+b)^* = \{a, b\}^*$

$\Sigma = \{a, b, c\}$ $\qquad$ $\Sigma^* = (a+b+c)^* = \{a, b, c\}^*$

(46) $(a^*)^* = \underbrace{(a^*)^0}_{\varepsilon} + \underbrace{(a^*)^1}_{a^*} + \underbrace{(a^*)^2}_{a^*} + \underbrace{(a^*)^3}_{a^*} + \cdots = a^*$

(47) $(a^*)^+ = a^*$

(48) $(a^+)^* = \overbrace{\boxed{\underbrace{(a^+)^0}_{\varepsilon} + \underbrace{(a^+)^1}_{a^+}}}^{=a^*} + \underbrace{(a^+)^2 + \cdots}_{} = a^*$

(49) $(a^+)^+ = \underbrace{(a^+)^1} + (a^+)^2 + (a^+)^3 + \cdots$

(50) $((a^*)^*)^* = a^*$

$a^* . a^* = a^*$

$\underset{\varepsilon}{\underline{a^*}} . \underset{\varepsilon}{\underline{a^*}} . a^* = a^*$

$(a^*)^4 = a^*$

$(a^*)^5 = a^*$

$$(a^+)^1 = \underbrace{a^+}_{\text{min } 1a}$$

$$(a^+)^2 = \underbrace{a^+ a^+}_{\text{min } 2a\text{'s}}$$

$$(a^+)^3 = \underbrace{a^+ a^+ a^+}_{\text{min } 3a\text{'s}}$$

$$\vdots$$

Union $\Rightarrow a^+$

$$(ab)^* = (ab)^0 + (ab)^1 + (ab)^2 + \cdots$$

$$R^* = R^0 + R^1 + R^2 + \cdots$$

$$= \{\varepsilon, ab, abab, ababab, \ldots\}$$

$$(ab)^+ = \{ab, abab, (ab)^3, \ldots\}$$

a

b

$$(a+b)^* = \underbrace{\varepsilon + a + b + aa + ab + ba + bb + \ldots}_{\text{All strings}}$$

either a or b

X a

X b

$$(a.b)^* = \varepsilon + ab + abab$$

$$(a+b)^*$$ any no. of times

$$(a+b)^2 = (a+b).(a+b)$$

a	a
a	b
b	a
b	b

Write Regular Expression (R)

$A^* = A^+ + \varepsilon$

Universal set

① L = Set of all strings over $\Sigma = \{a, b\}$

$$\boxed{R = (a+b)^*} = \Sigma^* = (a+b)^+ + \varepsilon$$

② L = Set of all strings over $\Sigma = \{a, b, c\}$

$$\boxed{R = (a+b+c)^*} = \Sigma^* = (a+b+c)^+ + \varepsilon$$

empty set

③ L = empty set over $\Sigma = \{a, b\}$

$$\boxed{R = \phi} = \phi.a = \phi.b = \phi.ab = \phi.a^* = \phi.\text{any}$$

④ L = empty set over $\Sigma = \{a, b, c\}$

$$\boxed{R = \phi} = \phi.a = \phi b = \phi.c = \phi aca = \phi.\text{any}$$

$L = \{\ \}$ empty set over Σ

ϕ

ϕ never contain strings

Σ^* is never be empty

Universal set

All strings are there in Σ^*

Write Regular Expression

5. $L = \{ w \mid w \in \{a,b\}^*,\ \underbrace{|w| = 0}_{\text{length of string is zero}} \} = \{ \varepsilon \}$

$$\boxed{R = \varepsilon}$$

6. $L = \{ w \mid w \in \{a,b\}^*,\ \underbrace{|w| \le 0}_{} \}$

$|w| = 0, \underbrace{-1, -2, -3, \ldots}_{\text{there is no one}}$

$0 \rightarrow \varepsilon$

$$\boxed{R = \varepsilon}$$

7. $L = \{ w \mid w \in \{a,b\}^*,\ \underbrace{|w| \not\geq 1}_{} \}$

$$\boxed{R = \varepsilon}$$

a^{-2} ×

a^{-1} × there is no string

$a^{0} = \varepsilon$

$a^{1} = a$

$a^{2} = aa$

string

$|w| \leq 0$

$|w| = 0$

$|w| \ngtr 1$

all are same

$w \in \{a, b\}^*$, $|w| = 0$

$\text{string} \in \{\varepsilon, \underbrace{a, b, aa, ab, ba, bb, \ldots}_{\times}\}$

