5 Theory of Computation (276)

Regular expressions and finite automata, Context-free grammars and push-down automata, Regular and context-free languages, Pumping lemma, Turing machines and undecidability.

Mark Distribution in Previous GATE

Year	2019	2018	2017-1	2017-2	2016-1	2016-2	Minimum	Average	Maximum
1 Mark Count	2	2	2	3	3	3	2	2.5	3
2 Marks Count	3	3	5	3	3	3	3	3.3	5
Total Marks	8	8	12	9	9	9	**8**	**9.2**	**12**

5.1 Closure Property (10)

5.1.1 Closure Property: GATE1989-3-ii https://gateoverflow.in/87117

Context-free languages and regular languages are both closed under the operation (s) of :

A. Union B. Intersection C. Concatenation D. Complementation

gate1989 easy theory-of-computation closure-property

5.1.2 Closure Property: GATE1992-16 https://gateoverflow.in/595

Which of the following three statements are true? Prove your answer.

i. The union of two recursive languages is recursive.
ii. The language $\{O^n \mid n \text{ is a prime}\}$ is not regular.
iii. Regular languages are closed under infinite union.

gate1992 theory-of-computation normal closure-property

5.1.3 Closure Property: GATE2002-2.14 https://gateoverflow.in/844

Which of the following is true?

A. The complement of a recursive language is recursive
B. The complement of a recursively enumerable language is recursively enumerable
C. The complement of a recursive language is either recursive or recursively enumerable
D. The complement of a context-free language is context-free

gate2002 theory-of-computation easy closure-property

5.1.4 Closure Property: GATE2006-IT-32 https://gateoverflow.in/3571

Let L be a context-free language and M a regular language. Then the language $L \cap M$ is

A. always regular
B. never regular
C. always a deterministic context-free language
D. always a context-free language

gate2006-it theory-of-computation closure-property easy

5.1.5 Closure Property: GATE2013-17 https://gateoverflow.in/1439

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

gate2013 theory-of-computation normal closure-property

5.1.6 Closure Property: GATE2016-2-18 https://gateoverflow.in/39574

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

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

gate2016-2 theory-of-computation regular-languages context-free-language closure-property normal

5.1.7 Closure Property: GATE2017-2-04 https://gateoverflow.in/118143

Let L_1, L_2 be any two context-free languages and R be any regular language. Then which of the following is/are CORRECT?

I. $L_1 \cup L_2$ is context-free
II. $\overline{L_1}$ is context-free
III. $L_1 - R$ is context-free
IV. $L_1 \cap L_2$ is context-free

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

gate2017-2 theory-of-computation closure-property

5.1.8 Closure Property: GATE2018-7 https://gateoverflow.in/204081

The set of all recursively enumerable languages is:

A. closed under complementation
B. closed under intersection
C. a subset of the set of all recursive languages
D. an uncountable set

gate2018 theory-of-computation closure-property easy

5.1.9 Closure Property: TIFR2013-B-11 https://gateoverflow.in/25772

Which of the following statements is FALSE?

A. The intersection of a context free language with a regular language is context free.
B. The intersection of two regular languages is regular.
C. The intersection of two context free languages is context free
D. The intersection of a context free language and the complement of a regular language is context free.
E. The intersection of a regular language and the complement of a regular language is regular.

tifr2013 theory-of-computation closure-property

5.1.10 Closure Property: TIFR2014-B-14 https://gateoverflow.in/27321

Which the following is FALSE?

A. Complement of a recursive language is recursive.
B. A language recognized by a non-deterministic Turing machine can also be recognized by a deterministic Turing machine.
C. Complement of a context free language can be recognized by a Turing machine.
D. If a language and its complement are both recursively enumerable then it is recursive.
E. Complement of a non-recursive language can never be recognized by any Turing machine.

tifr2014 theory-of-computation closure-property

5.2 Context Free Language (31)

5.2.1 Context Free Language: GATE1987-1-xii https://gateoverflow.in/80291

A context-free grammar is ambiguous if:

A. The grammar contains useless non-terminals.
B. It produces more than one parse tree for some sentence.
C. Some production has two non terminals side by side on the right-hand side.
D. None of the above.

gate1987 theory-of-computation context-free-language ambiguous

5.2.2 Context Free Language: GATE1987-2k https://gateoverflow.in/80599

State whether the following statements are TRUE or FALSE:

The intersection of two CFL's is also a CFL.

gate1987 theory-of-computation context-free-language

5.2.3 Context Free Language: GATE1992-02,xix https://gateoverflow.in/572

02. Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

(xix) Context-free languages are:

A. closed under union
B. closed under complementation
C. closed under intersection
D. closed under Kleene closure

gate1992 context-free-language theory-of-computation normal

5.2.4 Context Free Language: GATE1992-02,xviii https://gateoverflow.in/576

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

If G is a context free grammar and w is a string of length l in $L(G)$, how long is a derivation of w in G, if G is in Chomsky normal form?

A. $2l$
B. $2l+1$
C. $2l-1$
D. l

gate1992 theory-of-computation context-free-language easy

5.2.5 Context Free Language: GATE1995-2.20 https://gateoverflow.in/2632

Which of the following definitions below generate the same language as L, where $L = \{x^n y^n \text{ such that } n \geq 1\}$?

I. $E \rightarrow xEy \mid xy$
II. $xy \mid (x^+ xyy^+)$
III. $x^+ y^+$

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

gate1995 theory-of-computation easy context-free-language

5.2.6 Context Free Language: GATE1996-2.8 https://gateoverflow.in/2737

If L_1 and L_2 are context free languages and R a regular set, one of the languages below is not necessarily a context free language. Which one?

A. $L_1 . L_2$
B. $L_1 \cap L_2$
C. $L_1 \cap R$
D. $L_1 \cup L_2$

gate1996 theory-of-computation context-free-language easy

5.2.7 Context Free Language: GATE1996-2.9 https://gateoverflow.in/2738

Define a context free languages $L \in \{0,1\}^*$, $\text{init}(L) = \{u \mid uv \in L \text{ for some } v \text{ in } \{0,1\}^*\}$ (in other words, $\text{init}(L)$ is the set of prefixes of L)

Let $L = \{w \mid w \text{ is nonempty and has an equal number of 0's and 1's}\}$

Then $\text{init}(L)$ is:

A. the set of all binary strings with unequal number of 0's and 1's

B. the set of all binary strings including null string
C. the set of all binary strings with exactly one more 0 than the number of 1's or one more 1 than the number of 0's
D. None of the above

gate1996 theory-of-computation context-free-language normal

5.2.8 Context Free Language: GATE1999-1.5 https://gateoverflow.in/1459

Context-free languages are closed under:

A. Union, intersection
B. Union, Kleene closure
C. Intersection, complement
D. Complement, Kleene closure

gate1999 theory-of-computation context-free-language easy

5.2.9 Context Free Language: GATE1999-7 https://gateoverflow.in/1506

Show that the language

$$L = \{xcx \mid x \in \{0,1\}^* \text{ and } c \text{ is a terminal symbol}\}$$

is not context free. c is not 0 or 1.

gate1999 theory-of-computation context-free-language normal

5.2.10 Context Free Language: GATE2000-7 https://gateoverflow.in/678

A. Construct as minimal finite state machine that accepts the language, over $\{0,1\}$, of all strings that contain neither the sub string 00 nor the sub string 11.
B. Consider the grammar

```
S →          aSAb
S →             ∈
A →            bA
A →             ∈
```

where S, A are non-terminal symbols with S being the start symbol; a, b are terminal symbols and ϵ is the empty string. This grammar generates strings of the form $a^i b^j$ for some $i, j \geq 0$, where i and j satisfy some condition. What is the condition on the values of i and j?

gate2000 theory-of-computation descriptive regular-languages context-free-language

5.2.11 Context Free Language: GATE2001-1.5 https://gateoverflow.in/698

Which of the following statements is true?

A. If a language is context free it can always be accepted by a deterministic push-down automaton
B. The union of two context free languages is context free
C. The intersection of two context free languages is a context free
D. The complement of a context free language is a context free

gate2001 theory-of-computation context-free-language easy

5.2.12 Context Free Language: GATE2003-51 https://gateoverflow.in/940

Let $G = (\{S\}, \{a, b\}, R, S)$ be a context free grammar where the rule set R is $S \rightarrow aSb \mid SS \mid \epsilon$
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 $L(G)$

gate2003 theory-of-computation context-free-language normal

5.2.13 Context Free Language: GATE2005-57 https://gateoverflow.in/1380

Consider the languages:

- $L_1 = \{ww^R \mid w \in \{0,1\}^*\}$
- $L_2 = \{w\#w^R \mid w \in \{0,1\}^*\}$, where $\#$ is a special symbol
- $L_3 = \{ww \mid w \in \{0,1\}^*\}$

Which one of the following is TRUE?

A. L_1 is a deterministic CFL
B. L_2 is a deterministic CFL
C. L_3 is a CFL, but not a deterministic CFL
D. L_3 is a deterministic CFL

gate2005 theory-of-computation context-free-language easy

5.2.14 Context Free Language: GATE2006-19 https://gateoverflow.in/980

Let
$L_1 = \{0^{n+m}1^n0^m \mid n,m \geq 0\}$,
$L_2 = \{0^{n+m}1^{n+m}0^m \mid n,m \geq 0\}$ 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. L_1 only
B. L_3 only
C. L_1 and L_2
D. L_2 and L_3

gate2006 theory-of-computation context-free-language normal

5.2.15 Context Free Language: GATE2006-IT-34 https://gateoverflow.in/3573

In the context-free grammar below, S is the start symbol, a and b are terminals, and ϵ denotes the empty string.

- $S \to aSAb \mid \epsilon$
- $A \to bA \mid \epsilon$

The grammar generates the language

A. $((a+b)^*b)$
B. $\{a^mb^n \mid m \leq n\}$
C. $\{a^mb^n \mid m = n)$
D. a^*b^*

gate2006-it theory-of-computation context-free-language normal

5.2.16 Context Free Language: GATE2006-IT-4 https://gateoverflow.in/3543

In the context-free grammar below, S is the start symbol, a and b are terminals, and ϵ denotes the empty string
$S \to aSa \mid bSb \mid a \mid b \mid \epsilon$
Which of the following strings is NOT generated by the grammar?

A. $aaaa$
B. $baba$
C. $abba$
D. $babaaabab$

gate2006-it theory-of-computation context-free-language easy

5.2.17 Context Free Language: GATE2007-IT-46 https://gateoverflow.in/3481

The two grammars given below generate a language over the alphabet $\{x, y, z\}$
$G1: S \to x \mid z \mid x\,S \mid z\,S \mid y\,B$
$\quad B \to y \mid z \mid y\,B \mid z\,B$

$G2: S \to y \mid z \mid y\,S \mid z\,S \mid x\,B$
$\quad B \to y \mid y\,S$

Which one of the following choices describes the properties satisfied by the strings in these languages?

A. $G1$: No y appears before any x
$G2$: Every x is followed by at least one y
B. $G1$: No y appears before any x

$G2$: No x appears before any y

C. $G1$: No y appears after any x
$G2$: Every x is followed by at least one y

D. $G1$: No y appears after any x
$G2$: Every y is followed by at least one x

gate2007-it theory-of-computation normal context-free-language

5.2.18 Context Free Language: GATE2007-IT-48 https://gateoverflow.in/3490

Consider the grammar given below:

$S \to x\,B \mid y\,A$
$A \to x \mid x\,S \mid y\,A\,A$
$B \to y \mid y\,S \mid x\,B\,B$

Consider the following strings.

i. $xxyyx$
ii. $xxyyxy$
iii. $xyxy$
iv. $yxxy$
v. yxx
vi. xyx

Which of the above strings are generated by the grammar ?

A. i, ii and iii
B. ii, v and vi
C. ii, iii and iv
D. i, iii and iv

gate2007-it theory-of-computation context-free-language normal

5.2.19 Context Free Language: GATE2007-IT-49 https://gateoverflow.in/3491

Consider the following grammars. Names representing terminals have been specified in capital letters.

$G1$:	stmnt	$\to$	WHILE (expr) stmnt		
	stmnt	$\to$	OTHER		
	expr	$\to$	ID		
$G2$:	stmnt	$\to$	WHILE (expr) stmnt		
	stmnt	$\to$	OTHER		
	expr	$\to$	expr	$+$	expr
	expr	$\to$	expr	$*$	expr
	expr	$\to$	ID		

Which one of the following statements is true?

A. G_1 is context-free but not regular and G_2 is regular
B. G_2 is context-free but not regular and G_1 is regular
C. Both G_1 and G_2 are regular
D. Both G_1 and G_2 are context-free but neither of them is regular

gate2007-it theory-of-computation context-free-language normal

5.2.20 Context Free Language: GATE2008-IT-34 https://gateoverflow.in/3344

Consider a CFG with the following productions.

$S \to AA \mid B$
$A \to 0A \mid A0 \mid 1$
$B \to 0B00 \mid 1$

S is the start symbol, A and B are non-terminals and 0 and 1 are the terminals. The language generated by this grammar is:

A. $\{0^n 10^{2n} \mid n \geq 1\}$

B. $\{0^i10^j10^k \mid i,j,k \geq 0\} \cup \{0^n10^{2n} \mid n \geq 0\}$
C. $\{0^i10^j \mid i,j \geq 0\} \cup \{0^n10^{2n} \mid n \geq 0\}$
D. The set of all strings over $\{0,1\}$ containing at least two 0's

gate2008-it theory-of-computation context-free-language normal

5.2.21 Context Free Language: GATE2008-IT-78 https://gateoverflow.in/3392

A CFG G is given with the following productions where S is the start symbol, A is a non-terminal and a and b are terminals.

- $S \to aS \mid A$
- $A \to aAb \mid bAa \mid \epsilon$

Which of the following strings is generated by the grammar above?

A. $aabbaba$ B. $aabaaba$ C. $abababb$ D. $aabbaab$

gate2008-it theory-of-computation normal context-free-language

5.2.22 Context Free Language: GATE2009-12, ISRO2016-37 https://gateoverflow.in/1304

$$S \to aSa \mid bSb \mid a \mid b$$

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

gate2009 theory-of-computation context-free-language easy isro2016

5.2.23 Context Free Language: GATE2015-3-32 https://gateoverflow.in/8489

Which of the following languages are context-free?

$L_1 : \{a^mb^na^nb^m \mid m,n \geq 1\}$

$L_2 : \{a^mb^na^mb^n \mid m,n \geq 1\}$

$L_3 : \{a^mb^n \mid m = 2n+1\}$

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

gate2015-3 theory-of-computation context-free-language normal

5.2.24 Context Free Language: GATE2016-1-16 https://gateoverflow.in/39640

Which of the following languages is generated by the given grammar?

$$S \to aS \mid bS \mid \varepsilon$$

A. $\{a^nb^m \mid n,m \geq 0\}$
B. $\{w \in \{a,b\}^* \mid w \text{ has equal number of a's and b's}\}$
C. $\{a^n \mid n \geq 0\} \cup \{b^n \mid n \geq 0\} \cup \{a^nb^n \mid n \geq 0\}$
D. $\{a,b\}^*$

gate2016-1 theory-of-computation context-free-language normal

5.2.25 Context Free Language: GATE2016-1-42 https://gateoverflow.in/39705

Consider the following context-free grammars;

$G_1 : S \to aS \mid B, B \to b \mid bB$

$G_2 : S \to aA \mid bB, A \to aA \mid B \mid \varepsilon, B \to bB \mid \varepsilon$

Which one of the following pairs of languages is generated by G_1 and G_2 ,respectively?

A. $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
B. $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n \geq 0\}$
C. $\{a^m b^n \mid m \geq 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$
D. $\{a^m b^n \mid m \geq 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$

gate2016-1 theory-of-computation context-free-language normal

5.2.26 Context Free Language: GATE2016-2-43 https://gateoverflow.in/39605

Consider the following languages:

$L_1 = \{a^n b^m c^{n+m} : m, n \geq 1\}$

$L_2 = \{a^n b^n c^{2n} : n \geq 1\}$

Which one of the following is TRUE?

A. Both L_1 and L_2 are context-free.
B. L_1 is context-free while L_2 is not context-free.
C. L_2 is context-free while L_1 is not context-free.
D. Neither L_1 nor L_2 is context-free.

gate2016-2 theory-of-computation context-free-language normal

5.2.27 Context Free Language: GATE2017-1-10 https://gateoverflow.in/118290

Consider the following context-free grammar over the alphabet $\sum = \{a, b, c\}$ 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. $\{(ab)^n cb^{m_1} cb^{m_2} \dots cb^{m_n} \mid n, m_1, m_2, \dots, m_n \geq 1\}$
C. $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$
D. $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

gate2017-1 theory-of-computation context-free-language normal

5.2.28 Context Free Language: GATE2017-1-34 https://gateoverflow.in/118316

If G is a grammar with productions

$S \rightarrow SaS|aSb|bSa|SS| \in$

where S is the start variable, then which one of the following strings is not generated by G?

