UNIVERSITY OF ENGINEERING & MANAGEMENT, KOLKATA

DEPARTMENT OF COMPUTER SCIENCE

Formal Language & Automata Theory

Code: PCCCS402

Contacts: 3L

Credits: 3

Module-1:

Introduction to concepts of alphabet, language, production rules, grammar and automaton, finite state model, concept of DFA and its problems, concept of NFA and its problems. NFA to DFA conversion, Construction of DFA & NFA for any given string and vice versa, Minimization of FA and equivalence of two FA, Mealy & moore machine and their problems. Limitations of FSM.

Module-2:

Introduction to the concept of Chomosky Classification of Grammar, language generation from production rules and vice- versa. regular language and regular expressions, identity rules. Arden's theorem state and prove, Construction of NFA from regular expression, Conversion of NFA with null moves to without null moves, closure properties, pumping lemma and its applications.

Module-3:

Introduction to Context Free Grammer, Derivation trees, sentential forms. Right most and leftmost derivation of strings, concepts of ambiguity. Minimization of CFG, Chomsky normal form, Greibach normal form, Pumping Lemma for Context Free Languages, Enumeration of properties of CFL (proofs omitted). Closure property of CFL, Ogden's lemma & its applications, Push Down Automata: Push down automata, definition and description, Acceptance of CFL, Acceptance by final state and acceptance by empty state and its equivalence, Equivalence of CFL and PDA, interconversion, DCFL and DPDA.

Module-4:

Turing Machine : Turing Machine, definition, model, Design of TM, Computable functions, Church's hypothesis, counter machine, Types of Turing machines (proofs not required), Universal Turing Machine, Halting problem, P, NP.

Module-5:

Basic definition of sequential circuit, block diagram, mathematical representation, concept of transition table and transition diagram, Design of sequence detector, Finite state machine:

Definitions, capability & state equivalent, kth- equivalent concept, Merger graph, Merger table, Compatibility graph, Finite memory definiteness, testing table & testing graph.

TEXT BOOKS:

1. "Theory of Computer Science ", Automata Languages and computation", Mishra and Chandrashekaran, 2nd edition, PHI.
2. "An Introduction to Formal Languages and Automata" , Peter Linz.
3. "Formal Languages and Automata Theory", C.K.Nagpal, Oxford.

REFERENCES:

1. "Switching & Finite Automata", ZVI Kohavi, 2nd Edn., Tata McGraw Hill.
2. "Introduction to Automata Theory Language and Computation", Hopcroft H.E. and Ullman J. D., Pearson Education.

UNIVERSITY OF ENGINEERING & MANAGEMENT, KOLKATA

Paper Name:	**Formal Language & Automata Theory**
Paper Code:	**PCCCS402**
Contact Hours:	**3**
Credit Point:	**3**

Course Educational Objective:		Understanding of theory of computation, grammars and basics of compiler design.
Prerequisites:		Elementary discrete mathematics including the notion of set,function,relation,product,partial order,equivalence relation,graph& tree. They should have a thorough understanding of the principle of mathematical induction.
Course Outcome:	**CO1**	After studying Finite Automata The student will be able to define a system and recognize the behavior of a system. They will be able to minimize a system and compare different systems.
	CO2	After studying regular language and grammer Student will convert Finite Automata to regular expression. Students will be able to check equivalence between regular linear grammar and FA.
	CO3	After studying CFG and PDA Students will be able to minimize context free grammar. Student will be able to check equivalence of CFL and PDA. They will be able to design Turing Machine.
	CO4	After studying turing machine Students will be able to design Turing machine.

Detailed Planning:

Module	Class Sequence	Topic	CO Mapping
1	1st Class	Introduction to concepts of alphabet,language,production rules,grammer and automaton.	CO1
1	2nd Class	Introduction to finite state model, concept of DFA and its problems.	CO1
1	3rd Class	Revision of DFA and introduction of NFA and its problems. NFA to DFA conversion	CO1
1	4th Class	Construction of DFA & NFA for any given string and vice versa.	CO1
1	5th Class	Minimization of FA and equivalence of two FA.	CO1
1	6th Class	Introduction to mealy & moore machine and their problems.	CO1
2	7th Class	Introduction to the concept of Chomosky Classification of Grammer.	CO2
2	8th Class	Introduction to language generation from production rules and vice versa.	CO2
2	9th Class	Introduction to regular language and regular expressions.	CO2

2	10th Class	Discussion of identity rules and corresponding problems.	CO2
2	11th Class	Discussion of Arden's theorem and proof of arden's theorem and its applications.	CO2
2	12th Class	Construction of NFA from regular expression.	CO2
2	13th Class	Conversion of NFA with null moves to without null moves.	CO2
2	14th Class	Discussion of closure properties.	CO2
2	15th Class	Discussion of pumping lemma and its applications.	CO2
3	16th Class	Introduction to Context Free Grammer, Derivation trees, sentential forms. Right most and leftmost derivation of strings, concepts of ambiguity.	CO3
3	17th Class	Minimization of CFG.	CO3
3	18th Class	Discussion of Chomsky normal form and its problems.	CO3
3	19th Class	Discussion of Greibach normal form and its problems.	CO3
3	20th Class	Pumping Lemma for Context Free Languages.	CO3
3	21st Class	Enumeration of properties of CFL (proofs omitted). Closure property of CFL, Ogden's lemma & its applications	CO3
3	22nd Class	Push Down Automata: Push down automata, definition and description.	CO3
3	23rd Class	Acceptance of CFL, Acceptance by final state and acceptance by empty state and its equivalence.	CO3
3	24th Class	Equivalence of CFL and PDA, interconversion.	CO3
3	25th Class	Introduction to DCFL and DPDA.	CO3
4	26th Class	Turing Machine : Turing Machine, definition, model, Design of TM, Computable functions.	CO4
4	27th Class	Church's hypothesis, counter machine, Types of Turing machines .	CO4
4	28th Class	Universal Turing Machine, Halting problem. Concept of P, NP class.	CO4
5	29th Class	Basic definition of sequential circuit, block diagram, mathematical representation, concept of transition table and transition diagram, Design of sequence detector.	CO5
5	30th Class	Finite state machine: Definitions, capability & state equivalent, kth- equivalent concept.	CO5
5	31st Class	Merger graph, Merger table, Compatibility graph.	CO5
5	32nd Class	Finite memory definiteness, testing table & testing graph.	CO5
5	33rd Class	Revision of all modules.	CO5

Text Books:

1 "Theory of Computer Science ", Automata Languages and computation", Mishra and Chandrashekaran, 2nd edition, PHI.

