{ Theory Of Computation }

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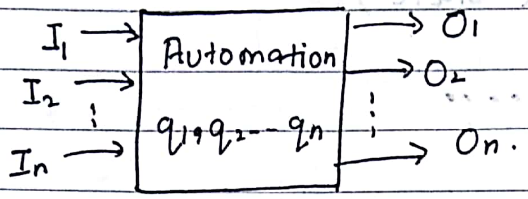
→ (TOC)...

- [illegible] system in which energy, material & information are transformed, transmitted & used for performing some function without participation of man.



$\Sigma \to$ finite & Non empty set of symbols.

- Basic Concept :- ① alphabet – {0,1}.
  {A, B, ----, Z, a, b, ---, z}.

  ② String – {0,1}
  {0, 11, 1, 00}.

imp →
**

$\Sigma^+ = \cup_i = {}^{\infty}_{1} \Sigma^i$.

$= \cup_{i=0..\infty} \Sigma^i - \Sigma^0$.

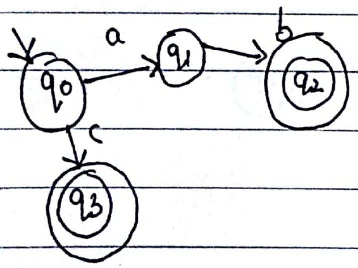
$= \cup_{i=0..\infty} \Sigma^i - \{\varepsilon\}$.

- DFA :- five tuple. (Determinate state finite automata).

$M = \{Q, \Sigma, \delta, q_0, F\}$.

Q = set of states.
Σ = set of input alphabets.
δ = transition function.
q_0 = initial state.
F = set of final states.

$\delta : (Q \times \Sigma) \to Q$.



$\delta(q_0, a) = q_1$.
$\delta(q_0, c) = q_3$.

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(TASK → create NFA & DFA).

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→ DFA ⇒ if $\delta : (Q \times \Sigma) \rightarrow Q$. } (only single O/P).

→ NFA ⇒ if ($\delta : (Q \times \Sigma) \rightarrow 2^Q$. } (Power set).

(Non-Determinant Finite state).

....PROPERTIES....

1. $|\lambda| = 0$.
2. $\lambda w = w\lambda$.
3. $|a| = 1$.
4. $|wa| = |w| + 1$.
5. $a^R = a$.
6. $(wa)^R = a \cdot w^R$.
7. $\delta(q, \lambda) = q$.
   State can be changed only by an I/P symbol.
8. $(wa)^R = a w^R$.
9. $\delta(q, aw) = \delta(\delta(q, a), w)$.
10. $\delta(q, wa) = \delta(\delta(q, w), a)$.

I/P. → (110101) → data is acceptable as initial state = final state.

S	0	1
q_0	q_2	q_1
q_1	q_3	q_0
q_2	q_0	q_0
q_3	q_1	q_0

$\delta(q_0, 11010, 1)$.

$\delta(q_1, 10101)$.

$\delta(q_0, 0101)$.

$\delta(q_2, 101)$.

$\delta(q_0, 01)$.

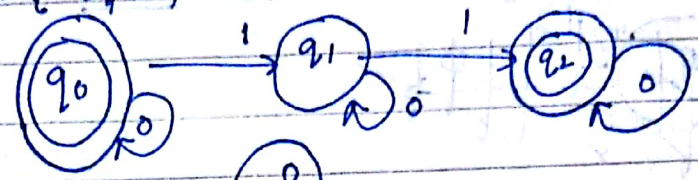
$\delta(q_2, 1)$.

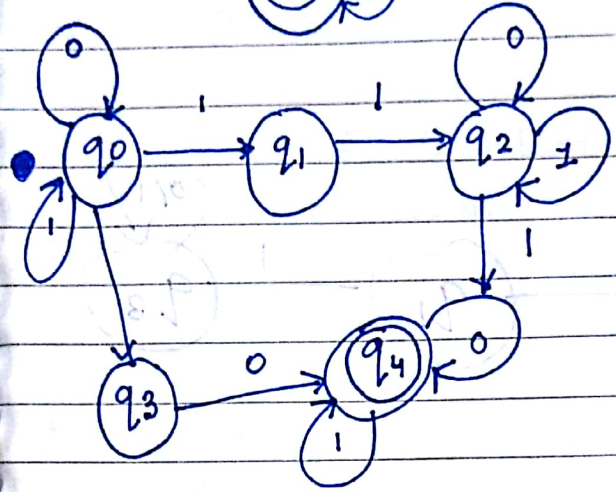
$\delta(q_0)$.

10/01/18 ToC

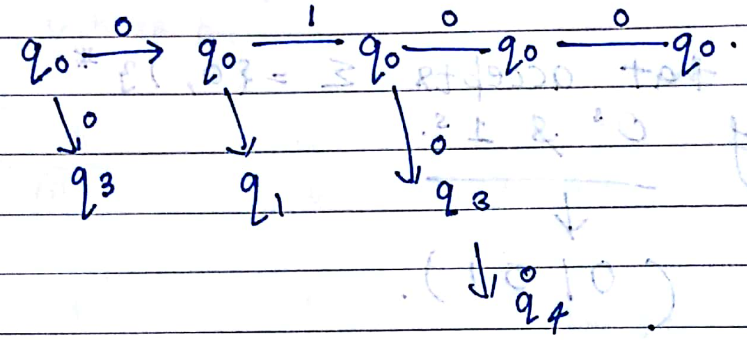
→ Design a DFA that accepts all strings of $\Sigma = \{0, 1\}$ with even no. of one's.

→ String = {0, 11, 0.0, 1111}.

⇒ 



→ (N.F.A).



$\delta(q_0, 0100) = \{q_0, q_3, q_4\}$.

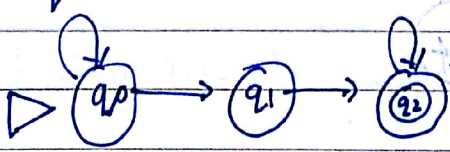
NFA :-

→ $Q \times (\Sigma \cup \lambda) \rightarrow 2^Q$ is the transition function.

→ Back track is allowed.

→ double move allowed.

q (lambda-closure); — without giving any input to move to nex state.



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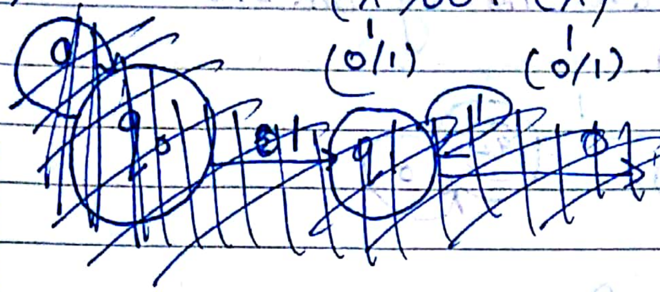
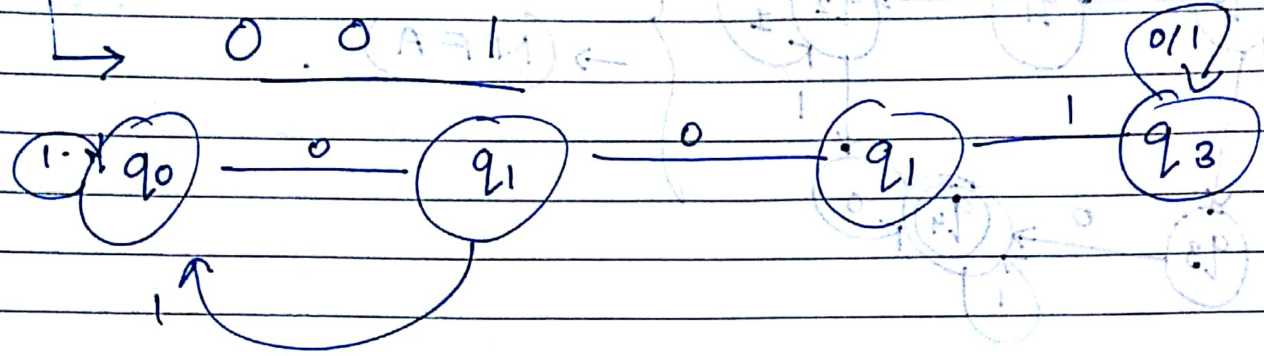
Design a DFA that accepts all string of $\Sigma = \{0, 1\}^*$ with 001 as substring.