A. $abab$ B. $aaab$ C. $abbaa$ D. $babba$

gate2017-1 theory-of-computation context-free-language normal

5.2.29 Context Free Language: GATE2017-1-38 https://gateoverflow.in/118321

Consider the following languages over the alphabet $\sum = \{a, b, c\}$. Let $L_1 = \{a^n b^n c^m | m, n \geq 0\}$ and $L_2 = \{a^m b^n c^n | m, n \geq 0\}$.

Which of the following are context-free languages?

I. $L_1 \cup L_2$
II. $L_1 \cap L_2$

A. I only B. II only C. I and II D. Neither I nor II

gate2017-1 theory-of-computation context-free-language normal

5.2.30 Context Free Language: GATE2017-2-16 https://gateoverflow.in/118243

Identify the language generated by the following grammar, where S is the start variable.

- $S \rightarrow XY$
- $X \rightarrow aX \mid a$
- $Y \rightarrow aYb \mid \epsilon$

A. $\{a^m b^n \mid m \geq n, n > 0\}$
B. $\{a^m b^n \mid m \geq n, n \geq 0\}$
C. $\{a^m b^n \mid m > n, n \geq 0\}$
D. $\{a^m b^n \mid m > n, n > 0\}$

gate2017-2 theory-of-computation context-free-language

5.2.31 Context Free Language: GATE2019-31 https://gateoverflow.in/302817

Which one of the following languages over $\Sigma = \{a, b\}$ is NOT context-free?

A. $\{ww^R \mid w \in \{a, b\}^*\}$
B. $\{wa^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$
C. $\{wa^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$
D. $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$

gate2019 theory-of-computation context-free-language

5.3 Countable Uncountable Set (2)

5.3.1 Countable Uncountable Set: GATE1997-3.4 https://gateoverflow.in/2235

Given $\Sigma = \{a, b\}$, which one of the following sets is not countable?

A. Set of all strings over Σ
B. Set of all languages over Σ
C. Set of all regular languages over Σ
D. Set of all languages over Σ accepted by Turing machines

gate1997 theory-of-computation normal countable-uncountable-set

5.3.2 Countable Uncountable Set: GATE2019-34 https://gateoverflow.in/302814

Consider the following sets:

S1: Set of all recursively enumerable languages over the alphabet $\{0, 1\}$

S2: Set of all syntactically valid C programs

S3: Set of all languages over the alphabet $\{0, 1\}$

S4: Set of all non-regular languages over the alphabet $\{0, 1\}$

Which of the above sets are uncountable?

A. S1 and S2
B. S3 and S4
C. S2 and S3
D. S1 and S4

gate2019 theory-of-computation countable-uncountable-set

5.4 Decidability (27)

5.4.1 Decidability: GATE1987-2l https://gateoverflow.in/80603

State whether the following statement are TRUE or FALSE.

A is recursive if both A and its complement are accepted by Turing machines.

gate1987 decidability

5.4.2 Decidability: GATE1987-2m https://gateoverflow.in/80606

State whether the following statements are TRUE or FALSE:

The problem as to whether a Turing machine M accepts input w is undecidable.

gate1987 theory-of-computation turing-machine decidability

5.4.3 Decidability: GATE1988-2viii https://gateoverflow.in/93948

State the halting problem of the Turing machine.

gate1988 theory-of-computation descriptive decidability

5.4.4 Decidability: GATE1989-3-iii https://gateoverflow.in/87123

Answer the following questions:

Which of the following problems are undecidable?

A. Membership problem in context-free languages.
B. Whether a given context-free language is regular.
C. Whether a finite state automation halts on all inputs.
D. Membership problem for type 0 languages.

gate1989 normal theory-of-computation decidability

5.4.5 Decidability: GATE1990-3-vii https://gateoverflow.in/84835

Choose the correct alternatives (More than one may be correct).

It is undecidable whether:

A. An arbitrary Turing machine halts after 100 steps.
B. A Turing machine prints a specific letter.
C. A Turing machine computes the products of two numbers
D. None of the above.

gate1990 normal theory-of-computation decidability

5.4.6 Decidability: GATE1995-11 https://gateoverflow.in/2647

Let L be a language over Σ i.e., $L \subseteq \Sigma^*$. Suppose L satisfies the two conditions given below.

i. L is in NP and
ii. For every n, there is exactly one string of length n that belongs to L.

Let L^c be the complement of L over Σ^*. Show that L^c is also in NP.

gate1995 theory-of-computation normal decidability

5.4.7 Decidability: GATE1996-1.9 https://gateoverflow.in/2713

Which of the following statements is false?

A. The Halting Problem of Turing machines is undecidable
B. Determining whether a context-free grammar is ambiguous is undecidable
C. Given two arbitrary context-free grammars G_1 and G_2 it is undecidable whether $L(G_1) = L(G_2)$
D. Given two regular grammars G_1 and G_2 it is undecidable whether $L(G_1) = L(G_2)$

gate1996 theory-of-computation decidability easy

5.4.8 Decidability: GATE1997-6.5 https://gateoverflow.in/2261

Which one of the following is not decidable?

A. Given a Turing machine M, a string s and an integer k, M accepts s within k steps
B. Equivalence of two given Turing machines
C. Language accepted by a given finite state machine is not empty
D. Language generated by a context free grammar is non-empty

gate1997 theory-of-computation decidability easy

5.4.9 Decidability: GATE2000-2.9 https://gateoverflow.in/656

Consider the following decision problems:

$(P1)$: Does a given finite state machine accept a given string?

$(P2)$: Does a given context free grammar generate an infinite number of strings?

Which of the following statements is true?

A. Both$(P1)$ and $(P2)$ are decidable
B. Neither $(P1)$ nor $(P2)$ is decidable
C. Only $(P1)$ is decidable
D. Only $(P2)$ is decidable

gate2000 theory-of-computation decidability normal

5.4.10 Decidability: GATE2001-2.7 https://gateoverflow.in/725

Consider the following problem X.

Given a Turing machine M over the input alphabet Σ, any state q of M and a word $w \in \Sigma^*$, does the computation of M on w visit the state of q?

Which of the following statements about X is correct?

A. X is decidable
B. X is undecidable but partially decidable
C. X is undecidable and not even partially decidable
D. X is not a decision problem

gate2001 theory-of-computation decidability normal

5.4.11 Decidability: GATE2001-7 https://gateoverflow.in/748

Let a decision problem X be defined as follows:

X: Given a Turing machine M over Σ and any word $w \in \Sigma$, does M loop forever on w?

You may assume that the halting problem of Turing machine is undecidable but partially decidable.

A. Show that X is undecidable
B. Show that X is not even partially decidable

gate2001 theory-of-computation decidability turing-machine easy descriptive

5.4.12 Decidability: GATE2002-14 https://gateoverflow.in/867

The aim of the following question is to prove that the language $\{M \mid M \text{ is the code of the Turing Machine which, irrespective of the input, halts and outputs a } 1\}$, is undecidable. This is to be done by reducing from the language $\{M', x \mid M' \text{ halts on } x\}$, which is known to be undecidable. In parts (a) and (b) describe the 2 main steps in the construction of M. In part (c) describe the key property which relates the behaviour of M on its input w to the behaviour of M' on x.

A. On input w, what is the first step that M must make?
B. On input w, based on the outcome of the first step, what is the second step M must make?
C. What key property relates the behaviour of M on w to the behaviour of M' on x?

gate2002 theory-of-computation decidability normal turing-machine descriptive difficult

5.4.13 Decidability: GATE2003-52 https://gateoverflow.in/356

Consider two languages L_1 and L_2 each on the alphabet Σ. Let $f : \Sigma^* \to \Sigma^*$ be a polynomial time computable bijection such that $(\forall x)[x \in L_1 \text{ iff } f(x) \in L_2]$. Further, let f^{-1} be also polynomial time computable.

Which of the following **CANNOT** be true?

A. $L_1 \in P$ and L_2 is finite
B. $L_1 \in NP$ and $L_2 \in P$
C. L_1 is undecidable and L_2 is decidable
D. L_1 is recursively enumerable and L_2 is recursive

gate2003 theory-of-computation normal decidability

5.4.14 Decidability: GATE2005-45 https://gateoverflow.in/1375

- Consider three decision problems P_1, P_2 and P_3. It is known that P_1 is decidable and P_2 is undecidable. Which one of the following is TRUE?

A. P_3 is decidable if P_1 is reducible to P_3
B. P_3 is undecidable if P_3 is reducible to P_2
C. P_3 is undecidable if P_2 is reducible to P_3
D. P_3 is decidable if P_3 is reducible to P_2's complement

gate2005 theory-of-computation decidability normal

5.4.15 Decidability: GATE2007-6 https://gateoverflow.in/1204

Which of the following problems is undecidable?

A. Membership problem for CFGs
B. Ambiguity problem for CFGs
C. Finiteness problem for FSAs
D. Equivalence problem for FSAs

gate2007 theory-of-computation decidability normal

5.4.16 Decidability: GATE2008-10 https://gateoverflow.in/408

Which of the following are decidable?

I. Whether the intersection of two regular languages is infinite
II. Whether a given context-free language is regular
III. Whether two push-down automata accept the same language
IV. Whether a given grammar is context-free

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

gate2008 theory-of-computation decidability easy

5.4.17 Decidability: GATE2012-24 https://gateoverflow.in/1608

Which of the following problems are decidable?

1. Does a given program ever produce an output?
2. If L is a context-free language, then, is $\bar{L}$ also context-free?
3. If L is a regular language, then, $\bar{L}$ is also regular?
4. If L is a recursive language, then, is $\bar{L}$also recursive?

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

gate2012 theory-of-computation decidability normal

5.4.18 Decidability: GATE2013-41 https://gateoverflow.in/1553

Which of the following is/are undecidable?

1. G is a CFG. Is $L(G) = \phi$?
2. G is a CFG. Is $L(G) = \Sigma^*$?
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

gate2013 theory-of-computation decidability normal

5.4.19 Decidability: GATE2014-3-35 https://gateoverflow.in/2069

Which one of the following problems is undecidable?

A. Deciding if a given context-free grammar is ambiguous.
B. Deciding if a given string is generated by a given context-free grammar.
C. Deciding if the language generated by a given context-free grammar is empty.

D. Deciding if the language generated by a given context-free grammar is finite.

gate2014-3 theory-of-computation context-free-language decidability normal

5.4.20 Decidability: GATE2015-2-21 https://gateoverflow.in/8111

Consider the following statements.

I. The complement of every Turing decidable language is Turing decidable
II. There exists some language which is in NP but is not Turing decidable
III. If L is a language in NP, L is Turing decidable

Which of the above statements is/are true?

I. is true. The solution to a decision problem is either "yes" or "no", and hence if we can decide a problem, we have also decided its complement- just reverse "yes" and "no". (This is applicable for decidability and not for acceptance)

II. is false. Because NP class is defined as the class of languages that can be solved in polynomial time by a non-deterministic Turing machine. So, none of the NP class problems is undecidable.

III. is true for same reason as II.

A. Only II
B. Only III
C. Only I and II
D. Only I and III

gate2015-2 theory-of-computation decidability easy

5.4.21 Decidability: GATE2015-3-53 https://gateoverflow.in/8562

Language L_1 is polynomial time reducible to language L_2. Language L_3 is polynomial time reducible to language L_2, which in turn polynomial time reducible to language L_4. Which of the following is/are true?

I. if $L_4 \in P$, then $L_2 \in P$
II. if $L_1 \in P$ or $L_3 \in P$, then $L_2 \in P$
III. $L_1 \in P$, if and only if $L_3 \in P$
IV. if $L_4 \in P$, then $L_3 \in P$

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

gate2015-3 theory-of-computation decidability normal

5.4.22 Decidability: GATE2016-1-17 https://gateoverflow.in/39651

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

gate2016-1 theory-of-computation decidability easy

5.4.23 Decidability: GATE2017-1-39 https://gateoverflow.in/118322

Let A and B be finite alphabets and let $\#$ be a symbol outside both A and B. Let f be a total function from A^* to B^*. We say f is *computable* if there exists a Turing machine M which given an input $x \in A^*$, always halts with $f(x)$ on its tape. Let L_f denote the language $\left\{x\#f(x) \mid x \in A^*\right\}$. Which of the following statements is true:

A. f is computable if and only if L_f is recursive.
B. f is computable if and only if L_f is recursively enumerable.
C. If f is computable then L_f is recursive, but not conversely.
D. If f is computable then L_f is recursively enumerable, but not conversely.

gate2017-1 theory-of-computation decidability difficult

5.4.24 Decidability: GATE2017-2-41 https://gateoverflow.in/118605

Let $L(R)$ be the language represented by regular expression R. Let $L(G)$ be the language generated by a context free grammar G. Let $L(M)$ be the language accepted by a Turing machine M. Which of the following decision problems are undecidable?

I. Given a regular expression R and a string w, is $w \in L(R)$?

II. Given a context-free grammar G, is $L(G) = \emptyset$
III. Given a context-free grammar G, is $L(G) = \Sigma^*$ for some alphabet Σ?
IV. Given a Turing machine M and a string w, is $w \in L(M)$?

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

gate2017-2 theory-of-computation decidability

5.4.25 Decidability: GATE2018-36 https://gateoverflow.in/204110

Consider the following problems. $L(G)$ denotes the language generated by a grammar G. L(M) denotes the language accepted by a machine M.

I. For an unrestricted grammar G and a string w, whether $w \epsilon L(G)$
II. Given a Turing machine M, whether $L(M)$ is regular
III. Given two grammarG_1 and G_2, whether $L(G_1) = L(G_2)$
IV. Given an NFA N, whether there is a deterministic PDA P such that N and P accept the same language

Which one of the following statement is correct?

A. Only I and II are undecidable
B. Only II is undecidable
C. Only II and IV are undecidable
D. Only I, II and III are undecidable

gate2018 theory-of-computation decidability easy

5.4.26 Decidability: TIFR2010-B-25 https://gateoverflow.in/18745

Which of the following problems is decidable? (Here, CFG means context free grammar and CFL means context free language.)

A. Given a CFG G, find whether $L(G) = R$, where R is regular set.
B. Given a CFG G, find whether $L(G) = \{\}$.
C. Find whether the intersection of two CFLs is empty.
D. Find whether the complement of CFL is a CFL.
E. Find whether CFG G_1 and CFG G_2 generate the same language, i.e, $L(G_1) = L(G_2)$.

tifr2010 theory-of-computation context-free-language decidability

5.4.27 Decidability: TIFR2011-B-25 https://gateoverflow.in/20404

Let A_{TM} be defined as follows:

$A_{TM} = \{\langle M, w\rangle \mid \text{The Turning machine } M \text{ accepts the word } w\}$

And let L be some $\mathbf{NP}-$ complete language. Which of the following statements is FALSE?

A. $L \in \mathbf{NP}$
B. Every problem in $\mathbf{NP}$ is polynomial time reducible to L.
C. Every problem in $\mathbf{NP}$ is polynomial time reducible to A_{TM}.
D. Since L is $\mathbf{NP}-$ complete, A_{TM} is polynomial time reducible to L.
E. $A_{TM} \notin \mathbf{NP}$.

tifr2011 theory-of-computation decidability

5.5 Finite Automata (37)

5.5.1 Finite Automata: GATE1991-17,b https://gateoverflow.in/544

Let L be the language of all binary strings in which the third symbol from the right is a 1. Give a non-deterministic finite automaton that recognizes L. How many states does the minimized equivalent deterministic finite automaton have? Justify your answer briefly?

gate1991 theory-of-computation finite-automata normal

5.5.2 Finite Automata: GATE1993-27 https://gateoverflow.in/2323

Draw the state transition of a deterministic finite state automaton which accepts all strings from the alphabet $\{a, b\}$, such that no string has 3 consecutive occurrences of the letter b.

gate1993 theory-of-computation finite-automata easy

5.5.3 Finite Automata: GATE1994-3.3 https://gateoverflow.in/2480

State True or False with one line explanation

A FSM (Finite State Machine) can be designed to add two integers of any arbitrary length (arbitrary number of digits).

gate1994 theory-of-computation finite-automata normal

5.5.4 Finite Automata: GATE1995-2.23 https://gateoverflow.in/2636

A finite state machine with the following state table has a single input x and a single out z.

present state	next state, z	
	x=1	x=0
A	D,0	B,0
B	B,1	C,1
C	B,0	D,1
D	B,1	C,0

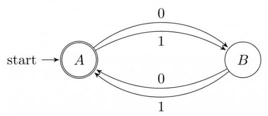
If the initial state is unknown, then the shortest input sequence to reach the final state C is:

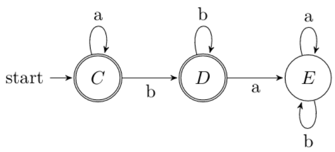
A. 01 B. 10 C. 101 D. 110

gate1995 theory-of-computation finite-automata normal

5.5.5 Finite Automata: GATE1996-12 https://gateoverflow.in/2764

Given below are the transition diagrams for two finite state machines M_1 and M_2 recognizing languages L_1 and L_2 respectively.