ε ✓

$w \in \{a, b\}^*$, $|w| = 2$

$\in \{\underbrace{\varepsilon, a, b,}_{\times} \underbrace{aa, ab, ba, bb,}_{\checkmark} \underbrace{\ldots}_{\times}\}$

Write Regular Expression

Same problems

(8) $\{w \in \{a,b\}^* \mid |w| \geq 1\} = \{\underbrace{a, b}_{1}, \underbrace{aa, ab, ba, bb}_{2}, \ldots\}$, $\underbrace{\qquad}_{\geq 1}$

$\boxed{R = \Sigma^+ = (a+b)^+}$

(9) $\{w \in \{a,b\}^* \mid |w| \neq 0\}$

$\boxed{R = (a+b)^+}$

(10) $\{w : w \in \{a,b\}^*, w \neq \varepsilon\}$

$\boxed{R = (a+b)^+}$

$$\underbrace{|w|<0}_{\phi} \cup \underbrace{|w|=0}_{\varepsilon} = \varepsilon$$

$$\phi + \varepsilon = \varepsilon$$

$$|w| \le 0$$

$$|w| \ngeq 1$$

Write Regular Expression

Same

(11) $\{\underbrace{aw}_{\text{form}} \mid \underbrace{w \in \{a,b\}^*}_{\text{conditions}}\} = a.(a+b)^* = a\Sigma^*$

(12) $\{\underbrace{w}_{\text{form}} \mid \underbrace{w \in \{a,b\}^*,\ w \text{ starts with `a'}}_{\text{conditions}}\} = \{\underline{a}, \underline{a}\boxed{a}, \underline{a}\boxed{b}, \ldots\}$

$= \underbrace{a}_{\text{must}}.\underbrace{(a+b)^*}$

$a\ .\ \varepsilon \longrightarrow a$

$a\ .\ a \longrightarrow aa$

$a\ .\ b \longrightarrow ab$

$$R = a(a+b)^* = a\Sigma^*$$

Write Regular Expression

(13) $L = \{ wb \mid w \in \{a,b\}^* \}$

$= \{ w \mid w \in \{a,b\}^*, w \text{ ends with } b \}$

$$R = (a+b)^* . b$$

$$= \Sigma^* b$$

$\underbrace{a(a+b)^*}_{\text{starts with 'a'}}$

$\underbrace{b(a+b)^*}_{\text{starts with } b}$

$\underbrace{(a+b)^* b}_{\text{ends with } b}$

Write Regular Expression

(14) $L = \{ w_1 a w_2 \mid w_1, w_2 \in \{a,b\}^* \}$

$= \{ w \mid w \in \{a,b\}^*,\ w \text{ contains `a' as substring} \}$

- ε ✗
- a ✓
- b ✗
- aa ✓
- ab ✓
- ba ✓
- bb ✗

$X \; a \; X$

$$\boxed{R = (a+b)^* . a . (a+b)^*} = \Sigma^* a \Sigma^*$$

Write Regular Expression

(15) Set of all strings ends with aa over $\Sigma = \{a, b\}$.

$$R = \Sigma^* aa$$

(16) Set of all strings starts with aa over $\Sigma = \{a, b\}$.

$$R = aa\Sigma^*$$

(17) Set of all strings containing 'aa' as substring over $\Sigma = \{a, b\}$

$$R = \Sigma^* aa \Sigma^*$$

Write Regular Expression

(18) $\{w \mid w \in \{a,b\}^*,\ |w| = 2\} = \{aa, ab, ba, bb\}$

$$\boxed{R = aa + ab + ba + bb = (a+b)^2 = \Sigma^2}$$

$\varepsilon \to 0$ len

$a+b \to 1$ len

$\varepsilon + a + b \to \leq 1$ len

(19) $\{w \mid w \in \{a,b\}^*,\ |w| \leq 2\} = \{\varepsilon, a, b, aa, ab, ba, bb\}$

$$R = \varepsilon + \underbrace{a+b} + (a+b)^2 = (\underbrace{\varepsilon + a + b}_{\leq 1})^2$$

