Q1)

Which of the following strings would match the regular expression : p+ [3 – 5]* [xyz]?

I. p443y

II. p6y

III. 3xyz

IV. p35z

V. p353535x

VI. ppp5

A) I, III and VI only
B) IV, V and VI only
C) II, IV and V only
D) I, IV and V only

Q2)

Which of the following are not regular?

(A) Strings of even number of a’s.

(B) Strings of a’s, whose length is a prime number.

(C) Set of all palindromes made up of a’s and b’s.

(D) Strings of a’s whose length is a perfect square.

A) (A) and (B) only

B) (A), (B) and (C) only

C) (B), (C) and (D) only

D) (B) and (D) only

Q3)

The number of strings of length 4 that are generated by the regular expression (0+1+|2+3+)*, where | is an alternation character and {+, *} are quantification characters, is:

A) 8

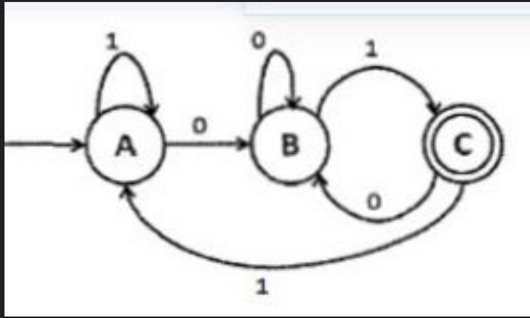
B) 9

C) 10

D) 12

Q4)

The following Finite Automaton recognizes which of the given languages?



A) {1, 0}* {01}

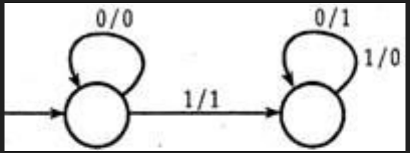
B) {1, 0}* {1}

C) {1}{1, 0}* {1}

D) 1*0* {0, 1}

Q5)

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 2's complement of the input number

B) It increments the input number

C) It computes 1's complement of the input number

D) None of these

Q6)

The smallest finite automata which accepts the language {x | length of x is divisible by 3}

as-------------------states

Q 7)

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

A. $((0+1)^*1(0+1)^*1)^*10^*$
B. $(0^*10^*10^*)^*0^*1$
C. $10^*(0^*10^*10^*)^*$
D. None of these

Q 8)

Consider the following languages $L1 = \{ww|w \in \{a,b\}*\}$

$L2 = \{ww^R|w \in \{a,b\}*, w^R is\ the\ reverse\ of\ \ w\}$, $L3 = \{0^{2i}|i\ is\ an\ integer\}$

$L4 = \left\{0^{i^2}|i\ is\ an\ integer\right\}$ Which of the languages are regular?

A) Only L1 and L2

B) Only L2, L3 and L4

C) Only L3 and L4

D) Only L3

Q9)

Let L1, L2 be any two context-free languages and R be any regular language. Then which of the following is/are False? (I) $(L1)' \cup L2 \cup L1$ is context-free (II) $R' \cup L2$ is context-free (III) $R \cap L1 \cap L2$ is context-free (IV) $R \cap L2$ is context-free

A) I, II and IV only

B) I and III only

C) II and IV only

D) I only

Q10)

Which of the following regular expressions, each describing a language of binary numbers (MSB to LSB) that represents non-negative decimal values, does not include even values ?

A) 0*1+0*1*

B) 0*1*0+1*

C) 0*1*0*1+

D) 0+1*0*1*

Q 11)

Let L1 be regular language, L2 be a deterministic context free language and L3 a recursively enumerable language, but not recursive. Which one of the following statements is false?

A) $L1 \cap L2$ is a deterministic CFL
B) $L3 \cap L1$ is recursive
C) $L1 \cup L2$ is context free
D) $L1 \cap L2 \cap L3$ is recursively enumerable

Q 12)

The number of strings of length 4 that are generated by the regular expression (0+1+|2+3+)*, where | is an alternation character and {+, *} are quantification characters, is:

A) 8

B) 9

C) 10

D) 12

Q13)

Which of the following languages is context-free?

A) $\{a^nb^n \mid n \geq 0\}$

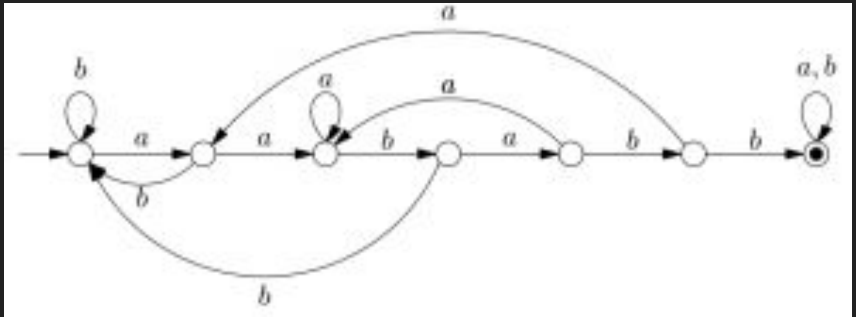
B) $\{a^nb^mc^n \mid n, m \geq 0\}$

C) $\{a^nb^nc^n \mid n \geq 0\}$

D) $\{a^n \mid n \text{ is a prime number}\}$

Q14)

Consider the following Deterministic Finite Automata   Which of the following is true?



A) It only accepts strings with prefix as "aababb"

B) It only accepts strings with substring as "aababb"

C) It only accepts strings with suffix as "aababb"

D) None of the above.

Q 15)

Consider the following two statements:
I. If all states of an NFA are accepting states then the language accepted by the NFA is Σ^* .

II. There exists a regular language A such that for all languages B, A U B is regular.
Which one of the following is CORRECT?

A) Only I is true

B) Only II is true

C) Both I and II are true

D) Both I and II are false

Q 16)

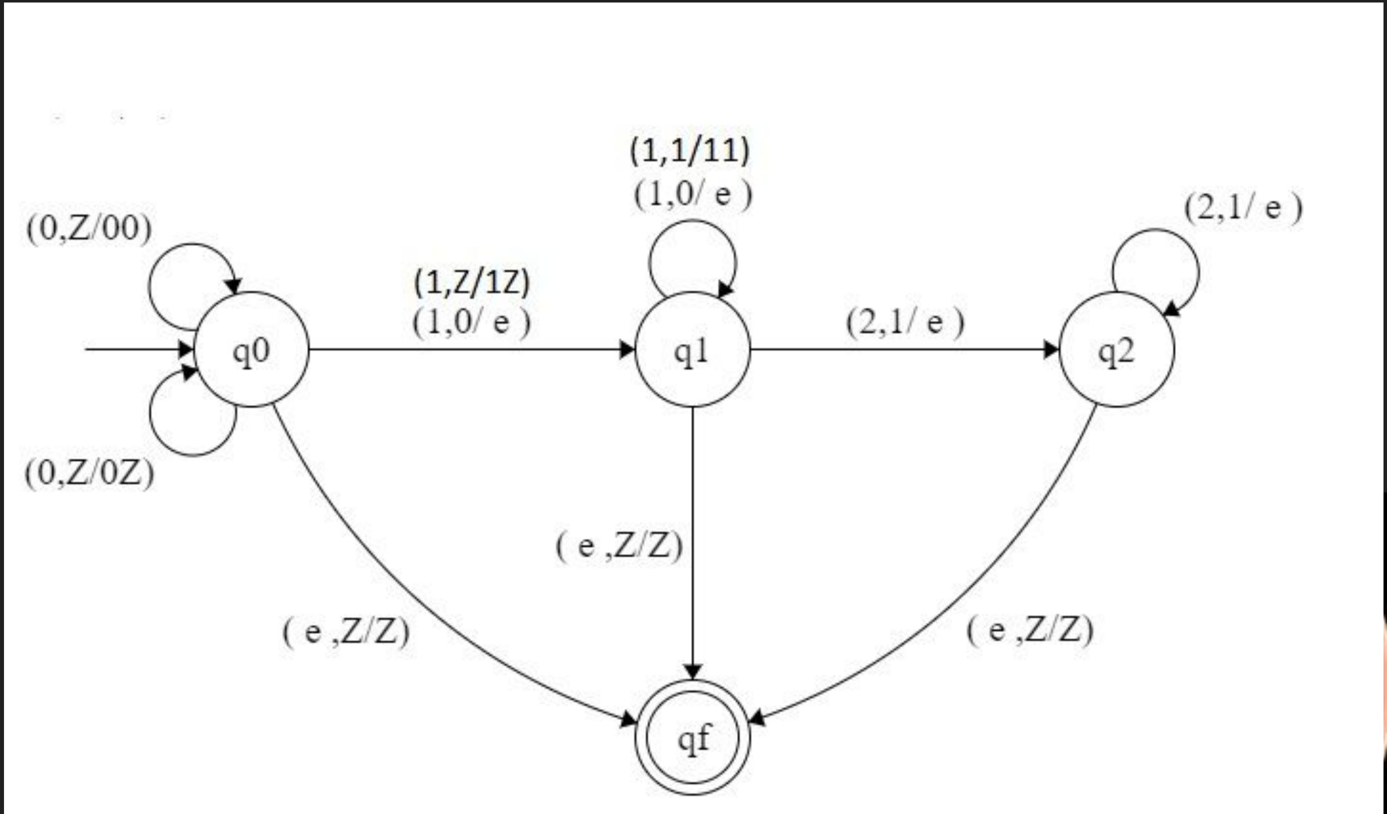
Consider the following PDA Which of the following strings Are accepted by the PDA

A) 011122

B) 00000112222

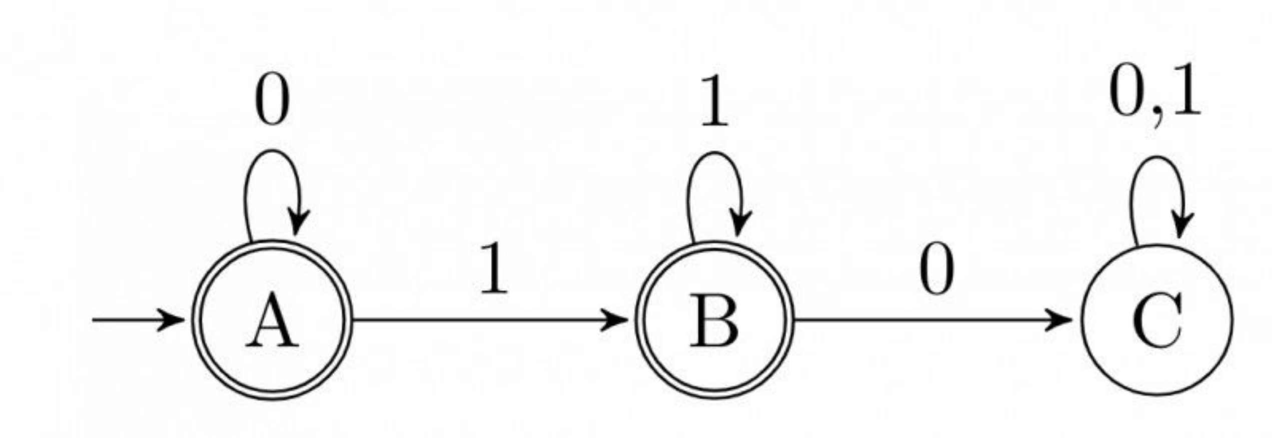
C) 0000011112222

D) 00011111112222



Q 17)

The regular expression for the language recognized by the finite state automaton of figure is



A) (01)*

B) 0*1*

C) (1+0)*

D) 1*+0*

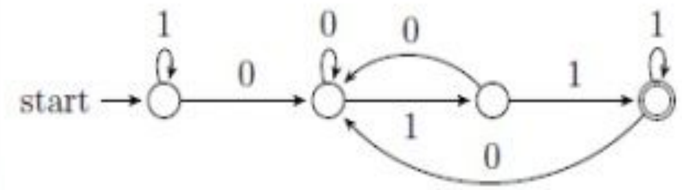
Q18)

Consider the following language:

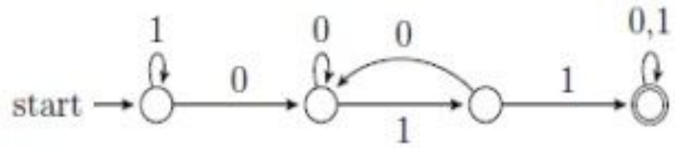
$$L = \{w \in \{0,1\}^* \mid w \text{ ends with the substring } 011\}$$

Which one of the following deterministic finite automata accepts L?