A. Display the transition diagram for a machine that recognizes $L_1 . L_2$, obtained from transition diagrams for M_1 and M_2 by adding only ε transitions and no new states.
B. Modify the transition diagram obtained in part (a) obtain a transition diagram for a machine that recognizes $(L_1 . L_2)^*$ by adding only ε transitions and no new states.
(Final states are enclosed in double circles).

gate1996 theory-of-computation finite-automata normal

5.5.6 Finite Automata: GATE1997-21 https://gateoverflow.in/2281

Given that L is a language accepted by a finite state machine, show that L^P and L^R are also accepted by some finite state machines, where

$$L^P = \{s \mid ss' \in L \text{ some string } s'\}$$

$$L^R = \{s \mid s \text{ obtained by reversing some string in } L\}$$

gate1997 theory-of-computation finite-automata proof

5.5.7 Finite Automata: GATE1998-1.10

https://gateoverflow.in/1647

Which of the following set can be recognized by a Deterministic Finite state Automaton?

A. The numbers $1, 2, 4, 8, \dots 2^n, \dots$ written in binary
B. The numbers $1, 2, 4, 8, \dots 2^n, \dots$ written in unary
C. The set of binary string in which the number of zeros is the same as the number of ones.
D. The set $\{1, 101, 11011, 1110111, \dots\}$

gate1998 theory-of-computation finite-automata normal

5.5.8 Finite Automata: GATE2001-5

https://gateoverflow.in/746

Construct DFA's for the following languages:

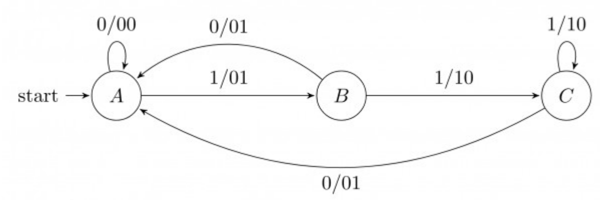
A. $L = \{w \mid w \in \{a, b\}^*, \text{ w has baab as a substring }\}$
B. $L = \{w \mid w \in \{a, b\}^*, \text{ w has an odd number of a's and an odd number of b's }\}$

gate2001 theory-of-computation easy descriptive finite-automata normal

5.5.9 Finite Automata: GATE2002-2.5

https://gateoverflow.in/835

The finite state machine described by the following state diagram with A as starting state, where an arc label is and x stands for 1-bit input and y stands for 2-bit output



A. outputs the sum of the present and the previous bits of the input
B. outputs 01 whenever the input sequence contains 11
C. outputs 00 whenever the input sequence contains 10
D. none of the above

gate2002 theory-of-computation normal finite-automata

5.5.10 Finite Automata: GATE2002-21

https://gateoverflow.in/874

We require a four state automaton to recognize the regular expression $(a \mid b)^* abb$

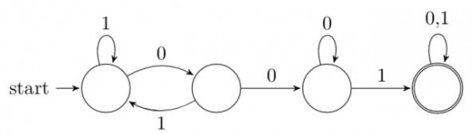
A. Give an NFA for this purpose
B. Give a DFA for this purpose

gate2002 theory-of-computation finite-automata normal descriptive

5.5.11 Finite Automata: GATE2003-50

https://gateoverflow.in/939

Consider the following deterministic finite state automaton M.



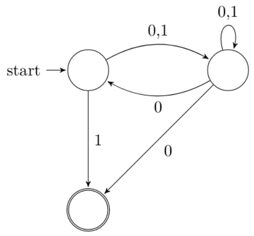
Let S denote the set of seven bit binary strings in which the first, the fourth, and the last bits are 1. The number of strings in S that are accepted by M is

A. 1 B. 5 C. 7 D. 8

gate2003 theory-of-computation finite-automata normal

5.5.12 Finite Automata: GATE2003-55 https://gateoverflow.in/943

Consider the NFA M shown below.



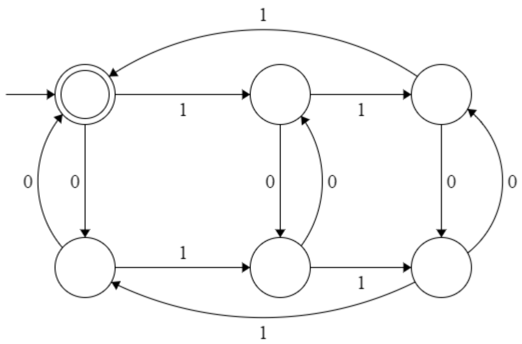
Let the language accepted by M be L. Let L_1 be the language accepted by the NFA M_1 obtained by changing the accepting state of M to a non-accepting state and by changing the non-accepting states of M to accepting states. Which of the following statements is true?

A. $L_1 = \{0,1\}^* - L$ B. $L_1 = \{0,1\}^*$ C. $L_1 \subseteq L$ D. $L_1 = L$

gate2003 theory-of-computation finite-automata normal

5.5.13 Finite Automata: GATE2004-86 https://gateoverflow.in/1080

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

gate2004 theory-of-computation finite-automata easy

5.5.14 Finite Automata: GATE2004-IT-41 https://gateoverflow.in/3684

Let $M = (K, \Sigma, \sigma, s, F)$ be a finite state automaton, where

$K = \{A, B\}, \Sigma = \{a, b\}, s = A, F = \{B\},$
$\sigma(A, a) = A, \sigma(A, b) = B, \sigma(B, a) = B$ and $\sigma(B, b) = A$

A grammar to generate the language accepted by M can be specified as $G = (V, \Sigma, R, S),$ where $V = K \cup \Sigma$, and $S = A$.

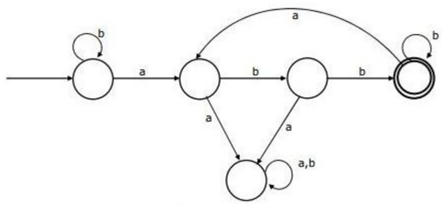
Which one of the following set of rules will make $L(G) = L(M)$?

A. $\{A \to aB, A \to bA, B \to bA, B \to aA, B \to \epsilon)$
B. $\{A \to aA, A \to bB, B \to aB, B \to bA, B \to \epsilon)$
C. $\{A \to bB, A \to aB, B \to aA, B \to bA, B \to \epsilon)$
D. $\{A \to aA, A \to bA, B \to aB, B \to bA, A \to \epsilon)$

gate2004-it theory-of-computation finite-automata normal

5.5.15 Finite Automata: GATE2005-53 https://gateoverflow.in/1376

Consider the machine M:



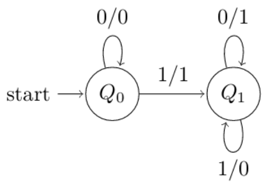
The language recognized by M is:

A. $\{w \in \{a, b\}^* \mid \text{every a in } w \text{ is followed by exactly two } b\text{'s}\}$
B. $\{w \in \{a, b\}^* \mid \text{every a in } w \text{ is followed by at least two } b\text{'s}\}$
C. $\{w \in \{a, b\}^* \mid w \text{ contains the substring '} abb \text{'}\}$
D. $\{w \in \{a, b\}^* \mid w \text{ does not contain '} aa \text{' as a substring}\}$

gate2005 theory-of-computation finite-automata normal

5.5.16 Finite Automata: GATE2005-63 https://gateoverflow.in/1386

The following diagram represents a finite state machine which takes as input a binary number from the least significant bit.



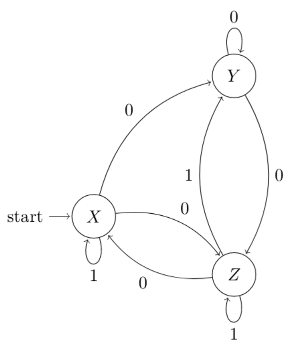
Which of the following is TRUE?

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

gate2005 theory-of-computation finite-automata easy

5.5.17 Finite Automata: GATE2005-IT-37 https://gateoverflow.in/3784

Consider the non-deterministic finite automaton (NFA) shown in the figure.



State X is the starting state of the automaton. Let the language accepted by the NFA with Y as the only accepting state be $L1$. Similarly, let the language accepted by the NFA with Z as the only accepting state be $L2$. Which of the following statements about $L1$ and $L2$ is TRUE?

A. $L1 = L2$
B. $L1 \subset L2$
C. $L2 \subset L1$
D. None of the above

gate2005-it theory-of-computation finite-automata normal

5.5.18 Finite Automata: GATE2005-IT-39 https://gateoverflow.in/3786

Consider the regular grammar:

- $S \rightarrow Xa \mid Ya$
- $X \rightarrow Za$
- $Z \rightarrow Sa \mid \epsilon$
- $Y \rightarrow Wa$
- $W \rightarrow Sa$

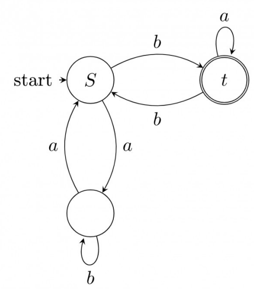
where S is the starting symbol, the set of terminals is $\{a\}$ and the set of non-terminals is $\{S, W, X, Y, Z\}$.
We wish to construct a deterministic finite automaton (DFA) to recognize the same language. What is the minimum number of states required for the DFA?

A. 2 B. 3 C. 4 D. 5

gate2005-it theory-of-computation finite-automata normal

5.5.19 Finite Automata: GATE2006-IT-3 https://gateoverflow.in/3542

In the automaton below, s is the start state and t is the only final state.



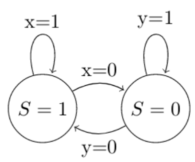
Consider the strings $u = abbaba, v = bab, \text{and} w = aabb$. Which of the following statements is true?

A. The automaton accepts u and v but not w
B. The automaton accepts each of u, v, and w
C. The automaton rejects each of u, v, and w
D. The automaton accepts u but rejects v and w

gate2006-it theory-of-computation finite-automata normal

5.5.20 Finite Automata: GATE2006-IT-37 https://gateoverflow.in/3576

For a state machine with the following state diagram the expression for the next state S^+ in terms of the current state S and the input variables x and y is

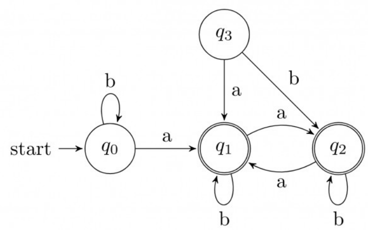


A. $S^+ = S'.y' + S.x$
B. $S^+ = S.x.y' + S'.y.x'$
C. $S^+ = x.y'$
D. $S^+ = S'.y + S.x'$

gate2006-it theory-of-computation finite-automata normal

5.5.21 Finite Automata: GATE2007-74 https://gateoverflow.in/1270

Consider the following Finite State Automaton:



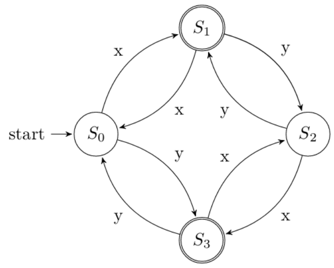
The language accepted by this automaton is given by the regular expression

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

gate2007 theory-of-computation finite-automata normal

5.5.22 Finite Automata: GATE2007-IT-47 https://gateoverflow.in/3489

Consider the following DFA in which S_0 is the start state and S_1, S_3 are the final states.



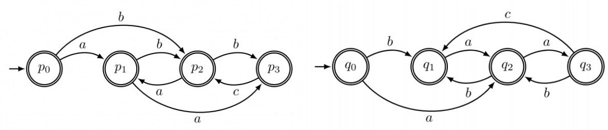
What language does this DFA recognize?

A. All strings of x and y
B. All strings of x and y which have either even number of x and even number of y or odd number of x and odd number of y
C. All strings of x and y which have equal number of x and y
D. All strings of x and y with either even number of x and odd number of y or odd number of x and even number of y

gate2007-it theory-of-computation finite-automata normal

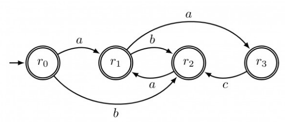
5.5.23 Finite Automata: GATE2007-IT-50 https://gateoverflow.in/3492

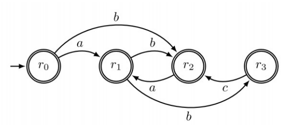
Consider the following finite automata P and Q over the alphabet $\{a, b, c\}$. The start states are indicated by a double arrow and final states are indicated by a double circle. Let the languages recognized by them be denoted by $L(P)$ and $L(Q)$ respectively.

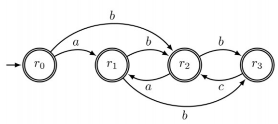


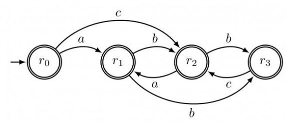
(P) (Q)

The automation which recognizes the language $L(P) \cap L(Q)$ is :

A. 

B. 

C. 

D. 

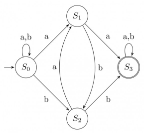
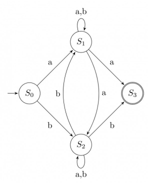
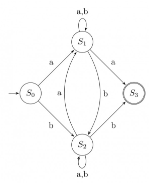
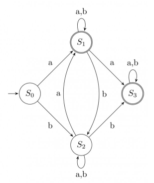
gate2007-it theory-of-computation finite-automata normal

5.5.24 Finite Automata: GATE2007-IT-71 https://gateoverflow.in/3523

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 transitions on the empty string.

A. B. C. D.

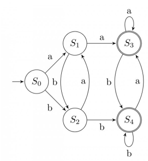





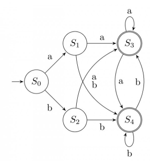
gate2007-it theory-of-computation finite-automata normal

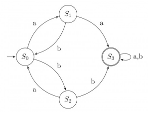
5.5.25 Finite Automata: GATE2007-IT-72 https://gateoverflow.in/3524

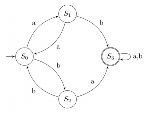
Consider the regular expression $R = (a+b)^*(aa+bb)(a+b)^*$

Which deterministic finite automaton accepts the language represented by the regular expression R?


A.


B.


C.


D.

gate2007-it theory-of-computation finite-automata normal

5.5.26 Finite Automata: GATE2008-49 https://gateoverflow.in/462

Given below are two finite state automata ($\rightarrow$ indicates the start state and F indicates a final state)

Y

	a	b
$\rightarrow 1$	1	2
$2(F)$	2	1

Z

	a	b
$\rightarrow 1$	2	2
$2(F)$	1	1

Which of the following represents the product automaton $Z \times Y$?

A.

	a	b
$\rightarrow P$	S	R
Q	R	S
R(F)	Q	P
S	Q	P

B.

	a	b
$\rightarrow P$	S	Q
Q	R	S
R(F)	Q	P
S	P	Q

C.

	a	b
$\rightarrow P$	Q	S
Q	R	S
R(F)	Q	P
S	Q	P

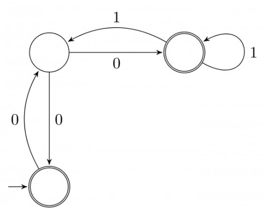
D.

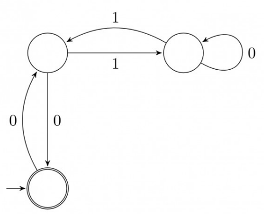
	a	b
$\rightarrow P$	S	Q
Q	S	R
R(F)	Q	P
S	Q	P

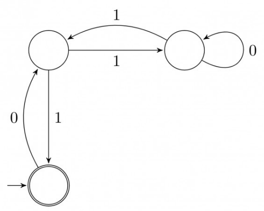
gate2008 normal theory-of-computation finite-automata

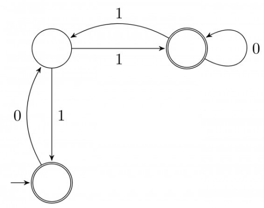
5.5.27 Finite Automata: GATE2008-52 https://gateoverflow.in/464

Match the following NFAs with the regular expressions they correspond to:


P


Q


R


S

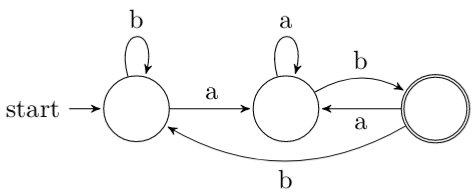
1. $\epsilon + 0(01^*1 + 00)^*01^*$
2. $\epsilon + 0(10^*1 + 00)^*0$
3. $\epsilon + 0(10^*1 + 10)^*1$
4. $\epsilon + 0(10^*1 + 10)^*10^*$

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

gate2008 theory-of-computation finite-automata normal

5.5.28 Finite Automata: GATE2008-IT-32 https://gateoverflow.in/3342

If the final states and non-final states in the DFA below are interchanged, then which of the following languages over the alphabet $\{a, b\}$ will be accepted by the new DFA?