⇒ $(\lambda)^* 001 (\lambda)^*$

$(0/1)$ $(0/1)$ → (10001001)



↳ 0 0 1

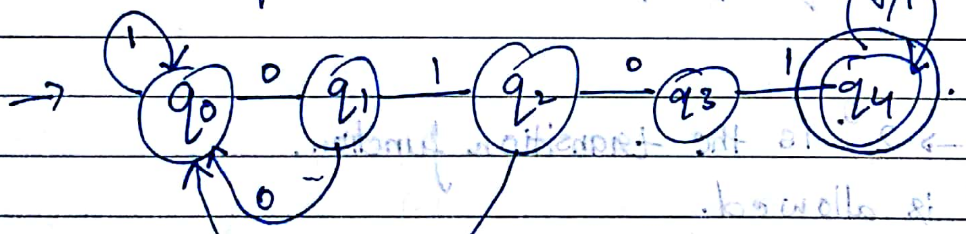


Design a DFA that accepts $\Sigma = \{0, 1\}^*$ even no. of 0^s & 1^s.

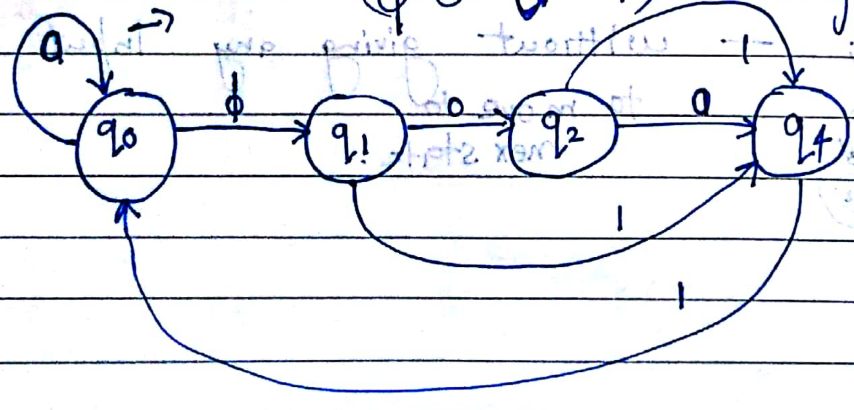
↓

(0101).

⇒



$(\phi\ 0\ 0\ 1)$ – string.



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Let $M = \{Q, \Sigma, \delta, q_0, F\}$.
be a NFA accepting L.
We construct $M' = \{Q', \Sigma, \delta', q_0', F'\}$.
where,

$Q' = 2^Q$

$q_0' = [q_0]$.

F' is set of all subset of Q containing F.

$\delta'([q_1, q_2 ----- q_i], a) = \delta(q_1, a) \cup \delta(q_2, a) -----$
$\cup \delta(q_i, a)$.

Construct a DFA equivalent to;
$M = \{\{q_0, q_1\}, \{0, 1\}, \delta, q_0, \{q_0\}\}$.
where δ ;

δ	0	1
$\rightarrow q_0$	q_0	q_1
q_1	q_1	q_0, q_1

$Q' = q^0$
q^1
ϕ
$q_0 q_1$

$q_0' = q_0$

$F' = q_0, q_0q_1$

δ	0	1
q_0	q_0	q_1
q_1	q_1	q_0q_1
q_0q_1	q_0q_1	q_0q_1
ϕ	ϕ	ϕ

$\delta((q_0, q_1), 0) = \delta(q_0, 0) \cup \delta(q_1, 0)$
$= q_0 \cup q_1$
$= q_0 \cdot q_1$

P.T.O.

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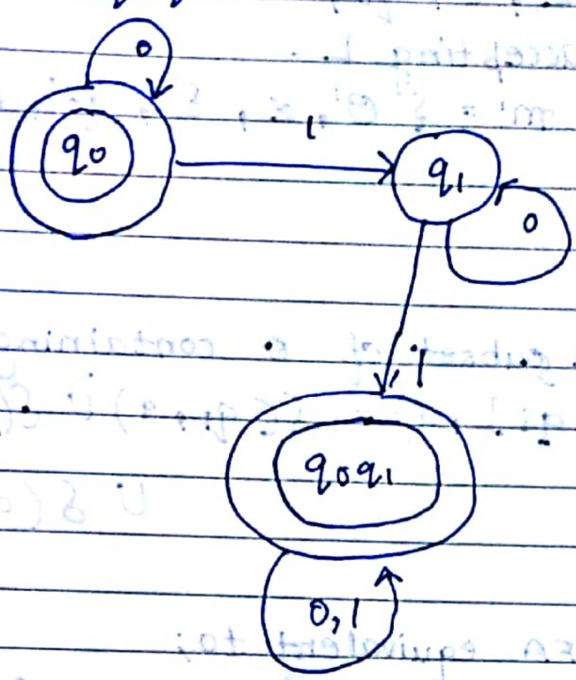
$\delta([q_0, q_1], 1) = \delta(q_0, 1) \cup \delta(q_1, 1)$

$= q_1 \cup [q_0, q_1].$

$= q_0 q_1.$

Hence; DFA;



- NFA;

$$M = (\underset{(Q)}{\{q_0, q_1, q_2\}}, \underset{(\Sigma)}{\{a, b, c\}}, \underset{(\delta)}{\delta}, \underset{(q_0)}{q_0}, \underset{(F)}{\{q_0\}})$$

δ is;

S	a	b
$\rightarrow q_0$	$q_0 q_1$	q_2
q_1	q_0	q_1
q_2	ϕ	q_0, q_1

$$Q' = \left.\begin{array}{l} \phi \checkmark \\ q_0 \checkmark \\ q_1 \\ q_2 \\ q_0 q_1 \checkmark \\ q_1 q_2 \\ q_0 q_2 \\ q_0 q_1 q_2 . \end{array}\right\} (8)$$

3 states in NFA.

Hence, 8 states in DFA.

→ THEOREM

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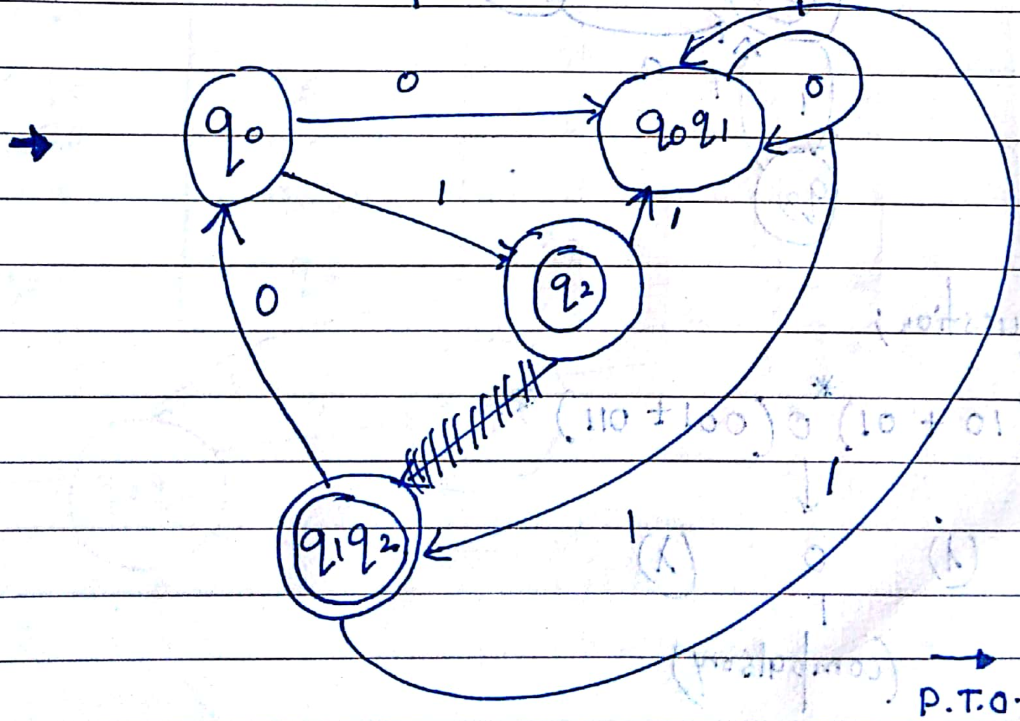
For every NFA, there exist a DFA which simulates the behaviour of NFA i.e., if L is accepted by NFA then there exist a DFA which also accepts (L).

for DFA;

	S	0	1
1.	ϕ	ϕ	ϕ
2.	q_0	q_0q_1	q_2.
3.	q_2	ϕ	q_0q_1.
4.	q_0q_1	q_0q_1	q_1q_2.
5.	q_1q_2	q_0	q_0q_1.