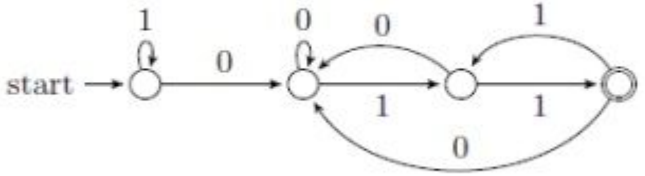
(A)



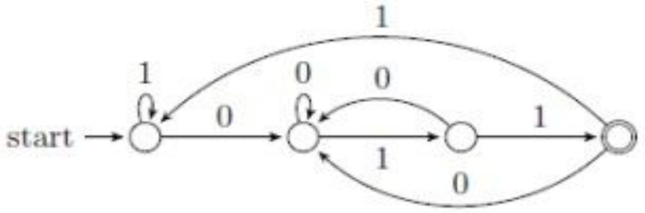
(B)



(C)



(D)



Q 19)

Let $\langle M \rangle$ denote an encoding of an automaton M. Suppose that $\Sigma = \{0, 1\}$. Which of the following languages is/are NOT recursive?

A. $L = \{\langle M \rangle \mid M$ is a DFA such that $L(M) = \emptyset\}$
B. $L = \{\langle M \rangle \mid M$ is a DFA such that $L(M) = \Sigma^*\}$
C. $L = \{\langle M \rangle \mid M$ is a PDA such that $L(M) = \emptyset\}$
D. $L = \{\langle M \rangle \mid M$ is a PDA such that $L(M) = \Sigma^*\}$

Q 20)

For any two languages L_1 and L_2 such that L_1 is context-free and L_2 is recursively enumerable but not recursive, which of the following is/are necessarily true?

I. $\bar{L}_1$ (Complement of L_1) is recursive
II. $\bar{L}_2$ (Complement of L_2) is recursive
III. $\bar{L}_1$ is context-free
IV. $\bar{L}_1 \cup L_2$ is recursively enumerable

A. I only
B. III only
C. III and IV only
D. I and IV only

Q 21)

Let w be any string of length n in{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) 2n+1

B) n + 1

C) n

D) n - 1

Q 22)

If we have more than one accepting states or an accepting state with an outdegree, which of the following actions will be taken?

A) addition of new state

B) removal of a state

C) make the newly added state as final

D) more than one option is correct

Q 23)

Consider a string w such that w∈L, and w=xyz. Which of the following portions cannot be an empty string?

A) x

B) y

C) z

D) all of the mentioned

Q 24)

Suppose a regular language L is closed under the operation halving, then the result would be:

A) 1/4 L will be regular

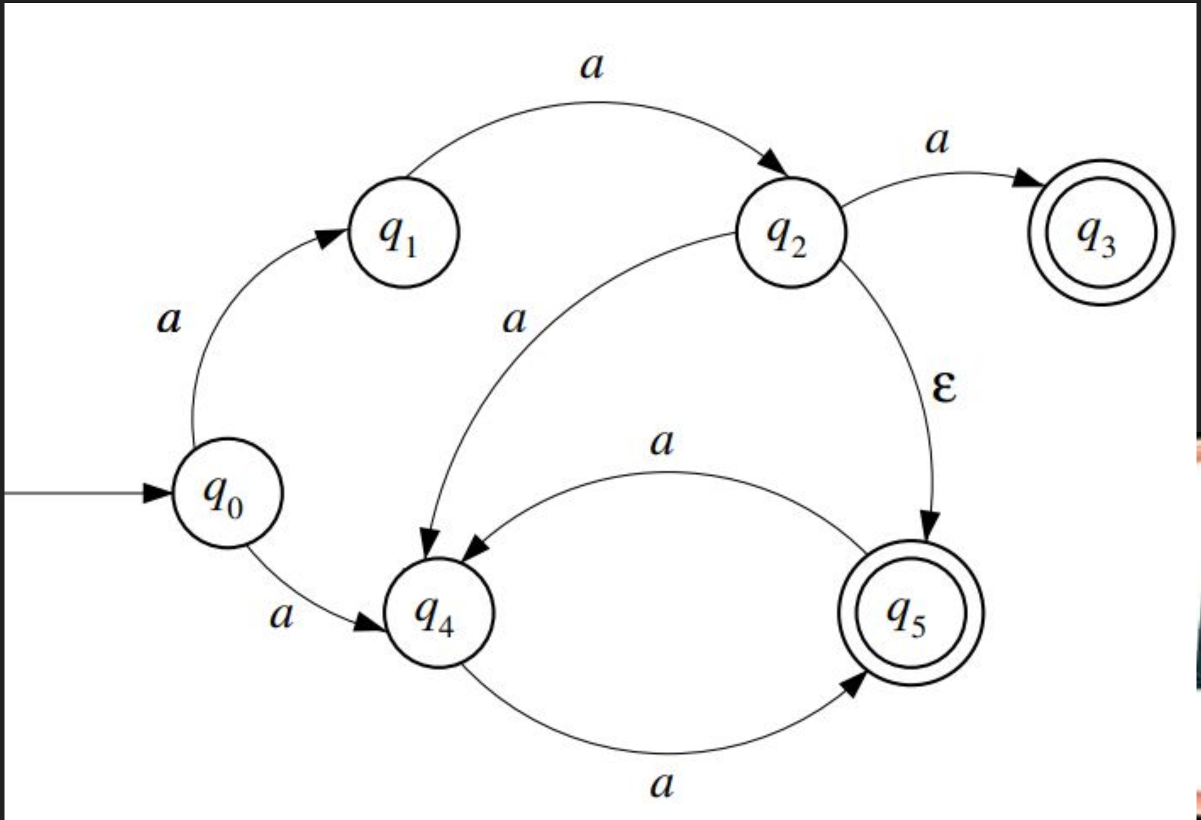
B) 1/2 L will be regular

C) 1/8 L will be regular

D) All of the mentioned

Q 25)

The number of states in the minimal DFA that accepts the language that is recognized by the above NFA over alphabet {a}, is ________



Q 26)

Let L be a language over an alphabet Σ. The equivalence relation ~L on the set Σ* of finite strings over Σ is defined by u~Lv if and only if for all w∈Σ* it is the case that uw∈L if and only if vw∈l.Suppose that L=L(M) is the language accepted by a deterministic finite automaton M. For each u∈Σ*, let s(u) be the unique state of M reached from the initial state after inputting the string u.
Now consider the following statements :

1. s(u)=s(v) implies u~Lv.
2. u~Lv implies s(u)=s(v)

Which of the above statements is correct?

A. Only 1
B. Only 2
C. Both
D. None

Q 27)

Question: Which of the following is/are undecidable?

1. G is a CFG. Is $L(G)=\phi$?
2. G is a CFG. Is $L(G)=\sum^*$?
3. M is a Turing machine. Is L(M) regular?
4. A is a DFA and N is an NFA. Is L(A)=L(N)?

A. 3 only
B. 3 and 4 only
C. 1, 2 and 3 only
D. 2 and 3 only

Q 28)

Which of the following is true?

A. Every subset of a regular set is regular

B. Every finite subset of non-regular set is regular

C. The union of two non regular set is not regular

D. Infinite union of finite set is regular

Q 29)

Which of the following is FALSE with respect to possible outcomes of executing a Turing Machine over a given input?

A. it may halt and accept the input
B. it may halt by changing the input
C. it may halt and reject the input
D. it may never halt

Q 30)

Consider three decision problems P1, P2 and P3. It is known that P1 is decidable and P2 is undecidable. Which one of the following is TRUE?

A. P3 is undecidable if P2 is reducible to P3
B. P3 is decidable if P3 is reducible to P2's complement
C. P3 is undecidable if P3 is reducible to P2
D. P3 is decidable if P1 is reducible to P3

Q 31)

Consider the following context-free grammar over the alphabet $\Sigma = \{a, b, c\}$ with S as the start symbol:

$$S \rightarrow abScT \mid abcT$$

$$T \rightarrow bT \mid b$$

Which one of the following represents the language generated by the above grammar?

A. $\{(ab)^n (cb)^n \mid n \geq 1\}$
B. $\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots, m_n \geq 1\}$
C. $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$
D. $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

Q 32)

Consider the following types of languages: L_1: Regular, L_2: Context-free, L_3: Recursive, L_4: Recursively enumerable. Which of the following is/are **TRUE ?**

I. $\overline{L_3} \cup L_4$ is recursively enumerable.
II. $\overline{L_2} \cup L_3$ is recursive.
III. $L_1^* \cap L_2$ is context-free.
IV. $L_1 \cup \overline{L_2}$ is context-free.

Q 33)

Let X be a recursive language and Y be a recursively enumerable but not recursive language. Let W and Z be two languages such that $\overline{Y}$ reduces to W, and Z reduces to $\overline{X}$ (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

A. W can be recursively enumerable and Z is recursive.
B. W can be recursive and Z is recursively enumerable.
C. W is not recursively enumerable and Z is recursive.
D. W is not recursively enumerable and Z is not recursive.

Q 34)

Which of the following decision problems are undecidable?

I. Given NFAs N_1 and N_2 , is $L(N_1) \cap L(N_2) = \Phi$
II. Given a CFG $G = (N, \Sigma, P, S)$ and a string $x \in \Sigma^*$, does $x \in L(G)\}$?
III. Given CFGs G_1 and G_2, is $L(G_1) = L(G_2)$?
IV. Given a TM M, is $L(M) = \Phi$?

A. I and IV only
B. II and III only
C. III and IV only
D. II and IV only

Q 35)

Consider the alphabet $\Sigma = \{0, 1\}$, the null/empty string λ and the set of strings $X_0, X_1,$ and X_2 generated by the corresponding non-terminals of a regular grammar. $X_0, X_1,$ and X_2 are related as follows.

- $X_0 = 1X_1$
- $X_1 = 0X_1 + 1X_2$
- $X_2 = 0X_1 + \{\lambda\}$

Which one of the following choices precisely represents the strings in X_0?

A. $10(0^* + (10)^*)1$
B. $10(0^* + (10)^*)^*1$
C. $1(0 + 10)^*1$
D. $10(0 + 10)^*1 + 110(0 + 10)^*1$

Q 36)

Consider the following languages:

1. The language of regular expression (0+1)*11(0+1)*
2. The language of regular expression (0*1*11)*0*110*1*

Which of the following is true?