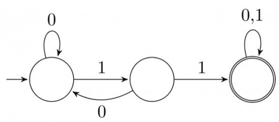


A. Set of all strings that do not end with ab
B. Set of all strings that begin with either an a or $a\,b$
C. Set of all strings that do not contain the substring ab,
D. The set described by the regular expression $b^*aa^*(ba)^*b^*$

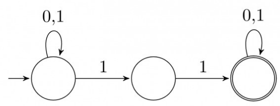
gate2008-it theory-of-computation finite-automata normal

5.5.29 Finite Automata: GATE2008-IT-36 https://gateoverflow.in/3346

Consider the following two finite automata. M_1 accepts L_1 and M_2 accepts L_2.



M_1



M_2

Which one of the following is TRUE?

A. $L_1 = L_2$
B. $L_1 \subset L_2$
C. $L_1 \cap L_2^C = \varnothing$
D. $L_1 \cup L_2 \neq L_1$

gate2008-it theory-of-computation finite-automata normal

5.5.30 Finite Automata: GATE2009-27 https://gateoverflow.in/1313

Given the following state table of an FSM with two states A and B,one input and one output.

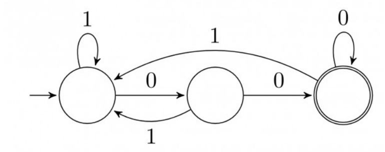
PRESENT STATE A	PRESENT STATE B	Input	Next State A	Next State B	Output
0	0	0	0	0	1
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	1	0	0
0	0	1	0	1	0
0	1	1	0	0	1
1	0	1	0	1	1
1	1	1	0	0	1

If the initial state is $A = 0, B = 0$ what is the minimum length of an input string which will take the machine to the state $A = 0, B = 1$ with $output = 1$.

A. 3 B. 4 C. 5 D. 6

gate2009 theory-of-computation finite-automata normal

5.5.31 Finite Automata: GATE2009-41 https://gateoverflow.in/1327



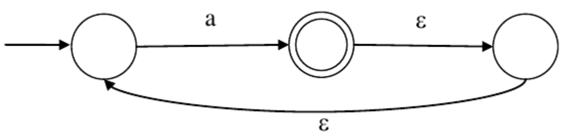
The above DFA accepts the set of all strings over $\{0,1\}$ that

A. begin either with 0 or 1.
B. end with 0.
C. end with 00.
D. contain the substring 00.

gate2009 theory-of-computation finite-automata easy

5.5.32 Finite Automata: GATE2012-12 https://gateoverflow.in/44

What is the complement of the language accepted by the NFA shown below?
Assume $\Sigma = \{a\}$ and ϵ is the empty string.

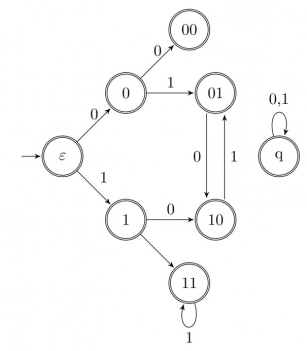


A. ϕ B. $\{\epsilon\}$ C. a^* D. $\{a, \epsilon\}$

gate2012 finite-automata easy theory-of-computation

5.5.33 Finite Automata: GATE2012-46 https://gateoverflow.in/2159

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.

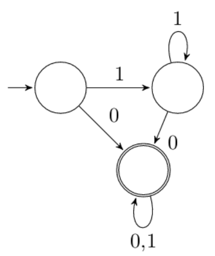
	00	01	10	11	q
00		1			0
01				1	
10	0				
11			0		

gate2012 theory-of-computation finite-automata normal

5.5.34 Finite Automata: GATE2013-33

https://gateoverflow.in/1544

Consider the DFA A given below.



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.

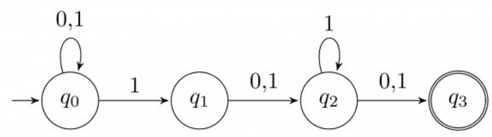
A. 1 and 3 only B. 2 and 4 only C. 2 and 3 only D. 3 and 4 only

gate2013 theory-of-computation finite-automata normal

5.5.35 Finite Automata: GATE2014-1-16

https://gateoverflow.in/1782

Consider the finite automaton in the following figure:



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

A. $\{q_0, q_1, q_2\}$ B. $\{q_0, q_1\}$ C. $\{q_0, q_1, q_2, q_3\}$ D. $\{q_3\}$

gate2014-1 theory-of-computation finite-automata easy

5.5.36 Finite Automata: GATE2016-2-42 https://gateoverflow.in/39591

Consider the following two statements:

I. If all states of an **NFA** are accepting states then the language accepted by the **NFA** is $\sum^*$. False, not necessary for all
II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.
A ={}, then this statemant will true as {} intersection with 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

gate2016-2 theory-of-computation finite-automata normal

5.5.37 Finite Automata: GATE2017-2-39 https://gateoverflow.in/118384

Let δ denote the transition function and $\hat{\delta}$ denote the extended transition function of the ϵ-NFA whose transition table is given below:

δ	ϵ	a	b
$\rightarrow q_0$	$\{q_2\}$	$\{q_1\}$	$\{q_0\}$
q_1	$\{q_2\}$	$\{q_2\}$	$\{q_3\}$
q_2	$\{q_0\}$	$\emptyset$	$\emptyset$
q_3	$\emptyset$	$\emptyset$	$\{q_2\}$

Then $\hat{\delta}(q_2, aba)$ is

A. $\emptyset$
B. $\{q_0, q_1, q_3\}$
C. $\{q_0, q_1, q_2\}$
D. $\{q_0, q_2, q_3\}$

gate2017-2 theory-of-computation finite-automata

5.6 Grammar (1)

5.6.1 Grammar: GATE2008-51 https://gateoverflow.in/463

Match the following:

E.	Checking that identifiers are declared before their use	P.	$L = \{a^n b^m c^n d^m \mid n \geq 1, m \geq 1\}$
F.	Number of formal parameters in the declaration of a function agrees with the number of actual parameters in a use of that function	Q.	$X \rightarrow XbX \mid XcX \mid dXf \mid g$
G.	Arithmetic expressions with matched pairs of parentheses	R.	$L = \{wcw \mid w \in (a \mid b)^*\}$
H.	Palindromes	S.	$X \rightarrow bXb \mid cXc \mid \epsilon$

A. E-P, F-R, G-Q, H-S
B. E-R, F-P, G-S, H-Q
C. E-R, F-P, G-Q, H-S
D. E-P, F-R, G-S, H-Q

gate2008 normal theory-of-computation grammar

5.7 Identify Class Language (34)

5.7.1 Identify Class Language: GATE1987-1-xiii https://gateoverflow.in/80293

FORTRAN is a:

A. Regular language.
B. Context-free language.
C. Context-senstive language.
D. None of the above.

gate1987 theory-of-computation identify-class-language

5.7.2 Identify Class Language: GATE1988-2ix https://gateoverflow.in/93949

What is the type of the language L, where $L = \{a^n b^n \mid 0 < n < 327\text{-th prime number}\}$

gate1988 normal descriptive algorithms theory-of-computation identify-class-language

5.7.3 Identify Class Language: GATE1991-17,a https://gateoverflow.in/26653

Show that the Turing machines, which have a read only input tape and constant size work tape, recognize precisely the class of regular languages.

gate1991 theory-of-computation descriptive identify-class-language

5.7.4 Identify Class Language: GATE1994-19 https://gateoverflow.in/2515

(a) Given a set:

$$S = \{x \mid \text{ there is an x-block of 5's in the decimal expansion of } \pi\}$$

(Note: x-*block* is a maximal block of x successive 5's)
Which of the following statements is true with respect to S? No reason to be given for the answer.

i. S is regular
ii. S is recursively enumerable
iii. S is not recursively enumerable
iv. S is recursive

(b) Given that a language L_1 is regular and and that the language $L_1 \cup L_2$ is regular, is the language L_2 always regular? Prove your answer.

gate1994 theory-of-computation identify-class-language normal

5.7.5 Identify Class Language: GATE1999-2.4 https://gateoverflow.in/1482

Multiple choices may be correct:
If $L1$ is context free language and $L2$ is a regular language which of the following is/are false?

A. $L1 - L2$ is not context free
B. $L1 \cap L2$ is context free
C. $\sim L1$ is context free
D. $\sim L2$ is regular

gate1999 theory-of-computation identify-class-language normal

5.7.6 Identify Class Language: GATE2000-1.5 https://gateoverflow.in/628

Let L denote the languages generated by the grammar $S \rightarrow 0S0 \mid 00$.
Which of the following is TRUE?

A. $L = 0^+$
B. L is regular but not 0^+
C. L is context free but not regular
D. L is not context free

gate2000 theory-of-computation easy identify-class-language

5.7.7 Identify Class Language: GATE2002-1.7 https://gateoverflow.in/811

The language accepted by a Pushdown Automaton in which the stack is limited to 10 items is best described as

A. Context free
B. Regular
C. Deterministic Context free
D. Recursive

gate2002 theory-of-computation easy identify-class-language

5.7.8 Identify Class Language: GATE2004-87 https://gateoverflow.in/1081

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

gate2004 theory-of-computation normal identify-class-language

5.7.9 Identify Class Language: GATE2005-55 https://gateoverflow.in/1378

Consider the languages:
$L_1 = \{a^n b^n c^m \mid n, m > 0\}$ and $L_2 = \{a^n b^m c^m \mid n, m > 0\}$
Which one of the following statements is FALSE?

A. $L_1 \cap L_2$ is a context-free language
B. $L_1 \cup L_2$ is a context-free language
C. L_1 and L_2 are context-free languages
D. $L_1 \cap L_2$ is a context sensitive language

gate2005 theory-of-computation identify-class-language normal

5.7.10 Identify Class Language: GATE2005-IT-4 https://gateoverflow.in/3748

Let L be a regular language and M be a context-free language, both over the alphabet Σ. Let L^c and M^c denote the complements of L and M respectively. Which of the following statements about the language $L^c \cup M^c$ is TRUE?

A. It is necessarily regular but not necessarily context-free.
B. It is necessarily context-free.
C. It is necessarily non-regular.
D. None of the above

gate2005-it theory-of-computation normal identify-class-language

5.7.11 Identify Class Language: GATE2005-IT-6 https://gateoverflow.in/3751

The language $\{0^n 1^n 2^n \mid 1 \leq n \leq 10^6\}$ is

A. regular
B. context-free but not regular
C. context-free but its complement is not context-free
D. not context-free

gate2005-it theory-of-computation easy identify-class-language

5.7.12 Identify Class Language: GATE2006-30 https://gateoverflow.in/993

For $s \in (0+1)^*$ let $d(s)$ denote the decimal value of s (e.g. $d(101) = 5$). Let

$$L = \{s \in (0+1)^* \mid d(s) \bmod 5 = 2 \text{ and } d(s) \bmod 7 \neq 4\}$$

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

gate2006 theory-of-computation normal identify-class-language

5.7.13 Identify Class Language: GATE2006-33 https://gateoverflow.in/996

Let L_1 be a regular language, L_2 be a deterministic context-free language and L_3 a recursively enumerable, but not recursive, language. Which one of the following statements is false?

A. $L_1 \cap L_2$ is a deterministic CFL
B. $L_3 \cap L_1$ is recursive
C. $L_1 \cup L_2$ is context free
D. $L_1 \cap L_2 \cap L_3$ is recursively enumerable

gate2006 theory-of-computation normal identify-class-language

5.7.14 Identify Class Language: GATE2007-30 https://gateoverflow.in/1228

The language $L = \{0^i 2 1^i \mid i \geq 0\}$ 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

gate2007 theory-of-computation normal identify-class-language

5.7.15 Identify Class Language: GATE2008-9 https://gateoverflow.in/407

Which of the following is true for the language

$$\{a^p \mid p \text{ is a prime }\}?$$

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

gate2008 theory-of-computation easy identify-class-language

5.7.16 Identify Class Language: GATE2008-IT-33 https://gateoverflow.in/3343

Consider the following languages.

- $L_1 = \{a^i b^j c^k \mid i = j, k \geq 1\}$
- $L_2 = \{a^i b^j \mid j = 2i, i \geq 0\}$

Which of the following is true?

A. L_1 is not a CFL but L_2 is
B. $L_1 \cap L_2 = \varnothing$ and L_1 is non-regular
C. $L_1 \cup L_2$ is not a CFL but L_2 is
D. There is a 4-state PDA that accepts L_1, but there is no DPDA that accepts L_2.

gate2008-it theory-of-computation normal identify-class-language

5.7.17 Identify Class Language: GATE2009-40 https://gateoverflow.in/1326

Let $L = L_1 \cap L_2$, where L_1 and L_2 are languages as defined below:

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

$L_2 = \left\{a^i b^j c^k \mid i, j, k \geq 0\right\}$

Then L is

A. Not recursive
B. Regular
C. Context free but not regular
D. Recursively enumerable but not context free.

gate2009 theory-of-computation easy identify-class-language

5.7.18 Identify Class Language: GATE2010-40 https://gateoverflow.in/2341

Consider the languages

$L1 = \{0^i 1^j \mid i \neq j\}$,

$L2 = \{0^i 1^j \mid i = j\}$,

$L3 = \{0^i 1^j \mid i = 2j + 1\}$,

$L4 = \{0^i 1^j \mid i \neq 2j\}$

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

gate2010 theory-of-computation context-free-language identify-class-language normal

5.7.19 Identify Class Language: GATE2011-26 https://gateoverflow.in/2128

Consider the languages $L1,\ L2\ and\ L3$ as given below.

$L1 = \{0^p 1^q \mid p, q \in N\}, L2 = \{0^p 1^q \mid p, q \in N\ and\ p = q\}\ and L3 = \{0^p 1^q 0^r \mid p, q, r \in N\ and\ p = q = r\}.$

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 machines can be used to recognize all the languages

gate2011 theory-of-computation identify-class-language normal

5.7.20 Identify Class Language: GATE2013-32 https://gateoverflow.in/1543

Consider the following languages.

$L_1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\}$

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

Which one of the following statements is **FALSE**?

A. L_2 is context-free.
B. $L_1 \cap L_2$ is context-free.
C. Complement of L_2 is recursive.
D. Complement of L_1 is context-free but not regular.

gate2013 theory-of-computation identify-class-language normal

5.7.21 Identify Class Language: GATE2014-3-36 https://gateoverflow.in/2070

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

$L_1 = \{0^n 1^n \mid n \geq 0\}$

$L_2 = \{wcw^r \mid w \in \{0, 1\}^*\}$

$L_3 = \{ww^r \mid w \in \{0, 1\}^*\}$

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 L_1
C. Only L_1 and L_2
D. All the three languages

gate2014-3 theory-of-computation identify-class-language context-free-language normal

5.7.22 Identify Class Language: GATE2017-1-37 https://gateoverflow.in/118320

Consider the context-free grammars over the alphabet $\{a, b, c\}$ given below. S and T are non-terminals.

$G_1 : S \to aSb \mid T, T \to cT \mid \epsilon$

$G_2 : S \to bSa \mid T, T \to cT \mid \epsilon$

The language $L(G_1) \cap L(G_2)$ is

A. Finite
B. Not finite but regular
C. Context-Free but not regular
D. Recursive but not context-free

gate2017-1 theory-of-computation context-free-language identify-class-language normal

5.7.23 Identify Class Language: GATE2017-2-40 https://gateoverflow.in/118615

Consider the following languages.

- $L_1 = \{a^p \mid p \text{ is a prime number}\}$
- $L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$
- $L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$
- $L_4 = \{a^n b^n \mid n \geq 1\}$

Which of the following are CORRECT?