$$\underbrace{\leq 1 . \leq 1}_{\leq 2}$$

(20) $\{w \mid w \in \{a,b\}^*,\ |w| \geq 2\}$

$$= (a+b)^2 . \Sigma^* = (a+b)^2 (a+b)^*$$

$$(\varepsilon+a+b)^2 = (\varepsilon+a+b)\cdot(\varepsilon+a+b)$$

$$\left.\begin{array}{lll}
\boxed{\varepsilon \quad \varepsilon} & = \varepsilon \\
\boxed{\varepsilon \quad a} & = a \\
\boxed{\varepsilon \quad b} & = b \\
\boxed{a \quad \varepsilon} & = a \\
\boxed{a \quad a} & = aa \\
\boxed{a \quad b} & = ab \\
\boxed{b \quad \varepsilon} & = b \\
\boxed{b \quad a} & = ba \\
\boxed{b \quad b} & = bb
\end{array}\right\} \leq 2\,\mathrm{len}$$

$$= \underbrace{\underbrace{(a+b)^2}_{=2} \cdot \underbrace{(a+b)^*}_{\geq 0}}_{\geq 2 \text{ length}}$$

must

$$= (a+b)^* (a+b)^2$$

$$= \underbrace{\underbrace{(a+b)}_{=1} \underbrace{(a+b)^*}_{\geq 0} \underbrace{(a+b)}_{=1}}_{\geq 2}$$

$= (a+b)^+ (a+b)$

$= (a+b) \cdot (a+b)^+$

$x x^* = x^+$

$x^* x = x^+$

Write Regular Expression

Exactly 2 a's

(21) $\{w \mid w \in \{a,b\}^*,\ n_a(w) = 2\}$

$$\boxed{b^* a\, b^* a\, b^*}$$

$\underbrace{\varepsilon + a}_{\text{at most 'a'}}$

(22) $\{w \mid w \in \{a,b\}^*,\ n_a(w) \le 2\}$

$0,\ 1,\ 2$

$$\boxed{b^* + b^* a b^* + b^* a b^* a b^*}$$

$$\boxed{b^* (\varepsilon + a)\, b^* (\varepsilon + a)\, b^*}$$

(23) $\{w \mid w \in \{a,b\}^*,\ n_a(w) \ge 2\}$

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

23

$$= \underbrace{\Sigma^* a \Sigma^* a \Sigma^*}_{\text{min 2a's}}$$

$$= b^* a b^* a \Sigma^*$$

$$= b^* a \Sigma^* a b^*$$

$$= \Sigma^* a b^* a b^*$$

$$= \Sigma^* a \Sigma^* a b^*$$

Infinite answers

b^* → without b

→ with b

ε →

b

bb

$\underbrace{b^+}_{}$

b must

$\underbrace{b^*}_{}$

b optimal

Write Regular Expression

(24) $\{w \mid w \in \{a,b\}^*,\ 2^{nd}$ symbol is 'a' $\}$

$\underbrace{1^{st}}_{\text{any symbol}}\ \underbrace{2^{nd}}_{\text{must } a}\ \underbrace{X}_{\text{any sequence}} = \underbrace{(a+b)}_{1^{st}\text{ position}}\ \underbrace{a}_{2^{nd}}\ \underbrace{(a+b)^*}\ = \Sigma a \Sigma^*$

$= (aa+ba)(a+b)^*$

$= [aa(a+b)^*] + [ba(a+b)^*]$

(25) $\{w \mid w \in \{a,b\}^*,\ 2^{nd}$ symbol from end is 'a' $\}$

any seq a last $= \Sigma^* a \Sigma$

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

2nd symbol is 'a'

a $\boxed{b}$ a

position?

$$\underbrace{(a+b)^{+}} \; \boxed{a} \; (a+b)^{*}$$

a

b

aa

ab

bb

bb

Write Regular Expression

(26) $\{w \mid w \in \{a,b\}^*,\ \underbrace{|w| \text{ is even}}_{\substack{|w| = 2n,\ n \geq 0 \\ |w| \text{ is div by } 2}}\}$

