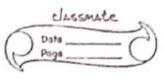


	Smith to be a second to the se
	Theory of Computation (TOC)
	Toc is a study of mathematical computation possblems & various
	computational models which goe used to solve such problems.
<u></u>	It has 3 aspects:
	1) Complexity Theory
	2) Computability Theory
	3) Automata & Language Theory.
	La resta Daniela de Maria
1.	Complexity Theory
	It deals with the classification of computational problems as
las	ber the computational difficulties.
	In other mords it classifies the mathematical problems as
	easy or hard. It uses time in space as measures for
	Computational difficulties.
2.	Computability Theory: - It deals with the classification of
- 1	mathematical porblems as solvable or unsolvable.
3.	Automata & Language Theory:
14 0	It deals with various mathematical models of computation/
1.1	abstract mudels, these definations, properties & mudels.
->	These abstract muchienes are known as automata.
	These field also gives the formal definations for automobiles of
	their capabilities.
4	Based on their capabilities automata are of 4 types.
1)	
2)	
3)	Linear bounded Automata (LDA)
4)	Turing Machine (TM)
	Principal Management of the Control
	the first to the state of the first the state of the stat
	The state of the s
	Scanned with CamScanner

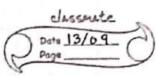
Clascoute Pege

Mathema	tical	Nutations
100000	-,	1.0.461-10

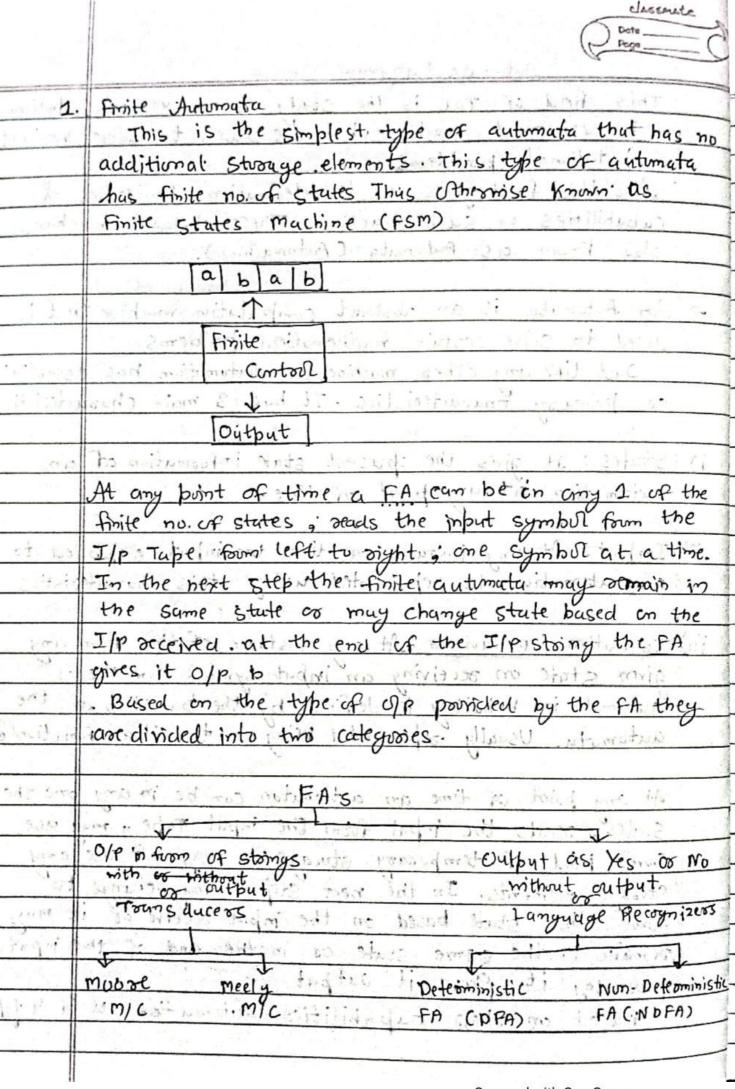
The concept of sets Unordered collections of objects Sequences & Tuples To Denoted -> () E. y. a = (2,15, 23) Tuples = 3 Symbol Alphabet (Z) Stoiny (W) The finite sequence of A set of symbols Symbols tuking from any a Finite non empty The finite sequence of A set of symbols Symbols tuking from any alphabet usually moither: y. z = 2a, b? alphabet usually moither: y. z = 20,13 to each other without separate by, 100 blank space. Ey z = 2a, b} Stoiny (W) = ababa Consortenation of a Stoiny/Symbol Length of stoiny = IW I To Denoted by -> (.) W1 d us are two stoings then there concatenation written and of us are two stoings then there concatenation written and of us are two stoings then there concatenation written and us are ababa W2 = ababa