I. L_1 is context free but not regular
II. L_2 is not context free
III. L_3 is not context free but recursive
IV. L_4 is deterministic context free

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

gate2017-2 theory-of-computation identify-class-language

5.7.24 Identify Class Language: GATE2018-35 https://gateoverflow.in/204109

Consider the following languages:

I. $\{a^m b^n c^p d^q \mid m+p=n+q, \text{ where } m,n,p,q \geq 0\}$
II. $\{a^m b^n c^p d^q \mid m=n \text{ and } p=q, \text{ where } m,n,p,q \geq 0\}$
III. $\{a^m b^n c^p d^q \mid m=n=p \text{ and } p \neq q, \text{ where } m,n,p,q \geq 0\}$
IV. $\{a^m b^n c^p d^q \mid mn=p+q, \text{ where } m,n,p,q \geq 0\}$

Which of the above languages are context-free?

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

gate2018 theory-of-computation identify-class-language context-free-language normal

5.7.25 Identify Class Language: TIFR2010-B-22 https://gateoverflow.in/18622

Let L consist of all binary strings beginning with a 1 such that its value when converted to decimal is divisible by 5. Which of the following is true?

A. L can be recognized by a deterministic finite state automaton.
B. L can be recognized by a non-deterministic finite state automaton but not by a deterministic finite state automaton.
C. L can be recognized by a deterministic push-down automaton but not by a non-deterministic finite state automaton.
D. L can be recognized by a non-deterministic push-down automaton but not by a deterministic push-down automaton.
E. L cannot be recognized by any push-down automaton.

tifr2010 theory-of-computation identify-class-language

5.7.26 Identify Class Language: TIFR2010-B-35 https://gateoverflow.in/19247

Consider the following languages over the alphabet $\{0,1\}$.

$L1 = \{x.x^R \mid x \in \{0,1\}^*\}$

$L2 = \{x.x \mid x \in \{0,1\}^*\}$

Where x^R is the reverse of string x; e.g. $011^R = 110$. Which of the following is true?

A. Both $L1$ and $L2$ are regular.
B. $L1$ is context-free but not regular where as $L2$ is regualr.
C. Both $L1$ and $L2$ are context free and neither is regular.
D. $L1$ is context free but $L2$ is not context free.
E. Both $L1$ and $L2$ are not context free.

tifr2010 theory-of-computation identify-class-language

5.7.27 Identify Class Language: TIFR2012-B-18 https://gateoverflow.in/25216

Let a^i denote a sequence $a.a\dots a$ with i letters and let $\aleph$ be the set of natural numbers $1,2,\dots$. Let $L_1 = \{a^i b^{2i} \mid i \in \aleph\}$ and $L_2 = \left\{a^i b^{i^2} \mid i \in \aleph\right\}$ be two languages. Which of the following is correct?

A. Both L_1 and L_2 are context-free languages.
B. L_1 is context-free and L_2 is recursive but not context-free.
C. Both L_1 and L_2 are recursive but not context-free.
D. L_1 is regular and L_2 is context-free.
E. Complement of L_2 is context-free.

tifr2012 theory-of-computation identify-class-language

5.7.28 Identify Class Language: TIFR2014-B-13 https://gateoverflow.in/27320

Let L be a given context-free language over the alphabet $\{a,b\}$. Construct L_1, L_2 as follows. Let $L_1 = L - \{xyx \mid x,y \in \{a,b\}^*\}$, and $L_2 = L \cdot L$. Then,

A. Both L_1 and L_2 are regular.
B. Both L_1 and L_2 are context free but not necessarily regular.

C. L_1 is regular and L_2 is context free.
D. L_1 and L_2 both may not be context free.
E. L_1 is regular but L_2 may not be context free.

tifr2014 theory-of-computation identify-class-language

5.7.29 Identify Class Language: TIFR2015-B-8 https://gateoverflow.in/29865

Let $\sum_1 = \{a\}$ be a one letter alphabet and $\sum_2 = \{a, b\}$ be a two letter alphabet. A language over an alphabet is a set of finite length words comprising letters of the alphabet. Let L_1 and L_2 be the set of languages over $\sum_1$ and $\sum_2$ respectively. Which of the following is true about L_1 and L_2:

A. Both are finite.
B. Both are countably infinite.
C. L_1 is countable but L_2 is not.
D. L_2 is countable but L_1 is not.
E. Neither of them is countable.

tifr2015 identify-class-language

5.7.30 Identify Class Language: TIFR2017-B-14 https://gateoverflow.in/95825

Consider the following grammar G with terminals $\{[,]\}$, start symbol S, and non-terminals $\{A, B, C\}$:

$$S \rightarrow AC \mid SS \mid AB$$

$$C \rightarrow SB$$

$$A \rightarrow [$$

$$B \rightarrow]$$

A language L is called prefix-closed if for every $x \in L$, every prefix of x is also in L. Which of the following is FALSE?

A. $L(G)$ is context free
B. $L(G)$ is infinite
C. $L(G)$ can be recognized by a deterministic push down automaton
D. $L(G)$ is prefix-closed
E. $L(G)$ is recursive

tifr2017 theory-of-computation identify-class-language

5.7.31 Identify Class Language: TIFR2017-B-4 https://gateoverflow.in/95680

Let L be the language over the alphabet $\{1, 2, 3, (,)\}$ generated by the following grammar (with start symbol S, and non-terminals $\{A, B, C\}$):

$S \rightarrow A\,B\,C A \rightarrow (\,(B \rightarrow 1\,B \mid 2\,B \mid 3\,BB \rightarrow 1 \mid 2 \mid 3C \rightarrow)$

Then, which of the following is TRUE?

A. L is finite
B. L is not recursively enumerable
C. L is regular
D. L contains only strings of even length
E. L is context-free but not regular

tifr2017 theory-of-computation identify-class-language

5.7.32 Identify Class Language: TIFR2018-B-11 https://gateoverflow.in/179295

Consider the language $L \subseteq \{a, b, c\}^*$ defined as

$L = \{a^p b^q c^r : p = q \quad or \quad q = r \quad or \quad r = p\}.$

Which of the following answer is TRUE about complexity of this language?

A. L is regular but not context-free
B. L is context-free but not regular
C. L is decidable but not context free
D. The complement of L, defined as $\overline{L} = \{a, b, c\}^*/L,$ is regular.
E. L is regular, context-free and decidable

tifr2018 identify-class-language theory-of-computation

5.7.33 Identify Class Language: TIFR2018-B-14

https://gateoverflow.in/179298

Define the language $\text{INFINITE}_{DFA} \equiv \{(A) \mid A \text{ is a DFA and } L(A) \text{ is an infinite language}\}$, where (A) denotes the description of the deterministic finite automata (DFA).Then which of the following about INFINITE_{DFA} is TRUE:

A. It is regular.
B. It is context-free but not regular.
C. It is Turing decidable (recursive).
D. It is Turing recognizable but not decidable.
E. Its complement is Turing recognizable but it is not decidable.

tifr2018 identify-class-language

5.7.34 Identify Class Language: TIFR2019-B-10

https://gateoverflow.in/280485

Let the language D be defined in the binary alphabet $\{0,1\}$ as follows:

$D := \{w \in \{0,1\}^* \mid \text{ substrings 01 and 10 occur an equal number of times in w}\}$

For example , $101 \in D$ while $1010 \notin D$. Which of the following must be TRUE of the language D ?

A. D is regular
B. D is context-free but not regular
C. D is decidable but not context-free
D. D is decidable but not in NP
E. D is undecidable

tifr2019 theory-of-computation identify-class-language

5.8 Minimal State Automata (25)

5.8.1 Minimal State Automata: GATE1987-2j

https://gateoverflow.in/80594

State whether the following statements are TRUE or FALSE:

A minimal DFA that is equivalent to an NDFA with n nodes has always 2^n states.

gate1987 theory-of-computation finite-automata minimal-state-automata

5.8.2 Minimal State Automata: GATE1996-2.23

https://gateoverflow.in/2752

Consider the following state table for a sequential machine. The number of states in the minimized machine will be

		Input	
		0	1
Present State	**A**	D,0	B,1
	B	A,0	C,1
	C	A,0	B,1
	D	A,1	C,1
		Next state, Output	

A. 4
B. 3
C. 2
D. 1

gate1996 theory-of-computation normal finite-automata minimal-state-automata

5.8.3 Minimal State Automata: GATE1997-20

https://gateoverflow.in/2280

Construct a finite state machine with minimum number of states, accepting all strings over (a,b) such that the number of a's is divisible by two and the number of b's is divisible by three.

gate1997 theory-of-computation finite-automata normal minimal-state-automata

5.8.4 Minimal State Automata: GATE1997-70

https://gateoverflow.in/19700

Following is a state table for time finite state machine.

Present State	Next State Output	
	Input- 0	Input-1
A	B.1	H.1
B	F.1	D.1
C	D.0	E.1
D	C.0	F.1
E	D.1	C.1
F	C.1	C.1
G	C.1	D.1
H	C.0	A.1

A. Find the equivalence partition on the states of the machine.

B. Give the state table for the minimal machine. (Use appropriate names for the equivalent states. For example if states X and Y are equivalent then use XY as the name for the equivalent state in the minimal machine).

gate1997 theory-of-computation minimal-state-automata

5.8.5 Minimal State Automata: GATE1998-2.5 https://gateoverflow.in/1677

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

A. 2 B. 5 C. 8 D. 3

gate1998 theory-of-computation finite-automata normal minimal-state-automata

5.8.6 Minimal State Automata: GATE1998-4 https://gateoverflow.in/1695

Design a deterministic finite state automaton (using minimum number of states) that recognizes the following language:

$L = \{w \in \{0,1\}^* \mid w$ interpreted as binary number (ignoring the leading zeros) is divisible by five $\}$.

gate1998 theory-of-computation finite-automata normal minimal-state-automata

5.8.7 Minimal State Automata: GATE1999-1.4 https://gateoverflow.in/1458

Consider the regular expression $(0+1)(0+1)\dots N$ times. The minimum state finite automaton that recognizes the language represented by this regular expression contains

A. n states B. $n+1$ states C. $n+2$ states D. None of the above

gate1999 theory-of-computation finite-automata easy minimal-state-automata

5.8.8 Minimal State Automata: GATE2001-1.6 https://gateoverflow.in/699

Given an arbitrary non-deterministic finite automaton (NFA) with N states, the maximum number of states in an equivalent minimized DFA at least

A. N^2 B. 2^N C. $2N$ D. $N!$

gate2001 finite-automata theory-of-computation easy minimal-state-automata

5.8.9 Minimal State Automata: GATE2001-2.5 https://gateoverflow.in/723

Consider a DFA over $\Sigma = \{a, b\}$ accepting all strings which have number of a's divisible by 6 and number of b's divisible by 8. What is the minimum number of states that the DFA will have?

A. 8 B. 14 C. 15 D. 48

gate2001 theory-of-computation finite-automata minimal-state-automata

5.8.10 Minimal State Automata: GATE2002-2.13 https://gateoverflow.in/843

The smallest finite automaton which accepts the language $\{x|$ length of x is divisible by $3\}$ has

A. 2 states B. 3 states C. 4 states D. 5 states

gate2002 theory-of-computation normal finite-automata minimal-state-automata

5.8.11 Minimal State Automata: GATE2006-34 https://gateoverflow.in/1291

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

gate2006 theory-of-computation finite-automata normal minimal-state-automata

5.8.12 Minimal State Automata: GATE2007-29 https://gateoverflow.in/1227

A minimum state deterministic finite automaton accepting the language

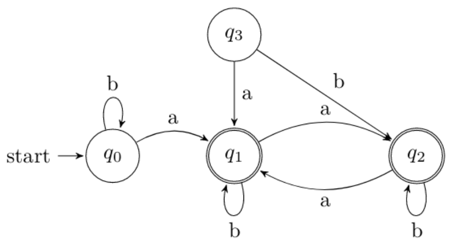
$L = \{w \mid w \in \{0,1\}^*,$ number of 0s and 1s in w are divisible by 3 and 5, respectively $\}$ has

A. 15 states B. 11 states C. 10 states D. 9 states

gate2007 theory-of-computation finite-automata normal minimal-state-automata

5.8.13 Minimal State Automata: GATE2007-75 https://gateoverflow.in/43514

Consider the following Finite State Automaton:



The minimum state automaton equivalent to the above FSA has the following number of states:

A. 1 B. 2 C. 3 D. 4

normal gate2007 theory-of-computation finite-automata minimal-state-automata

5.8.14 Minimal State Automata: GATE2008-IT-6 https://gateoverflow.in/3266

Let N be an NFA with n states and let M be the minimized DFA with m states recognizing the same language. Which of the following in NECESSARILY true?

A. $m \leq 2^n$
B. $n \leq m$
C. M has one accept state
D. $m = 2^n$

gate2008-it theory-of-computation finite-automata normal minimal-state-automata

5.8.15 Minimal State Automata: GATE2010-41 https://gateoverflow.in/2342

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 non-deterministic finite automation that accepts L?

A. $n-1$ B. n C. $n+1$ D. 2^{n-1}

gate2010 theory-of-computation finite-automata normal minimal-state-automata

5.8.16 Minimal State Automata: GATE2011-42 https://gateoverflow.in/2144

Definition of a language L with alphabet $\{a\}$ is given as following.

$$L = \{a^{nk} \mid k > 0, \ and \ n \text{ is a positive integer constant}\}$$

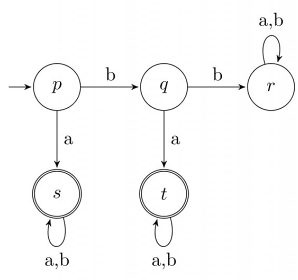
What is the minimum number of states needed in a DFA to recognize L?

A. $k+1$ B. $n+1$ C. 2^{n+1} D. 2^{k+1}

gate2011 theory-of-computation finite-automata normal minimal-state-automata

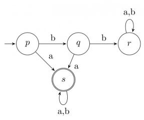
5.8.17 Minimal State Automata: GATE2011-45 https://gateoverflow.in/2147

A deterministic finite automaton (DFA) D with alphabet $\Sigma = \{a, b\}$ is given below.

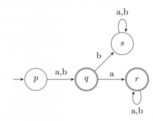


Which of the following finite state machines is a valid minimal DFA which accepts the same languages as D?

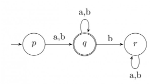
A.



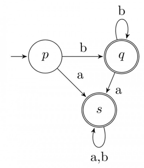
B.



C.

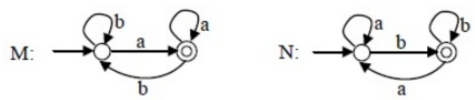


D.



gate2011 theory-of-computation finite-automata easy minimal-state-automata

5.8.18 Minimal State Automata: GATE2015-1-52 https://gateoverflow.in/8362



Consider the DFAs M and N given above. The number of states in a minimal DFA that accept the language $L(M) \cap L(N)$ is_____________.

gate2015-1 theory-of-computation finite-automata easy numerical-answers minimal-state-automata

5.8.19 Minimal State Automata: GATE2015-2-53 https://gateoverflow.in/8256

The number of states in the minimal deterministic finite automaton corresponding to the regular expression $(0+1)^*(10)$ is _____.

gate2015-2 theory-of-computation finite-automata normal numerical-answers minimal-state-automata

5.8.20 Minimal State Automata: GATE2015-3-18 https://gateoverflow.in/8415

Let L be the language represented by the regular expression $\Sigma^*0011\Sigma^*$ where $\Sigma = \{0, 1\}$. What is the minimum number of states in a DFA that recognizes $\bar{L}$ (complement of L)?

A. 4 B. 5 C. 6 D. 8

gate2015-3 theory-of-computation finite-automata normal minimal-state-automata

5.8.21 Minimal State Automata: GATE2016-2-16 https://gateoverflow.in/39562

The number of states in the minimum sized DFA that accepts the language defined by the regular expression.

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

is ________.

gate2016-2 theory-of-computation finite-automata normal numerical-answers minimal-state-automata

5.8.22 Minimal State Automata: GATE2017-1-22

https://gateoverflow.in/118302

Consider the language L given by the regular expression $(a+b)^*b(a+b)$ over the alphabet $\{a,b\}$. The smallest number of states needed in a deterministic finite-state automaton (DFA) accepting L is ________ .

gate2017-1 theory-of-computation finite-automata numerical-answers minimal-state-automata

5.8.23 Minimal State Automata: GATE2017-2-25

https://gateoverflow.in/118160

The minimum possible number of states of a deterministic finite automaton that accepts the regular language $L = \{ w_1 a w_2 \mid w_1, w_2 \in \{a,b\}^*, |w_1| = 2, |w_2| \geq 3 \}$ is __________ .

theory-of-computation gate2017-2 finite-automata numerical-answers minimal-state-automata

5.8.24 Minimal State Automata: GATE2018-6

https://gateoverflow.in/204080

Let N be an NFA with n states. Let k be the number of states of a minimal DFA which is equivalent to N. Which one of the following is necessarily true?

