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List of Examples of Minimal DFAs.

Contents

1	Very Basic examples	4
1.1	At least one a and at least one b .	4
1.2	String length is even.	4
1.3	String length is even different alphabet	4
1.4	String length is odd.	4
1.5	String length divisible by 3	5
1.6	Number of a 's in w is divisible by 3	5
1.7	String length NOT divisible by 3	5
1.8	Number of a 's in w NOT divisible by 3	5
1.9	n^{th} symbol from left is a	6
1.10	w contains At least n a 's.	6
1.10.1	w contains At least 1 a .	6
1.10.2	w contains At least 3 a 's.	6
1.11	w contains exactly n a 's.	7
1.11.1	w contains exactly 1 a .	7
1.11.2	w contains exactly 3 a 's.	7
1.12	w contains At most n a 's.	7
1.12.1	w contains At most 1 a .	7
1.12.2	w contains At most 3 a 's.	7
1.13	$\Sigma^*, \phi, \Sigma^+, \{\epsilon\}$	8
2	w starting with:	9
2.1	w starting with a	9
2.2	w starting with ab	9
2.3	w starting with aba	9
3	w contains substring:	10
3.1	w contains substring a	10
3.2	w contains substring ab	10
3.3	w contains substring $abaa$	10
3.4	w contains substring $aabb$	10
3.5	w contains substring $baba$	11
3.6	w contains substring $bbbb$	11

4	w ends with:	12
4.1	w ends with a	12
4.2	w ends with ab	12
4.3	w ends with $abaa$	12
4.4	w ends with $aabb$	12
4.5	w ends with $baba$	13
4.6	w ends with $bbbb$	13
5	n^{th} symbol from right is a	14
5.1	2^{nd} symbol from right is a	14
5.1.1	2^{nd} symbol from right is a , alphabet contains 2 symbols	14
5.1.2	2^{nd} symbol from right is a , alphabet contains 3 symbols	14
5.2	3^{rd} symbol from right is a	14
5.2.1	3^{rd} symbol from right is a , alphabet contains 2 symbols	14
5.2.2	3^{rd} symbol from right is a , alphabet contains 3 symbols	15
6	For same symbol, divisible by m, AND / NOT / OR divisible by n	16
6.1	n is multiple of m	16
6.1.1	w_a divisible by 2 OR divisible by 4.	16
6.1.2	w_a divisible by 2 AND divisible by 4.	16
6.1.3	w_a divisible by 2 but not divisible by 4.	16
6.1.4	w_a divisible by 4 but not divisible by 2.	16
6.2	n is NOT multiple of m	17
6.2.1	w_a is divisible by 4 OR divisible by 6.	17
6.2.2	w_a is divisible by 4 AND divisible by 6.	17
6.2.3	w_a is divisible by 4 but not divisible by 6.	17
6.2.4	w_a is divisible by 6 but not divisible by 4.	18
6.3	Some more variations and examples.	18
6.3.1	w_a divisible by 2, but not divisible by 6.	18
6.3.2	w_a is divisible by 2 OR 3, but not divisible by 6.	19
7	Divisible by conditions for different symbols	20
7.1	w_a is divisible by 2 and w_b is divisible by 2.	20
7.2	w_a is divisible by 2 OR w_b is divisible by 2.	20
7.3	w_a is divisible by 2 and w_b is NOT divisible by 2.	20
7.4	w_a is divisible by 2 and w_b is divisible by 3.	21
7.5	w_a is divisible by 2 OR w_b is divisible by 3.	21
7.6	w_a is divisible by 2 and w_b is NOT divisible by 3.	22
7.7	w_a is divisible by 4 and w_b is divisible by 3.	23
7.8	$w_a \bmod 4 \leq w_b \bmod 3$.	23
8	Miscellaneous Examples:	24
8.1	w starts and ends with different symbols.	24
8.2	w starts and ends with same symbol.	24
9	At least, At most, Exactly condition on different symbols.	25
9.1	Exactly 1 a and exactly 1 b	25
9.2	Exactly 3 a 's and exactly 2 b 's	25
9.3	At most 1 a and at most 1 b	25
9.4	At most 3 a 's and at most 2 b 's	26
9.5	At least 1 a and at least 1 b	26
9.6	At least 3 a 's and at least 2 b 's	27
9.7	Exactly 3 a 's and at most 2 b 's	27
9.8	At most 3 a 's and at least 2 b 's	27

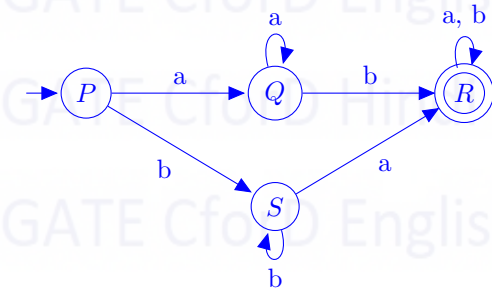
9.9 At least 3 *a*'s and exactly 2 *b*'s 28

1 Very Basic examples

1.1 At least one a and at least one b .

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at least one } a \text{ and contains at least one } b\}$$



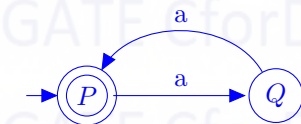
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1.2 String length is even.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid |w| \text{ is even.}\}$$



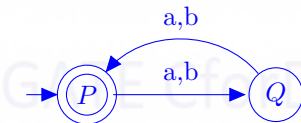
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1.3 String length is even different alphabet

$$\Sigma = \{a, b\} \quad \text{Here Alphabet contains 2 symbols.}$$

$$L = \{w \mid |w| \text{ is even.}\}$$



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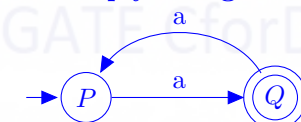
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1.4 String length is odd.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid |w| \text{ is odd.}\}$$

We simply change final state for 1.2.



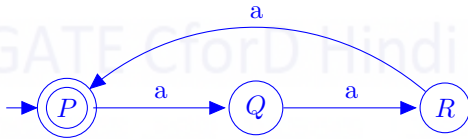
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1.5 String length divisible by 3

$$\Sigma = \{a\}$$

$$L = \{w \mid |w| \text{ is divisible by } 3.\}$$



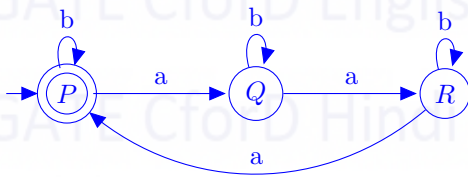
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1.6 Number of a's in w is divisible by 3

$$\Sigma = \{a, b\}$$

$$L = \{w \mid \#_a(w) \text{ is divisible by } 3.\} \quad \#_a(w) \text{ is number of } a\text{'s in } w.$$