→ P.T.O.

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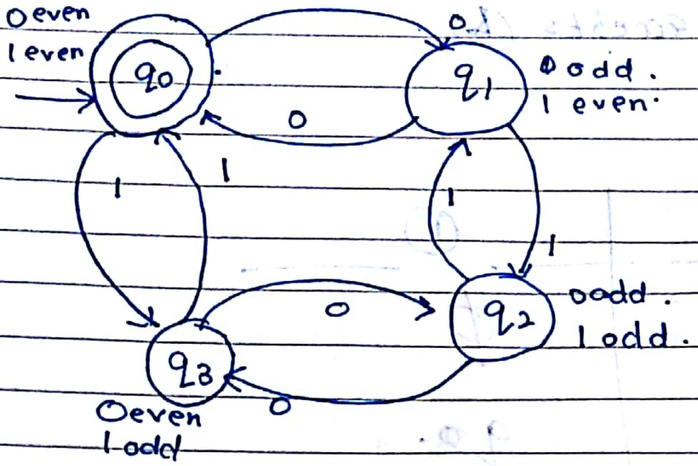
important ;

$\Sigma = (0, 1)$

all strings with even No. of 0's & 1's.



1 . 0

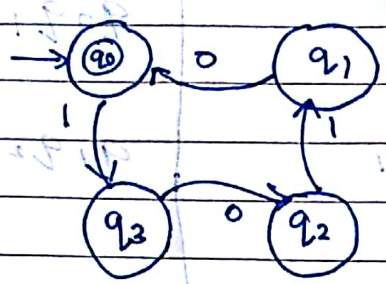
dot means 10 } - Both.

1/0 OR 1 + 0.

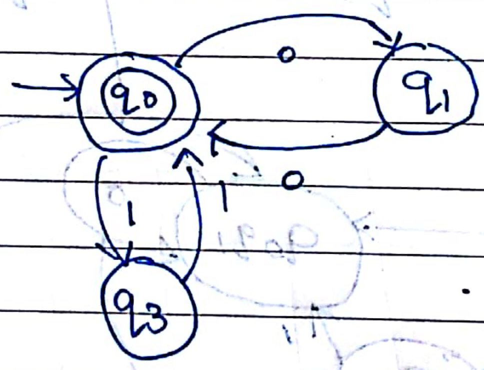
means can be 1 or can be 0.

for 1010 11001010 ;

① 1010



② 1100 &



Last sashional question ;

$*\ (10 + 01)^* \, 0 \, (001 + 011)^*$

(λ) 0 (λ)

(compulsory)

$\underline{10}\,\underline{10}\,\underline{01}$ 0 001

(1) (2) (3)

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# State	0	1
→ q_0	q_1	q_6
q_1	q_6	q_2
q_2	q_0	q_2
q_3	q_2	q_6
q_4	q_7	q_5
q_5	q_2	q_6
q_6	q_6	q_4
q_7	q_6	q_2

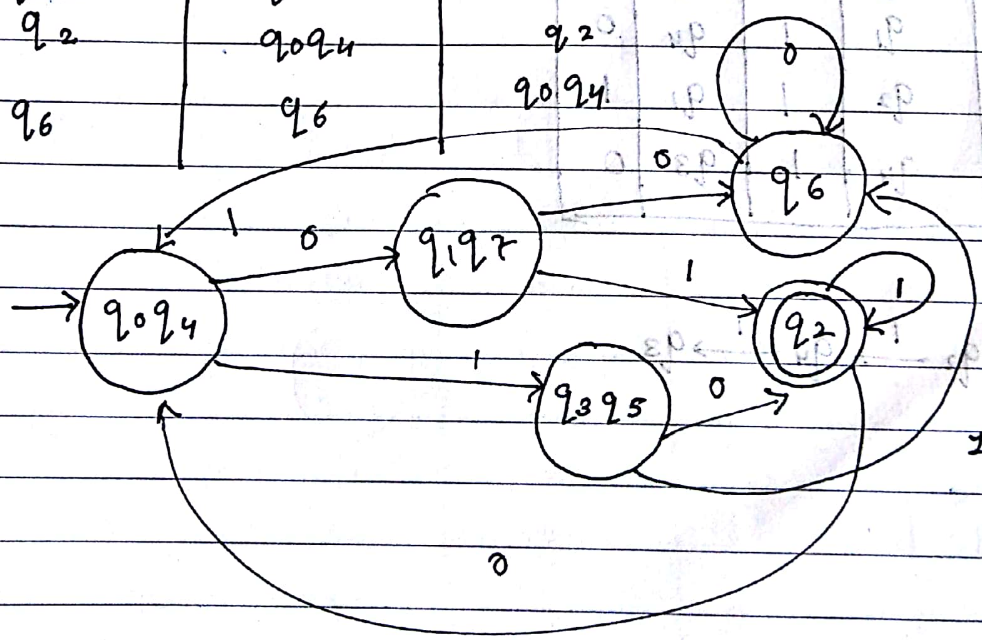
$\Pi_0 = \{q_2\} \{q_0\ q_1\ q_3\ q_4\ q_5\ q_6\ q_7\}$.

$\Pi_1 = \{q_2\} \{q_3\ q_5\} \{q_0\ q_4\ q_6\} \{q_1\ q_7\}$.

$\Pi_2 = \{q_2\} \{q_3\ q_5\} \{q_1\ q_7\} \{q_0\ q_4\} \{q_6\}$.

$\Pi_3 =$ ——— " ———

State	0	1
→ q_0q_4	q_1q_7	q_3q_5
q_1q_7	q_6	q_2
q_3q_5	q_2	q_6
q_2	q_0q_4	q_2
q_6	q_6	q_0q_4



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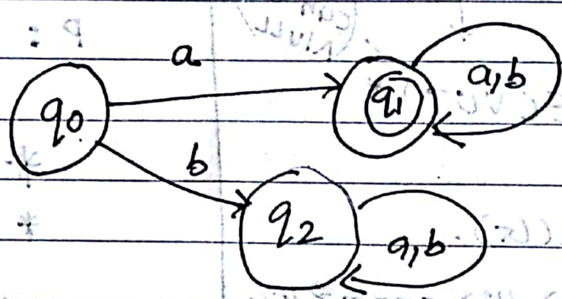
Question :-

Design a DFA that accepts all strings of Σ (a,b) that (i) starts with a.
(ii) end with (a).
(iii) start with a & end with b.
(iv) start with a & end with a.
(v) neither start with a nor end with b.

$(a+b)^*$

Answers :-

(i) minimum = a.



(ii)

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Grammer:-

$G = (V, T, S, P)$ — (set of productions).

(variable) — V; (Terminals) — T; $(S \in V)$ Start symbol — S.

$x \rightarrow y$

$x \in (V \cup T)^+$ (can't be NULL)

$y \in (V \cup T)^*$ (can be NULL)

$LPS \neq \lambda$

→ if $w \in L(G)$.

$S \Rightarrow w_1 \Rightarrow w_2 ---- \Rightarrow w$.

is a derivation of seq w.

find lang; $G = (\{S, A\}, \{a, b\}, S, P)$.

$$\left.\begin{array}{l} S \Rightarrow Ab \\ A \Rightarrow aAb \\ A \leftarrow \lambda \end{array}\right\} — (P).$$

→ $\{b, abb, aabbb, ---\}$.

$L(G) = \{a^n b^{n+1} : n \geq 0\}$.

→ $G = (\{A, S\}, \{a, b\}, S, P_1)$.

# $P_1 \Rightarrow S \rightarrow \lambda$	$A \rightarrow aAb$
$S \rightarrow aAb$	$A \rightarrow \lambda$.

Here, $S \rightarrow \lambda$

$S \rightarrow aAb \Rightarrow ab$.

$S \rightarrow aAb$

$aabb \longrightarrow aabb$.

$L = \{a^n b^n : n \geq 0\}$.