A. $k \geq 2^n$ B. $k \geq n$ C. $k \leq n^2$ D. $k \leq 2^n$

gate2018 theory-of-computation minimal-state-automata normal

5.8.25 Minimal State Automata: GATE2019-48

https://gateoverflow.in/302800

Let Σ be the set of all bijections from $\{1,\dots,5\}$ to $\{1,\dots,5\}$, where id denotes the identity function, i.e. $id(j) = j, \forall j$. Let $\circ$ denote composition on functions. For a string $x = x_1 x_2 \dots x_n \in \Sigma^n, n \geq 0$, let $\pi(x) = x_1 \circ x_2 \circ \dots \circ x_n$. Consider the language $L = \{x \in \Sigma^* \mid \pi(x) = id\}$. The minimum number of states in any DFA accepting L is _______

Total number of bijection function = 5! =120, so total states is 120

gate2019 numerical-answers theory-of-computation finite-automata minimal-state-automata

5.9 Non Determinism (7)

5.9.1 Non Determinism: GATE1992-02,xx

https://gateoverflow.in/577

02. Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

In which of the cases stated below is the following statement true?

"For every non-deterministic machine M_1 there exists an equivalent deterministic machine M_2 recognizing the same language".

A. M_1 is non-deterministic finite automaton.
B. M_1 is non-deterministic PDA.
C. M_1 is a non-deteministic Turing machine.
D. For no machines M_1 and M_2, the above statement true.

gate1992 theory-of-computation easy non-determinism

5.9.2 Non Determinism: GATE1994-1.16

https://gateoverflow.in/2459

Which of the following conversions is not possible (algorithmically)?

A. Regular grammar to context free grammar
B. Non-deterministic FSA to deterministic FSA
C. Non-deterministic PDA to deterministic PDA
D. Non-deterministic Turing machine to deterministic Turing machine

gate1994 theory-of-computation easy non-determinism

5.9.3 Non Determinism: GATE1998-1.11 https://gateoverflow.in/1648

Regarding the power of recognition of languages, which of the following statements is false?

A. The non-deterministic finite-state automata are equivalent to deterministic finite-state automata.
B. Non-deterministic Push-down automata are equivalent to deterministic Push-down automata.
C. Non-deterministic Turing machines are equivalent to deterministic Push-down automata.
D. Non-deterministic Turing machines are equivalent to deterministic Turing machines.
E. Multi-tape Turing machines are available are equivalent to Single-tape Turing machines.

gate1998 theory-of-computation easy non-determinism

5.9.4 Non Determinism: GATE2004-IT-9 https://gateoverflow.in/3650

Which one of the following statements is FALSE?

A. There exist context-free languages such that all the context-free grammars generating them are ambiguous
B. An unambiguous context-free grammar always has a unique parse tree for each string of the language generated by it
C. Both deterministic and non-deterministic pushdown automata always accept the same set of languages
D. A finite set of string from some alphabet is always a regular language

gate2004-it theory-of-computation easy non-determinism

5.9.5 Non Determinism: GATE2005-54 https://gateoverflow.in/1377

Let N_f and N_p denote the classes of languages accepted by non-deterministic finite automata and non-deterministic push-down automata, respectively. Let D_f and D_p denote the classes of languages accepted by deterministic finite automata and deterministic push-down automata respectively. Which one of the following is TRUE?

A. $D_f \subset N_f$ and $D_p \subset N_p$
B. $D_f \subset N_f$ and $D_p = N_p$
C. $D_f = N_f$ and $D_p = N_p$
D. $D_f = N_f$ and $D_p \subset N_p$

gate2005 theory-of-computation easy non-determinism

5.9.6 Non Determinism: GATE2009-16, ISRO2017-12 https://gateoverflow.in/1308

Which one of the following is FALSE?

A. There is a unique minimal DFA for every regular language
B. Every NFA can be converted to an equivalent PDA.
C. Complement of every context-free language is recursive.
D. Every nondeterministic PDA can be converted to an equivalent deterministic PDA.

gate2009 theory-of-computation easy isro2017 non-determinism

5.9.7 Non Determinism: GATE2011-8 https://gateoverflow.in/2110

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

gate2011 theory-of-computation easy non-determinism

5.10 P Np Npc Nph (5)

5.10.1 P Np Npc Nph: GATE2005-58 https://gateoverflow.in/1381

Consider the following two problems on undirected graphs:

- α: Given $G(V, E)$, does G have an independent set of size |V| - 4?
- β: Given $G(V, E)$, does G have an independent set of size 5?

Which one of the following is TRUE?

A. α is in P and β is NP-complete
B. α is NP-complete and β is in P
C. Both α and β are NP-complete
D. Both α and β are in P

gate2005 theory-of-computation p-np-npc-nph normal

5.10.2 P Np Npc Nph: GATE2006-31 https://gateoverflow.in/994

Let SHAM_3 be the problem of finding a Hamiltonian cycle in a graph $G = (V, E)$ with $|V|$ divisible by 3 and DHAM_3 be the problem of determining if a Hamiltonian cycle exists in such graphs. Which one of the following is true?

A. Both DHAM_3 and SHAM_3 are NP-hard
B. SHAM_3 is NP-hard, but DHAM_3 is not
C. DHAM_3 is NP-hard, but SHAM_3 is not
D. Neither DHAM_3 nor SHAM_3 is NP-hard

gate2006 theory-of-computation p-np-npc-nph normal

5.10.3 P Np Npc Nph: GATE2009-14 https://gateoverflow.in/1306

Let π_A be a problem that belongs to the class NP. Then which one of the following is TRUE?

A. There is no polynomial time algorithm for π_A.
B. If π_A can be solved deterministically in polynomial time, then P = NP.
C. If π_A is NP-hard, then it is NP-complete.
D. π_A may be undecidable.

gate2009 theory-of-computation p-np-npc-nph

5.10.4 P Np Npc Nph: GATE2012-4 https://gateoverflow.in/36

Assuming $P \neq NP$, which of the following is **TRUE**?

A. $NP-\ complete = NP$
B. $NP - complete \cap P = \phi$
C. $NP - hard = NP$
D. $P = NP - complete$

gate2012 theory-of-computation p-np-npc-nph

5.10.5 P Np Npc Nph: GATE2013-18 https://gateoverflow.in/1440

Which of the following statements are **TRUE**?

1. The problem of determining whether there exists a cycle in an undirected graph is in P.
2. The problem of determining whether there exists a cycle in an undirected graph is in NP.
3. If a problem A is $NP - Complete$, there exists a non-deterministic polynomial time algorithm to solve A

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

gate2013 theory-of-computation p-np-npc-nph normal

5.11 Pumping Lemma (2)

5.11.1 Pumping Lemma: GATE2005-IT-40 https://gateoverflow.in/3787

A language L satisfies the Pumping Lemma for regular languages, and also the Pumping Lemma for context-free languages. Which of the following statements about L is TRUE?

A. L is necessarily a regular language.
B. L is necessarily a context-free language, but not necessarily a regular language.
C. L is necessarily a non-regular language.
D. None of the above

gate2005-it theory-of-computation pumping-lemma easy

5.11.2 Pumping Lemma: GATE2019-15 https://gateoverflow.in/302833

For $\Sigma = \{a, b\}$, let us consider the regular language $L = \{x \mid x = a^{2+3k} \text{ or } x = b^{10+12k}, k \geq 0\}$. Which one of the following can be a pumping length (the constant guaranteed by the pumping lemma) for L?

A. 3 B. 5 C. 9 D. 24

gate2019 theory-of-computation pumping-lemma

5.12 Pushdown Automata (12)

5.12.1 Pushdown Automata: GATE1996-13 https://gateoverflow.in/2765

Let $Q = (\{q_1, q_2\}, \{a, b\}, \{a, b, \perp\}, \delta, \perp, \phi)$ be a pushdown automaton accepting by empty stack for the language which is the set of all nonempty even palindromes over the set $\{a, b\}$. Below is an incomplete specification of the transitions δ. Complete the specification. The top of the stack is assumed to be at the right end of the string representing stack contents.

1. $\delta(q_1, a, \perp) = \{(q_1, \perp a)\}$
2. $\delta(q_1, b, \perp) = \{(q_1, \perp b)\}$
3. $\delta(q_1, a, a) = \{(q_1, aa)\}$
4. $\delta(q_1, b, a) = \{(q_1, ab)\}$
5. $\delta(q_1, a, b) = \{(q_1, ba)\}$
6. $\delta(q_1, b, b) = \{(q_1, bb)\}$
7. $\delta(q_1, a, a) = \{(\ldots, \ldots)\}$
8. $\delta(q_1, b, b) = \{(\ldots, \ldots)\}$
9. $\delta(q_2, a, a) = \{(q_2, \epsilon)\}$
10. $\delta(q_2, b, b) = \{(q_2, \epsilon)\}$
11. $\delta(q_2, \epsilon, \perp) = \{(q_2, \epsilon)\}$

gate1996 theory-of-computation pushdown-automata normal

5.12.2 Pushdown Automata: GATE1997-6.6 https://gateoverflow.in/2262

Which of the following languages over $\{a, b, c\}$ is accepted by a deterministic pushdown automata?

A. $\{wcw^R \mid w \in \{a, b\}^*\}$
B. $\{ww^R \mid w \in \{a, b, c\}^*\}$
C. $\{a^n b^n c^n \mid n \geq 0\}$
D. $\{w \mid w \text{ is a palindrome over } \{a, b, c\}\}$

Note: w^R is the string obtained by reversing $'w'$.

gate1997 theory-of-computation pushdown-automata easy

5.12.3 Pushdown Automata: GATE1998-13 https://gateoverflow.in/1727

Let $M = (\{q_0, q_1\}, \{0, 1\}, \{z_0, X\}, \delta, q_0, z_0, \phi)$ be a Pushdown automation where δ is given by

$\delta(q_0, 1, z_0) = \{(q_0, Xz_0)\}$

$\delta(q_0, \epsilon, z_0) = \{(q_0, \epsilon)\}$

$\delta(q_0, 1, X) = \{(q_0, XX)\}$

$\delta(q_1, 1, X) = \{(q_1, \epsilon)\}$

$\delta(q_0, 0, X) = \{(q_1, X)\}$

$\delta(q_0, 0, z_0) = \{(q_0, z_0)\}$

a. What is the language accepted by this PDA by empty stack?
b. Describe informally the working of the PDA

gate1998 theory-of-computation pushdown-automata descriptive

5.12.4 Pushdown Automata: GATE1999-1.6 https://gateoverflow.in/377

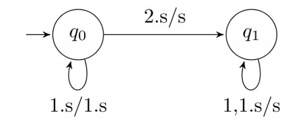
Let L_1 be the set of all languages accepted by a PDA by final state and L_2 the set of all languages accepted by empty stack. Which of the following is true?

A. $L_1 = L_2$
B. $L_1 \supset L_2$
C. $L_1 \subset L_2$
D. None

normal theory-of-computation gate1999 pushdown-automata

5.12.5 Pushdown Automata: GATE2000-8 https://gateoverflow.in/679

A push down automation (pda) is given in the following extended notation of finite state diagram:



The nodes denote the states while the edges denote the moves of the pda. The edge labels are of the form d, s/s' where d is the input symbol read and s, s' are the stack contents before and after the move. For example the edge labeled $1, s/1.s$ denotes the move from state q_0 to q_0 in which the input symbol 1 is read and pushed to the stack.

A. Introduce two edges with appropriate labels in the above diagram so that the resulting pda accepts the language $\left\{x2x^R \mid x \in \{0,1\}^*, x^R \text{ denotes reverse of x}\right\}$, by empty stack.
B. Describe a non-deterministic pda with three states in the above notation that accept the language $\{0^n 1^m \mid n \leq m \leq 2n\}$ by empty stack

gate2000 theory-of-computation descriptive pushdown-automata

5.12.6 Pushdown Automata: GATE2001-6 https://gateoverflow.in/747

Give a deterministic PDA for the language $L = \{a^n cb^{2n} \mid n \geq 1\}$ over the alphabet $\Sigma = \{a, b, c\}$. Specify the acceptance state.

gate2001 theory-of-computation normal pushdown-automata

5.12.7 Pushdown Automata: GATE2004-IT-40 https://gateoverflow.in/3683

Let $M = (K, \Sigma, \Gamma, \Delta, s, F)$ be a pushdown automaton, where
$K = (s, f), F = \{f\}, \Sigma = \{a, b\}, \Gamma = \{a\}$ and
$\Delta = \{((s, a, \epsilon), (s, a)), ((s, b, \epsilon), (s, a)), ((s, a, a), (f, \epsilon)), ((f, a, a), (f, \epsilon)), ((f, b, a), (f, \epsilon))\}$.
Which one of the following strings is not a member of $L(M)$?

A. aaa
B. $aabab$
C. $baaba$
D. bab

gate2004-it theory-of-computation pushdown-automata normal

5.12.8 Pushdown Automata: GATE2005-IT-38 https://gateoverflow.in/3785

Let P be a non-deterministic push-down automaton (NPDA) with exactly one state, q, and exactly one symbol, Z, in its stack alphabet. State q is both the starting as well as the accepting state of the PDA. The stack is initialized with one Z before the start of the operation of the PDA. Let the input alphabet of the PDA be Σ. Let $L(P)$ be the language accepted by the PDA by reading a string and reaching its accepting state. Let $N(P)$ be the language accepted by the PDA by reading a string and emptying its stack.
Which of the following statements is TRUE?

A. $L(P)$ is necessarily Σ^* but $N(P)$ is not necessarily Σ^*.
B. $N(P)$ is necessarily Σ^* but $L(P)$ is not necessarily Σ^*.
C. Both $L(P)$ and $N(P)$ are necessarily Σ^*.
D. Neither $L(P)$ nor $N(P)$ are necessarily Σ^*

gate2005-it theory-of-computation pushdown-automata normal

5.12.9 Pushdown Automata: GATE2006-IT-31 https://gateoverflow.in/3570

Which of the following languages is accepted by a non-deterministic pushdown automaton (PDA) but NOT by a deterministic PDA?

A. $\{a^n b^n c^n \mid n \geq 0\}$
B. $\{a^l b^m c^n \mid l \neq m \text{ or } m \neq n\}$
C. $\{a^n b^n \mid n \geq 0\}$
D. $\{a^m b^n \mid m, n \geq 0\}$

gate2006-it theory-of-computation pushdown-automata normal

5.12.10 Pushdown Automata: GATE2006-IT-33 https://gateoverflow.in/3572

Consider the pushdown automaton (PDA) below which runs over the input alphabet (a, b, c). It has the stack alphabet $\{Z_0, X\}$ where Z_0 is the bottom-of-stack marker. The set of states of the PDA is (s, t, u, f) where s is the start state and f is the final state. The PDA accepts by final state. The transitions of the PDA given below are depicted in a standard manner. For example, the transition $(s, b, X) \rightarrow (t, XZ_0)$ means that if the PDA is in state s and the symbol on the top of the stack is X, then it can read b from the input and move to state t after popping the top of stack and pushing the symbols Z_0 and X (in that order) on the stack.

$(s, a, Z_0) \rightarrow (s, XXZ_0)$
$(s, \epsilon, Z_0) \rightarrow (f, \epsilon)$
$(s, a, X) \rightarrow (s, XXX)$
$(s, b, X) \rightarrow (t, \epsilon)$
$(t, b, X) \rightarrow (t, \epsilon)$
$(t, c, X) \rightarrow (u, \epsilon)$
$(u, c, X) \rightarrow (u, \epsilon)$
$(u, \epsilon, Z_0) \rightarrow (f, \epsilon)$

The language accepted by the PDA is

A. $\{a^l b^m c^n \mid l = m = n\}$
B. $\{a^l b^m c^n \mid l = m\}$
C. $\{a^l b^m c^n \mid 2l = m + n\}$
D. $\{a^l b^m c^n \mid m = n\}$

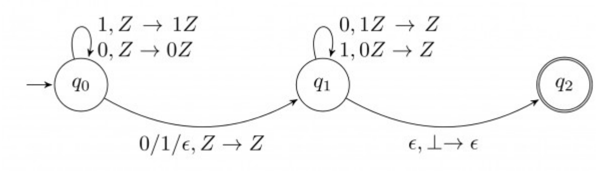
gate2006-it theory-of-computation pushdown-automata normal

5.12.11 Pushdown Automata: GATE2015-1-51 https://gateoverflow.in/8357

Consider the NPDA

$$\langle Q = \{q_0, q_1, q_2\}, \Sigma = \{0, 1\}, \Gamma = \{0, 1, \perp\}, \delta, q_0, \perp, F = \{q_2\} \rangle$$

, where (as per usual convention) Q is the set of states, Σ is the input alphabet, Γ is the stack alphabet, δ is the state transition function q_0 is the initial state, $\perp$ is the initial stack symbol, and F is the set of accepting states. The state transition is as follows:



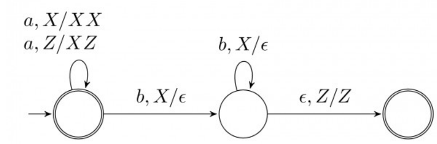
Which one of the following sequences must follow the string 101100 so that the overall string is accepted by the automaton?