Reverse of a stoing (w ^R) The finite sequence of Stoing (W) In I = 5 W1 d us are two stoings then there concatenation written and of us appending we to the end of us are two stoings then there concatenation written are appending of stoing (W) in the colposite ordered. Reverse of a stoing (w ^R) The stootand by writing symbols of Stoing (W) in the colposite ordered. Ey w = ababa The rew then it is a palindown create a given z. Ports : set of z Denoted as 7 · z m)		Mathematical Nutations
Unordered collections of objects Sequences of Tuples -> Oblived collections / Set -> Denoted -> () e.y. a = (2,15, 23) Tuples = 3 Symbol Alphabet (E) Stoing (W) a Finite run empty The finite sequence of A Set of symbols Symbols taken form any a e.y. z = sa, b? alphabet usually moither: i z = \$0,13 to each other mithout separate by, or blank space. e.y. z = sa, b? Concatenation of a Stoing/Symbol Length of stoing = Iw 1 -> Denoted by -> (.) W1 d w2 are two stoings then there concatenation written w2. w2. w2 or w2 w2 d obtained by appending w2 to the end of w2. e.y. z = \$a, b? W2 = aba ba Reverse of a stoing (w ^R) -> It is obtained by writing symbols of Stoing (w) in the opposite ordered. e.g. w = ababa , w ^R = ababa If w = w ^R then It is a palindown areo a given z.		The concept of sets
Sequences & Tuples - Oblived collections / Set - Denoted - () e.g. a = (2115 23) Tuples = 3 Symbol: Alphabet (\(\infty\) a Finite non empty The finite sequence of A Set of symbols Symbols taken from any a e.g. \(\infty\) = \(\infty\) alphabet usually written: i \(\infty\) = \(\infty\) to each other without separate by or blank space. e.g. \(\infty\) = \(\infty\) string (w) = ababa Concatenation of a String/Symbol length of string = 1w 1 i Denoted by -) (i \(\infty\) = \(\infty\) then there concatenation written in \(\infty\) = \(\infty\) ababa Using or ways of obtained by appending we to the end of \(\infty\). e.g. \(\infty\) = \(\infty\) then the end of \(\infty\). Peresse of a string (w ^R): i is obtained by writing symbols of String (w) in the opposite ordered. e.g. \(w = \text{ababa}\) = \(w^R = \text{ababa}\) If \(w = w^R\) then it is a pulindrom ones a given \(\infty\).		