A. 1 is a proper subset of 2
B. 2 is a proper subset of 1
C. 1=2
D. Neither 1 is subset of 2, nor 2 is subset of 1.

Q 37)

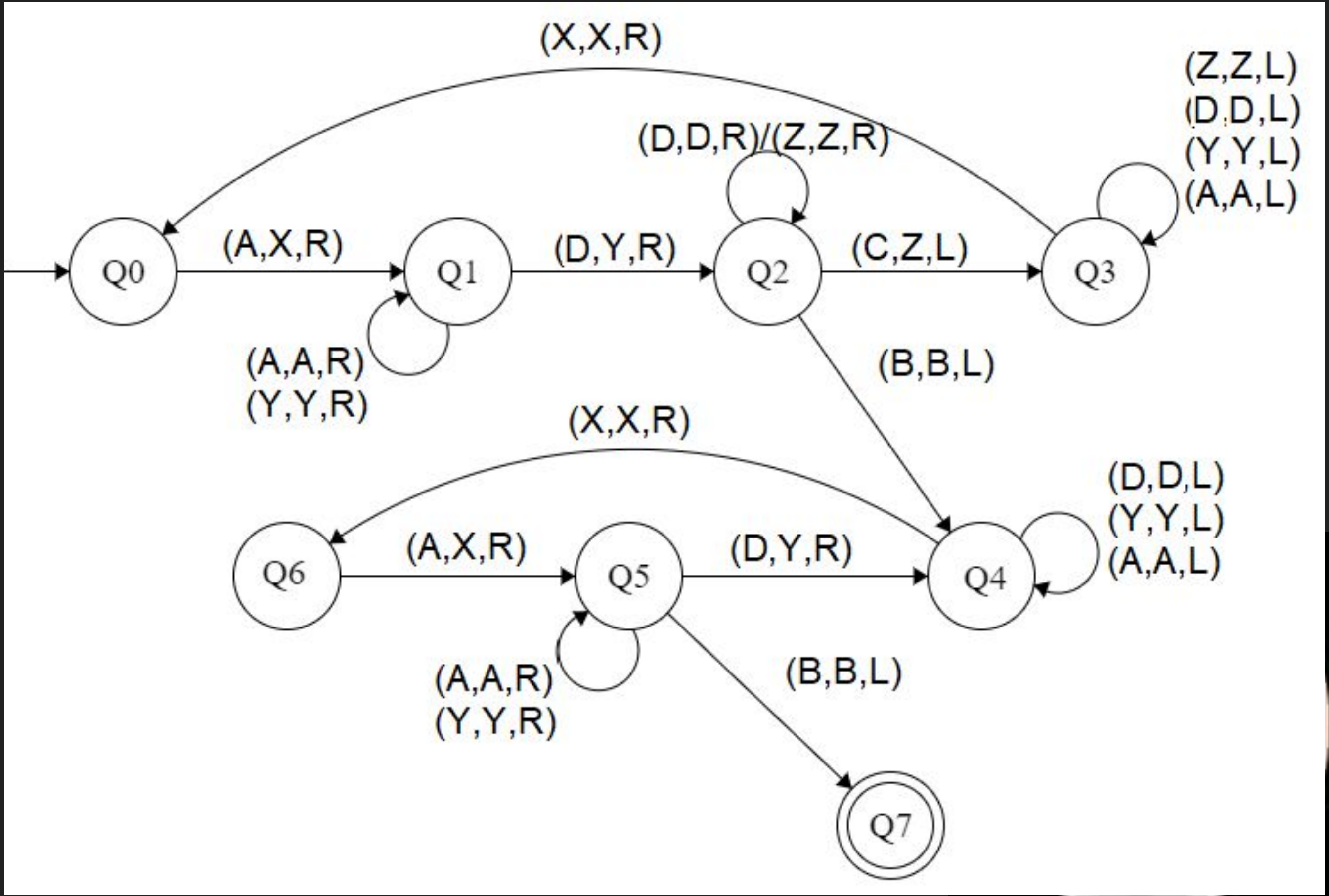
The language accepted by the turing machine, The language accepted by the Turing machine is

A) $L = \{a^i b^j c^k \mid i>j>k;\ k \geq 1\}$

B) $L = \{a^i b^{i+j} c^k \mid i>j>k;\ k \geq 1\}$

C) $L = \{a^i b^j c^{k+1} \mid i>j>k;\ k \geq 1\}$

D) $L = \{a^i b^{j+1} c^k \mid i>j>k;\ k \geq 1\}$



Q 38)

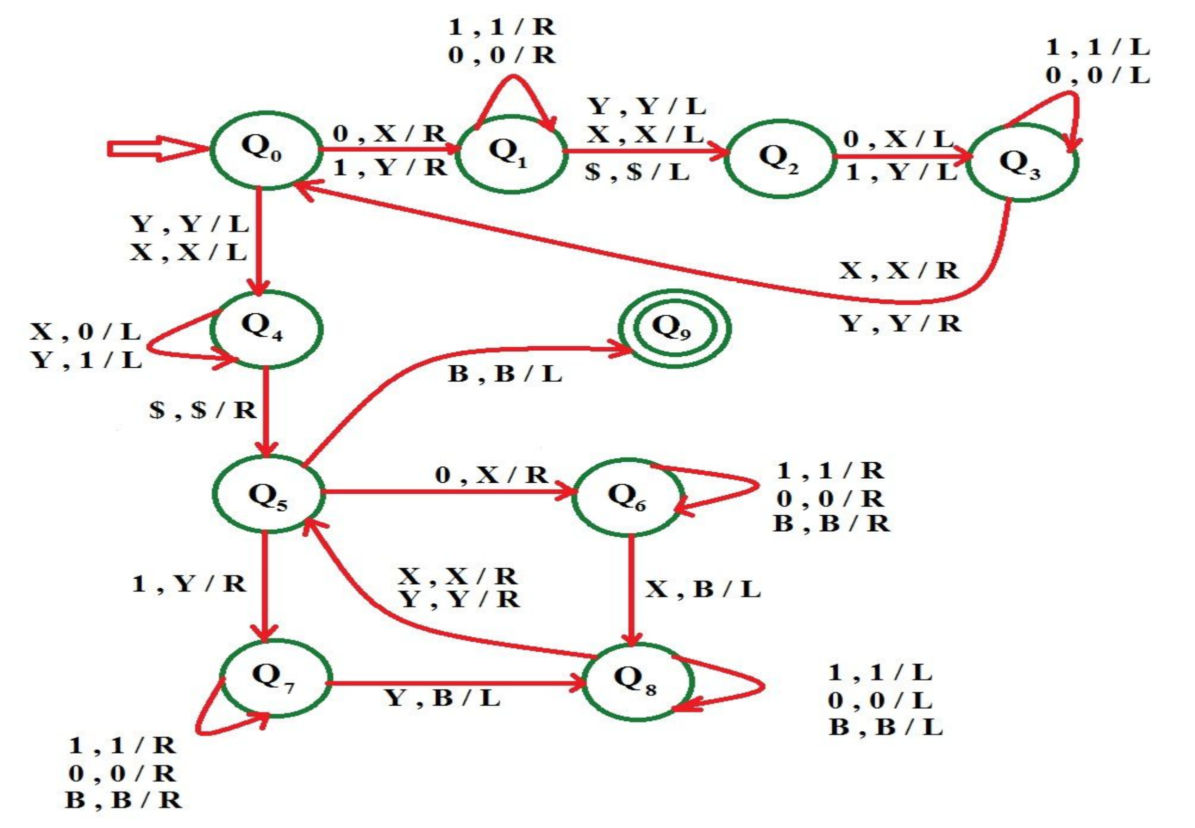
The string accepted by the following Turing machine is?

A) 11001000

B) 11001100

C) 10101011

D) 11001101



Q 39)

Consider the following language

A) $\{w^R x^R w^R y^R | w,x,0,1)^*\}$

B) $\{x w x^R | w,x \in (0,1)^*\}$

C) $\{w,x^R w y^R | w,x,y \in (0,1)*\}$

D) $\{w x^R w^R x | w,x,y \in (0,1)*\}$

Q 40)

Which of the following problems are undecidable

A) **Membership of turing machine**

B) **Finiteness of a Turing Machine?**

C) **Emptiness of a Turing Machine?**

D) **Whether the language accepted by Turing Machine is regular or CFL?**

Q 41)

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

Q 42)

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

Q 43)

Let X and Y be two languges over the alphabet {0, 1} such that ,

$X = |w|w \in 0, 1^3; n_0(w) = n_2(w)$

$Y = |w|w \in 0, 1^{49}; n_0(w) = n_1(w)$

If X and Y denote the cardinalities of X of Y respectively, then the value of X + Y is equal to _____.

Q44)

Consider the following language;

L1:$\{(XY)^m x^m y^m \mid m>0\}$

L2:$\{X{*}Y{*}Z{*}\{X^m Y^m Z^m \mid m>0\}\}$

L3:$\{(w \in \{0,1\}{*} \mid \exists\, K \geq 0$ and w is a binary encoding of $K)\}$

The number of the above languages which are CFL is________.

Q 45)

Consider the following languages over the alphabet $\sum=\{0,1,c\}$;

L1 $=\{0^n1^n | n\geq 0\}$

L2 $=\{wcw^r | w \epsilon \{0,1\}^*\}$

L3 $=\{ww^r | w \epsilon \{0,1\}^*\}$

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

A) None of the languages

B) Only L1 and L2

C) Only L1

D) All the three languages

Q 46)

Let $A \leq m$ 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 $A \leq m$ B and B is recursive then A is recursive
B) If $A \leq m$ B and A is undecidable then B is undecidable.
C) If $A \leq m$ B and B is recursively enumerable then A is recursively enumerable
D) If $A \leq m$ B and B is not recursively enumerable then A is not recursively enumerable.

Q 47)

If L is a regular language over $\Sigma = \{a, b\}$, which one of the following languages is NOT regular?

A. $L.L^R = \{xy \mid x \in L, y^R \in L\}$
B. $\{ww^R \mid w \in L\}$
C. $\text{Prefix }(L) = \{x \in \Sigma^* \mid \exists y \in \Sigma^* \text{such that } xy \in L\}$
D. $\text{Suffix }(L) = \{y \in \Sigma^* \mid \exists x \in \Sigma^* \text{such that } xy \in L\}$

Q 48)

Which of the following statements is TRUE about the regular expression 01*0?