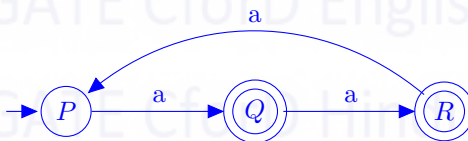
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1.7 String length NOT divisible by 3

$$\Sigma = \{a\}$$

$$L = \{w \mid |w| \text{ is NOT divisible by } 3.\}$$



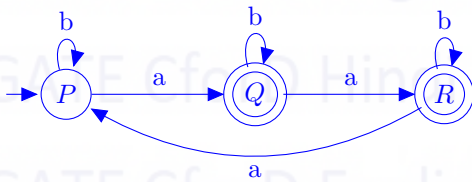
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1.8 Number of a's in w NOT divisible by 3

$$\Sigma = \{a, b\}$$

$$L = \{w \mid \#_a(w) \text{ is NOT divisible by } 3.\} \quad \#_a(w) \text{ is number of } a\text{'s in } w.$$



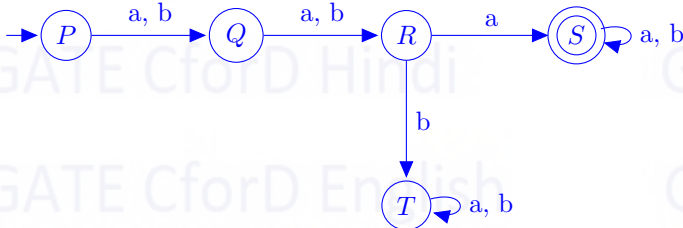
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1.9 n^{th} symbol from left is a

$$\Sigma = \{a, b\}$$

$$L = \{w \mid 3^{rd} \text{ symbol from left in } w \text{ is } a.\}$$



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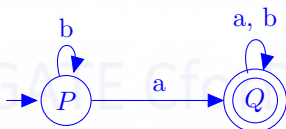
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1.10 w contains At least n a 's.

1.10.1 w contains At least 1 a .

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at least 1 } a.\}$$



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1.10.2 w contains At least 3 a 's.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at least 3 } a\text{'s.}\}$$



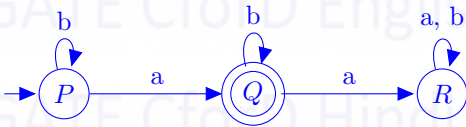
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1.11 w contains exactly n a 's.**1.11.1 w contains exactly 1 a .**

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains exactly 1 } a.\}$$



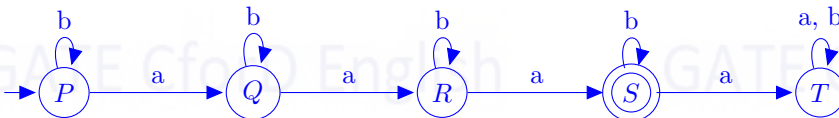
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1.11.2 w contains exactly 3 a 's.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains exactly 3 } a\text{'s.}\}$$



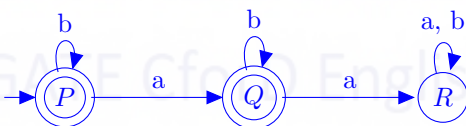
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1.12 w contains At most n a 's.**1.12.1 w contains At most 1 a .**

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at most 1 } a.\}$$



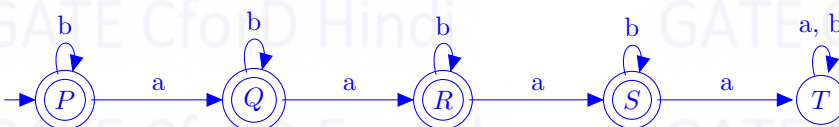
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1.12.2 w contains At most 3 a 's.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at most 3 } a\text{'s.}\}$$



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1.13 Σ^* , ϕ , Σ^+ , $\{\epsilon\}$

$$\Sigma = \{a, b\}$$

$$L = \Sigma^*.$$



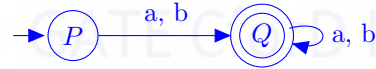
$$L = \phi.$$



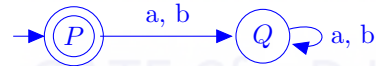
Final States: $\{\}$,

No final state in DFA.

$$L = \Sigma^+.$$



$$L = \{\epsilon\}.$$



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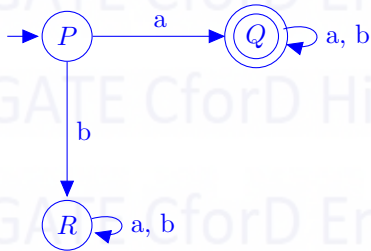
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2 w starting with:

2.1 w starting with a

$$\Sigma = \{a, b\}$$

$$L = \{w \mid |w| \text{ starts with } a.\}$$



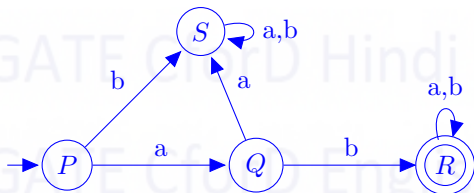
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2.2 w starting with ab

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ starts with } ab\}$$



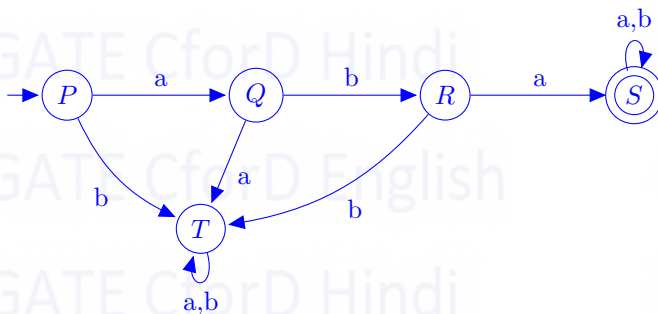
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2.3 w starting with aba

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ starts with } aba\}$$



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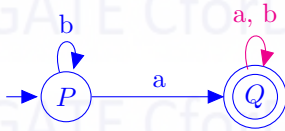
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3 w contains substring:

3.1 w contains substring a

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } a\}$$



For DFA of “ w contains substring”, final state has self-loop for all the symbols.

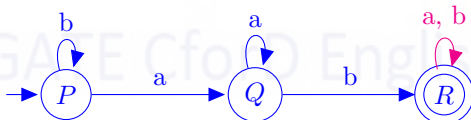
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3.2 w contains substring ab

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } ab\}$$



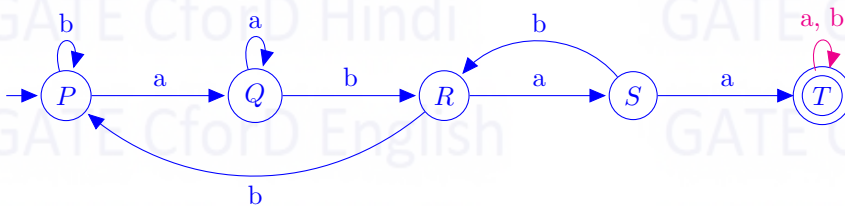
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3.3 w contains substring $abaa$