→ Osclesed collections / Set → Demoted → () e.g. a = (2115 23) Tuples = 3 Symbol: Alphabet (∑) Storing (W) a Finite run empty The finite sequence of A Set of symbols Symbols taken form any (a) e.g. z = sa, b? alphabet usually written: j. z = \$0,1? to each offer without separate by, us blank space. cy z = \$a, b? Storing (W) = ababa Concatenation of a Storing/Symbol length of storing = 1W i Demoted by → (.) 1VI = 5 W1 d w2 are two storings then there concatenation written and offer way appending w2 to the end offer w2. e.g. z = \$a, b? W2 = ababa Reverse of a storing (w ^R) i t is obtained by writing symbols of storing (W) in the opposite ordered. e.g. w = ababa , w ^R = ababa If w = w ^R then it is a pulindrom creo a given z. Ports : Set of z		
Symbol: Alphabet (\(\mathbb{Z}\)) E. y a = (2,15,23) Tuples = 3 Symbol: Alphabet (\(\mathbb{Z}\)) a Finite num empty The finite sequence of A Set of symbols Symbols taken form any alphabet usually notites: i \(\mathbb{Z} = \mathbb{Z} \alpha, \mathbb{D}\) alphabet usually notites: i \(\mathbb{Z} = \mathbb{Z} \alpha, \mathbb{D}\) to each other without separate by , or blank space. by , or blank space. cy \(\mathbb{Z} = \mathbb{Z} \alpha, \mathbb{D}\) Comatemation of a Stoiny/Symbol length of stoing = 1w 1 i \(\mathbb{D} = \mathbb{D} \) \(\mathbb{D} = \mathbb{D} \) Denoted by \(\mathred{\mathred{D}}\) (.) 1v1 = 5 w1 d w2 are two stoings then there concatenation in oiten a w1 w2 or w2 w2 d obtained by appending w2 to the end of w2. 2 = \(\mathred{Z} \alpha, \mathred{D}\) w2 = \(\mathred{D} = \mathred{D} \) w3 = \(\mathred{D} = \mathred{D} \) W3 = \(\mathred{D} = \mathred{D} \) W4 = \(\mathred{D} = \mathred{D} \) W5 = \(\mathred{D} = \mathred{D} \) W6 = \(\mathred{D} = \mathred{D} \) Py = \(\mathred{D} = \mathred{D} \) To be of a stoing (w ^R) To be of a stoing (w ^R) The continued by profiting symbols of stoing (w) in the copposite ordered. e.g. w = \(\mathred{D} = \mathred{D} = \mathred{D} \) The mathred \(\mathred{D} = \mathred{D} = \mathred{D} \) The mathred \(\mathred{D} = \mathred{D} = \mathred{D} \) Powers : set of \(\mathred{Z} = \mathred{D} \)		-) Ordered collections / set
E.g. a = (2,15, 23) Tuples = 3 Symbol: Alphabet (\(z\)) String (\(w\)) a Finite non empty The finite sequence of A set of symbols Symbols taken from any (a) e.g. z = \(\alpha\), b3 alphabet usually written: \(z=\xi_0,1\) to each other without separate by, or blank space. Ey z = \(\alpha\), b3 String (\(w\)) = ababa Concatenation of a String/Symbol Length of string = 1w 1 \(\delta\) Denoted by \(\to\) (.) \(\delta\) are two strings then there concatenation written of \(\omega\), w_1 w_2 or unual diobtained by appending we to the end of \(\omega\). E.g. z = \(\alpha\), b3 \(\omega\) = ababa \(\omega\) Are the ordered. E.g. w = ababa , w ^R = ababa. If w = \omega\) then it is a pulindown oner a giren z.		