2 "An Introduction to Formal Languages and Automata" , Peter Linz

3 "Formal Languages and Automata Theory", C.K.Nagpal, Oxford

Reference Books and Journals:

1 "Switching & Finite Automata", ZVI Kohavi, 2nd Edn., Tata McGraw Hill

2 "Introduction to Automata Theory Language and Computation", Hopcroft H.E. and Ullman J. D., Pearson Education.

University of Engineering & Management, Kolkata

Workbook, Even Semester, 2020

Course: B.Tech (CSE) **Semester: 4^{th}**

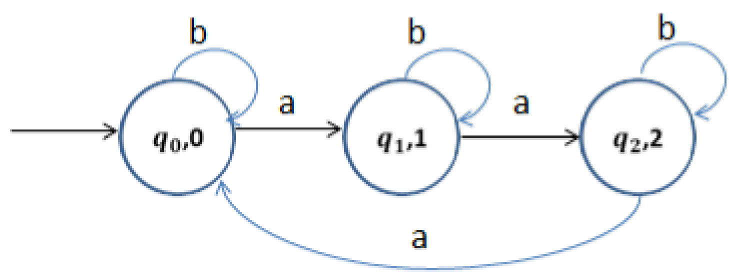
Paper Name: Formal Language and Automata Theory

Paper Code: PCCCS402

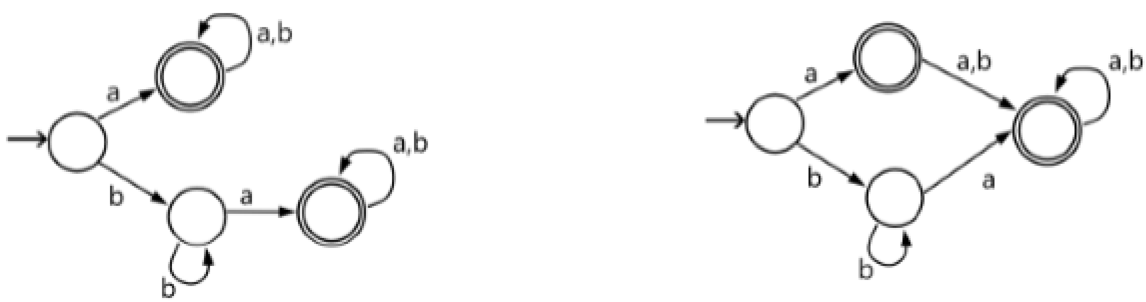
Finite Automata

1. Construct a DFA that accept all strings over the alphabets {a, b} where the string length is divisible by two.
2. Construct a DFA that accept all strings over the alphabets {a, b} where the string length is not divisible by two.
3. Construct a DFA where $|\omega| \cong 1 \; mod \; 3$
4. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' in the string is two.
5. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' in the string at most two.
6. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' in the string is even.
7. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' in the string is divisible by 3.
8. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'b' in the string is divisible by 5.
9. Construct a DFA that accept all strings over the alphabets {a, b} such that $n_b(\omega) \; \cong 1 \; mod \; 3$
10. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' and number of 'b' in the string is even.
11. Construct a DFA that accept all strings over the alphabets {a, b} where number of 'a' is divisible by 3 and number of 'b' in the string is divisible by 2.
12. Construct a minimal DFA which accepts all strings over {0,1}, which when interpreted as binary number is $\cong 2 \; mod \; 3$.
13. Construct a minimal DFA which accepts all strings over {0,1,2}, which when interpreted as ternary number is divisible by 4.
14. Construct a minimal DFA which accepts set of all strings over {a, b} where each string starts with an 'a'.

15. Construct a minimal DFA which accepts set of all strings over {a, b} where each string contains an ‘a’.
16. Construct a minimal DFA which accepts set of all strings over {a, b} where each string ends with an ‘a’.
17. Show that $L = \{a^p | p\ is\ prime\}$is not regular.
18. Show that $L = \{a^n b^n | n \geq 1\}$is not regular.
19. Construct Finite Automata equivalent the Regular Expression$(aa + bb)(a + b)^*$.
20. Construct a grammar for the language $L = \ a^n c^i b^n, n, i\ \geq 0$.
21. Construct a grammar for the language $L = \ 0^m 1^n$,where$m\ \neq n, m, n\ \geq 1$.
22. Construct a grammar for the language $L = \ 0^m 1^n$,where$m\ \neq n, m, n\ \geq 1$.



23. Check two given DFA are equivalent or not:



Push Down Automata

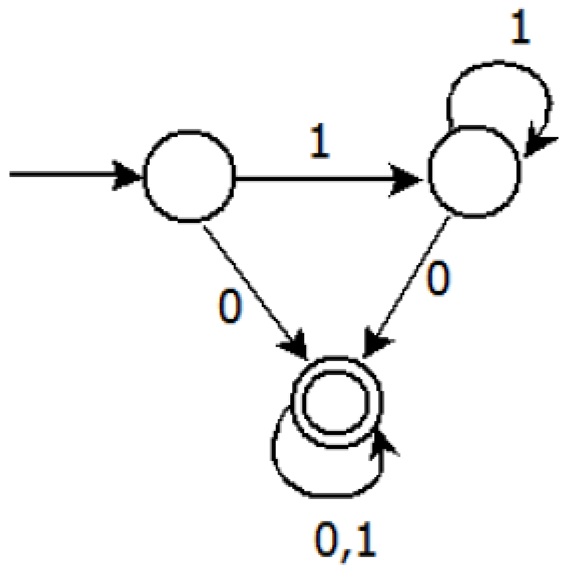
1. Write down the procedure or rule to construct the grammar G from PDA.
2. Construct the grammar G from the PDA A that accepting the language $L = \{a^n b^m a^n |\ m, n \geq 1\}$ by null store.
3. Construct the grammar G from the PDA A that accepting the language $L = \{a^n b^{2n} |\ n \geq 1\}$ by null store.
4. Construct the PDA A equivalent to the following grammar CFG: $S \rightarrow aSbb/ab$.
5. Construct the PDA A equivalent to the following grammar CFG: $S \rightarrow aABB/aAA\,; A \rightarrow aBB\ /\ a; B \rightarrow bBB\ /\ A$
6. Show that $L = \{a^{n^2} | n \geq 1\}$is not CFL.
7. Design the PDA for $L = \{a^n b^n | n \geq 1\}$ that accepting by final state.
8. Design the PDA for $L = \{wcw^T | w \in \{a, b\}^*\}$ that accepting by final state.