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } abaa\}$$



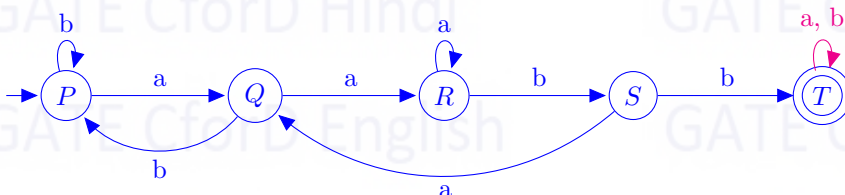
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3.4 w contains substring $aabb$

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } aabb\}$$



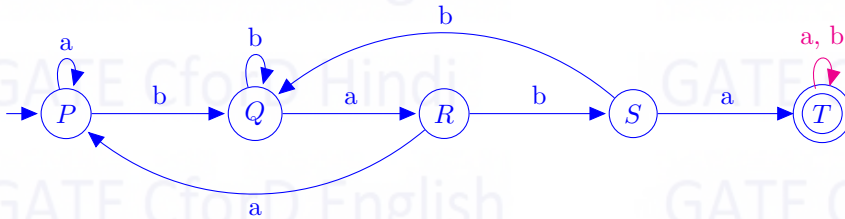
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3.5 w contains substring *baba*

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } baba\}$$



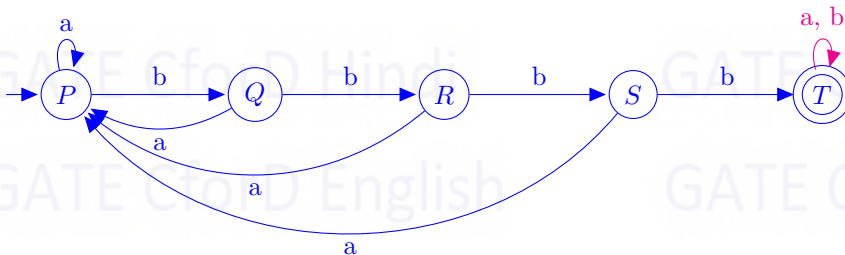
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3.6 w contains substring *bbbb*

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains substring } bbbb\}$$



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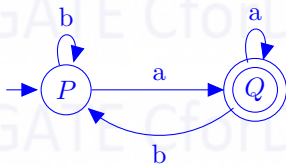
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4 w ends with:

4.1 w ends with a

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ ends with } a\}$$



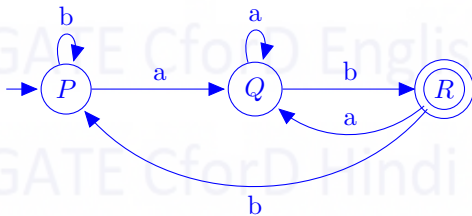
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4.2 w ends with ab

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ ends with } ab\}$$



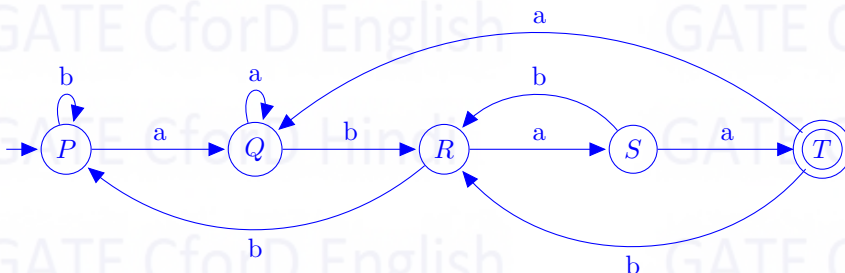
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4.3 w ends with $abaa$

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ ends with } abaa\}$$



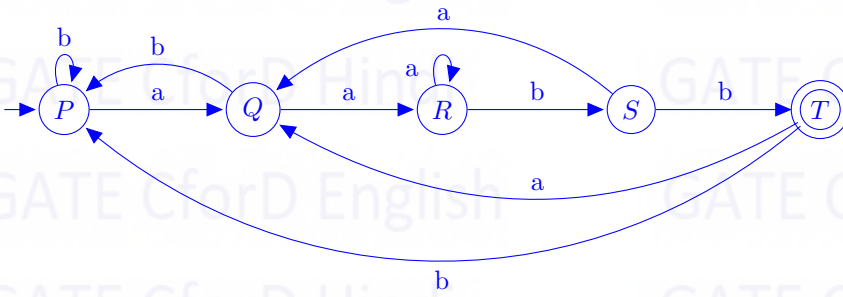
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4.4 w ends with $aabb$

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ ends with } aabb\}$$



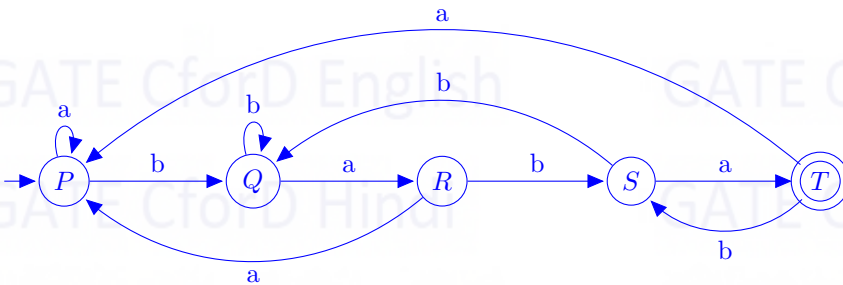
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4.5 w ends with *baba*

$\Sigma = \{a, b\}$

$L = \{w \mid w \text{ ends with } baba\}$



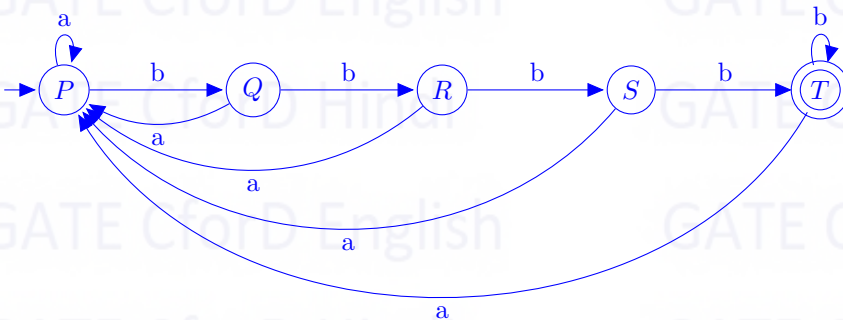
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4.6 w ends with *bbbb*

$\Sigma = \{a, b\}$

$L = \{w \mid w \text{ ends with } bbbb\}$



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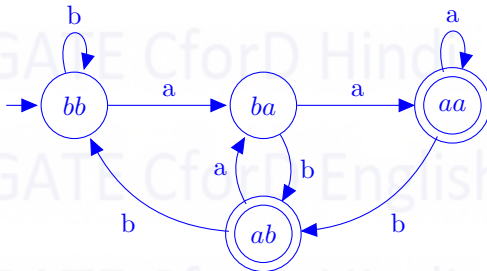
5 n^{th} symbol from right is a