$\left\{\begin{array}{l} x \text{ derives } y \\ y \text{ is derived from } x \end{array}\right.$

$\left\{\begin{array}{l} w_1 \Rightarrow w_2 \Rightarrow --. w_n. \\ w_1 \text{ derives } w_n. \\ w_1 \overset{*}{\Rightarrow} w_n. \end{array}\right.$

$G = (\{A, S\}, \{a, b\}, S, P)$.

$P_1 =$

$S \rightarrow aAb / \lambda$.

$A \rightarrow aAb / \lambda$.

$G = (\{S\}, \{a, b\}, S, P)$.

$P: S \rightarrow aSa / bSb / \lambda$.

* CAPS - Variable —
* Small — terminals — including {NULL}.

$G = (\{S\}, \{a, b\}, S, P)$.

$P: S \rightarrow aSa / bSb / \lambda$.

(E) aSa — aa

bSb — bb

aSSa — aaaa

bSSb — bbbb

aSa = abba.

absba = ab aaba.

$L = \{w w^R\}$.

→ $w \in (a, b)^*$.

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① # $G = \{ (S), (a,b), S, P \}$.
P: $S \to aSb$.
$S \to \lambda$.

$\to$ Sol:
$\to L = \{ a^n b^n : n \geq 0 \}$

② Find grammer for ; $L = \{ a^n b^{n+1} : n \geq 1 \}$.

$G = \{ (S), (a,b), S, P \}$.
P : $S \to SS / aSb / bSa / \lambda$.

③ $\to G = \{ (S), (a,b), S, P \}$.
$S \to \lambda$.

$S \to aSb \to ab \to aSb \to abab$.
$ab \to aSb \to aabb$.

$S \to bSa \to ba \to bSa \to baba$.
$ba \to bSa \to bbaa$.

$S \to SS \to aSSb \to ab \to aaabbb$.
$\to ba \to bbbaaa$.

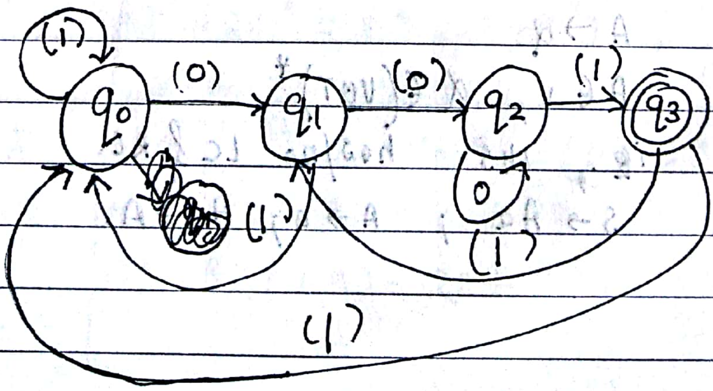
O/P Table
λ
ab
aabb
ba
bbaa
abab
baba
aaabbb
bbbaaa

$\therefore L = \{ w \in (a,b)^* : n_a = n_b \}$.

② $L = \{ a^n b^{n+1} : n \geq 1 \}$.
$\to S \to Ab$.
$A \to aAb / ab$.

Q1. Draw DFA that accept $\Sigma = (0,1)^*$ ending with 001

Sol :-



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...Arden's Theorem...

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<u>Theorem</u> :- Let P & Q be two regular expressions over Σ. If P doesn't contain λ then the following eqn.

$$R = Q + RP \ldots\ldots (A).$$

can be written as $R = QP^*$.

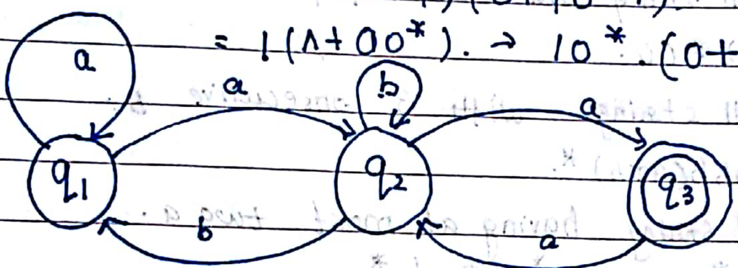
<u>Proof</u> :- To prove this theorem, we put the value of R in eqn. (A). Hence, we get

$$Q+RP = Q+(Q+RP)P.$$
$$= Q+QP+RPP.$$
$$= Q+QP+RP^2.$$
$$= Q+QP+QP^2+\ldots QP^i+RP^{i+1}.$$
$$= Q(\lambda+P+P2+\ldots+P^i)+RP^i.$$

<u>Prove</u> :- $(1+00^*1)+(1+00^*1)(0+10^*1)(0+10^*1) = 0^*1(0+10^*1)^*$.

$$(1+00^*1) = (\lambda+(0+10^*1)^*(0+10^*1)).$$
$$= (1+00^*1)(0+10^*1)^*$$
$$= 1(\lambda+00^*). \rightarrow 10^*.(0+10^*1)^*.$$

<u>Sashnl</u> :-



<u>Sol</u> :-
$$q_1 = q_1a + q_2a + \lambda.$$
$$q_2 = q_1a + q_2b + q_3b.$$
$$q_3 = q_2a.$$

put (3) in (2); $q_2 = q_1a + q_2(b+aa)$.

Apply Arden's $q_2 = q_1a(b+aa)^*$. — (4)

put (4) in (1); $q_1 = q_1a + q_1a(b+aa)^*b + \lambda$.
$$q_1 = \lambda + q_1(a+ab(b+aa)^*).$$

Apply Ardein's :- $q_1 = (a+ab(b+aa^*))$. — (5)

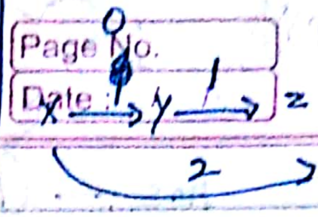
~~Ap~~ ~~put~~ :- $q_2 \rightarrow [(a+ab(b+aa)^*)^*]a(b+aa)^*$.