9. What do you mean by useless symbols in CFG? Eliminate the useless symbols from the following grammar $S \rightarrow AB/a\,; A \rightarrow b$.
10. Given the grammar $S \rightarrow AB; A \rightarrow a; B \rightarrow C/b\,; C \rightarrow D; E \rightarrow E; E \rightarrow a$, find an equivalent grammar which is reduced and has no unit production.
11. Reduce the following grammar G into Chomsky Normal Form (CNF). $S \rightarrow aAD; A \rightarrow aB/bAB\,; B \rightarrow b; D \rightarrow d$.
12. Convert the following grammar G into its equivalent GNF. $S \rightarrow abSb/aa$.
13. Convert the following grammar G into its equivalent GNF. $S \rightarrow ABb/a\,; A \rightarrow aaA/B\,; B \rightarrow bAb$.

Turing Machine

1. a) Write an unrestricted grammar to accept the language $L = a^i b^j c^k d^l | i = k \; and \; j = l$. Mention the start symbol of your grammar. Use upper case Roman letters for non-terminal symbols.b) Show a derivation of the string $a^2 b^3 c^2 d^3$ according to your grammar.
2. Design a Turing Machine to find 2's complement of a given binary number.

Gate questions for your Practice



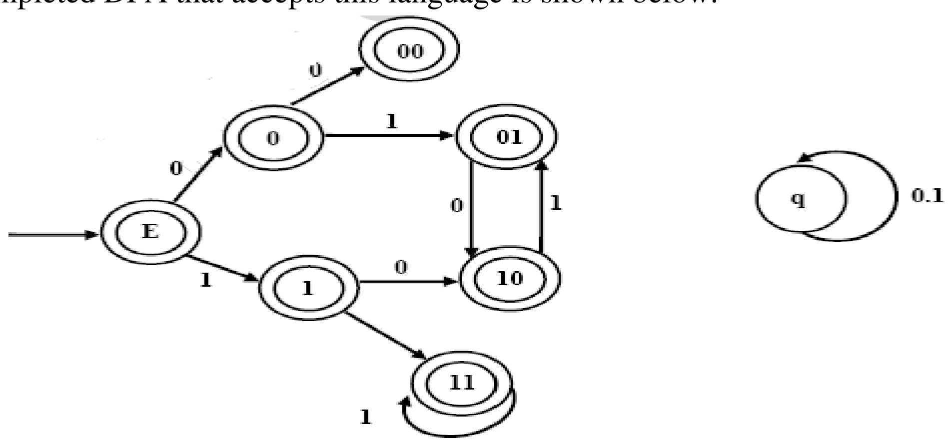
1.
Consider the DFA given. gatecs201313 Which of the following are FALSE?
1. Complement of L(A) is context-free.
2. L(A) = L((11*0+0)(0 + 1)*0*1*)
3. For the language accepted by A, A is the minimal DFA.
4. A accepts all strings over {0, 1} of length at least 2.
A 1 and 3 only
B 2 and 4 only
C 2 and 3 only
D 3 and 4 only

2. Given the language L = {ab, aa, baa}, which of the following strings are in L*?
1) abaabaaabaa
2) aaaabaaaa
3) baaaaabaaaab
4) baaaaabaa
A.1, 2 and 3
B.2, 3 and 4
C.1, 2 and 4
D.1, 3 and 4

3. Given the language L = {ab, aa, baa}, which of the following strings are in L*?
1) abaabaaabaa
2) aaaabaaaa
3) baaaaabaaaab

4) baaaaabaa
A.1, 2 and 3
B.2, 3 and 4
C.1, 2 and 4
D.1, 3 and 4

4. Consider the set of strings on {0,1} in which, every substring of 3 symbols has at most two zeros. For example, 001110 and 011001 are in the language, but 100010 is not. All strings of length less than 3 are also in the language. A partially completed DFA that accepts this language is shown below.



The missing arcs in the DFA are:

(A)

	00	01	10	11	q
00	1	0			
01				1	
10	0				
11			0		

(B)

	00	01	10	11	q
00		0			1
01		1			
10				0	
11		0			

(C)

	00	01	10	11	q
00		1			0
01		1			
10			0		
11		0			

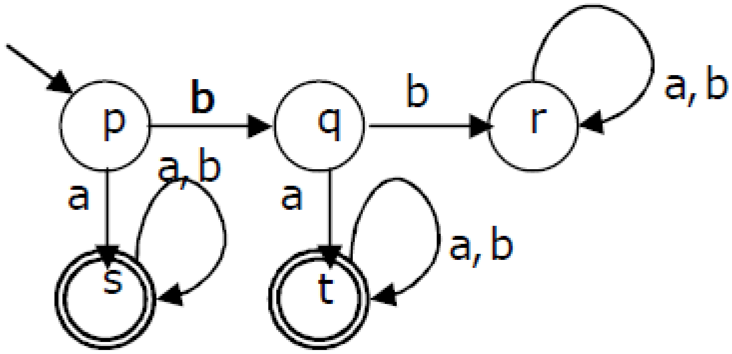
(D)

	00	01	10	11	q
00		1			0
01				1	
10	0				
11			0		

5. Definition of a language L with alphabet {a} is given as following.
L={a^(nk)| k>0, and n is a positive integer constant}
What is the minimum number of states needed in DFA to recognize L?