5.1 2^{nd} symbol from right is a

5.1.1 2^{nd} symbol from right is a , alphabet contains 2 symbols

$$\Sigma = \{a, b\}$$

$$L = \{w \mid \text{Second symbol from right in } w \text{ is } a\}$$



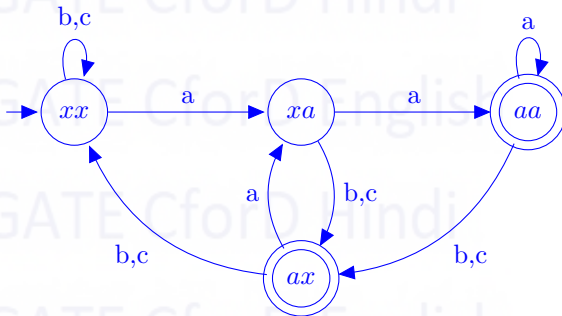
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5.1.2 2^{nd} symbol from right is a , alphabet contains 3 symbols

$$\Sigma = \{a, b, c\}$$

$$L = \{w \mid \text{Second symbol from right in } w \text{ is } a\}$$



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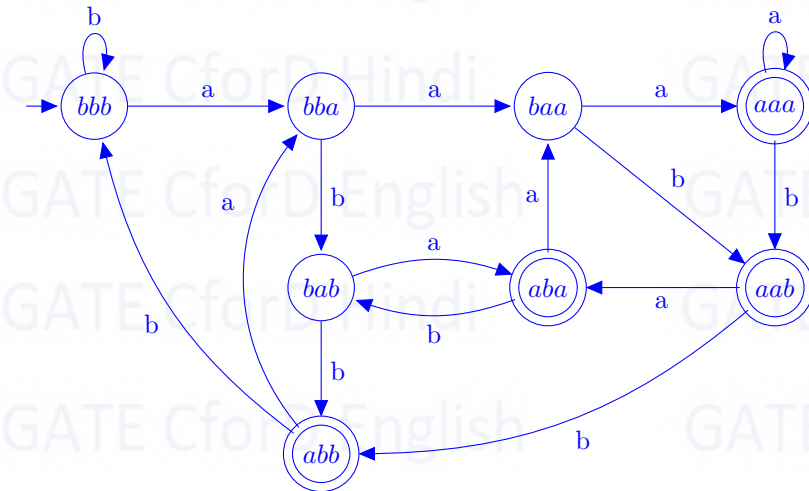
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5.2 3^{rd} symbol from right is a

5.2.1 3^{rd} symbol from right is a , alphabet contains 2 symbols

$$\Sigma = \{a, b\}$$

$$L = \{w \mid \text{Third symbol from right in } w \text{ is } a\}$$



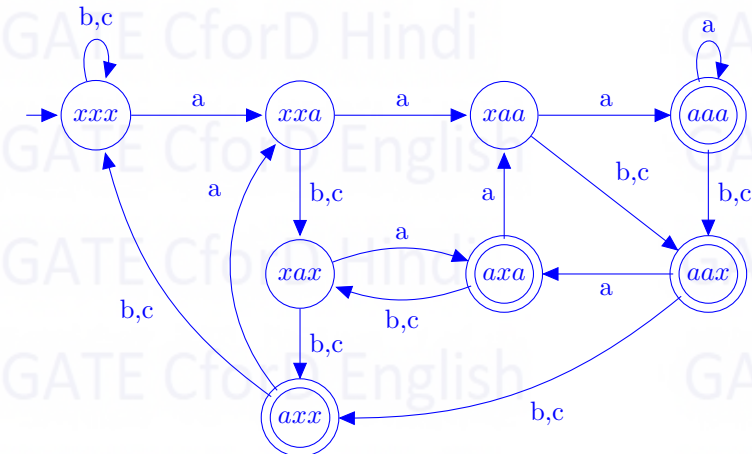
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5.2.2 3rd symbol from right is a , alphabet contains 3 symbols

$$\Sigma = \{a, b, c\}$$

$$L = \{w \mid \text{Third symbol from right in } w \text{ is } a\}$$



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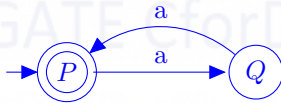
6 For same symbol, divisible by m , AND / NOT / OR divisible by n

6.1 n is multiple of m

6.1.1 w_a divisible by 2 OR divisible by 4.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 OR divisible by 4.}\}$$



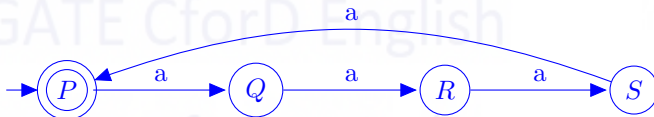
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6.1.2 w_a divisible by 2 AND divisible by 4.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 AND divisible by 4.}\}$$



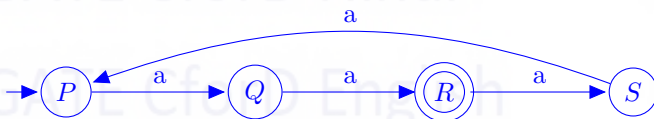
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6.1.3 w_a divisible by 2 but not divisible by 4.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 but not divisible by 4.}\}$$



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6.1.4 w_a divisible by 4 but not divisible by 2.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 4 but not divisible by 2.}\}$$



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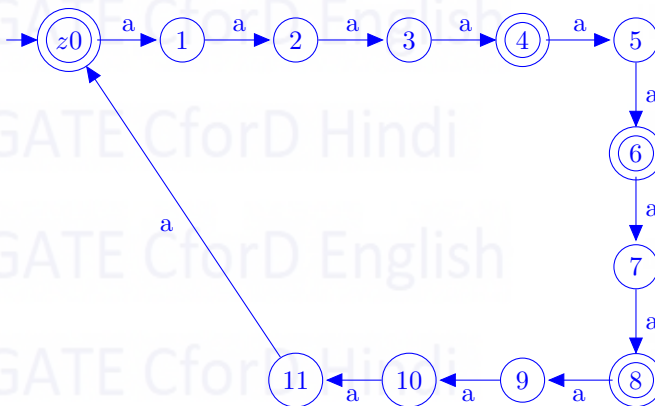
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6.2 n is NOT multiple of m

6.2.1 w_a is divisible by 4 OR divisible by 6.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 4 OR divisible by 6.}\}$$



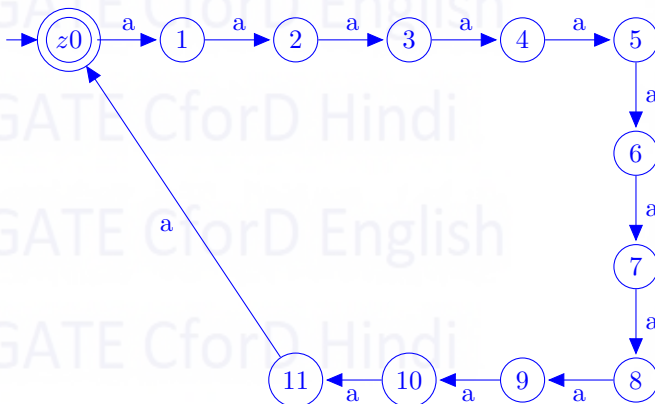
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6.2.2 w_a is divisible by 4 AND divisible by 6.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 4 AND divisible by 6.}\}$$