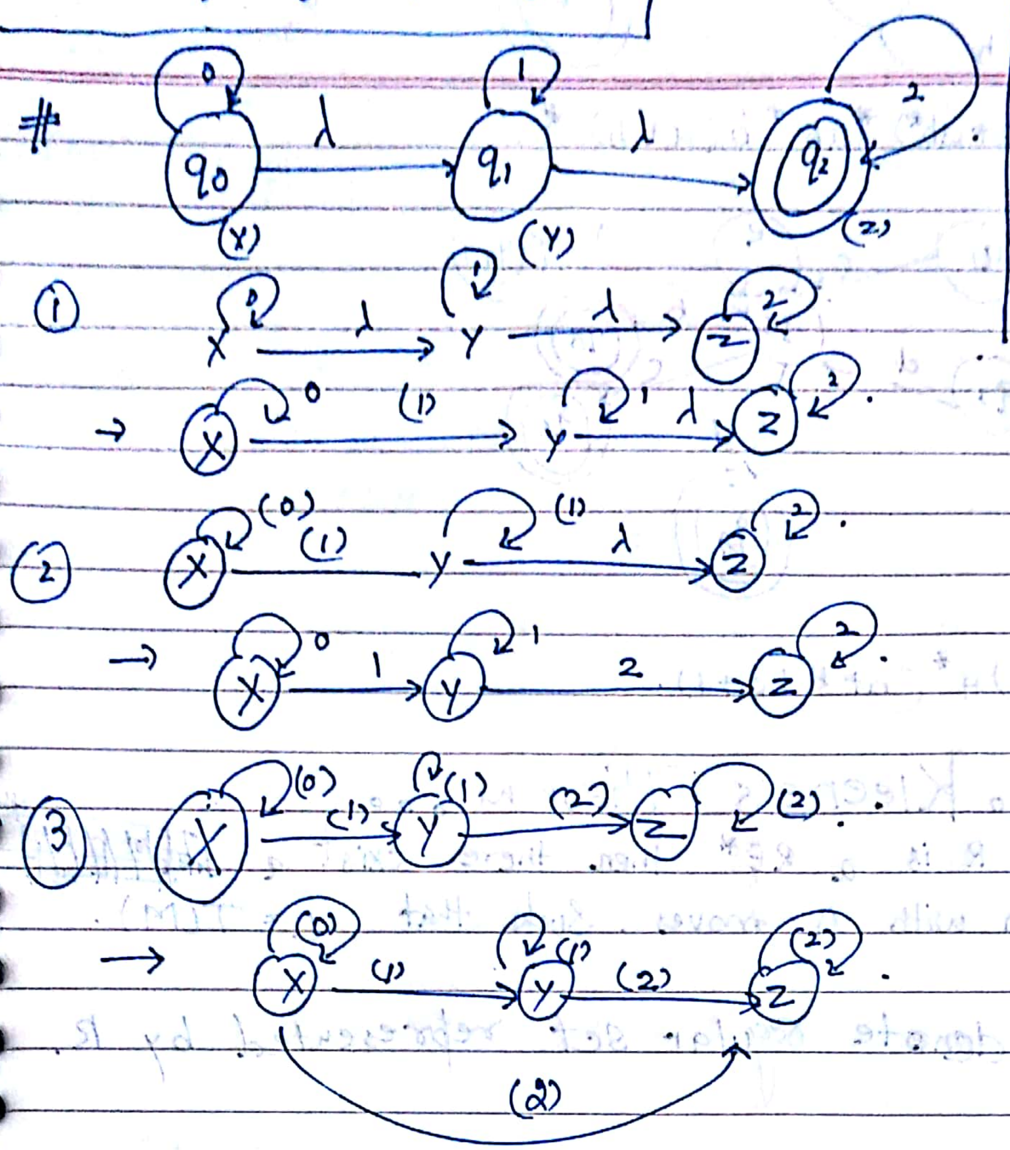
$$q_3 = q_2 \cdot a.$$

1
2
3
3in/2
(A)
4
4in 1
A
q_1
q_1
q_2
q_3

$1 \to q_1 = q_1A + q_0A + \lambda.$

$2 \to q_2 = q_1A + q_2A + q_2A.$





Steps :- ① Replace λ from V_1 to V_2.

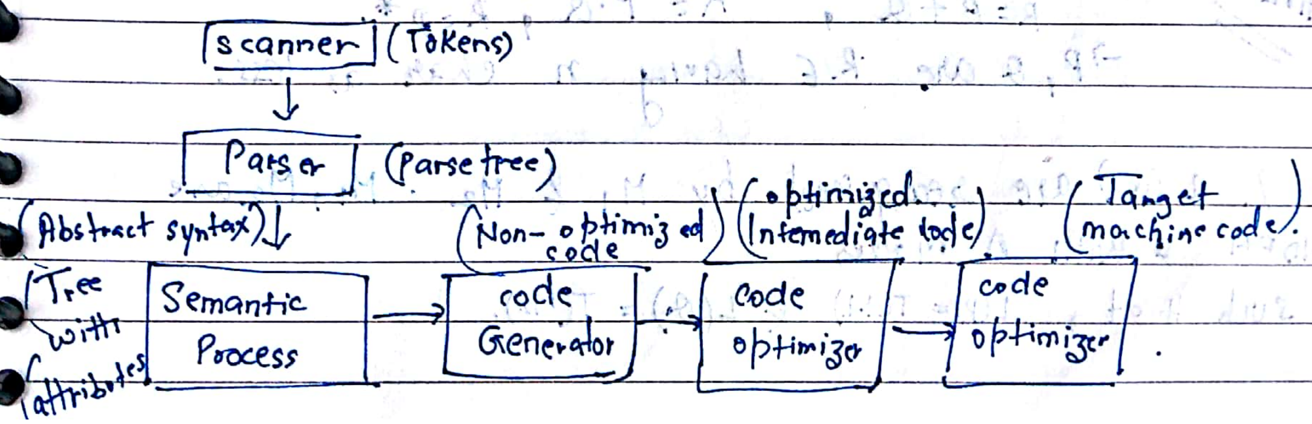
② find all edges starting from V_2.

③ Duplicate all the edges starting from V_1 without changes the edge ~~levels~~ labels.

④ If V_1 is an initial state make V_2 also initial.

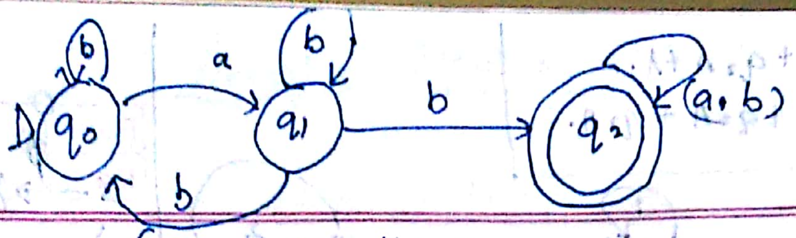
⑤ If V_2 —"— final —"— make V_1 also final.

- Process of compilation :-



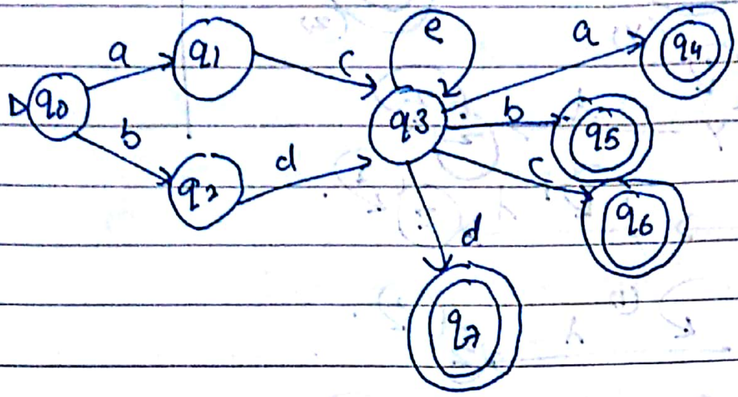
H.W.

(1)



Ans :— $(b+ab^*)^*ab^*b(a+b)^*$.

(2)



Ans :— $(ac+bd)e^*(a+b+c+d)$.

25/01/18

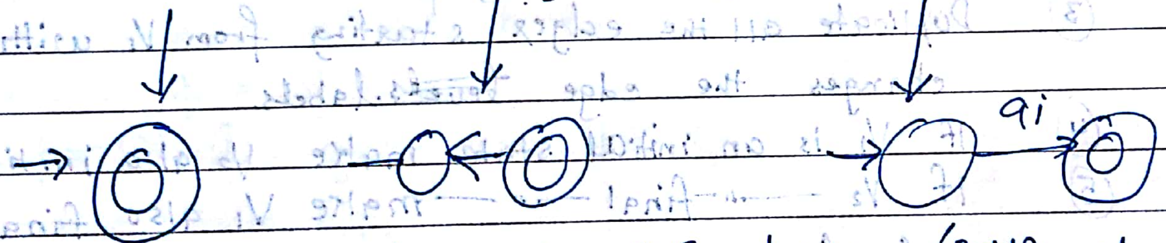
... Kleene's Theorem ...

⇒ if R is a RE* then there exist a ~~[illegible]~~ NFA m with Λ moves. Such that L = T(M).

Proof ⇒ Let L(R) denote regular set represented by R.

Basic Step ⇒ Let no. of char. in R be 1.

$R=\Lambda$ $\qquad$ $R=\phi$ $\qquad$ $R=a_i\ (a_i \in \Sigma)$.



Inductive Step :- Let R be R.E. having (n+1) char.

$R=P+Q$, $\quad R=P\cdot Q$, $\quad R=P^*$.

→ P, Q are R.E having n char as less.

L(P) & L(Q) are recognised by M_1 & M_2. M_1, M_2 are NDFA with Λ moves.

such that, $L(P)=T(M_1)$ & $L(Q)=T(M_2)$.