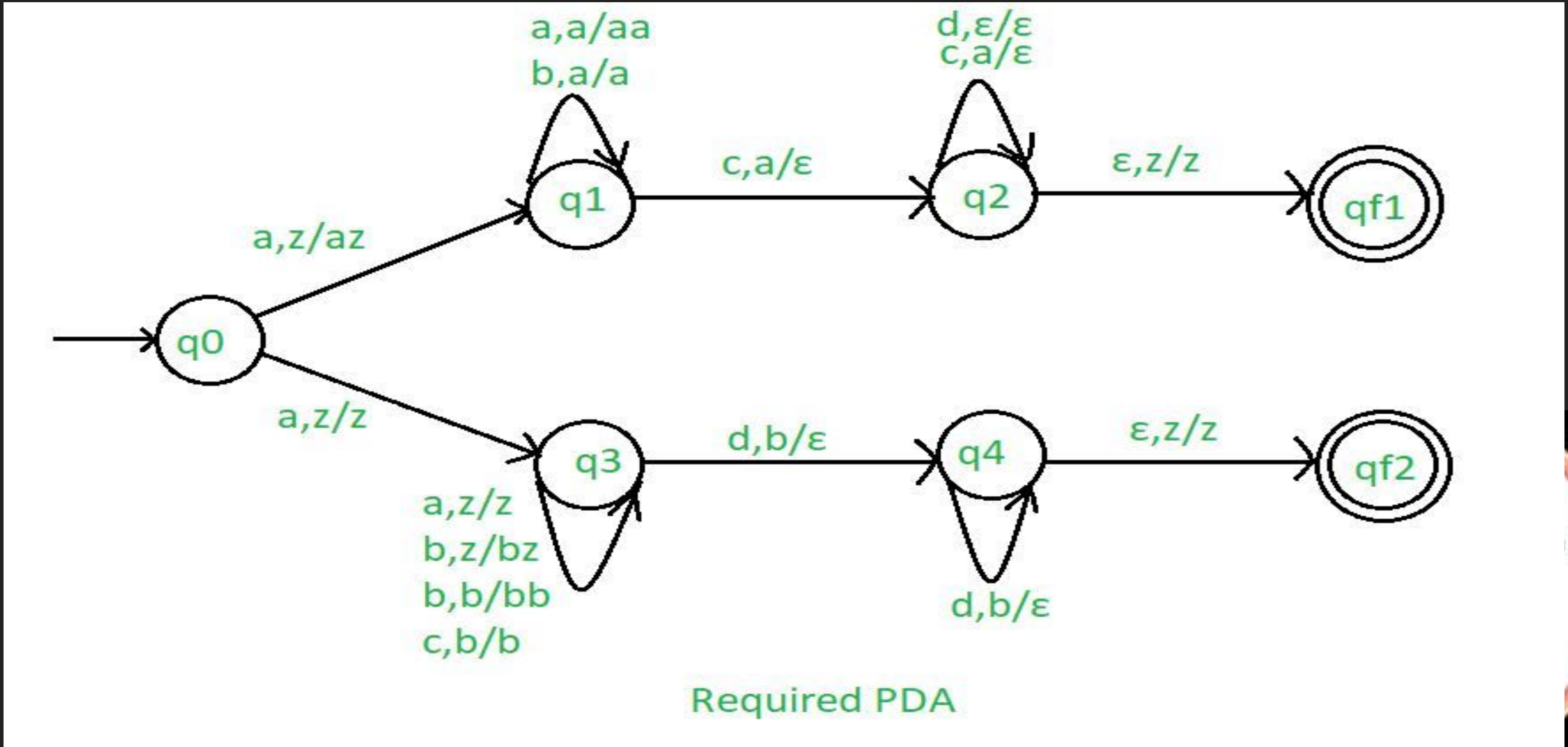
a) It represents a finite set of finite strings

b) It represents an infinite set of finite strings

c) It represents a finite set of infinite strings

d) It represents an infinite set of infinite strings

Q 49) The language accepted by the following Automata is?



[conti..]

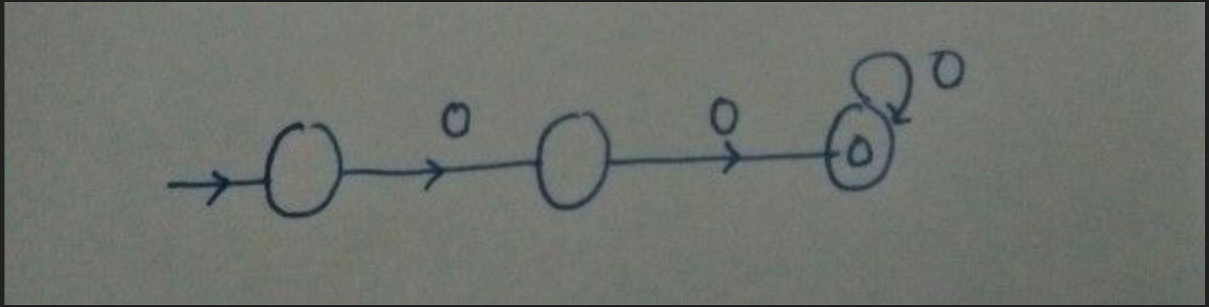
A) L = { $a^i b^j c^k d^l$: i==k or j==l, i>=0, j>=1},

B) L = { $a^i b^j c^k d^l$: i==k or j==l, i>=1, j>=0},

C) L = { $a^i b^j c^k d^l$: i==k or j==l, i>=1, j>=1},

D) L = { $a^i b^j c^k d^l$: i==k or j==l, i>1, j>=1}, Q 50) Consider the FInite automata The language generated by the FA is?

A) $L=\{(0^n)^m \; n<m, m>=1\}$
B) $L=\{(0^n)^m \; n, m>=1\}$
C) $L=\{(0^n)^m \; m<n, n>=1\}$
D) None of these



Q 51)

Which of the following is/are regular languages?

$L_1 : \left\{wxw^R \mid w, x \in \{a,b\}^* \text{ and } |w|, |x| > 0\right\}, w^R \text{ is the reverse of string } w$

$L_2 : \{a^n b^m \mid m \neq n \text{ and } m, n \geq 0\}$

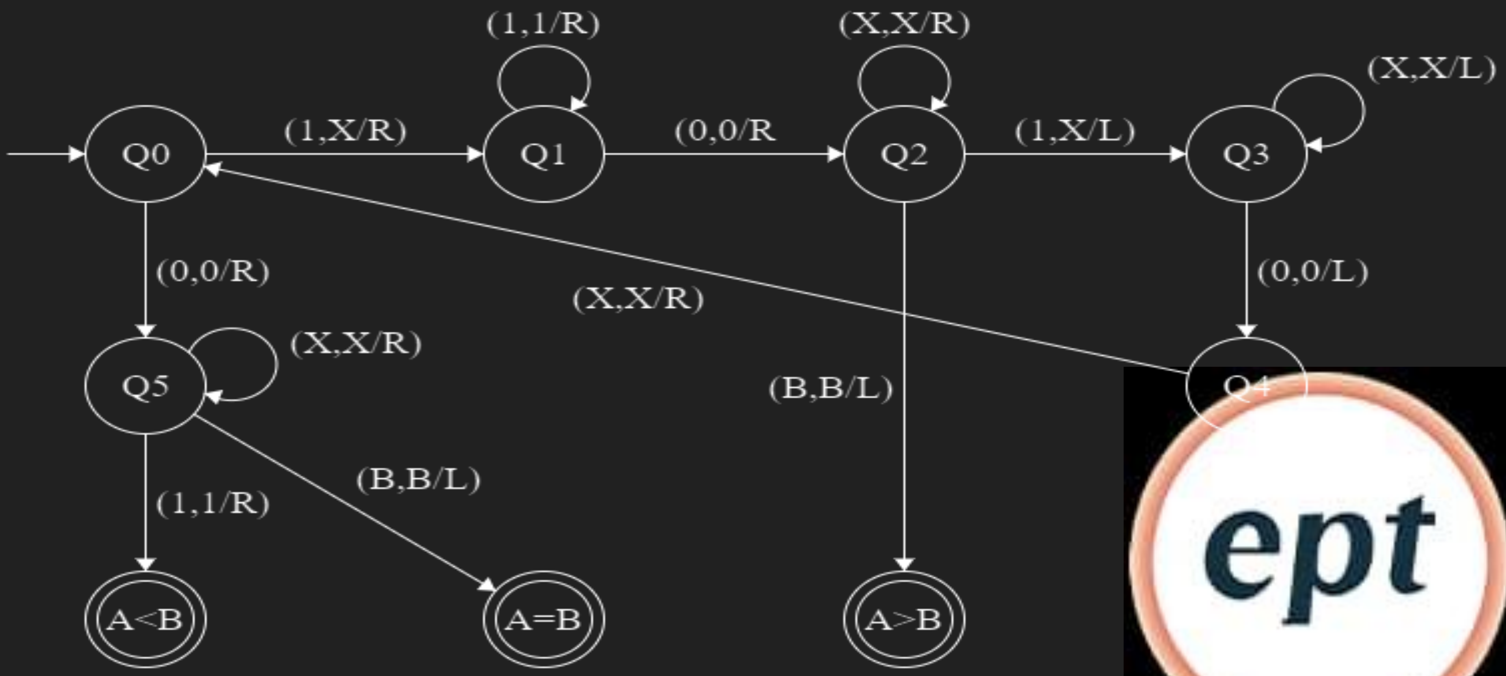
$L_3 : \{a^p b^q c^r \mid p, q, r \geq 0\}$

A. L_1 and L_3 only
B. L_2 only
C. L_2 and L_3 only
D. L_3 only

Q 52)

the given turing machine acts as?

A) Comparator
B) Multiplier
C) Divider
D) Mode divider



Q 53)

Which of the following is/are decidable?

a) Given two Turing machines M1 and M2, decide if L(M1)=L(M2).

b) Given a Turing machine M, decide if L(M) is regular.

c) Given a Turing machine M, decide if M accepts all strings.

d) Given a Turing machine M, decide if M takes more than 1073 steps on every string.

Q 54)

A minimum state deterministic finite automation accepting the language $L = \{w \mid w \epsilon (0,1)*\}$, number of 0s & 1s in w are divisible by 3 and 5, respectively has

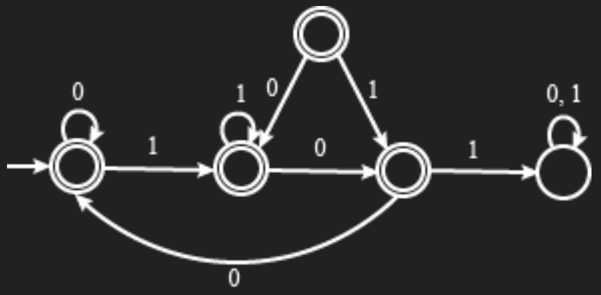
A) 9
B) 15
C) 11
D) 12

Q 55)

Let L be the set of all binary strings whose last two symbols are the same. The number of states in the minimum state deterministic finite state automaton accepting L is—--

Q 56)

Let M be a deterministic finite automata as shown below:



Let S denote the set of 7 bit binary strings in which the first, the fourth and the last bits are 1. The number of strings in S that accepted by M is equal to—-------------

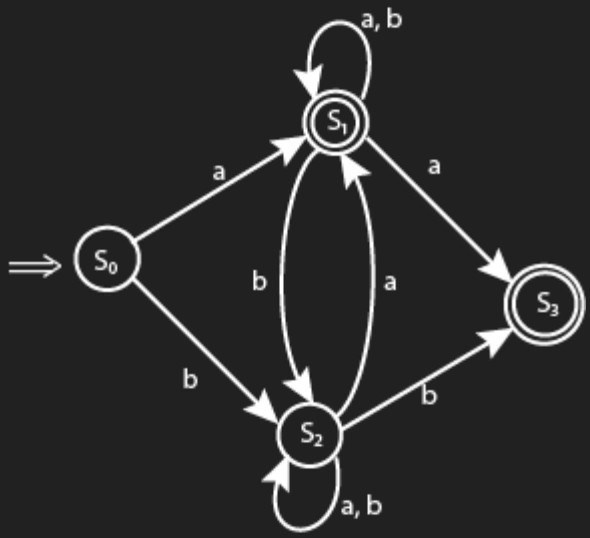
Q 57)

Consider the regular expression:

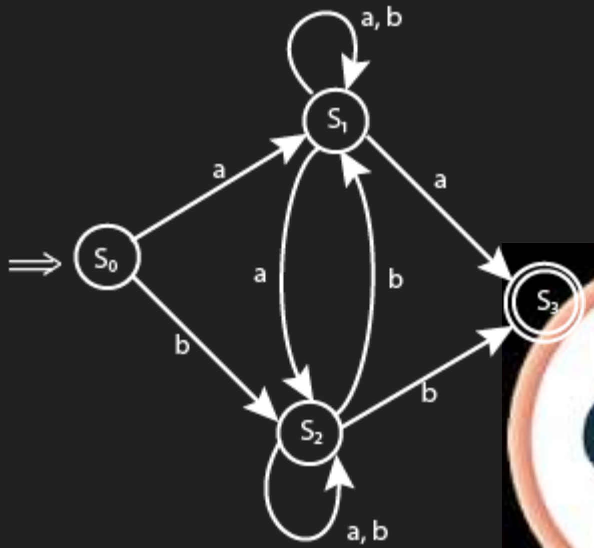
R=(a+b)*(aa+bb)(a+b)*

Which of the following non-deterministic finite automata recognizes the language defined by the regular expression R ? Edges labeled λ denote transition on the empty string.