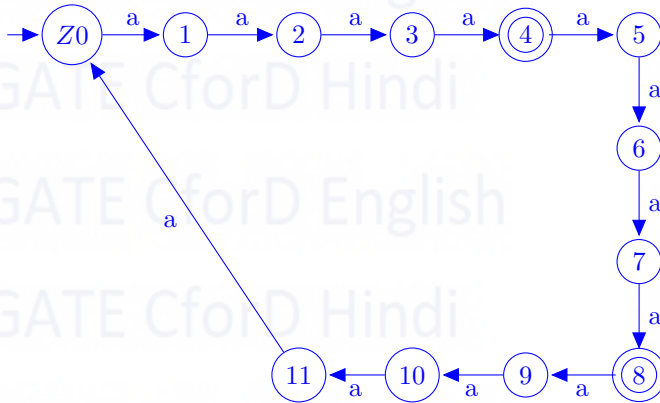
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6.2.3 w_a is divisible by 4 but not divisible by 6.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 4 but not divisible by 6.}\}$$



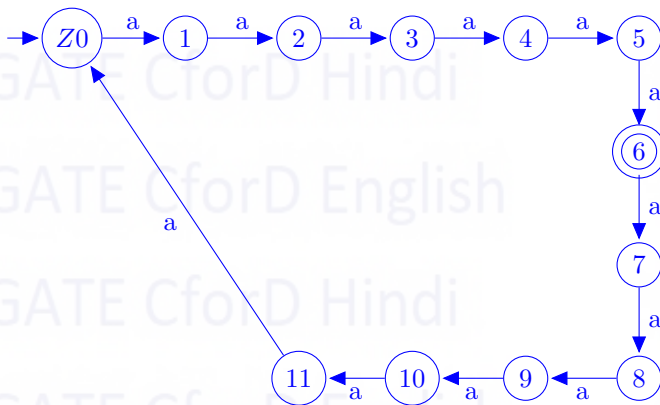
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6.2.4 w_a is divisible by 6 but not divisible by 4.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 6 but not divisible by 4.}\}$$



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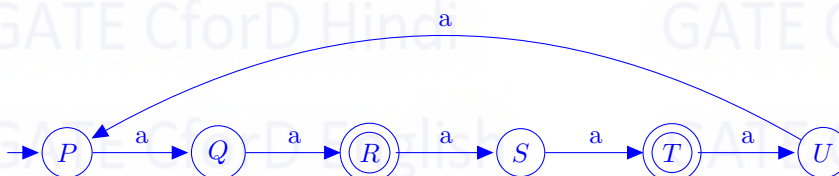
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6.3 Some more variations and examples.

6.3.1 w_a divisible by 2, but not divisible by 6.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 but not divisible by 6.}\}$$



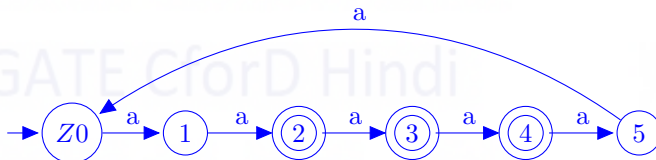
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6.3.2 w_a is divisible by 2 OR 3, but not divisible by 6.

$$\Sigma = \{a\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 or 3 but not divisible by 6.}\}$$



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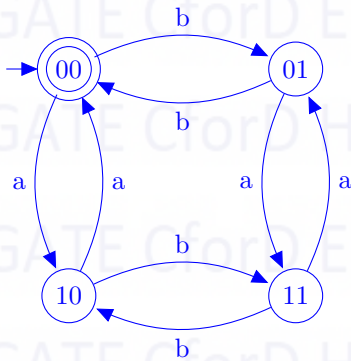
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7 Divisible by conditions for different symbols

7.1 w_a is divisible by 2 and w_b is divisible by 2.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 and } w_b \text{ is divisible by 2}\}$$



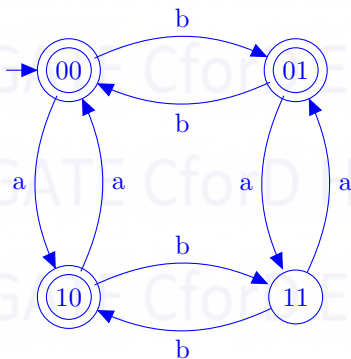
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7.2 w_a is divisible by 2 OR w_b is divisible by 2.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 OR } w_b \text{ is divisible by 2}\}$$



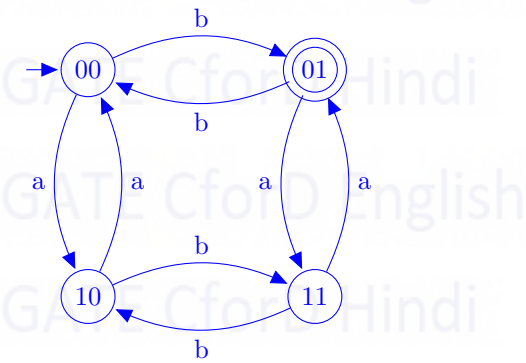
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7.3 w_a is divisible by 2 and w_b is NOT divisible by 2.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 and } w_b \text{ is NOT divisible by 2}\}$$



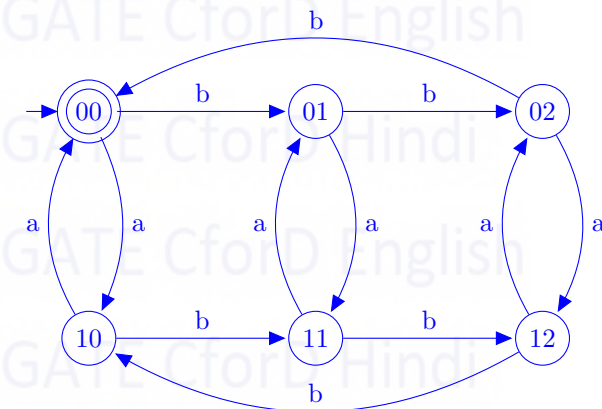
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7.4 w_a is divisible by 2 and w_b is divisible by 3.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid (w)_a \text{ is divisible by 2 and } (w)_b \text{ is divisible by 3}\}$$



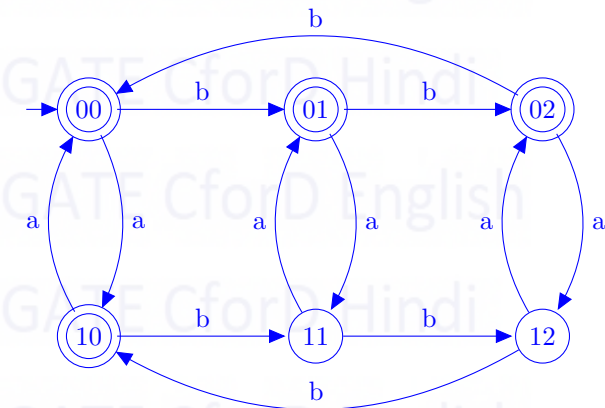
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7.5 w_a is divisible by 2 OR w_b is divisible by 3.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 OR } w_b \text{ is divisible by 3}\}$$