Symbol: Albhabet (\(\varepsilon\) Storny (\(\varepsilon\)) a Finite non empty The finite sequence of A set of symbols Symbols taken from any a liphabet usually norther: \(\varepsilon\) \(\varepsilon\) to each other mithout separate by, vs blank space. by, vs blank space. by, vs blank space. cy \(\varepsilon\) = \(\varepsilon\) storny (\(\varepsilon\)) = \(\varepsilon\) storny (\(\varepsilon\)) = \(\varepsilon\) storny (\(\varepsilon\)) = \(\varepsilon\) to each other mithout separate by, vs blank space. cy \(\varepsilon\) = \(\varepsilon\) storny (\(\varepsilon\)) = \(\varepsilon\) to each of the storny = \(\varepsilon\) with \(\varepsilon\) are two stornys then there concatenation vioritien of \(\varepsilon\), we appending we to the end of where \(\varepsilon\) = \(\varepsilon\) and \(\varepsilon\) appending we to the end of where \(\varepsilon\) = \(\varepsilon\) ababa Reverse of a storny (\(\warepsilon\))? The is obtained by noriting symbols of storny (\(\varepsilon\)) in the opposite ordered. cy \(\varepsilon\) = ababa \(\varepsilon\) ababa \(\varepsilon\) = ababa		
A set of symbols symbols taken from any (a) e.y &= &a,b? alphabet usually written: & & & & & & & & & & & & & & & & & &		The state of the state of the state of the
A set of symbols symbols taken from any (a) e.y &= &a,b? alphabet usually written: & & & & & & & & & & & & & & & & & &		Symbol: Albhabet (E) Stoiny (W)
A set of symbols symbols taken from any (a) e.y \(\xi = \xi_0 \) by alphabet usually writter: \(\xi = \xi_0 \) to each other without separate \(\xi = \xi_0 \) to each other without separate \(\xi_0 \xi_		a Finite non empty The finite securnce of
alphabet usually writter: i		A set of symbols symbols taken from any
to each other without separate by, us blank space. Ex \(\xi = \xi a_1 b_3 \) Stoing (W) = ababa Concatenation of a Stoiny/Symbol Length of stoing = IW 1 7 Denoted by -> (.) We do us are two stoings then there concatenation written who are two stoings then there concatenation written who are usual dobtained by appending we to the end of who is a set of a stoing (W) Perfore of a stoing (WR) 7 It is obtained by writing symbols of stoing (W) in the opposite ordered. E.g. w = ababa If w = wR then it is a palindrum oreo a given \(\xi \). Points is set of \(\xi \)		a e.y = sa, b3 alphabet usually written:
by, or blank space. Cy \(\xi = \xi_0 \xi_0 \) Storny (N) = ababa Comatenation of a Storny/Symbol Length of storny = IN To Denoted by -> (We was are two stornys then there concatenation norther a wing or wing a obtained by appending we to the end of we are ababa We = \xi = \xi_0 \xi_0 \xi Wi = \xi = \xi_0 \xi Wi = \xi = \xi_0 \xi Ports : Set of \xi		
Storny (W) = ababa Comatenation of a Storny/Symbol Length of storny = IW Then Denoted by -> (.) We was are two stornys then there concatenation written of which we was a obtained by appending we to the end of which we was a baba We get z=qa,b? Why = ababa Reverse of a storny (w) The sobtained by writing symbols of storny (W) in the opposite ordered. e.g. w = ababa , w = ababa If w = w then it is a pulindown oner a given z. Pomer : Set of z.		by, or blank share.
Story (W) = ababa Concatenation of a Story/Symbol Length of story = IW Therefore by -> (.) We are two Storys then there concatenation written of the concatenation of the con		ey £ = \$ a, b}
Concatenation of a Stoiny/Symbol Length of stoiny = IN The Denoted by -> (.) We do we are trous stoings them there concatenation written of which we are troused by appending we to the end of which we see a stoing (we). We see a stoing (we). The is obtained by writing symbols of stoing (N) in the opposite ordered. E. g. w = ababa , we = ababa. If w = we then it is a palindrom over a given see. Porce in Set of se		
W1 & w3 are two strings then there concatenation norten of w1. w2 or w2 w2 & obtained by appending w2 to the end of w3. e.y = = = = = = = = = = = = = = = = = = =		Concatenation of a Stoiny/Symbol Length of stoing = IW 1
We do we are two stoings then these concentration norten of we way or we way a obtained by appending we to the end of we great a stoing we want to be end of we great a stoing (we). All is obtained by writing symbols of stoing (x) in the opposite ordered. E.g. w = ababa graph ababa. If w = we then it is a palindrom one of a given 2. Ports : set of 2.		-> Denuted by -> (.)