A)

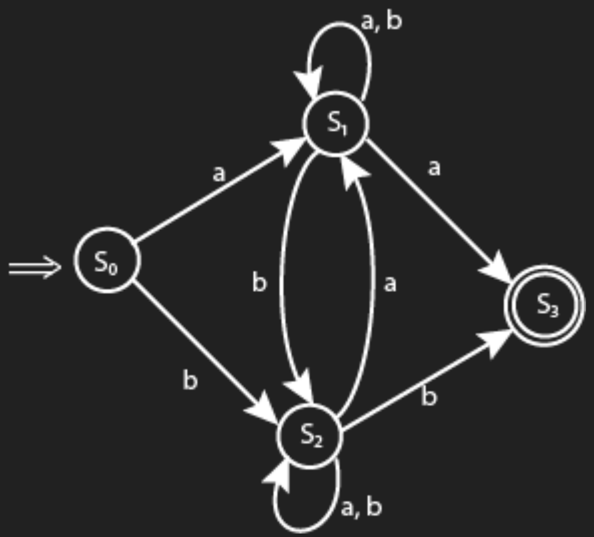


B)

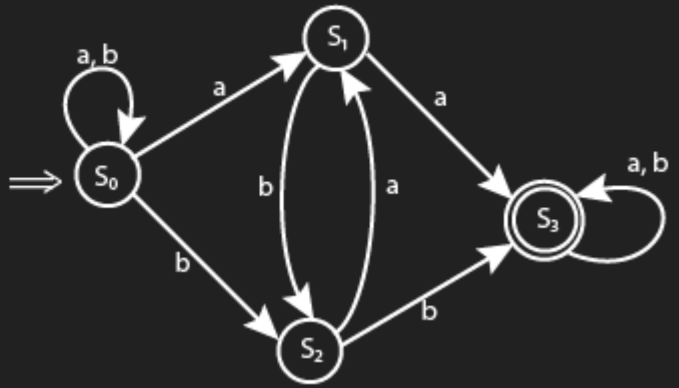


[conti..]

C)



D)



Q 58)

This set of Automata Theory Multiple Choice Questions & Answers (MCQs) focuses on “Regular Languages and D-PDA”.

1. Which of the following is analogous to the following?

:NFA and NPDA

A) Regular language and Context Free language

B) Regular language and Context Sensitive language

C) Context free language and Context Sensitive language

D) None of the mentioned

Q 59)

Which of the following is true regarding a Pushdown Automaton (PDA)?

a) PDA can recognize only regular languages.

b) PDA can recognize only context-free languages.

c) PDA can recognize both regular and context-free languages.

d) PDA can recognize any language.

Q 59)

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Q 60)

Let T={p, q, r, s, t}. The number of strings in S* of length 4 such that no symbols can be repeated.

a) 120

b) 625

c) 360

d) 36

Q 61)

Which of the following relates to Chomsky hierarchy?

a) Regular<CFL<CSL<Unrestricted

b) CFL<CSL<Unrestricted<Regular

c) CSL<Unrestricted<CF<Regular

d) None of the mentioned

Q 62)

Which of the following regular expression allows strings on {a,b}* with length n where n is a multiple of 4.

A) (a+b+ab+ba+aa+bb+aba+bab+abab+baba)*
B) (bbbb+aaaa)*
C) ((a+b)(a+b)(a+b)(a+b))*
D) None of the mentioned

Q 63)

A language accepted by Deterministic Push down automata is closed under which of the following?

A) Complement
B) Union
C) All of the mentioned
D) None of the mention

Q 64)

With reference of a DPDA, which among the following do we perform from the start state with an empty stack?

a) process the whole string

b) end in final state

c) end with an empty stack

d) all of the mentioned

Q 65)

A DPDA is a PDA in which:

a) No state p has two outgoing transitions

b) More than one state can have two or more outgoing transitions

c) Atleast one state has more than one transitions

d) None of the mentioned

S1) D

Explanation:

I. p443y valid
II. p6y invalid
III. 3xyz invalid
IV. p35z valid
V. p353535x valid
VI. ppp5 invalid

Hence option D is correct.

S2: C

Explanation:

1. **Strings of even number of a’s is Regular because we can draw Finite acceptor(FA) for this.**
2. **Strings of a’s, whose length is a prime number - There are infinite No. which are prime and we can't design FA for infinite language.This is not Regular**
3. **Set of all palindromes made up of a’s and b’s.This is not Regular because we can't design FA for infinite language.**
4. **Strings of a’s whose length is a perfect square.This is not Regular because we can't design FA for infinite language.**

S3:

Explanation:

S4: D

Explanation:

Power of Deterministic PDA is not same as the power of Non-deterministic PDA. Deterministic PDA cannot handle languages or grammars with ambiguity, but NDPDA can handle languages with ambiguity and any context-free grammar. So every non-deterministic PDA can not be converted to an equivalent deterministic PDA.

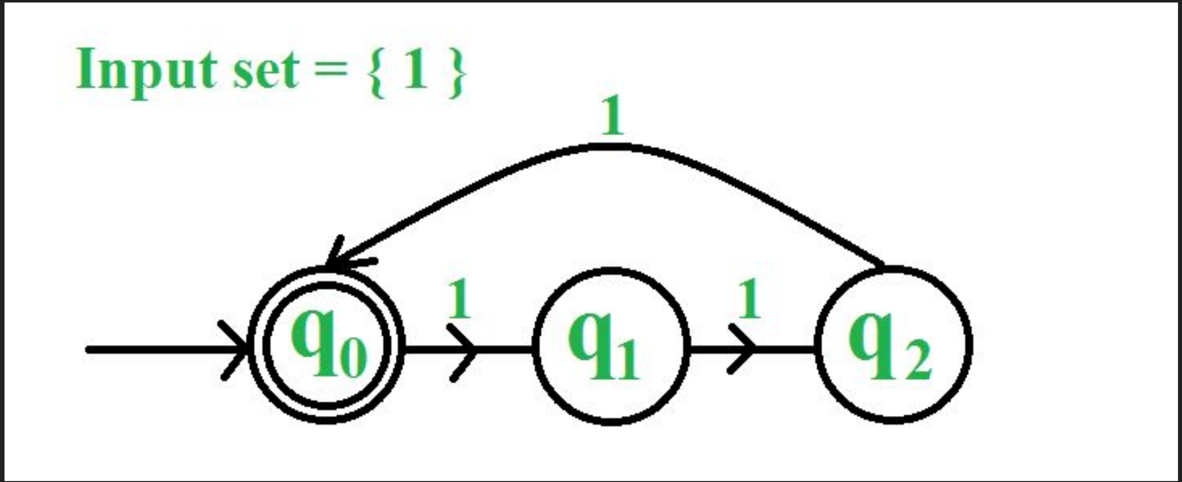
S5: A

Explanation:

The given finite state machine takes a binary number from LSB as input.
The given FSM remains unchanged till first ‘1’ . After that it takes 1’s complement of rest of the input string.
We assume the input string to be ‘110010’ . Thus, according to the FSM, output is ‘001110’ .
2’s complement of ‘110010’ = 1’s complement of ‘110010’ + 1 = 001101 + 1 = 001110 Thus, the FSM computes 2’s complement of the input string.

S6: 3

Explanation:



Thus, we require 3 states.

S7: D

Explanation:

Regular expression in option A cannot generate 001

Regular expression in option B cannot generate 100

Regular expression in option C cannot generate 001

Hence D is the answer

S8:

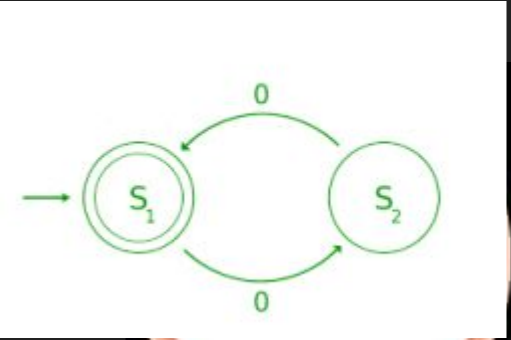
Explanation:

A language is known as regular language if there exists a finite automaton (no matter whether it is deterministic or non-deterministic) which recognizes it. So if for a given language, we can come up with an finite automaton, we can say that the language is regular. But sometimes, it is not quite obvious to design an automaton corresponding to a given language but it surely exists. In that case, we should not start thinking that the given language is not regular. We should use pumping lemma to decide whether the given language is regular or not. According to pumping lemma, “Suppose L is a regular language, then there exists a $l \geq 1$ such that for all string $s \in L$, where $|s| \geq l$, we can always split s (there exists at least one such splitting) in such a way that s can be written as xyz with $|xy| \leq l$ and $y \neq \varepsilon$ and for all $i \geq 0$, $xy^iz \in L$”. l is known as pumping length. Let’s rephrase the given Lemma for non regular languages. Suppose L is a language, if for all $l \geq 1$ there exist a string $s \in L$ with $|s| \geq l$ such that for all splitting (there doesn’t exists a single splitting which doesn’t follow this rule) of s in form of xyz such that $|xy| \geq l$ and $y \neq \varepsilon$, there exists an $i \geq 0$ such that $xy^iz \notin L$, then L is not regular. Notice that here we stress on finding such s if we want to prove that a language is not regular. Choice of the Questions: (a) In choice 1, Lets first consider w being of length n and containing only a. In this case the language represents a^na^n.

[Conti..]

The length of the string represented by language should be Even. Consider l = n, then xyz = anan with xy = a^n. lets assume y = a, then consider the membership of xy^iz with i = 0. This will simply be of odd length which doesn't belongs to L. So L is not regular. To discuss it in more detail, let's consider another example. Suppose w = apb, then string formed by L will be apbapb which is of length 2p + 2. Assume l = p, then xy = ap. suppose y = a, then consider the membership of xyiz with i = 0. This certainly doesn't belongs to L. So L is not regular. (b) In choice 2, The first example will work as above. In the second example, the string will be a^pbba^p, and there will be no changes in process for proving it to be non regular. (c) In choice 3, Assuming that we are considering integer from 0 and 02*n results in empty string, Which is also accepted, We can simply construct a DFA as given below. It simply accepts a string if it is either empty or contain even number of zeros. So the language is regular.

(d) In choice 4, We can simply assume that the pumping length l =i2/2. Now consider the xy = 0l with y = 0, Now if we check the membership of xy2z, we can find that this will represent 0i^2+1, and corresponding to which there exists no j such that j2 = i2 + 1 where i and j are integer except j = 1 and i = 0. But since i can't be zero. In Short, using pumping lemma, we can generate 0i^2+1 as well as 0^{i^2}-1, which won't be available in L. So L is not regular.