0, 2, 4, 6, 8, ... lengths

$$(\Sigma^2)^* = \left[(a+b)^2\right]^*$$

(27) $\{w \mid w \in \{a,b\}^*,\ |w| \text{ is odd}\}$

$$= \left[(a+b)^2\right]^*(a+b) \qquad = (a+b) \cdot \left[(a+b)^2\right]^*$$

(28) $\{w \mid w \in \{a,b\}^*,\ |w| \text{ is divisible by } 100\}$

$$= \left[(a+b)^{100}\right]^*$$

$$\left[(a+b)^2\right]^*$$

$$\hookrightarrow \varepsilon,\ (a+b)^2,\ (a+b)^4,\ \ldots$$

$|w|$ is div by 2

$$\boxed{|w| \% 2 = 0}$$

$$|w| = 0/2/4/6/8/\ldots$$

$$\left[(a+b)^{100}\right]^*$$

$\hookrightarrow \varepsilon$ ✓

$\hookrightarrow (a+b)^{100}$ ✓

$\hookrightarrow (a+b)^{200}$ ✓

$\vdots$

$|w|$ is div by 100

$$|w| \% 100 = 0$$

$$|w| = 0/100/200/300/400/\ldots$$

Odd = even + 1 In maths

$$\underbrace{\underbrace{\left[(a+b)^2\right]^*}_{\text{even length}} \cdot \underbrace{(a+b)}_{\text{one length}}}_{\text{odd length}}$$

Write Regular Expression

Homework

Write all equivalent answers

*** 29) $\{w \mid w \in \{a,b\}^*,\ n_a(w) = \text{even}\}$

$= b^*(b^*ab^*ab^*)^*b^*$

30) $\{w \mid w \in \{a,b\}^*,\ n_a(w) = \text{odd}\}$

$= b^*(b^*ab^*ab^*)^*b^*ab^*$

#a's = even

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

?

How do you generate $\underbrace{aabaa}_{\text{valid}}$?

ab^*aab^*a

?

Even a's over $\Sigma = \{a\}$

$(aa)^*$

bx

bbx

$\underbrace{(b^*ab^*ab^*)^*}$

It is not generating all strings

$b \longrightarrow$ even a's

Even a's over $\Sigma = \{a, b\}$

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

$= (b^*ab^*a\underline{b^*})^*\ b^*$

$= b^*(\underline{b^*}ab^*ab^*)^*$

$= b^*(ab^*ab^*)^*$

$= (b^*ab^*a)^*\ b^*$

$= (b^*ab^*ab^*)^* + b^*$

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

$$\varepsilon \qquad \underbrace{a\varepsilon a\boxed{b}aa}_{4\ a\text{'s}}$$

Practice Questions

$L = \{w \in \{a, b\}^* : \underbrace{\#_a(w) \leq 3}\}$.

A. $b^* \underline{(a \cup \varepsilon)}\, b^* \underline{(a \cup \varepsilon)}\, b^* \underline{(a \cup \varepsilon)}\, b^*$

B. $b^* (a)\, b^* (a \cup \varepsilon)\, b^* (a \cup \varepsilon)\, b^*$

C. $b^* (a)\, b^* (a)\, b^* (a \cup \varepsilon)\, b^*$

D. $b^* (a \cup \varepsilon)\, b^* (a)\, b^* (a)\, b^*$

$L = \{w \in \{a, b\}^* : \#_a(w) >= 3\}.$

A. $b^* (a \cup \varepsilon) b^* (a \cup \varepsilon) b^* (a \cup \varepsilon) b^*$

B. $(a \cup b)^* (a) b^* (a \cup \varepsilon) b^* (a \cup \varepsilon) b^*$

C. $b^* (a) b^* (a) b^* (a \cup \varepsilon) b^*$

D. $\underbrace{(a \cup b)^*}_{X}\ \underbrace{a}_{\text{must}}\ \underbrace{(a \cup b)^*}_{X}\ \underbrace{a}_{\text{must}}\ \underbrace{(a \cup b)^*}_{X}\ \underbrace{a}_{\text{must}}\ \underbrace{(a \cup b)^*}_{X}$

a a a

$L1 = a^*b^*$
$L2 = a^+b^+$

Find L2-L1.

A. a^*
B. b^*
C. $a^* + b^*$
D. None

$L1 = a^*+b^*$ and $L2 = a^*b^*$.

Which of the following is TRUE?

A. $L1 = L2$

B. $L1 \cup L2 = (a+b)^*$

C. $L1^* = L2^*$

D. None

L1 = a*+b* and L2 = a*b*.