A. 10110
B. 10010
C. 01010
D. 01001

gate2015-1 theory-of-computation pushdown-automata normal

5.12.12 Pushdown Automata: GATE2016-1-43 https://gateoverflow.in/39732

Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{X, Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA



Which one of the following is **TRUE**?

A. $L = \{a^n b^n \mid n \geq 0\}$ and is not accepted by any finite automata

B. $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is not accepted by any deterministic PDA
C. L is not accepted by any Turing machine that halts on every input
D. $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is deterministic context-free

gate2016-1 theory-of-computation pushdown-automata normal

5.13 Recursive And Recursively Enumerable Languages (14)

5.13.1 Recursive And Recursively Enumerable Languages: GATE1990-3-vi https://gateoverflow.in/84833

Choose the correct alternatives (More than one may be correct).

Recursive languages are:

A. A proper superset of context free languages.
B. Always recognizable by pushdown automata.
C. Also called type 0 languages.
D. Recognizable by Turing machines.

gate1990 normal theory-of-computation turing-machine recursive-and-recursively-enumerable-languages

5.13.2 Recursive And Recursively Enumerable Languages: GATE2003-13 https://gateoverflow.in/904

Nobody knows yet if $P = NP$. Consider the language L defined as follows.

$$L = \begin{cases} (0+1)^* & \text{if } P = NP \\ \phi & otherwise \end{cases}$$

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 recursively enumerable or not will be known after we find out if $P = NP$

gate2003 theory-of-computation normal recursive-and-recursively-enumerable-languages

5.13.3 Recursive And Recursively Enumerable Languages: GATE2003-15 https://gateoverflow.in/120

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

theory-of-computation gate2003 normal recursive-and-recursively-enumerable-languages

5.13.4 Recursive And Recursively Enumerable Languages: GATE2005-56 https://gateoverflow.in/1379

Let L_1 be a recursive language, and let L_2 be a recursively enumerable but not a recursive language. Which one of the following is TRUE?

A. L_1' is recursive and L_2' is recursively enumerable
B. L_1' is recursive and L_2' is not recursively enumerable
C. L_1' and L_2' are recursively enumerable
D. L_1' is recursively enumerable and L_2' is recursive

gate2005 theory-of-computation recursive-and-recursively-enumerable-languages easy

5.13.5 Recursive And Recursively Enumerable Languages: GATE2008-13, ISRO2016-36 https://gateoverflow.in/411

If L and $\bar{L}$ are recursively enumerable then L is

A. regular
B. context-free
C. context-sensitive
D. recursive

gate2008 theory-of-computation easy isro2016 recursive-and-recursively-enumerable-languages

5.13.6 Recursive And Recursively Enumerable Languages: GATE2008-48 https://gateoverflow.in/461

Which of the following statements is false?

A. Every NFA can be converted to an equivalent DFA
B. Every non-deterministic Turing machine can be converted to an equivalent deterministic Turing machine
C. Every regular language is also a context-free language
D. Every subset of a recursively enumerable set is recursive

gate2008 theory-of-computation easy recursive-and-recursively-enumerable-languages

5.13.7 Recursive And Recursively Enumerable Languages: GATE2010-17 https://gateoverflow.in/2190

Let L_1 be the recursive language. Let L_2 and L_3 be languages that are recursively enumerable but not recursive. Which of the following statements is not necessarily true?

A. $L_2 - L_1$ is recursively enumerable.
B. $L_1 - L_3$ is recursively enumerable.
C. $L_2 \cap L_3$ is recursively enumerable.
D. $L_2 \cup L_3$ is recursively enumerable.

gate2010 theory-of-computation recursive-and-recursively-enumerable-languages decidability normal

5.13.8 Recursive And Recursively Enumerable Languages: GATE2014-1-35 https://gateoverflow.in/1810

Let L be a language and $\bar{L}$ be its complement. Which one of the following is **NOT** a viable possibility?

A. Neither L nor $\bar{L}$ is recursively enumerable $(r.e.)$.
B. One of L and $\bar{L}$ is r.e. but not recursive; the other is not r.e.
C. Both L and $\bar{L}$ are r.e. but not recursive.
D. Both L and $\bar{L}$ are recursive.

gate2014-1 theory-of-computation easy recursive-and-recursively-enumerable-languages

5.13.9 Recursive And Recursively Enumerable Languages: GATE2014-2-16 https://gateoverflow.in/1972

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.

gate2014-2 theory-of-computation recursive-and-recursively-enumerable-languages normal

5.13.10 Recursive And Recursively Enumerable Languages: GATE2015-1-3 https://gateoverflow.in/8019

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. $\bar{L}_1$ (Compliment of L_1) is recursive
II. $\bar{L}_2$ (Compliment 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

gate2015-1 theory-of-computation recursive-and-recursively-enumerable-languages normal

5.13.11 Recursive And Recursively Enumerable Languages: GATE2016-1-44 https://gateoverflow.in/39721

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.

gate2016-1 theory-of-computation easy recursive-and-recursively-enumerable-languages

5.13.12 Recursive And Recursively Enumerable Languages: GATE2016-2-44 https://gateoverflow.in/39596

Consider the following languages.

- $L_1 = \{\langle M \rangle \mid M \text{ takes at least 2016 steps on some input}\}$,
- $L_2 = \{\langle M \rangle \mid M \text{ takes at least 2016 steps on all inputs}\}$ and
- $L_3 = \{\langle M \rangle \mid M \text{ accepts } \epsilon\}$,

where for each Turing machine $M, \langle M \rangle$ denotes a specific encoding of M. Which one of the following is TRUE?

A. L_1 is recursive and L_2, L_3 are not recursive
B. L_2 is recursive and L_1, L_3 are not recursive
C. L_1, L_2 are recursive and L_3 is not recursive
D. L_1, L_2, L_3 are recursive

gate2016-2 theory-of-computation recursive-and-recursively-enumerable-languages

5.13.13 Recursive And Recursively Enumerable Languages: TIFR2010-B-40 https://gateoverflow.in/19048

Which of the following statement is FALSE?

A. All recursive sets are recursively enumerable.
B. The complement of every recursively enumerable sets is recursively enumerable.
C. Every Non-empty recursively enumerable set is the range of some totally recursive function.
D. All finite sets are recursive.
E. The complement of every recursive set is recursive.

tifr2010 theory-of-computation recursive-and-recursively-enumerable-languages

5.13.14 Recursive And Recursively Enumerable Languages: TIFR2012-B-19 https://gateoverflow.in/25218

Which of the following statements is TRUE?

A. Every turning machine recognizable language is recursive.
B. The complement of every recursively enumerable language is recursively enumerable.
C. The complement of a recursive language is recursively enumerable.
D. The complement of a context-free language is context-free.
E. The set of turning machines which do not halt on empty input forms a recursively enumerable set.

tifr2012 theory-of-computation recursive-and-recursively-enumerable-languages

5.14 Regular Expressions (27)

5.14.1 Regular Expressions: GATE1987-10d https://gateoverflow.in/82455

Give a regular expression over the alphabet $\{0, 1\}$ to denote the set of proper non-null substrings of the string 0110.

gate1987 theory-of-computation regular-expressions

5.14.2 Regular Expressions: GATE1991-03,xiii https://gateoverflow.in/527

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only.

Let $r = 1(1+0)^*, s = 11^*0$ and $t = 1^*0$ be three regular expressions. Which one of the following is true?

A. $L(s) \subseteq L(r)$ and $L(s) \subseteq L(t)$
B. $L(r) \subseteq L(s)$ and $L(s) \subseteq L(t)$
C. $L(s) \subseteq L(t)$ and $L(s) \subseteq L(r)$
D. $L(t) \subseteq L(s)$ and $L(s) \subseteq L(r)$
E. None of the above

gate1991 theory-of-computation regular-expressions normal

5.14.3 Regular Expressions: GATE1992-02,xvii https://gateoverflow.in/575

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

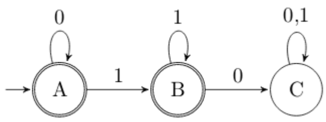
Which of the following regular expression identities is/are TRUE?

A. $r^{(*)} = r^*$
B. $(r^* s^*) = (r+s)^*$
C. $(r+s)^* = r^* + s^*$
D. $r^* s^* = r^* + s^*$

gate1992 theory-of-computation regular-expressions easy

5.14.4 Regular Expressions: GATE1994-2.10 https://gateoverflow.in/2477

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



gate1994 theory-of-computation finite-automata regular-expressions easy

5.14.5 Regular Expressions: GATE1995-1.9 , ISRO2017-13 https://gateoverflow.in/2596

In some programming language, an identifier is permitted to be a letter followed by any number of letters or digits. If L and D denote the sets of letters and digits respectively, which of the following expressions defines an identifier?

A. $(L+D)^+$
B. $(L.D)^*$
C. $L(L+D)^*$
D. $L(L.D)^*$

gate1995 theory-of-computation regular-expressions easy isro2017

5.14.6 Regular Expressions: GATE1996-1.8 https://gateoverflow.in/2712

Which two of the following four regular expressions are equivalent? (ε is the empty string).

i. $(00)^*(\varepsilon+0)$
ii. $(00)^*$
iii. 0^*
iv. $0(00)^*$

A. (i) and (ii)
B. (ii) and (iii)
C. (i) and (iii)
D. (iii) and (iv)

gate1996 theory-of-computation regular-expressions easy

5.14.7 Regular Expressions: GATE1997-6.4 https://gateoverflow.in/2260

Which one of the following regular expressions over $\{0,1\}$ denotes the set of all strings not containing 100 as substring?

A. $0^*(1+0)^*$
B. 0^*1010^*
C. $0^*1^*01^*$
D. $0^*(10+1)^*$

gate1997 theory-of-computation regular-expressions normal

5.14.8 Regular Expressions: GATE1998-1.12 https://gateoverflow.in/1649

The string 1101 does not belong to the set represented by

A. $110^*(0+1)$
B. $1(0+1)^*101$

C. $(10)^*(01)^*(00+11)^*$

D. $(00+(11)^*0)^*$

gatel998 theory-of-computation regular-expressions easy

5.14.9 Regular Expressions: GATE1998-1.9 https://gateoverflow.in/1646

If the regular set A is represented by $A=(01+1)^*$ and the regular set B is represented by $B=((01)^*1^*)^*$, which of the following is true?

A. $A\subset B$

B. $B\subset A$

C. A and B are incomparable

D. $A=B$

gate1998 theory-of-computation regular-expressions normal

5.14.10 Regular Expressions: GATE1998-3b https://gateoverflow.in/2941

Give a regular expression for the set of binary strings where every 0 is immediately followed by exactly k 1's and preceded by at least k 1's (k is a fixed integer)

gate1998 theory-of-computation regular-expressions easy

5.14.11 Regular Expressions: GATE2000-1.4 https://gateoverflow.in/627

Let S and T be languages over $\Sigma=\{a.b\}$ represented by the regular expressions $(a+b^*)^*$ and $(a+b)^*$, respectively. Which of the following is true?

A. $S\subset T$

B. $T\subset S$

C. $S=T$

D. $S\cap T=\phi$

gate2000 theory-of-computation regular-expressions easy

5.14.12 Regular Expressions: GATE2003-14 https://gateoverflow.in/905

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 the above

gate2003 theory-of-computation regular-expressions easy

5.14.13 Regular Expressions: GATE2004-IT-7 https://gateoverflow.in/3648

Which one of the following regular expressions is NOT equivalent to the regular expression $(a+b+c)^*$?

A. $(a^*+b^*+c^*)^*$

B. $(a^*b^*c^*)^*$

C. $((ab)^*+c^*)^*$

D. $(a^*b^*+c^*)^*$

gate2004-it theory-of-computation regular-expressions normal

5.14.14 Regular Expressions: GATE2005-IT-5 https://gateoverflow.in/3749

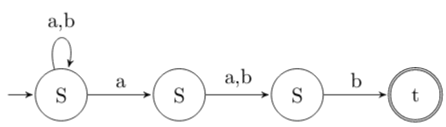
Which of the following statements is TRUE about the regular expression 01^*0?

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.

gate2005-it theory-of-computation regular-expressions easy

5.14.15 Regular Expressions: GATE2006-IT-5 https://gateoverflow.in/3544

Which regular expression best describes the language accepted by the non-deterministic automaton below?



A. $(a+b)^*\ a(a+b)b$

B. $(abb)^*$

C. $(a+b)^*\ a(a+b)^*\ b(a+b)^*$

D. $(a+b)^*$

gate2006-it theory-of-computation regular-expressions normal

5.14.16 Regular Expressions: GATE2007-IT-73 https://gateoverflow.in/3525

Consider the regular expression $R = (a+b)^* \ (aa+bb) \ (a+b)^*$

Which one of the regular expressions given below defines the same language as defined by the regular expression R ?

A. $(a(ba)^* + b(ab)^*)(a+b)^+$
B. $(a(ba)^* + b(ab)^*)^*(a+b)^*$
C. $(a(ba)^*(a+bb) + b(ab)^*(b+aa))(a+b)^*$
D. $(a(ba)^*(a+bb) + b(ab)^*(b+aa))(a+b)^+$

gate2007-it theory-of-computation regular-expressions normal

5.14.17 Regular Expressions: GATE2008-IT-5 https://gateoverflow.in/3265

Which of the following regular expressions describes the language over $\{0,1\}$ consisting of strings that contain exactly two 1's?

A. $(0+1)^* \ 11(0+1)^*$
B. $0^* \ 110^*$
C. $0^*10^*10^*$
D. $(0+1)^*1(0+1)^*1(0+1)^*$

gate2008-it theory-of-computation regular-expressions easy

5.14.18 Regular Expressions: GATE2009-15 https://gateoverflow.in/1307

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

gate2009 theory-of-computation regular-expressions easy

5.14.19 Regular Expressions: GATE2010-39 https://gateoverflow.in/2340

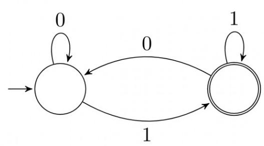
Let $L = \{w \in \ (0+1)^* \mid w \text{ has even number of } 1s\}$. i.e., L is the set of all the bit strings with even numbers of 1s. Which one of the regular expressions below represents L?

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

gate2010 theory-of-computation regular-expressions normal

5.14.20 Regular Expressions: GATE2014-1-36 https://gateoverflow.in/1914

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

gate2014-1 theory-of-computation regular-expressions finite-automata easy

5.14.21 Regular Expressions: GATE2014-3-15 https://gateoverflow.in/2049

The length of the shortest string NOT in the language (over $\Sigma = \{a,b\}$) of the following regular expression is _______.

$$a^* b^* (ba)^* a^*$$

gate2014-3 theory-of-computation regular-expressions numerical-answers easy

5.14.22 Regular Expressions: GATE2016-1-18 https://gateoverflow.in/39647

Which one of the following regular expressions represents the language: *the set of all binary strings having two consecutive* 0*'s and two consecutive* 1*'s*?

A. $(0+1)^* 0011(0+1)^* + (0+1)^* 1100(0+1)^*$
B. $(0+1)^* (00(0+1)^* 11 + 11(0+1)^* 00)(0+1)^*$
C. $(0+1)^* 00(0+1)^* + (0+1)^* 11(0+1)^*$
D. $00(0+1)^* 11 + 11(0+1)^* 00$

gate2016-1 theory-of-computation regular-expressions normal

5.14.23 Regular Expressions: TIFR2010-B-34 https://gateoverflow.in/19047

Let r, s, t be regular expressions. Which of the following identities is correct?

A. $(r+s)^* = r^* s^*$
B. $r(s+t) = rs + t$
C. $(r+s)^* = r^* + s^*$
D. $(rs+r)^* r = r(sr+r)^*$
E. $(r^* s)^* = (rs)^*$

tifr2010 theory-of-computation regular-expressions

5.14.24 Regular Expressions: TIFR2015-B-7 https://gateoverflow.in/29861

Let a, b, c be regular expressions. Which of the following identities is correct?