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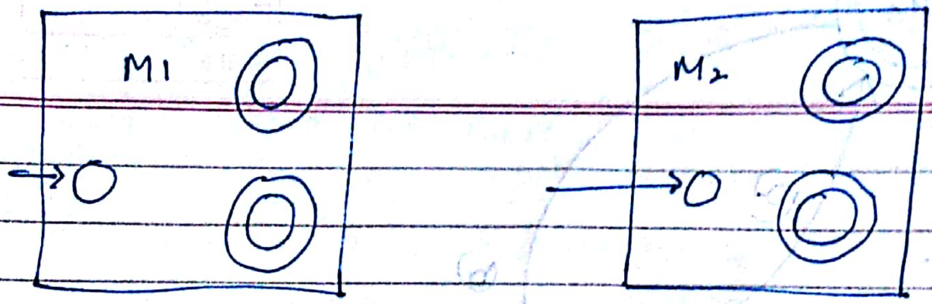
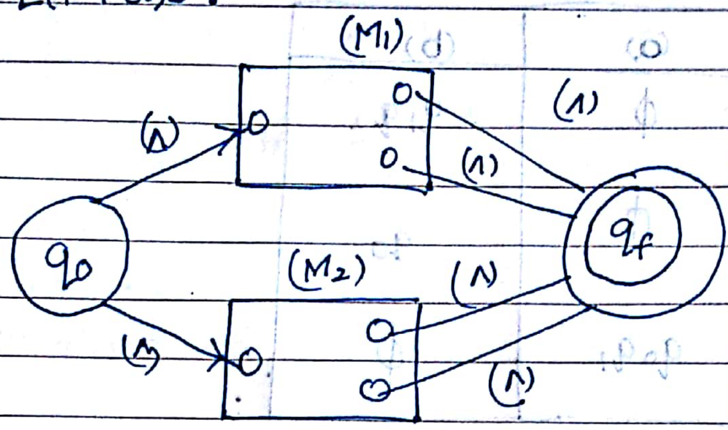


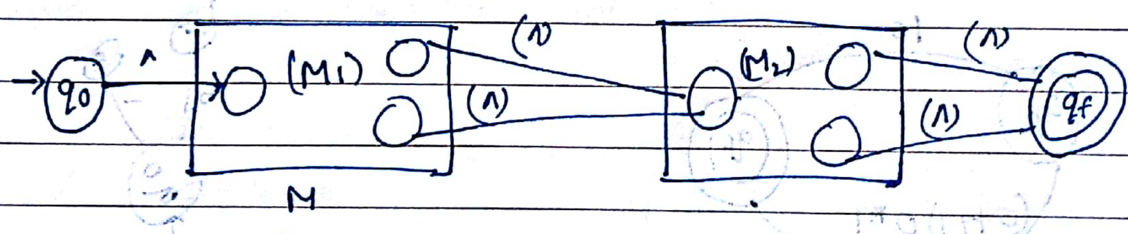
CASE 1 :- $R = P + Q$.

We construct NDFA M with Λ moves that accepts $L(P+Q)$:



$T(M) = T(M_1) \cup T(M_2) = L(P+Q)$.

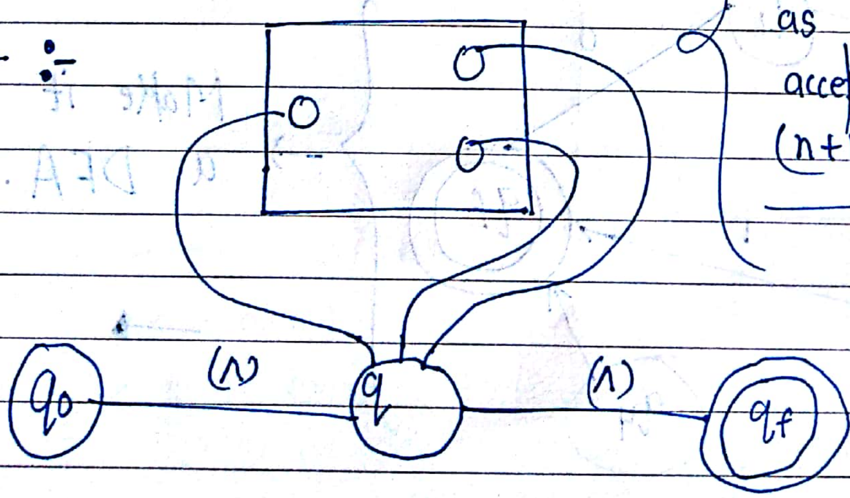
CASE 2 :- $R = P.Q$.

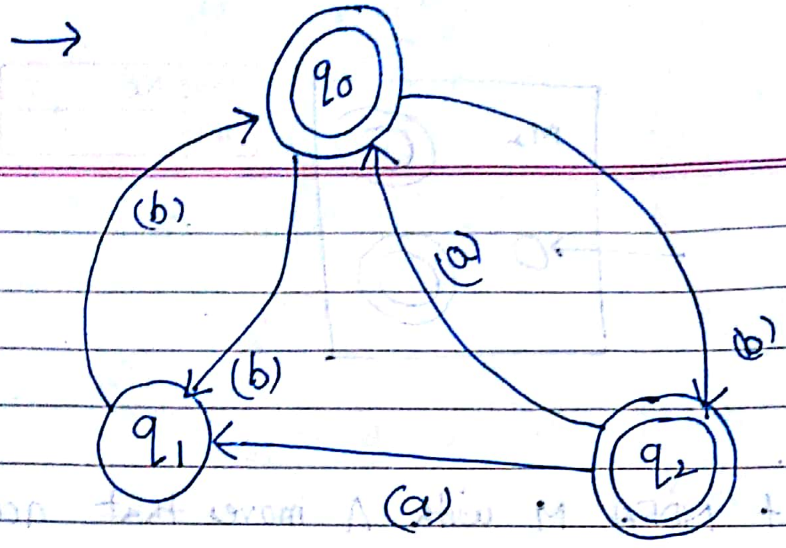


$\Rightarrow T(M) = T(M_1) + T(M_2)$
$= L(PQ)$.

This in all cases, there Exist as NFA M with Λ moves, accepting $R \in R$ with $(n+1)$ ~~dep~~.

CASE 3 :-



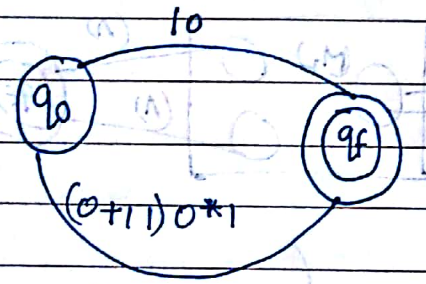


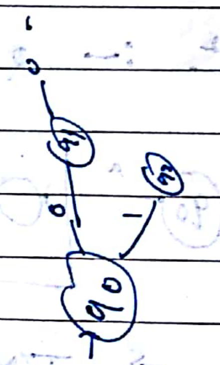
⇒

S	(a)	(b)
→ q_0	ϕ	$q_1 q_2$
→ q_1	ϕ	q_0
q_2	$q_0 q_1$	ϕ

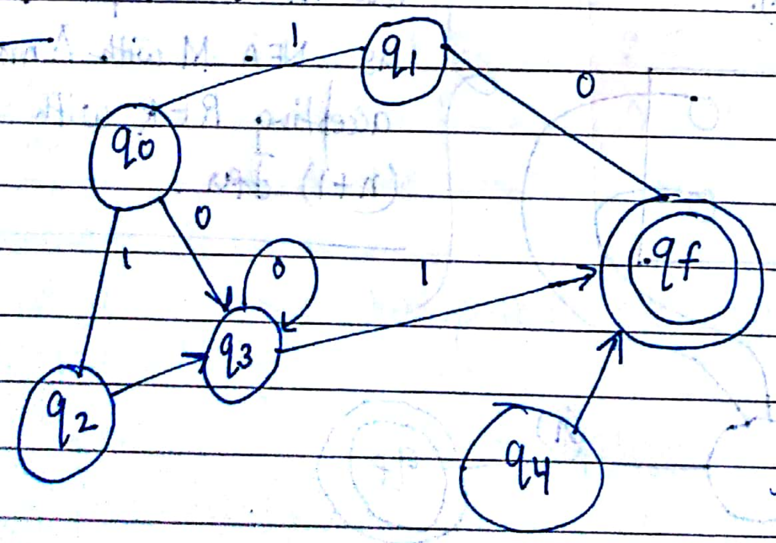
	(a)	(b)
→ $q_0 q_1$	ϕ	$q_0 q_1 q_2$
$q_0 q_1 q_2$	$q_0 q_1$	$q_0 q_1 q_2$
ϕ	ϕ	ϕ

Q=1:





Ans:—



Make it a DFA.

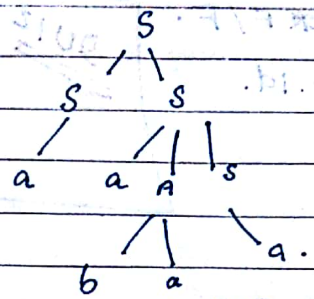
30/01/18

• CONTEXT FREE GRAMMAR :—

→ A grammar $G = (V, T, P, S)$ is said to be context free where, V = finite set of non-terminal, generally represent by capital letters.