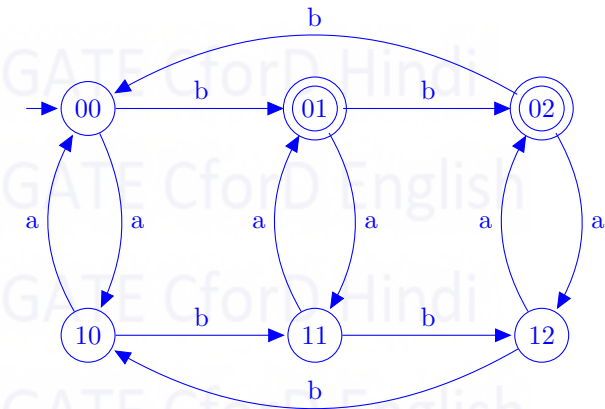
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7.6 w_a is divisible by 2 and w_b is NOT divisible by 3.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w_a \text{ is divisible by 2 and } w_b \text{ is Not divisible by 3}\}$$

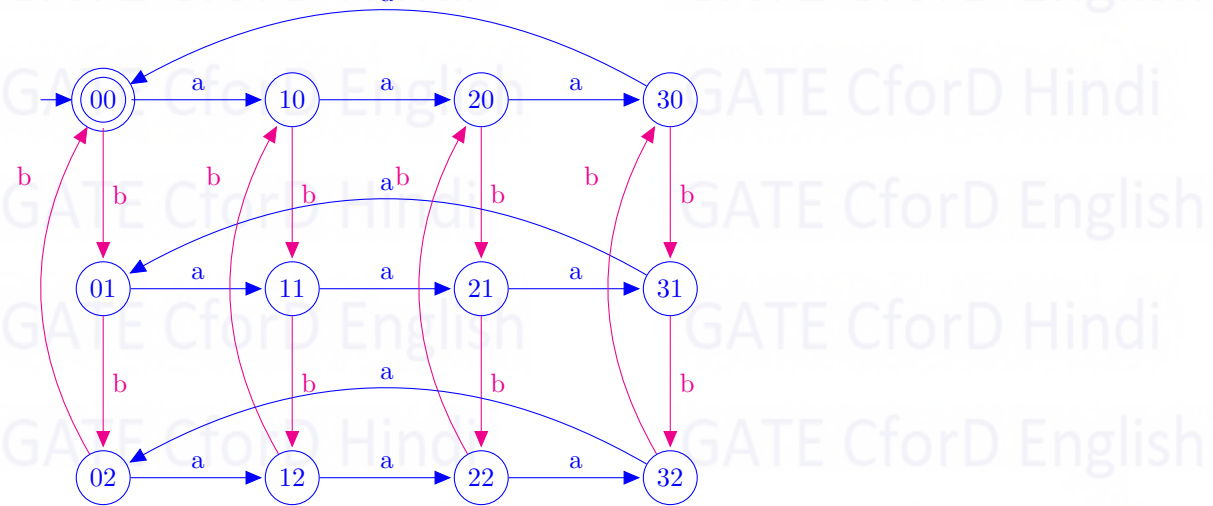


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7.7 w_a is divisible by 4 and w_b is divisible by 3.

$\Sigma = \{a, b\}$ $L = \{w \mid w_a \text{ is divisible by 4 and } w_b \text{ is divisible by 3}\}$

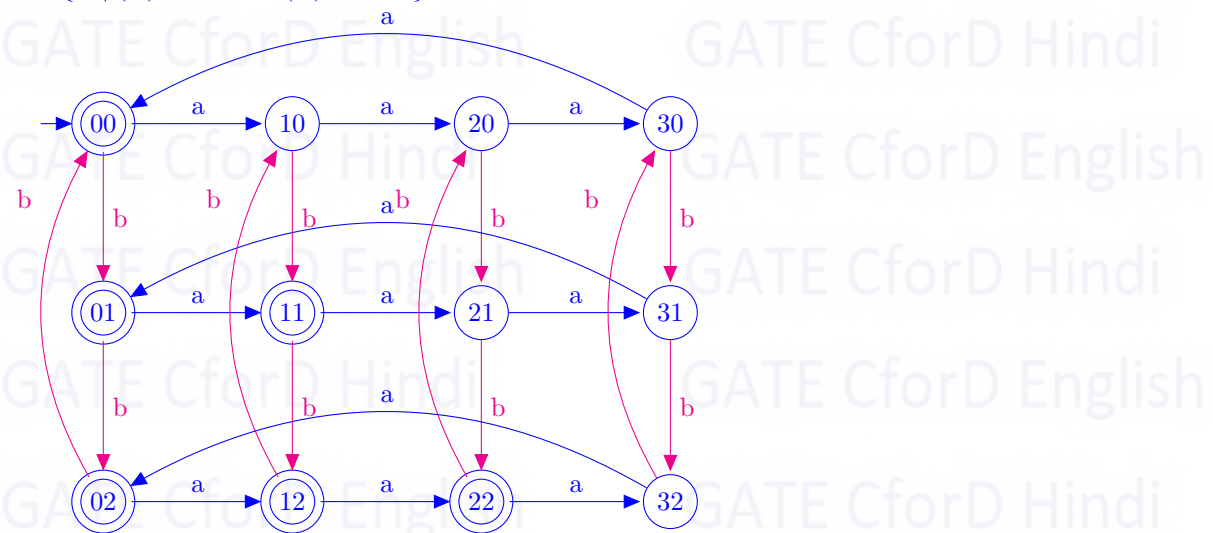


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7.8 $w_a \bmod 4 \leq w_b \bmod 3$.

$L = \{w \mid (w)_a \bmod 4 \leq (w)_b \bmod 3\}$



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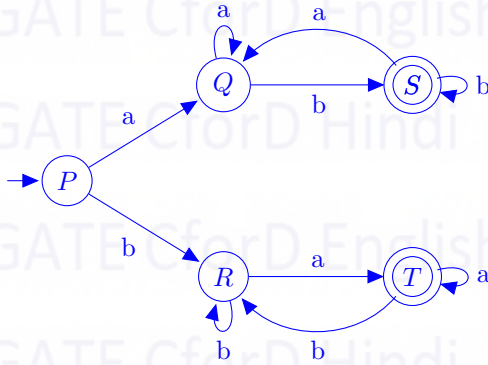
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8 Miscellaneous Examples:

8.1 w starts and ends with different symbols.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ starts and ends with different symbols.}\}$$



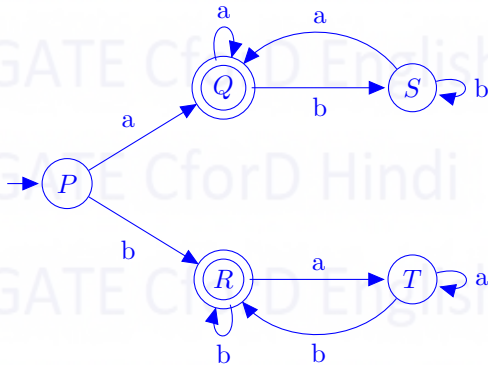
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8.2 w starts and ends with same symbol.