S9: B

Explanation:

Context free languages are not closed under complementary and intersection properties. Therefore, statements (I), (III) are false

S10: C

Explanation:

Regular expression for binary numbers that represents non negative odd numbers: It's LSB must be 1

S11: A

Explanation:

(A) This statement is true because deterministic context free languages are closed under intersection with regular languages.
(B) This statement is false because L1 is recursive and every recursive language is decidable. L3 is recursively enumerable but not recursive. So, L3 is undecidable. Intersection of recursive language and recursive enumerable language is recursively enumerable .
(C) This statement is true because L1 is regular. Every regular language is also a context free languages. L2 is a deterministic context free language and every DCFL is also a context free languages. Every context free language is closed under Union.
(D) This statement is true because L1 is regular hence it is also recursively enumerable. L2 is deterministic context free language so, it is also recursively enumerable . Recursively enumerable languages are closed under intersection.
Thus, problem mentioned in option (A) is undecidable.

S12: C

Explanation:

Possible strings of length 4 are: 0001, 0111, 0011, 0101, 0123, 2323, 2333, 2223, 2233, 2301. Total 10 strings are possible. So, option (C) is correct.

S13: A, B

Explanation:

A) {a^nb^n | n ≥ 0} ——-------->equal no of a`s and b`s hence context free

B) {a^nb^mc^n | n, m ≥ 0} ——-------->equal no of a`s and c`s and any number of b`s hence context free

C) {a^nb^nc^n | n ≥ 0} ——------->more than one comparision exist hence not CFL

D) {a^n | n is a prime number} ——---------->no regular repeatetion hence not CGL

S14: B

Explanation:

To reach the accepting state, any string will have to go through edges having aababb as labels in order. Though it might not be a continuous substring, but it sure will be a substring. There might be some cases where same substring always exists as a prefix or suffix for some DFA, but in this situation we don’t have to consider those cases, given this question has single choice answer. − > O − a− > O − a− > O − b− > O − a− > O − b− > O − b− > O Hence, correct answer should be B.

S15: B

Explanation:

Statement I : False, Since there is no mention of transition between states. There may be a case, where between two states there is no transition defined.
Statement II: True, Since any Complete language (i.e., A = sigma*) is regular and its intersection with any other language is Φ. Thus A U B is regular.

S16: A, D

Explanation:

The Language accepted by the given PDA is $L = \{0^m 1^{(n+m)} 2^n \mid m,n \geq 0\}$

Hence strings A and D are accepted

S17: B

Explanation:

A) String 0101 fails
B) Accepts all strings of this language
C) String 010 fails
D) 01 accepted by the given FA which is not in the language

S18: D

Explanation:

The correct automata for L must accept every binary string ending with “011” and not accept any other binary string.

A. **False** it accepts binary strings ending with 111
B. **False** it accepts binary strings ending with $0, 00, 00, 100, 001, 111$ etc.
C. **False** it accepts binary string ending with 1111
D. **True** it accepts all strings that end with 011 and no other strings.

S19: D

Explanation:

A & B are **recursive**, since for every **regular language**, there exists a **unique minimal DFA** and we've a **minimization procedure** for the same. We could therefore compare any two **regular languages** which makes options A and B **recursive** (corresponding problem is decidable)

Option C is **recursive**.
For every **PDA** there is a corresponding **CFG** and vice versa. Moreover they're inter-convertible (see the references). So, we can convert the given **PDA** to its equivalent **CFG**. Then, we have algorithms to remove **empty, unit and useless productions.** If the language of the given **PDA** is **empty** then the **Start Symbol** would be **useless** (not generating any strings) which is **decidable** using an algorithm.

Option D is the Universality problem of CFLs and it is not **decidable** (not even **semi-decidable**). So, the given language is neither **recursive nor recursively enumerable.**

S20: D

Explanation:

L_1 is context-free and hence recursive also. Recursive set being closed under complement, L_1' will be recursive.

L_1' being recursive it is also recursively enumerable and Recursively Enumerable set is closed under Union. So, $L_1' \cup L_2$ is recursively enumerable.

Context free languages are not closed under complement, so III is false

Recursive set is closed under complement. So, if L_2' is recursive, (L_2')' $= L_2$ is also recursive which is not the case here. So, II is also false.

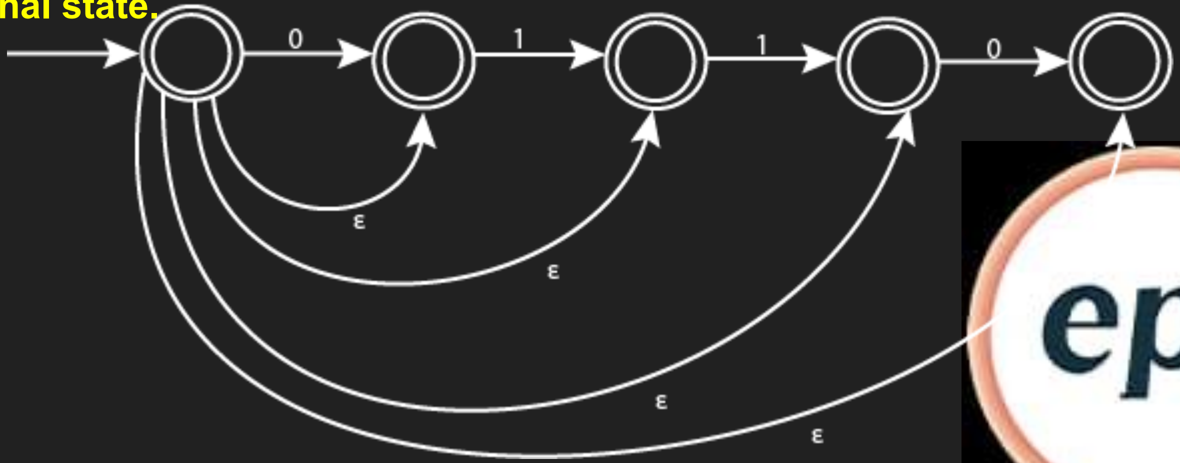
S21: B

Explanation:

Let w = "0110". To design a minimal NFA to accept all the substrings of this string, first accept the string itself as follows.

Now, to accept all the other substrings of "0110" make every state as starting state by using null moves and also make every state as final state.

The final NFA is shown below.



Since a string of length 4 requires 5 states, a string of length n will require n + 1 states

S22: D

Explanation:

If there is more than one accepting state or if the single accepting state as an out degree, add a new accepting state, make all other states non accepting, and hold an e-transitions from each former accepting state to the new accepting state

S23: B

Explanation:

The lemma says, the portion y in xyz cannot be zero or empty i.e. $|y|>0$, this condition needs to be fulfilled to check the conclusion condition.

S24: D

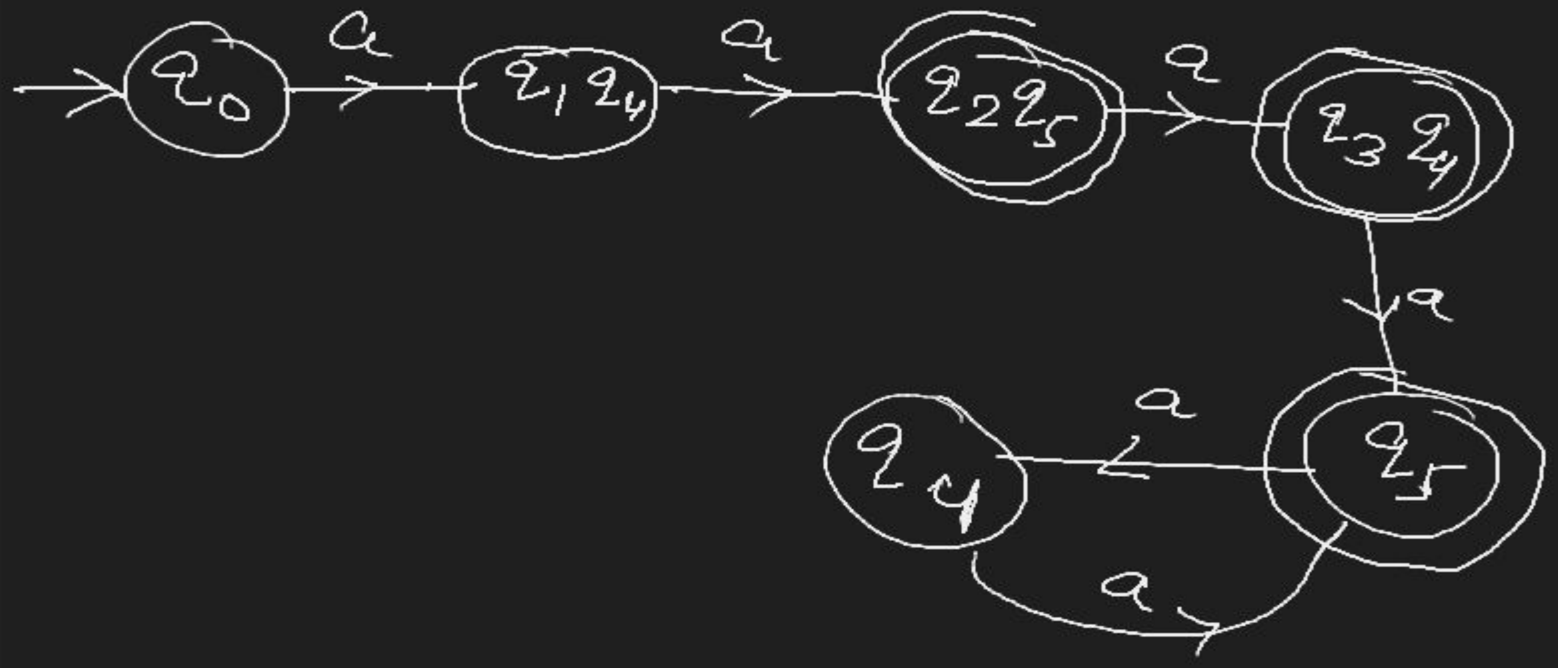
Explanation:

At first stage 1/2 L will be regular and subsequently, all the options will be regular

S25: 6

Explanation:

The minimized DFA will be

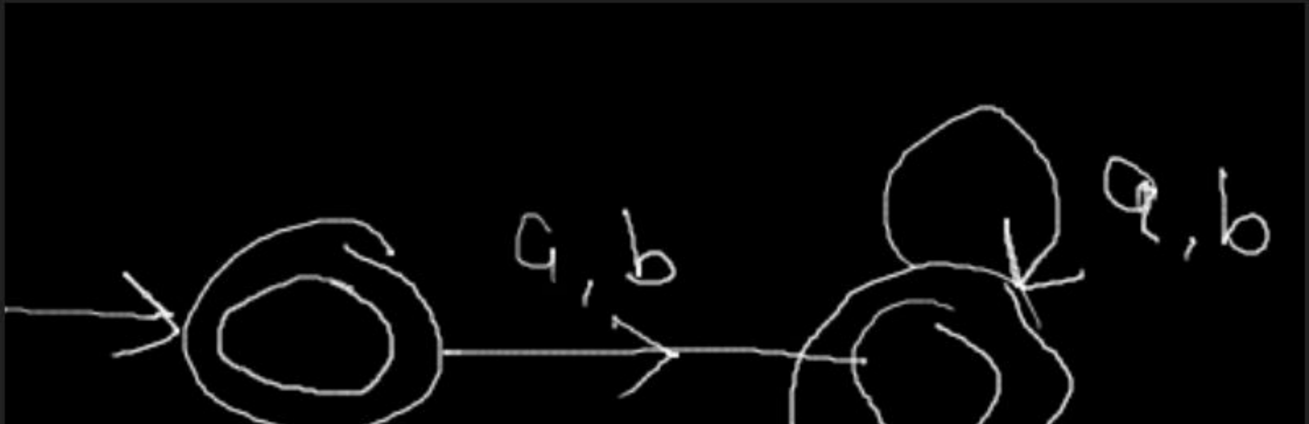


S26: A

Explanation:

The given equivalence relation is actually the Myhill-Neord relation. Statement 1 is true because in DFA each string has a unique sequence of states and a unique path.