Which of the following is TRUE?

A. L1 is subset of L2
B. L2 is subset of L1
C. L1 U L2 = L1
D. None

$L1 = a^+b^+$ and $L2 = a^*b^*$.

Which of the following is FALSE?

A. L1 is subset of L2

B. $L1^* = L2^*$

C. L1 U L2 = L2

D. None

$L1 = a^+ + b^+$ and $L2 = a^* + b^*$.

Which of the following is TRUE?

A. $L1 = L2$

B. $L1^+ = L2^+$

C. $L1 \cup L2 = L2$

D. None

$L1 = a^+$ and $L2 = a^*$

Which of the following is TRUE?

A. $L1+ = L2*$

B. $L1^+ = L2^+$

C. $L1* = L2^+$

D. None

$A = a^*$ and $B = b^*$

$AB = ?$

A. $\{ a^n b^n \mid n >= 0 \}$

B. $\{ a^m b^n \mid m, n >= 0 \}$

C. $(a+b)^*$

D. None

$A = aa^*$ and $B = bb^*$

$(A \cup B)^* = ?$

A. $\{ a^n b^n \mid n >= 0 \}$

B. $\{ a^m b^n \mid m, n >= 0 \}$

C. $(a+b)^*$

D. None

Given the language $L = \{ab, aa, baa\}$, which of the following strings are not in L^*?

1) abaabaaabaa
2) aaaabaaaa
3) baaaaabaaaab

A. 1 only
B. 2 only
C. 3 only
D. None

The length of the shortest string NOT in the language (over $\Sigma = \{a, b\}$) of the following regular expression is __________________.

$a^*(ba)^*a^*$

A. 1
B. 2
C. 3
D. 4

$L = a(a+b)^*$ is equivalent to ________

A. $(ab^*)^+$
B. $(a^+b^*)^+$
C. $a^*(ab^*)^+$
D. All of the above

$L = (a+b)^*b$ is equivalent to ________

A. $(ab^*)^+$

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

C. $b^*(ab^*)^*b$

D. None

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

A. $(a+b)^*$
B. $a(a+b)^*a$
C. $b(a+b)^*b$
D. None

$\{w \in \{a, b\}^* : \#_a(w) \equiv_3 0\}$.

A. $(b^*ab^*ab^*a)^*b^*$

B. $(b^*ab^*ab^*a)^*$

C. $(ab^*ab^*a)^*$

D. $(ab^*ab^*a)^*b^*$

$(a \cup b)^* (a \cup \varepsilon) b^* =$

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

B. $(a+b)^*$

C. $(aa+b)^*$

D. None

$L = \{w \in \{a, b\}^* \mid w$ has bba as a substring$\}$
Which of the following describes L ?

A. $(a \cup b)^*\, bba\, (a \cup b)^*$
B. $(a \cup b)^+\, bba\, (a \cup b)^*$
C. $(a \cup b)^+\, bba\, (a \cup b)^+$
D. $(a \cup b)^*\, bba\, (a \cup b)^+$

$L = \{w \in \{a, b\}^*\}$

1. $(a + b)^*$
2. $(a + b + \text{epsilon})^+$
3. $\text{Epsilon} + (a + b)^+$
4. $(a^*b^*)^*$
5. $(b^*a^*)^*$
6. $(a^+b^+)^*$

How many of above are equivalent to given L ?

A. 4 B. 5 C. 6 D. 3

GATE PYQs

Which Two of the following four regular expressions are equivalent?

(i) $(00)^*(\varepsilon + 0)$ (ii) $(00)^*$ (iii) 0^* (iv) $0\,(00)^*$

(a) (i) and (ii) (b) (ii) and (iii)

(c) (i) and (iii) (d) (iii) and (iv)

(GATE - 96)

If the regular set A is represented by $A = (01+1)^*$ and the regular set 'B' is represented by $B = ((01)^* 1^*)^*$, which of the following is true? **(GATE - 98)**