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ starts and ends with same symbol.}\}$$



Note: $\epsilon \notin L$, $a \in L$, $b \in L$.
 ϵ starts with ϵ and ends with ϵ , but ϵ is not a symbol.

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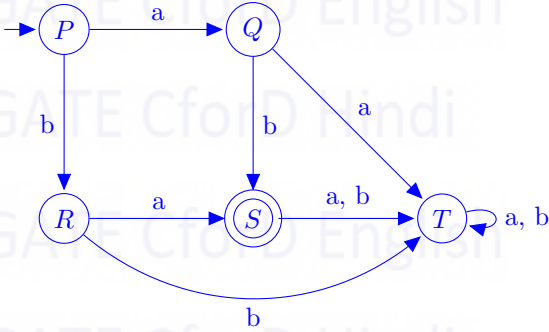
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9 At least, At most, Exactly condition on different symbols.

9.1 Exactly 1 a and exactly 1 b

$$\Sigma = \{a, b\}$$

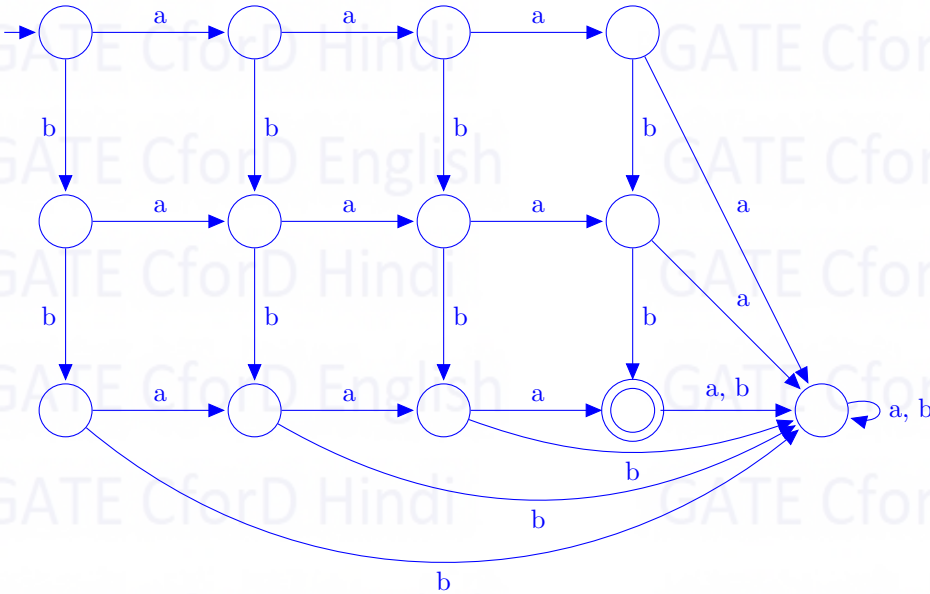
$$L = \{w \mid w \text{ contains exactly 1 } a \text{ and exactly 1 } b.\}$$



9.2 Exactly 3 a 's and exactly 2 b 's

$$\Sigma = \{a, b\}$$

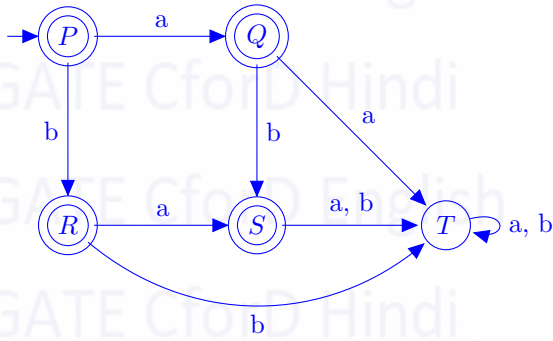
$$L = \{w \mid w \text{ contains exactly 3 } a\text{'s and exactly 2 } b\text{'s.}\}$$



9.3 At most 1 a and at most 1 b

$$\Sigma = \{a, b\}$$

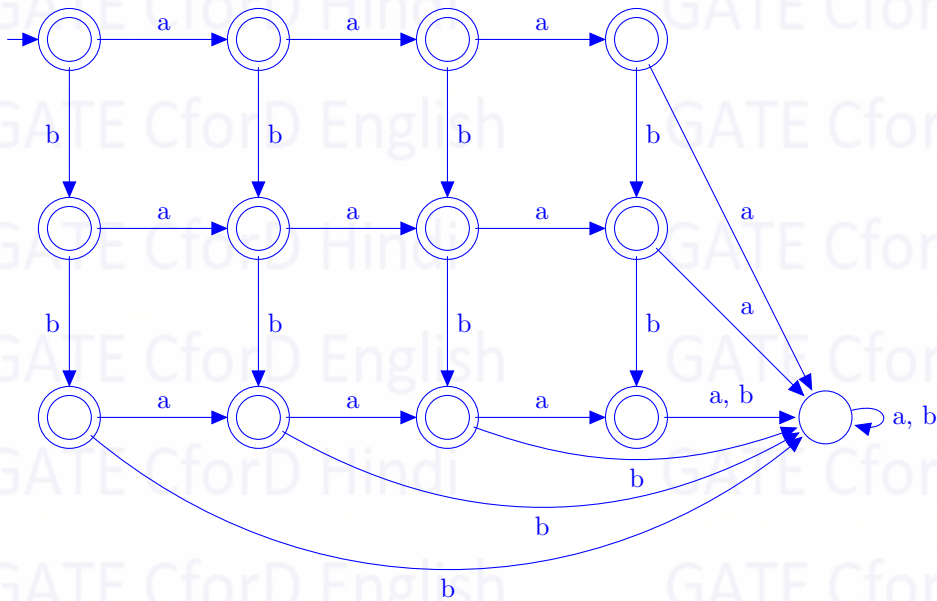
$$L = \{w \mid w \text{ contains at most 1 } a \text{ and at most 1 } b.\}$$



9.4 At most 3 a's and at most 2 b's

$$\Sigma = \{a, b\}$$

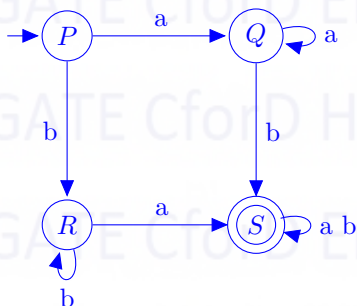
$$L = \{w \mid w \text{ contains at most 3 } a\text{'s and at most 2 } b\text{'s.}\}$$