wy. wz co wywz d Obtained by appending wz to the end of wz. e.y. z= aba wz=ba. wy = ababa Peresse of a stoing (wR) It is obtained by writing symbols of stoing (w) in the opposite ordered. e.g. w = ababa , wR = ababa. If w = wR then it is a palindown over a given z. Power : set of z	A	WI do ws are two storys then there concatenation written a
ey = \$\int \text{2} = \$\int \alpha_1 \text{bg}. \[\text{W}_1 \text{w}_2 = \text{ababa} \text{w}_2 = \text{ababa}. \[\text{W}_1 \text{w}_2 = \text{ababa} \text{ababa}. \[\text{Percentage} \text{CP} \text{voiting} \text{Symbols of Stoing (v) in the opposite ordered.} \[\text{e.g.} \text{w} = \text{ababa} \text{ababa}, \text{w}^R = \text{ababa} bulindown over a girln \$\text{\vec{\vec{\vec{\vec{\vec{\vec{\vec{\vec		wy.wz or wywz of obtained by appending we to the end of
Wy = aba wz = ba. Wy = ababa Reverse of a storing (wR) The is obtained by writing symbols of storing (N) in the opposite ordered. e.g. w = ababa, wR = ababa. If w = wR then it is a pulindown over a given z. Porty: Set of z.		was introction as some as a partition of the lower to
Wy = aba wz = ba. Wy = ababa Reverse of a storing (wR) The is obtained by writing symbols of storing (N) in the opposite ordered. e.g. w = ababa, wR = ababa. If w = wR then it is a palindown over a given z. Porty : Set of z.	, n	ey. == \a, b3
Reverse of a storing (wR) 7 It is obtained by writing symbols of Storing (w) in the opposite ordered. e.g. w = ababa , wR = ababa. If w = wR then it is a palindown over a given \(\frac{z}{2}\). Porty : Set of \(\frac{z}{2}\).		Wy = aba Wz = ba.
Reverse of a storing (wR) 7 It is obtained by worting symbols of Storing (w) in the opposite ordered. e.g. w = ababa , wR = ababa. If w = wR then it is a palindown over a given \(\frac{z}{2}\). Porty : Set of \(\frac{z}{2}\).		W, wa = ababa
7 It is obtained by writing symbols of String (N) in the opposite ordered. e.g. w = ababa, w ^R = ababa. If w = w ^R then it is a palindown over a given z. Porty : set of z.		
7 It is obtained by writing symbols of String (N) in the opposite ordered. e.g. w = ababa, w ^R = ababa. If w = w ^R then it is a palindown over a given z. Porty : set of z.		Reverse of a string (wR)
e.g. w = ababa , w ^R = ababa. If w = w ^R then it is a palindown creo a giren \(\mathcal{z}\). Porty : Set of \(\mathcal{z}\).	7	It is obtained by writing symbols of Stoing (w) in the
Ports : set of z		Opposite ordered.
Ports : set of z		e.g w = ababa , w = ababa.
Porres : Set of z		If w=wR then it is a balindown over a giren E.
Ports : set of z. Denoted as 7. (zm)		January Ofter St.
Densted as 7. (zn)		Porrer : set of z
		Denoted as 7. (zn)
Scanned with CamScanner		

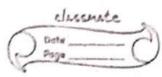


7	Set of all possible stoings over == \$a, b3.
	== = 2" n=length of Strings (neN)
	2= no. or symbols in &
4	En can be obtained by depentedly concatenating the
	Symbols form the & , O or more no. of times
7	5" = 5° U z' U ξ2 U Uż" = E υ (a,b) υ (aa,ab).
	a°/ 60 = [-> null storny = {: E : a, b, aa lab, ba, bb ; }
	5#: Set of all possible storys over & that can be obtained
1 1	by (incutenating symbols form 12' zero / more no. of times.
	> The complete language over == Sab?
	=> 15# - Klein clusure / Stuo Operation.
and.	Et The Closuse of E. 1 1
	&+ : It is obtained by concatenating the symbols form (2) 1
	of muse no. of times.
	£+ = ½ 1 U £ 2 U U £ 7
	= { a, b, a a, ab, b a, b b,
	=> 2*- {e} = 2+ mit (lustre)
	3. Per de l'adartion
	Poefix & Suffix of Stoings.