T = a finite set of terminals, generally represented by small letters.

→ $S \to aAS / a / SS$.
$A \to SbA / ba$.



Yeild: aabaa.
$S \Rightarrow SS \Rightarrow aS \Rightarrow aaAS$.
$\Rightarrow aabaS \Rightarrow aabaa$.

→ $S \to aAb / a$.
$A \to SbA / SS / ba$.
$S \Rightarrow aabbaa$.

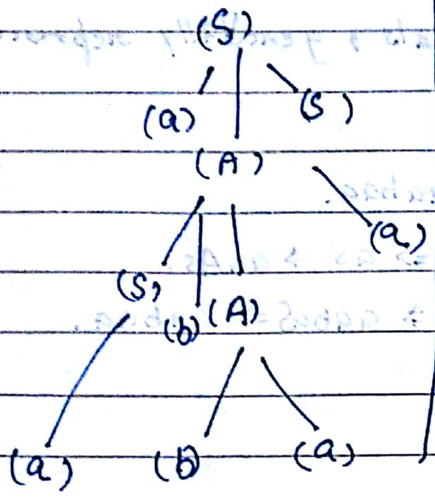
• $E \to E \text{ op } E / id$.
$op \to - / /$.

→ A context-free grammar G such that some word has two parse tree is known as ambigous.

Problems 1) Associativity.
2) Precedence.
3)

Sashional :- $S \to 0B / 1A$.
$A \to 0 / 0S / 1AA$.
$B \to 1 / 1S / 0BB$.
00110101
LMD ; RMD. →

→ S → aAS.
asbAS.
aabAS.
aabbaa.



Removal of Ambiguity :-

E → E+E / E*E / id.

S → S+A.

A →

E → E+T/T.

T → T*F/F.

F ⇒ id.

QUIZ :- Simplification of context-free grammar

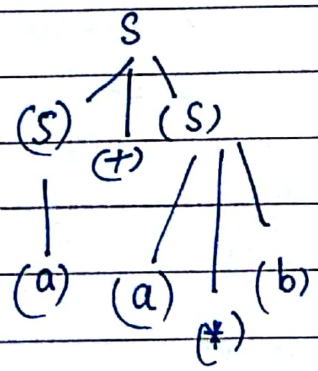
for LMD :- S → 0B.
→ 00BB.
→ 001B.
→ 0011S.
→ 00110B.
→ 001101S.
→ 0011010B.
→ 00110101.

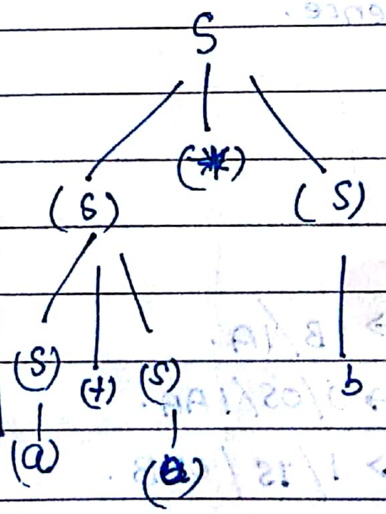
RMD :-
S → 0B.
→ 00BB.
→ 00B1S.
→ 00B10B.
→ 00B101S.
→ 00B1010B.
→ 00B10101.
→ 00110101.

Production of S
- S → S+S / S*S / a/b. } → Prove this to be ambigous.

o/p → a+a*b. } - (Answer).

Ans :-





{ T.O.C. }

06/02/18

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$L = \{a^n b^n ;\ n \geq 0\}$.

$(\{q_0, q_1\}, \{a, b\}, \{z, 1\}, \delta, q_0, z, q_1)$.

δ :: (This is wrong)

$\delta(q_0, a, z) = (q_0, 1, z)$

$\delta(q_0, a, 1) = (q_0, 11)$

$\delta(q_0, b, 1) = (q_0, \Lambda)$

$\delta(q_0, \Lambda, z) = (q_1, \Lambda)$

ω = aaabbb.

$(q_0, aaabbb, z)$

$\vdash (q_0, aabbb, 1z)$.

$\vdash (q_0, abbb, 11z)$.

$\vdash (q_0, bbb, 111z)$.

$\vdash (q_0, bb, 11z)$.

$\vdash (q_0, b, 1z)$.

$\vdash (q_0, \Lambda, z)$.

$\vdash (q_1, \Lambda, \Lambda)$.

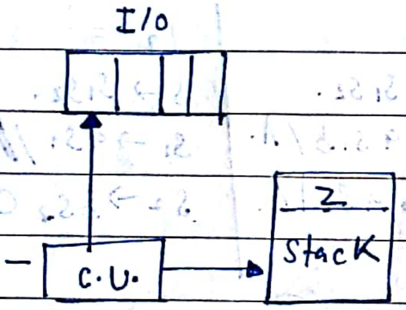
→ abab $\notin L$.

— $(q_0, abab, z) \vdash (q_0, bab, 1z)$.

$\vdash (q_0, ab, z) \vdash (q_0, b, 1z)$.

$\vdash (q_0, \Lambda, z) \vdash (q_1, \Lambda, \Lambda)$.

accepted.



• correction of this :-

δ : $\delta(q_0, a, z) = (q_0, 1z)$

$\delta(q_0, a, 1) = (q_0, 11z)$

$\delta(q_0, b, 1) = (q_1, \Lambda)$

$\delta(q_1, b, 1) = (q_1, \Lambda)$

$\delta(q_1, \Lambda, z) = (q_2, \Lambda)$

$\delta(q_0, \Lambda, z) = (q_2, \Lambda)$

→ $(q_0, abab, z) \vdash (q_0, bab, 1z)$

$\vdash (q_1, ab, z)$ = HALT

$(q_0, aabb, z)$.

$\vdash (q_0, abb, 1z)$.

$\vdash (q_0, bb, 11z)$.

$\vdash (q_1, b, 1z)$.

$\vdash (q_1, \Lambda, z)$.

$\vdash (q_2, \Lambda)$.

Q:1 Design a PDA using :- $L = \{a^n b^{2n} : n \geq 0\}$.

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Ans :- $(\{q_0, q_1, q_2\}, \{a, b\}, \{z, 1\}, \delta, q_0, z, q_2)$.

δ: $\delta(q_0, a, z) = (q_0, 1z)$.

$\delta(q_0, a, 1) = (q_0, 1111z)$.

~~$\delta(q_0, b, 1) = (q_0, 11z)$.~~

$\delta(q_1, b, 1) = (q_1, \Lambda)$.

$\delta(q_1, \Lambda, z) = (q_1, \Lambda)$.

$\delta(q_2, \Lambda, z) = (q_2, \Lambda)$.

:- L_1 and L_2 CFL.

$G_1 = (V_1 T_1 S_1 P_1)$ $G_2 = (V_2 T_2 S_2 P_2)$.

$(V_1 \cap V_2) = \phi$.

$G_3 = (V_3 T_3 S_3 P_3)$ CFG.

$L(G_3) = L(G_1) \cup L(G_2)$.

$V_3 = V_1 \cup V_2 \cup \{S_3\}$.

$T_3 = T_1 \cup T_2$.

S_3 = Start sym.

$P_3 \to P_1 \cup P_2 \cup \{S_3 \to S_1 / S_2\}$

Let $G_4 = (V_4\ T_4\ S_4\ P_4)$.

$L(G_4) = L(G_1) . L(G_2)$.

$V_4 = V_1 \cup V_2 \cup \{S_4\}$.

$T_4 = T_1 \cup T_2$.

S_4 = S. S.

$P_4 = P_1 \cup P_u \cup \{S_u \to S_1 S_2\}$.

Let $G_5 = \{V_5 T_5 S_5 P_5\}$.

$L(G_5) = L(G_1)^*$.

$V_5 = V_1 \cup \{S_5\}$.

$T_5 = T_1$.

S_5

$P_5 = P_1 \cup \{S_5 \to S_1 S_5 / \Lambda\}$.

Let $(G_3) = L_1 \cup L_2$.

$w \in L_1 \Rightarrow S_3 \to S_1 \Rightarrow w$.

$w \in L_2 \Rightarrow S_3 \Rightarrow S_2 \stackrel{*}{\Rightarrow} w$.

If $w \in L(G_3)$.

1) either $S_3 \Rightarrow S_1$

2) or $S_3 \Rightarrow S_2$.