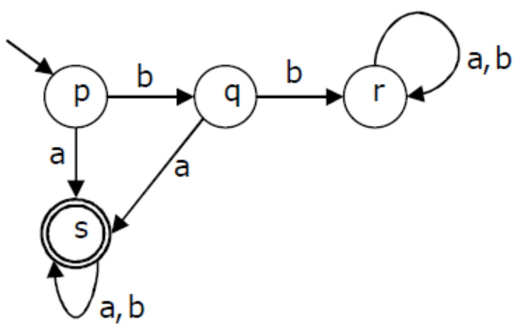
A.k+1
B.n+1
C.2^(n+1)
D.2^(k+1)

6. A deterministic finite automation (DFA)D with alphabet {a,b} is given below

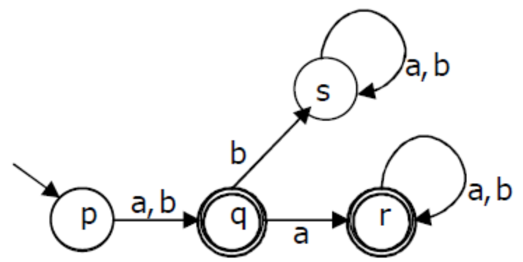


Which of the following finite state machines is a valid minimal DFA which accepts the same language as D?

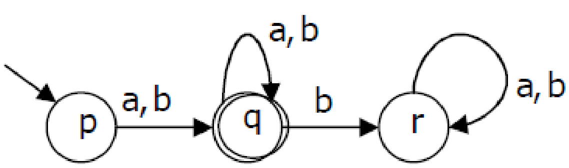
(A)



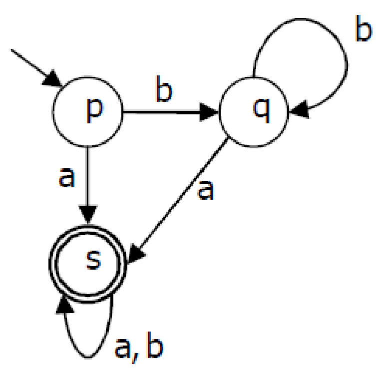
(B)



(C)



(D)



7. Let w be any string of length n is {0,1}*. Let L be the set of all substrings of w. What is the minimum number of states in a non-deterministic finite automaton that accepts L?

A.n-1
B.n
C.n+1
D.2n-1

8. 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)*?
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.

9. Given below are two finite state automata (→ indicates the start state and F indicates a final state)Which of the following represents the product automaton Z×Y?

Y:

	a	b
→ 1	1	2
2 (F)	2	1

Z:

	a	b
→ 1	2	2
2 (F)	1	1

(A)

	a	b
→ P	S	R
Q	R	S
R (F)	Q	P
S	Q	P

(B)

	a	b
→ P	S	Q
Q	R	S
R (F)	Q	P
S	P	Q

(C)

	a	b
→ P	Q	S
Q	R	S
R (F)	Q	P
S	Q	P

(D)

	a	b
→ P	S	Q
Q	S	R
R (F)	Q	P
S	Q	P

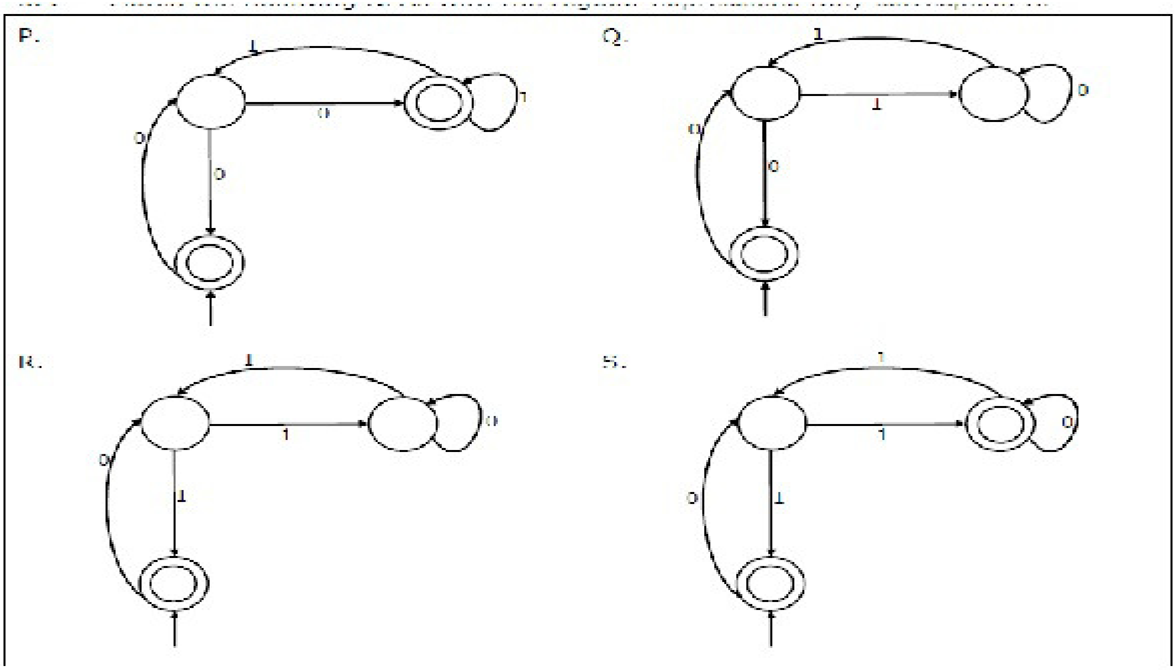
10. Match the following NFAs with the regular expressions they correspond to

1. $\epsilon + 0(01^*1 + 00)^*01^*$

2. $\epsilon + 0(10^*1 + 00)^*0$

3. $\epsilon + 0(10^*1 + 10)^*1$

4. $\epsilon + 0(10^*1 + 10)^*10^*$



A.P - 2, Q - 1, R - 3, S - 4

B.P - 1, Q - 3, R - 2, S - 4

C.P - 1, Q - 2, R - 3, S - 4

D.P - 3, Q - 2, R - 1, S – 4

11. Which of the following are regular sets?

I. $\{a^n b^{2m} \mid n \geq 0, m \geq 0\}$
II. $\{a^n b^m \mid n = 2m\}$
III. $\{a^n b^m \mid n \neq m\}$
IV. $\{xcy \mid x, y \in \{a,b\}^*\}$