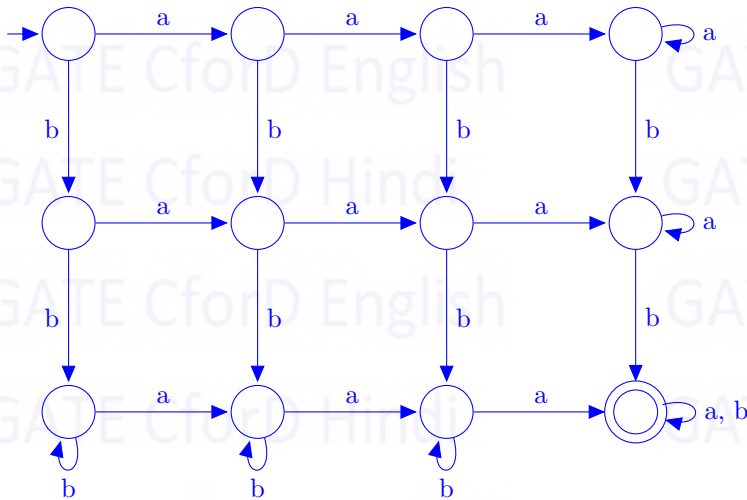
9.5 At least 1 a and at least 1 b

$$\Sigma = \{a, b\}$$

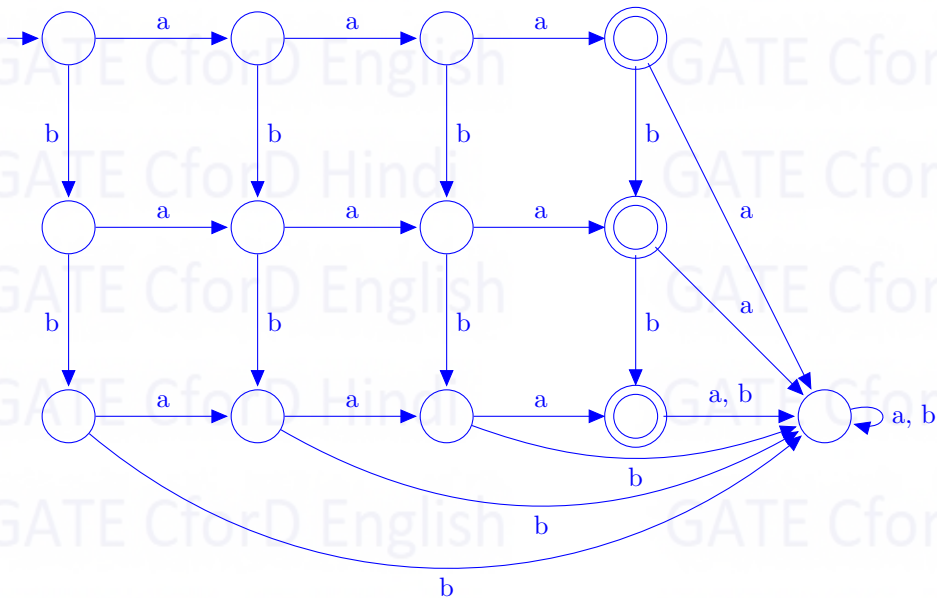
$$L = \{w \mid w \text{ contains at least 1 } a \text{ and at least 1 } b.\}$$



9.6 At least 3 a 's and at least 2 b 's

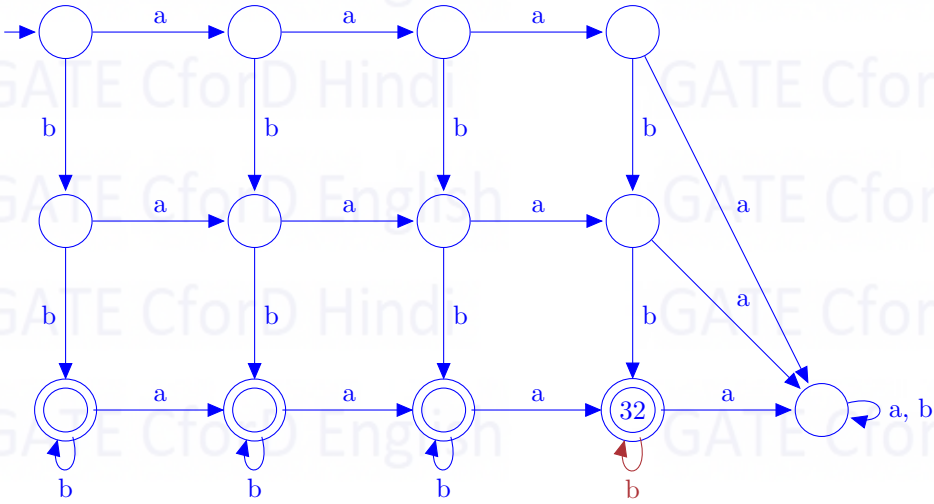
 $\Sigma = \{a, b\}$
 $L = \{w \mid w \text{ contains at least 3 } a\text{'s and at least 2 } b\text{'s.}\}$


9.7 Exactly 3 a 's and at most 2 b 's

 $\Sigma = \{a, b\}$
 $L = \{w \mid w \text{ contains exactly 3 } a\text{'s and at most 2 } b\text{'s.}\}$


9.8 At most 3 a 's and at least 2 b 's

 $\Sigma = \{a, b\}$
 $L = \{w \mid w \text{ contains At most 3 } a\text{'s and at least 2 } b\text{'s.}\}$

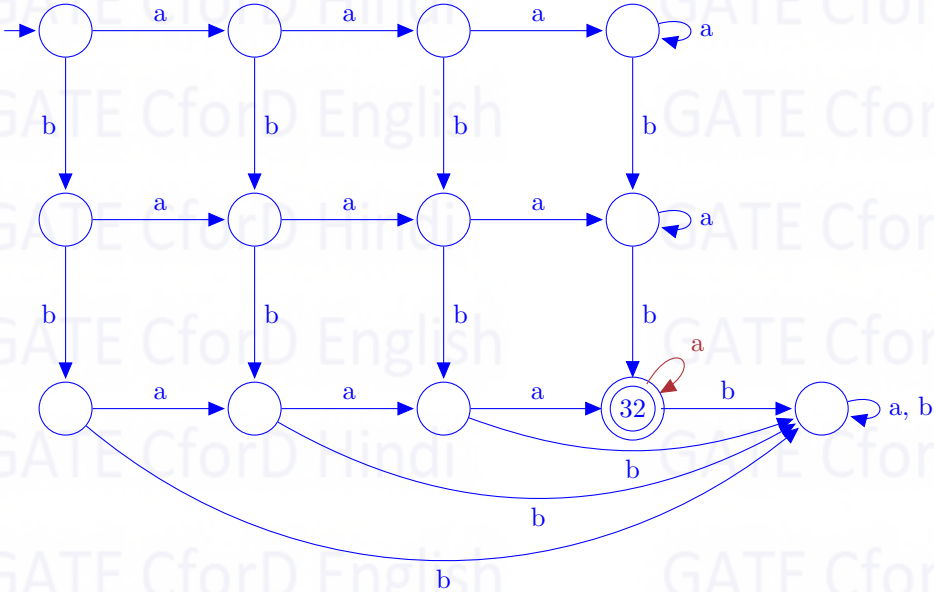


Note: For state (32), self loop for b , and transition to trap state on a .
By mistake for $\delta(32, b)$, do not transition to trap state.

9.9 At least 3 a 's and exactly 2 b 's

$$\Sigma = \{a, b\}$$

$$L = \{w \mid w \text{ contains at least 3 } a\text{'s and exactly 2 } b\text{'s.}\}$$



Note: For state (32), self loop for a , and transition to trap state on b .
By mistake for $\delta(32, b)$, do not add transition to trap state.