If $S_3 \Rightarrow S_1$ has V_1 & $(V_1 \cap V_2 \neq 0)$.

then $S_1 \stackrel{*}{\Rightarrow} w$ involves Prod P_1 only.

If $S_3 \Rightarrow S_2$, has V_2.

$S_2 \stackrel{*}{\Rightarrow} w$.

Prod. P_2 only.

so, either 1 or 2.

(2) Not closed under Intersection & comp.

* consider 2 langs;

$L_1 = \{a^n b^n c^m : n, m \geq 0\}$.

$L_2 = \{a^n b^m c^m : n, m \geq 0\}$.

L_1 =	L_2 =
$S_0 \to S_1 S_2$.	$S \to S_1 S_2$.
$S_1 \to a S_1 b / \Lambda$.	$S_1 \to a S_1 / \Lambda$.
$S_2 \to a S_2 / \Lambda$.	$S_2 \to b S_2 C / \Lambda$.

• compl :- L_1 L_2

i.e., $\bar{L_1}$ & $\bar{L_2}$ are CFL.

$\Rightarrow \bar{L_1} \cup \bar{L_2}$

$\Rightarrow \overline{\bar{L_1} \cup \bar{L_2}}$

$\Rightarrow L_1 \cap L_2$. is NOT CFF.

$\to$ $L_1 \cap L_2 = \{a^n b^n c^n : n \geq 0\}$.

is not CFL {using P.L.}.

07/02/18 ... PDA ...

$\lambda ; \varepsilon ; \Lambda$.

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Q-1: Design a PDA accepting set of all string with equal no. of A and B.

Ans :– $L = \{a^n b^n : n \geq 0\}$.

$\rightarrow (\{q_0, q_1\}, \{a, b\}, \{z, 1\}, \delta, q_0, z, q_1)$.

δ : $\delta(q_0, a, z) = (q_0, az)$.

$(q_0, b, z) = (q_0, bz)$.

$(q_0, a, a) = (q_0, aa)$.

$(q_0, b, b) = (q_0, bb)$.

$(q_0, a, b) = (q_0, \Lambda)$.

$(q_0, b, a) = (q_0, \Lambda)$.

$(q_0, \Lambda, z) = (q_f, \Lambda)$.

e.g. a b a b b b a a a Λ

$\alpha\alpha b$ b α α z

abab Λ

α α Z

$\delta(q_0, a, z) = (q_0, az)$.

$\delta(q_0, b, z) = (q_0, bz)$.

$\delta(q_0, a, a) = (q_0, aa)$.

$\delta(q_0, b, b) = (q_0, bb)$.

$\delta(q_0, a, b) = (q_0, ab)$.

$\delta(q_0, b, a) = (q_0, ba)$.

$\delta(q_0, \Lambda, a) = (q_1, a)$.

$\delta(q_0, \Lambda, b) = (q_1, b)$.

$\delta(q_1, \Lambda, z) = (q_2, \Lambda)$.

(Deterministic)

... DPDA ...

$M = (Q\, \Sigma\, \Gamma\, \delta\, q_0\, z\, F)$ is determine.

If for every $q \in Q$, $q \in \Sigma \cup \Lambda$ & $b \in \Gamma$,

① $\delta(q, a, b)$ containt atmost one element.

② if $\delta(q, \Lambda, b)$ is not empty. then,

$\delta(q, c, b)$ must be empty for every $c \in \Sigma$.

A PDA is said to be deterministic

... {on next Page} ...

Topics left...

PDA to CFG

CFG to PDA ✓ (Assignment)

~~P.L~~ 1

2

~~Properties lang.~~

LEX. YACC ✓ (Assignment)

• $A = \{Q, T, V \cup T, \delta, q, S, \phi\}$

$Q \quad \Sigma \quad \Gamma \quad \delta \quad q_0 \quad z \quad F$

$A \to \alpha$.

R_1 : $\delta(q, \Lambda, A) = (q, \alpha)$.

R_2 : $\delta(q, a, a) = (q, \Lambda)$

for every a in T

State – state

Terminal – alphabet.

variable + Terminal – stack state.

state – initial state.

ϕ – final state.

$S \to aSbb/a$.

$M = (\{q\}, \{a, b\}, \{a, b, S\}, \delta, q, S, \phi)$.

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δ :

$\delta(q, \Lambda, S) = \{(q, aSbb), (q, a)\}$.

$\delta(q, a, a) = \{q, \Lambda\}$.

$\delta(q, b, b) = (q, \Lambda)$.

let take any sequence;

$S \to aSbb / a$.

↓ (put aSbb)

$S \to aaSbbbb$.

↓ (put a).

$S \to aaabbbb$.

($aaabbbb \in L$).

$(q, aaabbbb, S)$.

$\vdash (q, aaabbbb, S)$.

$\vdash (q, aaabbbb, aSbb)$.

$\vdash (q, aabbbb, Sbb)$.

$\vdash (q, aabbbb, aSbbbb)$.

$\vdash (q, abbbb, abbbb)$.

$\vdash^* (q, \Lambda, \Lambda)$.

* Pumping Lemma :-

→ Theorem :- $M = (Q, \Sigma, \delta, q_0, F)$, F.A. with n states.

let L be a RS accepted by M.

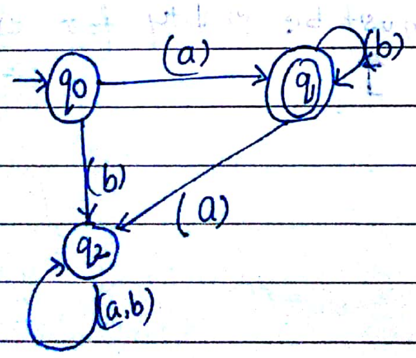
Then, the M at $w \in L$, $|w| \geq m$ & $M \geq n$.

can be decomposed into; $w = xyz$.

$|xy| \leq n \quad y \neq \Lambda$.

$xy^iz \in L$ for $i \geq 0$.

e.g. :- $\boxed{ab^n. \; n > 0}$.



$w = |w| \geq 3$.

$= abb$.

$w = x \; y \; z$.

(a) (b) (b)

$|xy| \leq n \quad 2 \leq 3$.

$|y| = |b| = |z|$.

$w = xy^iz$.

$= ab^ib \in L$ {L is regular}.

Proof :- $w = a_0, a_2, --- a_m$, $m \geq n$.

~~$\delta(q_0, a_1, a_2 --- a_i) = q_i$. $i = 1, 2, --- m$.~~

$\Theta = \{q_0, q_1, ---- q_m\}$.

Θ is seq of states in path.

$w = a_1, a_2, --- a_m$.

As only n ~~distinct~~ distinct states atleast 2 states in Q_1. consider,

Let then take as q_j & q_k $(q_j = q_k)$.

$\Rightarrow$ Then, $0 \leq j < k \leq n$.

$\underbrace{a_1, a_2, --- a_j}_{(X)}$; $\underbrace{a_{j+1}, --- a_k}_{(Y)}$ & $\underbrace{a_{k+1} --- a_m}_{(Z)}$.

$k \leq n$; $|xy| \leq n$.

• Using final State :- CFG → PDA.

If L is λ free then there exist a CFG in GNF form.

$M = \{ (q_0, q_1, q_f), T, V \cup \{z\},$

Θ Σ Γ

Σ , q_0 , Z , $\{q_f\}\}$.

δ q_0 Z F

$z \notin V$.

$\delta(q_0, \Lambda, z) = (q_1, Sz)$.

$\delta(q_1, \Lambda, Z) = (q_f, z)$.

$\delta(q_1, a, S) = (q_1, A)$.

$\delta(q_1, a, A) = \{(q_1, ABC), (q_0, \Lambda\}$.

$\delta(q_1, b, A) = (a_1, B)$.

$\delta(q_1, b, B) = (q, \Lambda)$.

$\delta(q_1, c, C) = q_1, \Lambda)$

$w = aaabc \in L$.

$= (q_0, \Lambda aaabc, z)$.

$\vdash (q_1, aaa, bc, Sz)$.

$\vdash (q_1, aabc, Az)$

$\vdash (q_1, abc, ABCz)$.

on next Page...

* whether a^{p} ~~where~~ P is prime. prove it to be non-prime :

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→ PL for CFL ;

L ⇒ CFL.

$w \in L$ with $|w| \geq m$

$w = uvxyz$

$\Rightarrow |vxy| \leq m$