A.I and IV only

B.I and III only

C.I only

D.IV only

12. A minimum state deterministic finite automaton accepting the language L={w I w ε {0,1} *, number of 0s and 1s in w are divisible by 3 and 5, respectively} has

A.15 states

B.11 states

C.10 states

D.9 states

13. Which of the following languages is regular?

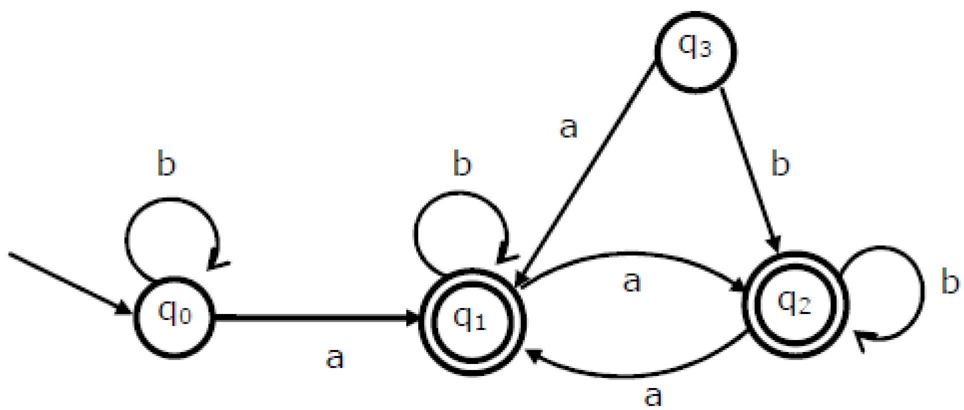
(A) $\{ww^R \mid w \in \{0,1\}^+\}$

(B) $\{ww^R x \mid x, w \in \{0,1\}^+\}$

(C) $\{wxw^R \mid x, w \in \{0,1\}^+\}$

(D) $\{xww^R \mid x, w \in \{0,1\}^+\}$

14. Consider the following Finite State Automaton. The language accepted by this automaton is given by the regular expression



(A) $b^*ab^*ab^*ab^*$ (B) $(a+b)^*$ (C) $b^*a(a+b)^*$ (D) $b^*ab^*ab^*$

15. Which one of the following is TRUE?

(A) The language $L = \{a^n b^n \mid n \geq 0\}$ is regular.

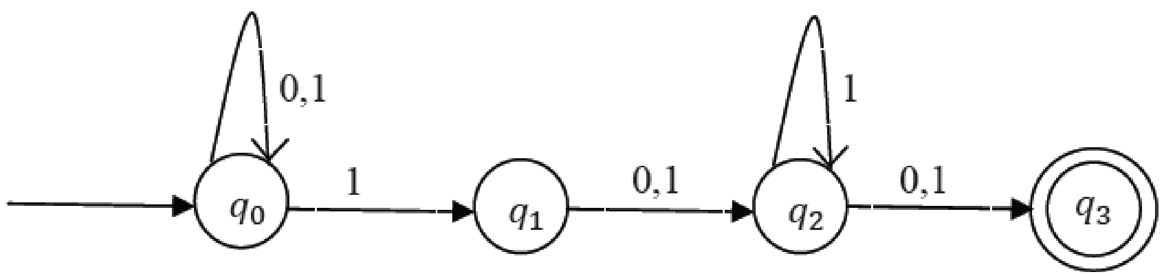
(B) The language $L = \{a^n \mid n \text{ is prime}\}$ is regular.

(C) The language $L = \{w \mid w \text{ has } 3k + 1\ b's \text{ for some } k \in \mathbb{N} \text{ with } \Sigma = \{a, b\}\}$ is regular.

(D) The language $L = \{ ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0,1\}\}$ is regular.

16.

Consider the finite automaton in the following figure.



What is the set of reachable states for the input string 0011?

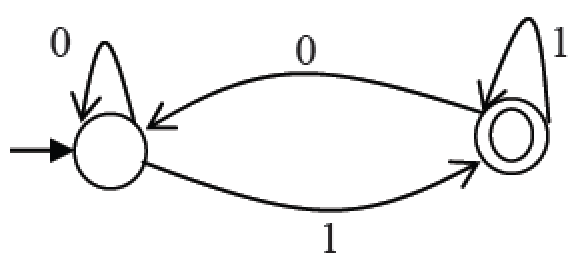
A.{q0, q1, q2}

B.{q0, q1}

C.{q0, q1, q2, q3}

D.{q3}

17. Which of the regular expressions given below represent the following DFA?



I) 0*1(1+00*1)*

II) 0*1*1+11*0*1

III) (0+1)*1

A.I and II only

B.I and III only

C.II and III only

D.I, II, and III

18. If $L_1 = \{a^n \mid n \geq 0\}$ and $L_2 = \{b^n \mid n \geq 0\}$, consider

(I) $L_1 \cdot L_2$ is a regular language

(II) $L_1 \cdot L_2 = \{a^n b^n \mid n \geq 0\}$

Which one of the following is CORRECT?

A.Only (I)

B.Only (II)

C.Both (I) and (II)

D.Neither (I) nor (II)

19. Let L1 = {w ∈ {0,1}∗ | w has at least as many occurrences

of (110)’s as (011)’s}.

Let L2 = { ∈ {0,1}∗ | w has at least as many occurrences

of (000)’s as (111)’s}.

Which one of the following is TRUE?

A.L1 is regular but not L2

B.L2 is regular but not L!

C.Both L2 and L1 are regular

D.Neither L1 nor L2 are regular

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

a*b*(ba)*a*

A.2

B.3

C.4

D.5

21. If s is a string over (0 + 1)* then let $n_0(s)$ denote the number of 0's in s and $n_1(s)$ the number of 1's in s. Which one of the following languages is not regular?