Since M is some DFA (not necessarily minimal) so statement 2 is false. Consider $\mathrm{L} = \Sigma^*$, for this L, we will have only one equivalence class in Myhill Neord relation, so all strings in Σ^* will belong to that equivalence class. But assume M is the following DFA of two states which accepts Σ^* then even though empty string and string a are related under $\sim_\mathrm{L}$ but still $\mathrm{s}(\epsilon)$ and $\mathrm{s}(\mathrm{a})$ are Not same.



S27: D

<u>**Explanation:**</u>

- **Option 1 is whether a CFG is empty or not, this problem is decidable.**
- **Option 2 is whether a CFG will generate all possible strings (everything or completeness of CFG), this problem is undecidable.**
- **Option 3 is whether language generated by TM is regular is undecidable.**
- **Option 4 is whether language generated by DFA and NFA are same is decidable. So option D is correct.**

S28: B

Explanation:

A. " Every subset of a regular set is regular": False. Regular Languages not closed under subset operation.

Ex: P = $(a+b)*$, Q = $a^nb^n, n > 0$

C." The union of two non regular set is not regular": Not necessarily.

False Example: P $= a^nb^n, n > 100$, Q$= a^nb^n, n > 0$P $\bigcup$ Q$= a^nb^n, n > 100$, True Example: P $= a^nb^n, n < m, m, n >= 0$ Q$= a^nb^n, , n >= m, m, n >= 0$, P $\bigcup$ Q$= a^mb^n, m, n >= 0$

D. " Infinite union of finite set is regular ": False

In infinite union union operation is done infinite (uncountably many) times.

B. " Every finite subset of non-regular set is regular": True.

Finite language is always regular.

S29: B

Explanation:

If the input belongs to a recursive language, either it may halt and accept the input or it may halt and reject the input.

If the input belongs to a recursively enumerable language, then either it may halt and accept the input or it may never halt.

I don't think it can halt by changing the input, because TM just transits from one state to another state on a given input. It only does the transitions that it is supposed to do on the given input as per it's definition.

TM is like a slave and input is like the command given by a master, so possibly it can not alter commands given to it. However I am not very sure about it.

S30: A

Explanation:

- Option A says P2≤P3. According to theorem 2 discussed, if P2 is undecidable then P3 is undecidable. It is given that P2 is undecidable, so P3 will also be undecidable. So option (A) is correct.
- Option C says P3≤P2. According to theorem 2 discussed, if P3 is undecidable then P2 is undecidable. But it is not given in question about undecidability of P3. So option (C) is not correct.
- Option D says P1≤P3. According to theorem 1 discussed, if P3 is decidable then P1 is also decidable. But it is not given in question about decidability of P3. So option (D) is not correct.
- Option (B) says P3≤P2’. According to theorem 2 discussed, if P3 is undecidable then P2’ is undecidable. But it is not given in question about undecidability of P3. So option (B) is not correct.

S31: B

Explanation:

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

$S \to abScT \mid abcT$

$T \to bT \mid b$

$T \to bT \mid b \cong b^+$

$S \to abScb^+ \mid abcb^+$

$S \cong \underbrace{(ab)^m ab}_{}\, c\, \underbrace{b^+(cb^+)^m}_{} \mid abcb^+$

$\cong (ab)^{m+1}(cb^+)^{m+1} \mid abcb^+ \cong (ab)^n(cb^+)^n \mid n \geq 1$ ✓ — ①

$\ncong (ab)^n(cb^m)^n \mid m,n \geq 1$ c — ②

both are not equivalent!

① ≠ ②

S32: D

Explanation:

I. I. $\overline{L_3} \cup L_4$

L_3 is recursive, so $\overline{L_3}$ is also recursive (closed under complement),
So, $\overline{L_3}$ is recursive enumerable.
L_4 is recursive enumerable,
so, $\overline{L_3} \cup L_4$ is also recursive enumerable (closed under union).

II. $\overline{L_2} \cup L_3$

L_2 is Context-free, so $\overline{L_2}$, may or may not be Context-free (not closed under complement), but definitely $\overline{L_2}$ is Recursive.
L_3 is recursive.
so $\overline{L_2} \cup L_3$ is also recursive (closed under union).

III. $L_1^* \cap L_2$

L_1 is Regular, so L_1^* is also regular (closed under kleene star)

L_2 is Context-free

so, $L_1^* \cap L_2$ is also context-free (closed under intersection with regular).

IV. $L_1 \cup \overline{L_2}$

L_1 is regular.

L_2 is context-free, so $\overline{L_2}$ may or may not be Context-free (not closed under complement).

so, $L_1 \cup \overline{L_2}$ may or may not be Context-free.

Here, answer is **D**.

S33:

Explanation:

X is recursive language, so $\overline{X}$ is also recursive.

Y is recursively enumerable,but not recursive so $\overline{Y}$ is not recursively enumerable language.

$A \leq B$, (A is reducible to B) , i. e, solving A cannot be "harder" than solving B.

1. If A is reducible to B, and B is decidable, then A is decidable.
   i) if A is reducible to B, and B is recursive, then A is recursive.
2. If A is undecidable and reducible to B, then B is undecidable.
   i) if B is recursively enumerable, and A is reducible to B, then A is recursively enumerable.
   ii) if A is not recursively enumerable, and reducible to B, then B is not recursively enumerable.

Now Back to question.

$\overline{Y}$ is not recursively enumerable, and reducible to W, then W is not recursively enumerable (using 2(ii)).

Z is reducible to $\overline{X}$ and $\overline{X}$ is recursive, then Z is recursive (using 1(i)).

Option **C** is correct.

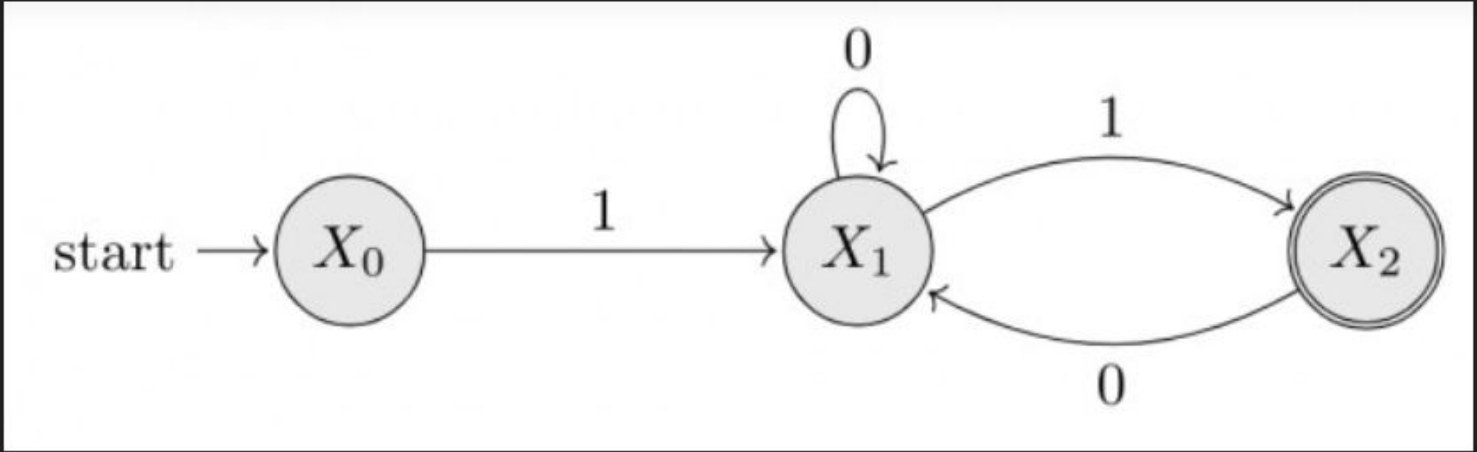
S34: C

Explanation:

I. is Decidable, we may use cross product of NFA (or by converting them into DFA) , if We didn't get final states of both together at any state in it. then $L(N_1) \cap L(N_2) = \phi$, Disjoint languages.
II. Membership in CFG is Decidable (CYK algorithm)
III. Equivalence of Two context free grammars is Undecidable.
IV. For TM M , $L(M) = \phi$ is Undecidable.

S35: C

Explanation:



Convert the given transitions to a state diagram

From the given diagram we can write

$X_0 = 1(0 + 10)^*1$

Correct Option: **C**

S36: B

Explanation:

$$L2 = (0^*1^*11)^*0^*110^*1^*$$

$$(0^*1^*11)^*0^* \subset (1+0)^*$$

$$0^*1^* \subset (1+0)^*$$

So $L2 \subset L1$

S37: A

Explanation:

every string of ‘a’, ‘b’ and ‘c’ have certain number of a’s, then certain number of b’s and then certain number of c’s. The condition is that count of 3rd symbols should be atleast 1. ‘a’ and ‘b’ can have thereafter be as many but count of c is less than count of ‘b’ and count of ‘b’ is less than count of ‘a’.

S38: B

Explanation:

The language is L={ww | w E (0+1)*

S39: A,B, C

Explanation:

Try to avoid string matching by putting w as $\in$ and make x and y go to(0+1).
Therefore we're shown that the subset itself is $\sum *$ and thus 1 is regular.

Similary For II we can put xas $\in$ and then put w as(0+1)*.Therefore II is also regular.

Now in III, put w as $\in$ and make x^R and y^R goto $\sum *$ (note that between xandy there's no string matching). So III is also regular.

But IV is not regular let 's see why.Try getting rid if string matching by putting W as $\in$.So it we start all over again by putting x as $\in$, we are again w wR, another string matching. So we cannot got rid of string matching at all here, as even it both w and x are made $\in$ the subset is $\in$, but this proves nothing only says that a subset of thus language is regular, but that doesn't say anything at all about the language itself.So IV is not regular

S40: A, B, C and D

Explanation:

All the given problems of turing machine are undecidable.

S41: C

Explanation:

A recognizer of a language is a machine that recognizes that language. A decider of a language is a machine that decides that language. Both types of machine halt in the Accept state on strings that are in the language A Decider also halts if the string is not in the language A Recognizer MAY or MAY NOT halt on strings that are not in the language On all input: A Decider MUST halt (in Accept or Reject state) A Recognizer MAY or MAY NOT halt on some strings (Q: Which ones?) A language is Turing-decidable (or decidable) if some Turing machine decides it. Aka Recursive Language. A language is Turing-recognizable if some Turing machine recognizes it. Aka Recursively Enumerable Language. Source: http://www.radford.edu/~nokie/classes/420/Chap3-Langs.html Recursive (Turing Decidable) languages are closed under following Kleene star, concatenation, union, intersection, complement and set difference. Recursively enumerable language are closed under Kleene star, concatenation, union, intersection. They are NOT closed under complement or set difference.

S42: C

Explanation:

A) It is possible if L itself is NOT RE. Then L' will also not be RE. B) Suppose there is a language such that turing machine halts on the input. The given language is RE but not recursive and its complement is NOT RE. C) This is not possible because if we can write enumeration procedure for both languages and it's complement, then the language becomes recursive. D) It is possible because L is closed under complement if it is recursive. Thus, C is the correct choice.

S43: 70

Explanation:

Indirectly the question is, " Number of bit strings of length n having equal number of 0's and 1's , which will be equal to "Cn/2 if n is even, 0 if in is odd (as it's not possible to set equal 0's and 1's in case of an odd length bit string).