7	If y=xz then the symbol x & stoing az including the null stoing are its prefix
	ex w= abab Paefix (w)= { E, a, ab, aba, abab}
	If length of wisn, then it has n+1 poefix = length (w)=4, Poefix=5
7	The set of all other brefixes of the given stoing excluding the
	Stoing itself gives its pouper prefixes.
	If length of w=n, then its boulder bacfixes = n.
	If length of w=n, then its bouber prefixes = n. Pouper (w) = SE, a, ab, aba}
	Suffix
	If y=xz, then the symbol. & stoing xz includes the null stoing
	are its suffix. e.g w=abab > E. abab. E
	Suffix (w) = {E, b, ab, bab, abab}
	Length (w)= 4, 64ffix (FV)=5
	0



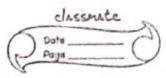
	Automata Language Theory
	This field of Toc is the study of ravorous computational
-85	machine labstract machine which are used to solve various
9	Computational porblems.
	Also this field gives us the defination, portesties of
	cababilities of such machine. These abstract machines.
	also known as Automaty (Automachine).
	0 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
->	An Automata is an abstract computation muchine that is
	used to solve certain mathematical pardems.
	Just like any other muchine, an automation has essential
	or poimary characteristics. It has 3 main characteristics
	The the second of the property to be able to
(i	States: It gives the present state information of an
38.	automation at any point of time.
9	I still Redamps thegai not store; some spream make
(ii.	Input: At any instance of time the input supplied to
-01	an automation is deposented using this characteristics.
	the board state appropriate year was that a home a constitution
	Toursitions / Behaviour: At any instance of time form any
144	given state on seceiving an imput symbol how the.
	automata in behaving is defined by the townsition of the
	automata in behaving is defined by the toursition of the automata. Usually sepoesented using a toursition function (8)
1.40	At any point of time an automatom can be in any one the
	States, reads the input form the input Tape, may use
3 18	Some kind of temporary storage or may not use any
	Stronge elements. In the next step it may change to
2704	Stronge elements. In the next step it may change to some other state based on the input seceive or it may
Δ,	bemain in the same state or in the end of the input
· .	bourcessing it gave it output.
1.4	Based on their capabilities automation are of 4 types





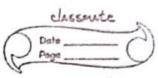
	Notation to deported TA
	Theor are two notations used to represent any type of
	Automata:
1.	State - Toursition Diagram.
	In this deposentations circles are used to repossent states of
	disended edges labelled the inbut symbol used to sepoesent the
	toungtim form 1 to Other State.
	PRESS
	(On) (off)
	PAESS
	The second of th
	Always a FA (every other automata as well) starts proviessing the
	inputs from a state known as the initial state or stust state.
7	In this method a circle / state pointed by an directed edge.
	with no origin is represented as an initial state
	And a FA always accepts the input strong if and only if
	at the end of the input stoing it enters to an accepting.
E .	state. In this method an accepting state / final state is
	represented using a double circle ().
-	There is exactly one initial state for every type of automata.
	where as these can be mose than one final state to every.
	type of automata.
	- And or as a selection
<u> </u>	Transition Table representation.
41	In this method the automata are represented using tubles
	where the owns of the tuble represents the states of
1. 1.	automata & the columns of the table represents the input
	symbols. The value under erroy (sor, column) pair.
	represents the transition from one state to other.
	In this method the initial state / stuot state is marked by
	using an directed edge pointing from no where to a pusticular
	State and an accepting state is represented using an *
	Scanned with CamScanner

	astrisk munk one	the giren symbol.		
15 19 100	states Input	water a maintain of the same		
	States			
		services of the second of the second		
3 11		OFF		
3-18	OFF*	ON		
		And the second of the second		
		formally defined as a 5 tuple as follows		
	1	S, 90, F).		
	Q: Finite non empty set.			
17 175	2: Input alphabet.			