(A) $L = \{s \in (0+1)^* \mid n_0(s) \text{ is a 3-digit prime}\}$

(B) $L = \{s \in (0+1)^* \mid \text{ for every prefix } s' \text{ of } s, |n_0(s') - n_1(s')| \le 2\}$

(C) $L = \{s \in (0+1)^* \mid |n_0(s) - n_1(s)| \le 4\}$

(D) $L = \{s \in (0+1)^* \mid n_0(s) \bmod 7 = n_1(s) \bmod 5 = 0\}$

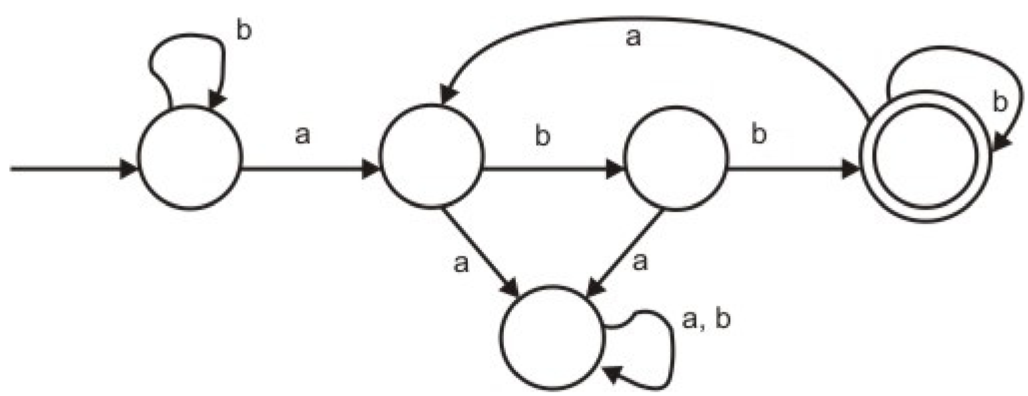
22. Consider the regular language L = (111 + 11111)*. The minimum number of states in any DFA accepting this languages is:

A.3

B.5

C.8

D.9



23.

Consider the machine M: GATECS2005Q53 The language recognized by M is :

A.{w ∈ {a, b}* / every a in w is followed by ex-actly two b's}

B.{w ∈ {a, b}* every a in w is followed by at least two b'}

C.{w ∈ {a, b}* w contains the substring 'abb'}

D.{w ∈ {a, b}* w does not contain 'aa' as a substring}

24. Let Nf and Np denote the classes of languages accepted by non-deterministic finite automata and non-deterministic push-down automata, respectively. Let Df and Dp denote the classes of languages accepted by deterministic finite automata and deterministic push-down automata, respectively. Which one of the following is TRUE?

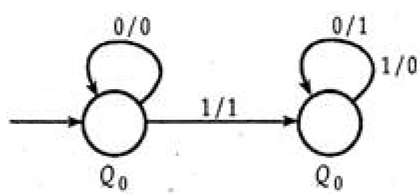
A.Df ⊂ Nf and Dp ⊂ Np

B.Df ⊂ Nf and Dp = Np

C.Df = Nf and Dp = Np

D.Df = Nf and Dp ⊂ Np

25. The following diagram represents a finite state machine which takes as input a



binary number from the least significant bit. Which one of the following is TRUE?

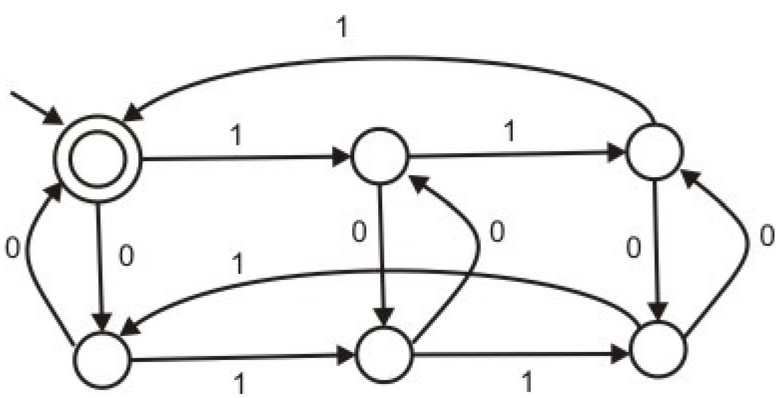
A.It computes 1's complement of the input number

B.It computes 2's complement of the input number

C.It increments the input number

D.It decrements the input number

26. The following finite state machine accepts all those binary strings in which the number of 1's and 0's are respectively.



A.divisible by 3 and 2

B.odd and even

C.even and odd

D.divisible by 2 and 3

27. The regular expression 0*(10*)* denotes the same set as

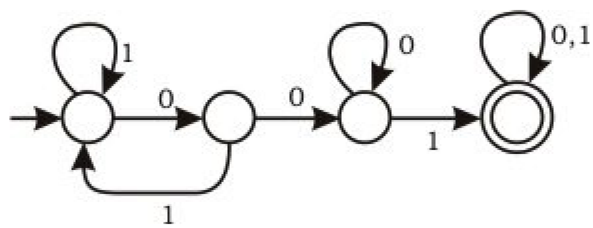
A.(1*0)*1*

B.0 + (0 + 10)*

C.(0 + 1)* 10(0 + 1)*

D.none of these

28. Consider the following deterministic finite state automaton M.



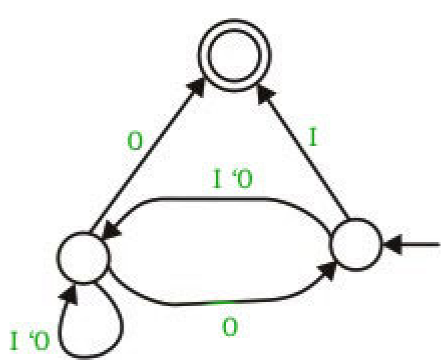
Let S denote the set of seven bit binary strings in which the first, the fourth, and the last bits are 1. The number of strings in S that are accepted by M is

A.1

B.5

C.7

D.8

29. 