Let's find |X| first.X consist of binary string of length 8 having equal 0's and 1's.

Since 8 is even , hence |X| = 8C4 = 70

But |Y| will be 0, because 49 is odd, and its not possible to have an odd length string with equal number of 0's and 1's.Hence, |Y| = 0.

Therefore, their sum is equal to 70.

S44: 2

Explanation:

- L1 is CSL.
- L2 is CFL.

$L2=(X^mY^nZ^p|m,n,p\leq 0 \text{ and } m\neq p\}$

- L3 is regular.. So L3 is also CFL.

$L3=0^*(1+10^*1)$

S45: B

Explanation:

Only L1 and L2

L1 $=\{0^n1^n|n\geq 0\}$ is DCFL
L2 $=\{wcw^r|w\epsilon\{0,1\}^*\}$ is DCFL
L3 $=\{ww^r|w\epsilon\{0,1\}^*\}$ is CFL but not DCFL

S46: D

Explanation:

- $A \leq_m B$ means language A is mapping reducible to language B.Thus, A cannot be harder than B. Since, A can be reduced to B, instead of deciding A we can now decide B. So, the first three options are correct.
- As B is not recursively enumerable, it doesn't guarantee A is not recursively enumerable.Thus, if $A \leq_m B$ and B is not recursively enumerable then A is not recursively enumerable.

S47: B

Explanation:

ww^R is well known CFL - the PDA can non-deterministically determine the middle position of the string and start popping (this is not DCFL though).

Reverse, Suffix, Prefix, Concatenation of Regular(s) is Regular. **Answer is (B)**.

S48: B

Explanation:

- The regular expression starts with 0, which means the first character of every string in this set is fixed and finite. - The regular expression allows zero or more occurrences of 1 after the first character. This means that the number of 1's in the string can be any non-negative integer, which makes the set of strings infinite. - The regular expression ends with an optional 0. This means that the last character of every string can either be 0 or absent, which makes the set of strings infinite.

S49: C

Explanation:

In each string, the number of a’s are followed by any number of b’s and b’s are followed by the number of c’s equal to the number of a’s and c’s are followed by number of d’s equal number of b’s.

S50: A

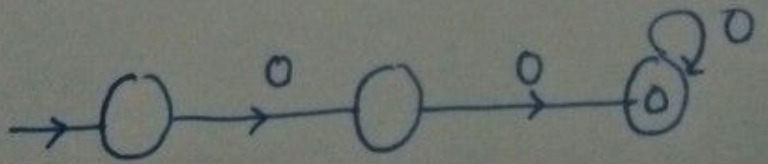
Explanation:

The given fa generates the language as follows

$$L = \{(0^n)^m \,/\, n \leq m,\ m \geq 1\}$$

$$L = \{00,\ 000,\ 0000 \ldots\ldots\}$$

$$L = \{000^*\}$$



S51: A

Explanation:

L_1: all strings of length 3 or more with same start and end letter- because everything in middle can be consumed by x as per the definition of L.

L_2: We need to compare number of a's and b's and these are not bounded. So, we need at least a **DPDA.**

L_3: Any number of a's followed by any number of b's followed by any number of c's. Hence regular.

S52: A

Explanation:

The given Turing machine acts as

1. Comparing two numbers by comparing number of ‘1’s.
2. Comparing ‘1’s by marking them ‘X’.
3. If ‘1’s are remaining in left of ‘0’, then first number is greater.
4. If ‘1’s are remaining in right of ‘0’, then second number is greater.
5. If both ‘1’ are finished then both numbers are equal.

S53: D

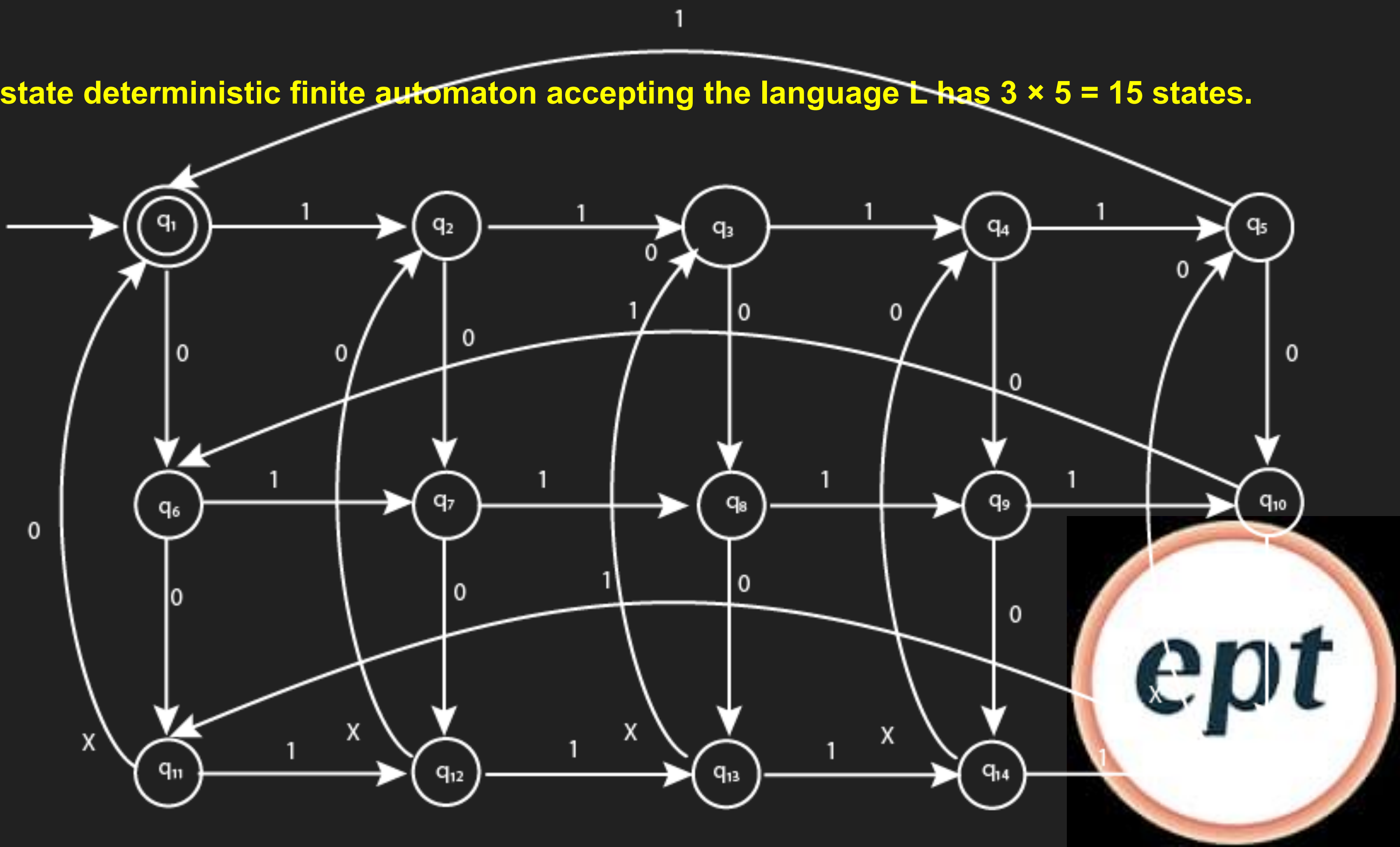
Explanation:

1. Given two Turing machines M1 and M2, decide if $L(M1) = L(M2)$. → Equivalence Problem of TM (**Undecidable**)
2. Given a Turing machine M, decide if $L(M)$ is regular → Regularity Problem of TM (**Undecidable**)
3. Given a Turing machine M, decide if M accepts all strings → Completeness Problem of TM (**Undecidable**)
4. Given a Turing machine M, decide if M takes more than 1073 steps on every string → **Decidable** (just check for <= 1074 steps)

S54: B

<u>**Explanation:**</u>

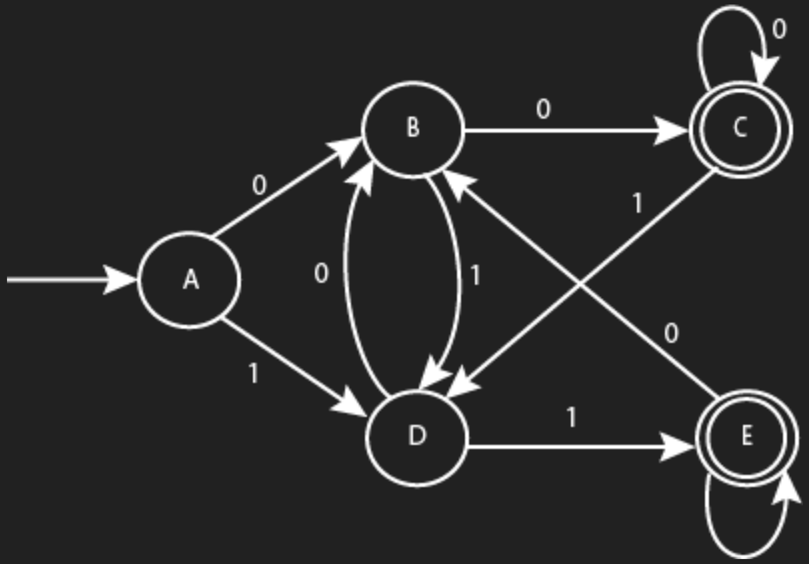
The minimum state deterministic finite automaton accepting the language L has 3 × 5 = 15 states.



S55: 5

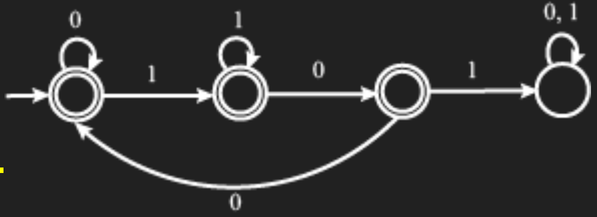
<u>Explanation:</u>

The minimum state dfa is



S56: 4

<u>Explanation:</u>



The DFA has an unreachable state, so lets first simplify the DFA.

Now we can see that the DFA represents set of strings not containing '101' as a substring.
We have count number of 7 bit binary strings in which the first, 4th and 7th bits is '1', which go to the accepting state of DFA.
1_ _ 1 _ _ 1
b1b2b3b4b5b6b7

(b2,b3) can be either (0,0) or (1,1) -> 2 ways

(b5,b6)can be either (0,0) or (1,1)--> 2 ways

Total number of ways=2×2=4
so there are 4 strings which will be accepted by M.

S57: D

Explanation:

The language of the given regular expression R is 'containing the substring aa or bb' Option (a) is the correct machine for this language

S58: A

Explanation:

All regular languages can be accepted by a non deterministic finite automata and all context free languages can be accepted by a non deterministic push down automata.

S59: C

Explanation:

PDA accepts both languages regular and context free

S60: B

Explanation:

Using the permutation rule, we can calculate that there will be total of 625 permutations on 5 elements taking 4 as the length.

S61: A

Explanation:

The chomsky hierarchy lays down the following order: Regular<CFL<CSL<Unrestricted

S62: C

Explanation:

Other mentioned options do not many of the combinations while option c seems most reliable.

S63: A

<u>**Explanation:**</u>

Deterministic Context free languages(one accepted by PDA by final state), are drastically different from the context free languages. For example they are closed under complementation and not union.

S64: D

Explanation:

The empty stack in the end is our requirement relative to finite state automatons

S65: A

Explanation:

A Deterministic Push Down Automata is a Push Down Automata in which no state p has two or more transitions