(a) $A \subset B$

(b) $B \subset A$

(c) A and B are incomparable

(d) $A = B$

The string 1101 does not belong to the set represented by **(GATE - 98)**

(a) $110^*(0+1)$

(b) $1(0+1)^*101$

(c) $(10)^*(01)^*(00+11)^*$

(d) $(00+(11)^*0)^*$

Let S and T be languages over $\Sigma = \{a, b\}$ represented by the regular expressions $(a + b^*)^*$ and $(a + b)^*$, respectively. Which of the following is true? **(GATE - 2000)**

(a) $S \subset T$

(b) $T \subset S$

(c) $S = T$

(d) $S \cap T = \phi$

Consider the set $\sum^*$ of all strings over the alphabet $\sum = \{0, 1\}$.
$\sum^*$ with the concatenation operator for strings **(GATE - 03)**

(a) Does not form a group

(b) Forms a non-commutative group

(c) Does not have a right identity element

(d) Forms a group if the empty string is removed from $\sum^*$

The regular expression $0^*(10^*)^*$ denotes the same set as **(GATE - 03)**

(a) $(1^*0)^*1^*$

(b) $0+(0+10)^*$

(c) $(0+1)^*10(0+1)^*$

(d) None of the above

Which one of the following languages over the alphabet $\{0, 1\}$ is described by the regular expression $(0+1)^*0(0+1)^*0(0+1)^*$ **(GATE - 09)**

(a) The set of all strings containing the substring 00

(b) The set of all strings containing at most two 0's

(c) The set of all strings containing at least two 0's

(d) The set of all strings that begin and end with either 0 or 1

Consider the languages $L_1 = \phi$ and $L_2 = \{a\}$. Which one of the following represents $L_1 L_2^* \cup L_1^*$? **(GATE - 13)**

(a) $\{\varepsilon\}$

(b) ϕ

(c) a^*

(d) $\{\varepsilon, a\}$

The length of the shortest string NOT in the language (over Σ = $\{a, b\}$) of the following regular expression is ________.

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

(GATE – 14-SET3)

Which one of the following regular expressions represents the language: the set of all binary strings having two consecutive 0's and two consecutive 1's? **(GATE – 16 – SET1)**

(a) $(0+1)^* 0011(0+1)^* + (0+1)^* 1100(0+1)^*$

(b) $(0+1)^* (00(0+1)^* 11 + 11(0+1)^* 00)(0+1)^*$

(c) $(0+1)^* 00(0+1)^* + (0+1)^* 11(0+1)^*$

(d) $00(0+1)^* 11 + 11(0+1)^* 00$

Let $r = 1(1+0)^*$, $s = 11^*0$ and $t = 1^*0$ be three regular expressions. Which one of the following is true? **(GATE - 91)**

(a) $L(s) \subseteq L(r)$ and $L(s) \subseteq L(t)$

(b) $L(r) \subseteq L(s)$ and $L(s) \subseteq L(t)$

(c) $L(s) \subseteq L(t)$ and $L(s) \subseteq L(r)$

(d) $L(t) \subseteq L(s)$ and $L(s) \subseteq L(r)$.

Which of the following regular expression identities are true?

(GATE - 92)

(a) $r(^*) = r^*$

(b) $(r^*s^*)^* = (r+s)^*$

(c) $(r+s)^* = r^* + s^*$

(d) $r^*s^* = r^* + s^*$

Which one of the following regular expressions represents the set of all binary strings with an odd number of $1's$?

A. $((0+1)^*1(0+1)^*1)^*10^*$
B. $(0^*10^*10^*)^*0^*1$
C. $10^*(0^*10^*10^*)^*$
D. $(0^*10^*10^*)^*10^*$

GATE 2020

Which one of the following regular expressions over $\{0, 1\}$ denotes the set of all strings **not** containing 100 as a substring?

(GATE - 97)

(a) $0^*(1^+0)^*$

(b) 0^*1010^*

(c) $0^*1^*01^*$

(d) $0^*(10+1)^*$

Model GATE Questions

- Identify correct regular expression for given Language.
- Find the expression that can generate given String.
- Find the string that can be generated by given expression.
- Find shortest length string generated by given expression.
- Identify the equivalent expression for given expression.
- Identify equivalent expressions from given expressions.
- Find number of equivalence classes for the language generated by given expression.
- Find the language generated by expression is finite or infinite.

Summary

Reg Exp ⇒ ✓

next FA

→ 80 to 100 problems

→ Reg Exp ✓

→ FA ✓


THANK YOU GW
SOLDIERS !