Consider the NFA M shown below. GATECS2003Q55 Let the language accepted by M be L. Let L1 be the language accepted by the NFA M1, obtained by changing the accepting state of M to a non-accepting state and by changing the non-accepting state of M to accepting states. Which of the following statements is true ?

A.L1 = {0, 1}* - L

B.L1 = {0, 1}*

C.L1 ⊆ L

D.L1 = L

30.

$$L_1 = \left\{0^p\, 1^q\, 0^r \mid p, q, r \geq 0\right\}$$
$$L_2 = \left\{0^p\, 1^q\, 0^r \mid p, q, r \geq 0,\ p \neq r\right\}$$

Consider the following languages. Which one of the following statements is FALSE?

A.L2 is context-free.

B.L1 intersection L2 is context-free.

C.Complement of L2 is recursive.

D.Complement of L1 is context-free but not regular

31. Which of the following pairs have DIFFERENT expressive power?

A.Deterministic finite automata(DFA) and Non-deterministic finite automata(NFA)

B.Deterministic push down automata(DPDA)and Non-deterministic push down automata(NPDA)

C.Deterministic single-tape Turing machine and Non-deterministic single-tape Turing machine

D.Single-tape Turing machine and multi-tape Turing machine

32. Consider the language L1,L2,L3 as given below. L1={0^{p}1^{q} | p,q € N} L2={0^{p}1^{q} | p,q € N and p=q} L3={0^{p}1^{q}0^{r} | p,q,r € N and p=q=r} Which of the following statements is NOT TRUE?

A.Push Down Automata (PDA) can be used to recognize L1 and L2

B.L1 is a regular language

C.All the three languages are context free

D.Turing machine can be used to recognize all the three languages

33. Consider the languages L1 = {0^i1^j | i != j}. L2 = {0^i1^j | i = j}. L3 = {0^i1^j | i = 2j+1}. L4 = {0i1j | i != 2j}.

A.Only L2 is context free

B.Only L2 and L3 are context free

C.Only L1 and L2 are context free

D.All are context free

34. S -> aSa|bSb|a|b; The language generated by the above grammar over the alphabet {a,b} is the set of

A.All palindromes

B.All odd length palindromes.

C.Strings that begin and end with the same symbol

D.All even length palindromes

35. Let L = L1∩L2, where L1 and L2 are languages as defined below:

L1 = {a^mb^mca^nb^n | m, n >= 0 }

L2 = {a^ib^jc^k | i, j, k >= 0 }

Then L is

A.Not recursive

B.Regular

C.Context free but not regular

D.Recursively enumerable but not context free.

36. The language L= {0^i21^i | i≥0 } over the alphabet {0,1, 2} is:

A.not recursive

B.is recursive and is a deterministic CFL.

C.is a regular language.

D.is not a deterministic CFL but a CFL.

37. Consider the CFG with {S,A,B) as the non-terminal alphabet, {a,b) as the terminal alphabet, S as the start symbol and the following set of production rules

S --> aB S --> bA

B --> b A --> a

B --> bS A --> aS

B --> aBB A --> bAA

Which of the following strings is generated by the grammar?

A.aaaabb

B.aabbbb

C.aabbab

D.abbbba

38.

Consider the following languages over the alphabet $\Sigma = \{0,1,c\}$:

$$L_1 = \{0^n 1^n \mid n \geq 0\}$$
$$L_2 = \{wcw^r \mid w \in \{0,1\}^*\}$$
$$L_3 = \{ww^r \mid w \in \{0,1\}^*\}$$

Here, w^r is the reverse of the string w. Which of these languages are deterministic Context-free languages?

A.None of the languages

B.Only L1

C.Only L1 and L2

D.All the three languages

39.

Let $L_1 = \{0^{n+m}1^n 0^m \mid n, m \geq 0\}$, $L_2 = \{0^{n+m}1^{n+m} 0^m \mid n, m \geq 0\}$, and $L_3 = \{0^{n+m} 1^{n+m} 0^{n+m} \mid n, m \geq 0\}$. Which of these languages are NOT context free?

A.L1 only

B.L3 Only

C.L1 and L2

D.L2 and L3

40. Consider the following statements about the context free grammar

G = {S → SS, S → ab, S → ba, S → E}

I. G is ambiguous

II. G produces all strings with equal number of a's and b's

III. G can be accepted by a deterministic PDA.

Which combination below expresses all the true statements about G?

A.I only

B.I and III only

C.II and III only

D.I, II and III

41. Which one of the following grammars generates the language $L = \{a^i b^j \mid i \neq j\}$

(A)

$S \rightarrow AC | CB$

$C \rightarrow aCb | a | b$

$A \rightarrow aA | \in$

$B \rightarrow Bb | \in$

(B) $S \rightarrow aS | Sb | a | b$

(C)

$S \rightarrow AC | CB$

$C \rightarrow aCb | \in$

$A \rightarrow aA | \in$

$B \rightarrow Bb | \in$

(D)

$S \rightarrow AC | CB$

$C \rightarrow aCb | \in$

$A \rightarrow aA | a$

$B \rightarrow Bb | b$

42. In the correct grammar of above question, what is the length of the derivation (number of steps starring from S) to generate the string a^lb^m with l ≠ m?

A.max(l,m) + 2

B.l + m + 2

C.l + m + 3

D.max(l, m) + 3

43. Consider the languages:

L1 = {a^nb^nc^m | n, m > 0}

L2 = {a^nb^mc^m | n, m > 0}

Which one of the following statements is FALSE?

A.L1 ∩ L2 is a context-free language

B.L1 U L2 is a context-free language

C.L1 and L2 are context-free language

D.L1 ∩ L2 is a context sensitive language

44. Consider the languages:

$L1 = \{ww^R \mid w \in \{0, 1\}^*\}$

$L2 = \{w\#w^R \mid w \in \{0, 1\}^*\}$, where # is a special symbol

$L3 = \{ww \mid w \in (0, 1\}^*)$

Which one of the following is TRUE?