3.3	D: Founsition	of function.		
2010	qui 9 niti al /	Stuff State (go E Q)		
		of Accepting / Anal States (FEQ)		
1,	1 Committee to	of tell regions to the 87 is to		
· · · · · · · · ·	1	Automota		
	A OFA is the simple	st FA that uses Detroministic computation.		
	in other moods in a	DFA form any single state on any		
- 13 m 40	Single input symbo	I at any point of time there is exact		
+ t/a/t/2	one path of comput	ation / exactly one townsition defined.		
	and the party of the	ship is the		
	Acceptance Mechanis	m of DFA		
1 4 1	Stusting form the 's	nitial state, deading the imput storny		
25,407	from input take from	o left to sight one symbol at a time		
	at the end of pour	cessing the input stoing if a DFA.		
1,000	enters accepting /14	mul State then the inhut ching is said		
	to be accepted of	permise regiented		
	00 : 0	il a one		
	(P)	93		
	and the section	0,1		



	formally a DFA is sepresented as a 5 tuples.
	D= (Q, 1, 8, 90, F).
	$S: Q \times S \rightarrow Q$
	A STATE OF THE STA
	Q = \q
	Z = \$0, 13
	$\delta: \delta(q_{0}, 0) \rightarrow q_{0} \qquad \delta(q_{2}, 0) \rightarrow q_{1}$
	δ (q0,1) + q1, (δ (q2,11) + q1)
	δ (41,0) + 42
	$\delta(q_1, 1) \rightarrow q_1$
	90: 5 903
	F: { 9, 3
12.	1
	m1 () O
	(90)
	Elist +
	mi= (990, 1913, 80, 13, "8, 8903, 89133
	S: S(40,0) -> 4,
	$\delta(q_0, 1) \rightarrow q_0$
	8(91,0) -) 90
	δ (quy 10) -) qi 10 - 10 - 10 - 10 - 10
	0 1 0 0 10000
	(90) (92)
	0,1
	W=1 touce fix i/p W=1
	$\begin{cases} (q_{0,1}1) \rightarrow q_1 \end{cases}$
-	V=01.
	$\delta(q_{0,102}) \rightarrow \delta(q_{0,1}) \rightarrow q_{1}$
	W=100 X
	S(90,00) → S(90,0) → 90

	W=101 - 10 1 10 10 10 10 10 10 10 10 10 10 10 1
	δ(q0,1011) -> δ(q0,011) -> δ(q2,11) -> q1
	W=1010100 V
	W = 10111010 X
	M= 000/00 N
	W=11101 V
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	L(m) = SWIW = \$0,13 that contains atteast one '1' and the
	last 1 in the stoing w will always followed by even no. of 0's 3.
Q	Consider the DFA and identify the language recognised.
	0' 0 Q'
	(90) (91)
	L(m2)= &WIN E So, 13 that contains odd no. of 0's 3.
	W= 0
	W=10 (1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	W=01 , 6- () ()
	W= 101
	at a* + 5 a" 1 n > 0 3 6, a, aa.
8 - 1	
	* vad '0's * (00, 62,04,06)= (00)*
= =	A STATE OF THE STA
	A O OT
	(90)
1 6	
197411	L(mg) = & WIW & & O,13 that contains even no. of 0's }
	the first the first the first the



Note	Any Automata in which the initial state itself a final state
	excepts & by definelt or nie yersa.
	Q1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	(P) (P) (P)
_	(bw9)
	(0+1)* 001 (0+1)*
	(011) 001 (041)
0	0001411111
Ψ	Design a DFA for a giren language. L = & V W & So, 13 that contain 5 OD1 95 substoing ?.
	= { 001, 0001, 00011
	O' O° O°
142	(9) 0 (9) 1 (9) (9) (9) (9) (9) (9) (9) (9) (9) (9)
1.50	16 20 and and and migrand had single
	W= 001 2 mayor promoted out all is appell.
	IW) = 3 , No. of state = 3+ 2, = 4.
	and the start of t
	000000000000000000000000000000000000000
	THE PARTY OF THE P
	Design a DFA for a girth language.
	L= 9 W I W = & a, b3 that contains even a's ?
	Qb a
	(a ord)
	a delication
	C Thomas de