A.L1 is a deterministic CFL

B.L2 is a deterministic CFL

C.L3 is a CFL, but not a deterministic CFL

D.L3 is a deterministic CFL

45. The language $\{a^m b^n C^{(m+n)} \mid m, n \geq 1\}$ is

A.regular

B.context-free but not regular

C.context sensitive but not context free

D.type-0 but not context sensitive

46. If the strings of a language L can be effectively enumerated in lexicographic (i.e., alphabetic) order, which of the following statements is true ?

A.L is necessarily finite

B.L is regular but not necessarily finite

C.L is context free but not necessarily regular

D.L is recursive but not necessarily context free

47. Let G = ({S}, {a, b} R, S) be a context free grammar where the rule set R is $S \rightarrow a S b \mid SS \mid \varepsilon$ Which of the following statements is true?

A.G is not ambiguous

B.There exist x, y, $\in$ L (G) such that $xy \notin L(G)$

C.There is a deterministic pushdown automaton that accepts L(G)

D.We can find a deterministic finite state automaton that accepts L(G)

48. Which of the following statements is/are FALSE?

1. For every non-deterministic Turing machine,

   there exists an equivalent deterministic Turing machine.

2. Turing recognizable languages are closed under union

   and complementation.

3. Turing decidable languages are closed under intersection

   and complementation.

4. Turing recognizable languages are closed under union

   and intersection.

A.1 and 4 only

B.1 and 3 only

C.2 only

D.3 only

49. Let L1 be a recursive language. Let L2 and L3 be languages that are recursively enumerable but not recursive. Which of the following statements is not necessarily true?

(A) L2 – L1 is recursively enumerable.

(B) L1 – L3 is recursively enumerable

(C) L2 ∩ L1 is recursively enumerable

(D) L2 ∪ L1 is recursively enumerable

50. $\left\{a^p \mid p \text{ is a prime}\right\}$?

Which of the following is true for the language 16

A.It is not accepted by a Turing Machine

B.It is regular but not context-free

C.It is context-free but not regular

D.It is neither regular nor context-free, but accepted by a Turing machine

51. If L and L' are recursively enumerable, then L is

A.regular

B.context-free

C.context-sensitive

D.recursive

52. Let L be a language and L' be its complement. Which one of the following is NOT a viable possibility?

A.Neither L nor L' is recursively enumerable (r.e.).

B.One of L and L' is r.e. but not recursive; the other is not r.e.

C.Both L and L' are r.e. but not recursive.

D.Both L and L' are recursive

53. Let A ≤m B denotes that language A is mapping reducible (also known as many-to-one reducible) to language B. Which one of the following is FALSE? a) If A ≤m B and B is recursive then A is recursive. b) If A ≤m B and A is undecidable then B is undecidable. c) If A ≤m B and B is recursively enumerable then A is recursively enumerable. d) If A ≤m B and B is not recursively enumerable then A is not recursively enumerable.

A.a

B.b

C.c

D.d

54. For S ∈ (0 + 1) * let d(s) denote the decimal value of s (e.g. d(101) = 5). Let L = {s ∈ (0 + 1)* d(s)mod5 = 2 and d(s)mod7 != 4}. Which one of the following statements is true?

A.L is recursively enumerable, but not recursive

B.L is recursive, but not context-free

C.L is context-free, but not regular

D.L is regular

55. Let L1 be a recursive language, and let L2 be a recursively enumerable but not a recursive language. Which one of the following is TRUE?

L1' --> Complement of L1

L2' --> Complement of L2

A.L1' is recursive and L2' is recursively enumer-able

B.L1' is recursive and L2' is not recursively enumerable

C.L1' and L2' are recursively enumerable

D.L1' is recursively enumerable and L2' is recursive

56. L1 is a recursively enumerable language over Σ. An algorithm A effectively enumerates its words as w1, w2, w3, ... Define another language L2 over Σ Union {#} as {w^i # w^j : wi, wj ∈ L1, i < j}. Here # is a new symbol. Consider the following assertions.

S1 : L1 is recursive implies L2 is recursive

S2 : L2 is recursive implies L1 is recursive

Which of the following statements is true ?

A.Both S1 and S2 are true

B.S1 is true but S2 is not necessarily true

C.S2 is true but S1 is not necessarily true

D.Neither is necessarily true

57. Nobody knows yet if P = NP. Consider the language L defined as follows : GATECS2003Q13 Which of the following statements is true ?

A.L is recursive

B.L is recursively enumerable but not recursive

C.L is not recursively enumerable

D.Whether L is recursive or not will be known after we find out if P = NP

58. A single tape Turing Machine M has two states q0 and q1, of which q0 is the starting state. The tape alphabet of M is {0, 1, B} and its input alphabet is {0, 1}. The symbol B is the blank

symbol used to indicate end of an input string. The transition function of M is described in the following table

	0	1	B
q0	q1, 1, R	q1, 1, R	Halt
q1	q1, 1, R	q0, 1, L	q0, B, L

The table is interpreted as illustrated below. The entry (q1, 1, R) in row q0 and column 1 signifies that if M is in state q0 and reads 1 on the current tape square, then it writes 1 on the same tape square, moves its tape head one position to the right and transitions to state q1. Which of the following statements is true about M ?

A.M does not halt on any string in (0 + 1)+

B.M does not halt on any string in (00 + 1)*

C.M halts on all string ending in a 0

D.M halts on all string ending in a 1

59. Define languages L0 and L1 as follows :

L0 = {< M, w, 0 > | M halts on w}

L1 = {< M, w, 1 > | M does not halts on w}

Here < M, w, i > is a triplet, whose first component. M is an encoding of a Turing Machine, second component, w, is a string, and third component, i, is a bit. Let L = L0 ∪ L1. Which of the following is true ?

A.L is recursively enumerable, but L' is not

B.L' is recursively enumerable, but L is not

C.Both L and L' are recursive

D.Neither L nor L' is recursively enumerable

60. For any two languages L1 and L2 such that L1 is context free and L2 is recursively enumerable but not recursive, which of the following is/are necessarily true?

1. L1' (complement of L1) is recursive

2. L2' (complement of L2) is recursive

3. L1' is context-free

4. L1' ∪ L2 is recursively enumerable

A.1 only

B.3 only

C.3 and 4 only

D.1 and 4 only