A. $(a+b)^* = a^* b^*$
B. $a(b+c) = ab + c$
C. $(a+b)^* = a^* + b^*$
D. $(ab+a)^* a = a(ba+a)^*$
E. None of the above.

tifr2015 theory-of-computation regular-expressions

5.14.25 Regular Expressions: TIFR2017-B-9 https://gateoverflow.in/95705

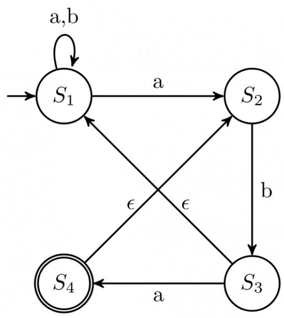
Which of the following regular expressions correctly accepts the set of all $0/1$-strings with an even (poossibly zero) number of 1s?

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

tifr2017 theory-of-computation regular-expressions

5.14.26 Regular Expressions: TIFR2018-B-2 https://gateoverflow.in/179286

Consider the following non-deterministic automation, where s_1 is the start state and s_4 is the final (accepting) state. The alphabet is $\{a, b\}$. A transition with label ϵ can be taken without consuming any symbol from the input.



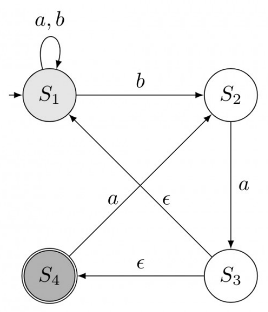
Which of the following regular expressions corresponds to the language accepted by this automation ?

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

tifr2018 regular-expressions finite-automata

5.14.27 Regular Expressions: TIFR2019-B-11 https://gateoverflow.in/280484

Consider the following non-deterministic automaton,where s_1 is the start state and s_4 is the final (accepting) state. The alphabet is $\{a, b\}$. A transition with label ϵ can be taken without consuming any symbol from the input.



Which of the following regular expressions correspond to the language accepted by this automaton ?

A. $(a+b)^*aba$ B. $(a+b)^*ba^*$ C. $(a+b)^*ba(aa)^*$ D. $(a+b)^*$ E. $(a+b)^*baa^*$

tifr2019 theory-of-computation regular-expressions

5.15 Regular Grammar (3)

5.15.1 Regular Grammar: GATE1990-15a https://gateoverflow.in/86864

Is the language generated by the grammar G regular? If so, give a regular expression for it, else prove otherwise

- G:
  - $S \to aB$
  - $B \to bC$
  - $C \to xB$
  - $C \to c$

gate1990 descriptive theory-of-computation regular-languages regular-grammar grammar

5.15.2 Regular Grammar: GATE2006-IT-29 https://gateoverflow.in/3568

Consider the regular grammar below

$S \to bS \mid aA \mid \epsilon$
$A \to aS \mid bA$

The Myhill-Nerode equivalence classes for the language generated by the grammar are

A. $\{w \in (a+b)^* \mid \#a(w) \text{ is even}) \text{ and} \{w \in (a+b)^* \mid \#a(w) \text{ is odd}\}$
B. $\{w \in (a+b)^* \mid \#a(w) \text{ is even}) \text{ and} \{w \in (a+b)^* \mid \#b(w) \text{ is odd}\}$
C. $\{w \in (a+b)^* \mid \#a(w) = \#b(w) \text{and } \{w \in (a+b)^* \mid \#a(w) \neq \#b(w)\}$
D. $\{\epsilon\}, \{wa \mid w \in (a+b)^* \text{and} \{wb \mid w \in (a+b)^*\}$

gate2006-it theory-of-computation normal regular-grammar

5.15.3 Regular Grammar: GATE2015-2-35 https://gateoverflow.in/8159

Consider the alphabet $\Sigma = \{0, 1\}$, the null/empty string λ and the set of strings $X_0, X_1, \text{ and } X_2$ generated by the corresponding non-terminals of a regular grammar. $X_0, X_1, \text{ and } X_2$ 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. $10(0 + 10)^*1 + 110(0 + 10)^*1$

gate2015-2 theory-of-computation regular-grammar normal

5.16 Regular Languages (35)

5.16.1 Regular Languages: GATE1987-2h https://gateoverflow.in/80589

State whether the following statements are TRUE or FALSE:

Regularity is preserved under the operation of string reversal.

gate1987 regular-languages theory-of-computation

5.16.2 Regular Languages: GATE1987-2i https://gateoverflow.in/80590

State whether the following statements are TRUE or FALSE:

All subsets of regular sets are regular.

gate1987 theory-of-computation regular-languages

5.16.3 Regular Languages: GATE1990-3-viii https://gateoverflow.in/84837

Choose the correct alternatives (More than one may be correct).
Let R_1 and R_2 be regular sets defined over the alphabet Σ Then:

A. $R_1 \cap R_2$ is not regular.
B. $R_1 \cup R_2$ is regular.
C. $\Sigma^* - R_1$ is regular.
D. R_1^* is not regular.

gate1990 normal theory-of-computation regular-languages

5.16.4 Regular Languages: GATE1991-03,xiv https://gateoverflow.in/528

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

Which of the following is the strongest correct statement about a finite language over some finite alphabet Σ ?

A. It could be undecidable
B. It is Turing-machine recognizable
C. It is a context sensitive language.
D. It is a regular language.
E. None of the above,

gate1991 theory-of-computation easy regular-languages

5.16.5 Regular Languages: GATE1995-2.24 https://gateoverflow.in/2637

Let $\Sigma = \{0,1\}, L = \Sigma^*$ and $R = \{0^n 1^n \mid n > 0\}$ then the languages $L \cup R$ and R are respectively

A. regular, regular
B. not regular, regular
C. regular, not regular
D. not regular, not regular

gate1995 theory-of-computation easy regular-languages

5.16.6 Regular Languages: GATE1996-1.10 https://gateoverflow.in/2714

Let $L \subseteq \Sigma^*$ where $\Sigma = \{a, b\}$. Which of the following is true?

a. $L = \{x \mid x \text{ has an equal number of } a\text{'s and } b\text{'s}\}$ is regular
b. $L = \{a^n b^n \mid n \geq 1\}$ is regular
c. $L = \{x \mid x \text{ has more number of } a\text{'s than } b\text{'s}\}$ is regular
d. $L = \{a^m b^n \mid m \geq 1, n \geq 1\}$ is regular

gate1996 theory-of-computation normal regular-languages

5.16.7 Regular Languages: GATE1998-2.6 https://gateoverflow.in/1678

Which of the following statements is false?

a. Every finite subset of a non-regular set is regular
b. Every subset of a regular set is regular
c. Every finite subset of a regular set is regular
d. The intersection of two regular sets is regular

gate1998 theory-of-computation easy regular-languages

5.16.8 Regular Languages: GATE1999-6 https://gateoverflow.in/1505

A. Given that A is regular and $(A \cup B)$ is regular, does it follow that B is necessarily regular? Justify your answer.
B. Given two finite automata $M1, M2$, outline an algorithm to decide if $L(M1) \subset L(M2)$. (note: strict subset)

gate1999 theory-of-computation normal regular-languages

5.16.9 Regular Languages: GATE2000-2.8 https://gateoverflow.in/655

What can be said about a regular language L over $\{a\}$ whose minimal finite state automaton has two states?

A. L must be $\{a^n \mid n \text{ is odd}\}$
B. L must be $\{a^n \mid n \text{ is even}\}$
C. L must be $\{a^n \mid n \geq 0\}$
D. Either L must be $\{a^n \mid n \text{ is odd}\}$, or L must be $\{a^n \mid n \text{ is even}\}$

gate2000 theory-of-computation easy regular-languages

5.16.10 Regular Languages: GATE2001-1.4 https://gateoverflow.in/697

Consider the following two statements:

$S_1 : \left\{0^{2n} \mid n \geq 1\right\}$ is a regular language

$S_2 : \{0^m 1^n 0^{m+n} \mid m \geq 1 \text{ and } n \geq 1\}$ is a regular language

Which of the following statement is correct?

A. Only S_1 is correct
B. Only S_2 is correct
C. Both S_1 and S_2 are correct
D. None of S_1 and S_2 is correct

gate2001 theory-of-computation easy regular-languages

5.16.11 Regular Languages: GATE2001-2.6 https://gateoverflow.in/724

Consider the following languages:

- $L1 = \{ww \mid w \in \{a,b\}^*\}$
- $L2 = \left\{ww^R \mid w \in \{a,b\}^*, w^R \text{ is the reverse of w}\right\}$
- $L3 = \left\{0^{2i} \mid \text{i is an integer}\right\}$
- $L4 = \left\{0^{i^2} \mid \text{i is an integer}\right\}$

Which of the languages are regular?

A. Only $L1$ and $L2$
B. Only $L2, L3$ and $L4$
C. Only $L3$ and $L4$
D. Only $L3$

gate2001 theory-of-computation normal regular-languages

5.16.12 Regular Languages: GATE2006-29 https://gateoverflow.in/992

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. $L = \{s \in (0+1)^* \mid \text{ for every prefix s' of s, } \mid n_0(s') - n_1(s') \mid \leq 2\}$
C. $L = \{s \in (0+1)^* \mid n_0(s) - n_1(s) \mid \leq 4\}$
D. $L = \{s \in (0+1)^* \mid n_0(s) \mod 7 = n_1(s) \mod 5 = 0\}$

gate2006 theory-of-computation normal regular-languages

5.16.13 Regular Languages: GATE2006-IT-30 https://gateoverflow.in/3569

Which of the following statements about regular languages is NOT true ?

A. Every language has a regular superset
B. Every language has a regular subset
C. Every subset of a regular language is regular
D. Every subset of a finite language is regular

gate2006-it theory-of-computation easy regular-languages

5.16.14 Regular Languages: GATE2006-IT-80 https://gateoverflow.in/3624

Let L be a regular language. Consider the constructions on L below:

I. repeat $(L) = \{ww \mid w \in L\}$
II. prefix $(L) = \{u \mid \exists v : uv \in L\}$
III. suffix $(L) = \{v \mid \exists u : uv \in L\}$
IV. half $(L) = \{u \mid \exists v : |v| = |u| \text{ and } uv \in L\}$

Which of the constructions could lead to a non-regular language?

A. Both I and IV B. Only I C. Only IV D. Both II and III

gate2006-it theory-of-computation normal regular-languages

5.16.15 Regular Languages: GATE2006-IT-81 https://gateoverflow.in/3637

Let L be a regular language. Consider the constructions on L below:

I. $\text{repeat}(L) = \{ww \mid w \in L\}$
II. $\text{prefix}(L) = \{u \mid \exists v : uv \in L\}$
III. $\text{suffix}(L) = \{v \mid \exists u : uv \in L\}$
IV. $\text{half}(L) = \{u \mid \exists v : |v| = |u| \text{ and } uv \in L\}$

Which of the constructions could lead to a non-regular language?

a. Both I and IV
b. Only 1
c. Only IV
d. Both II and III

Which choice of L is best suited to support your answer above?

A. $(a+b)^*$
B. $\{\epsilon, a, ab, bab\}$
C. $(ab)^*$
D. $\{a^nb^n \mid n \geq 0\}$

gate2006-it theory-of-computation normal regular-languages

5.16.16 Regular Languages: GATE2007-31 https://gateoverflow.in/1229

Which of the following languages is regular?

A. $\{ww^R \mid w \in \{0,1\}^+\}$
B. $\{ww^Rx \mid x, w \in \{0,1\}^+\}$
C. $\{wxw^R \mid x, w \in \{0,1\}^+\}$
D. $\{xww^R \mid x, w \in \{0,1\}^+\}$

C. Any string which begins and ends with same symbol, can be written in form of “wxwR”

gate2007 theory-of-computation normal regular-languages

5.16.17 Regular Languages: GATE2007-7 https://gateoverflow.in/1205

Which of the following is TRUE?

A. Every subset of a regular set is regular
B. Every finite subset of a non-regular set is regular
C. The union of two non-regular sets is not regular
D. Infinite union of finite sets is regular

gate2007 theory-of-computation easy regular-languages

5.16.18 Regular Languages: GATE2008-53 https://gateoverflow.in/476

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

gate2008 theory-of-computation normal regular-languages

5.16.19 Regular Languages: GATE2008-IT-35 https://gateoverflow.in/3345

Which of the following languages is (are) non-regular?

- $L_1 = \{0^m 1^n \mid 0 \leq m \leq n \leq 10000\}$
- $L_2 = \{w \mid w$ reads the same forward and backward$\}$
- $L_3 = \{w \in \{0, 1\}^* \mid w$ contains an even number of 0's and an even number of 1's $\}$

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

gate2008-it theory-of-computation normal regular-languages

5.16.20 Regular Languages: GATE2011-24 https://gateoverflow.in/3429

Let P be a regular language and Q be a context-free language such that $Q \subseteq P$. (For example, let P be the language represented by the regular expression p^*q^* and Q be $\{p^n q^n \mid n \in N\}$). Then which of the following is **ALWAYS** regular?

A. $P \cap Q$ B. $P - Q$ C. $\Sigma^* - P$ D. $\Sigma^* - Q$

gate2011 theory-of-computation easy regular-languages

5.16.21 Regular Languages: GATE2012-25 https://gateoverflow.in/1609

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

gate2012 theory-of-computation easy regular-languages

5.16.22 Regular Languages: GATE2013-8 https://gateoverflow.in/1417

Consider the languages $L_1 = \phi$ and $L_2 = \{a\}$. Which one of the following represents $L_1 L_2{}^* \cup L_1{}^*$?

A. $\{\epsilon\}$ B. ϕ C. a^* D. $\{\epsilon, a\}$

gate2013 theory-of-computation normal regular-languages

5.16.23 Regular Languages: GATE2014-1-15 https://gateoverflow.in/1781

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= $\{w \mid w \text{ has } 3k + 1\ b's \text{ for some } k \in N \text{ with } \Sigma = \{a, b\}\}$ is regular.
D. The language $L = \{ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0, 1\}\}$ is regular.

gate2014-1 theory-of-computation regular-languages normal

5.16.24 Regular Languages: GATE2014-2-15 https://gateoverflow.in/1971

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

I. $L_1 . L_2$ is a regular language
II. $L_1 . L_2 = \{a^n b^n \mid n \geq 0\}$

Which one of the following is CORRECT?

A. Only I
B. Only II
C. Both I and II
D. Neither I nor II

gate2014-2 theory-of-computation normal regular-languages

5.16.25 Regular Languages: GATE2014-2-36 https://gateoverflow.in/1995

Let $L_1 = \{w \in \{0,1\}^* \mid w$ has at least as many occurrences of $(110)'$ s as $(011)'$ s$\}$. Let $L_2 = \{w \in \{0,1\}^* \mid w$ has at least as many occurrences of $(000)'$ s as $(111)'$ s$\}$. Which one of the following is TRUE?

A. L_1 is regular but not L_2
B. L_2 is regular but not L_1
C. Both L_1 and L_2 are regular
D. Neither L_1 nor L_2 are regular

gate2014-2 theory-of-computation normal regular-languages

5.16.26 Regular Languages: GATE2015-2-51 https://gateoverflow.in/8254

Which of the following is/are regular languages?

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

gate2015-2 theory-of-computation normal regular-languages

5.16.27 Regular Languages: GATE2016-2-17 https://gateoverflow.in/39542

Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b \mid \varepsilon$

Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2 \mid \varepsilon$

Consider the following statements:

- P: L_1 is regular
- Q: L_2 is regular

Which one of the following is **TRUE**?

A. Both P and Q are true.
B. P is true and Q is false.
C. P is false and Q is true.
D. Both P and Q are false.

gate2016-2 theory-of-computation normal regular-languages

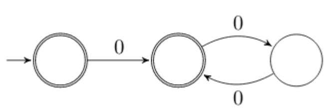
5.16.28 Regular Languages: GATE2018-52 https://gateoverflow.in/204127

Given a language L, define L^i as follows:

$$L^0 = \{\varepsilon\}$$

$$L^i = L^{i-1} \bullet L \text{ for all } I > 0$$

The order of a language L is defined as the smallest k such that $L^k = L^{k+1}$. Consider the language L_1 (over alphabet O) accepted by the following automaton.



The order of L_1 is ____

gate2018 theory-of-computation numerical-answers regular-languages

5.16.29 Regular Languages: GATE2019-7 https://gateoverflow.in/302841

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. $\text{Suffix}(L) = \{y \in \Sigma^* \mid \exists x \in \Sigma^* \text{ such that } xy \in L\}$

gate2019 theory-of-computation regular-languages

5.16.30 Regular Languages: TIFR2013-B-6 https://gateoverflow.in/25667

Let L and L' be languages over the alphabet Σ. The left quotient of L by L' is

$$L/L' \stackrel{def}{=} \{w \in \Sigma^* : wx \in L \text{ for some } x \in L'\}$$

Which of the following is true?

A. If L/L' is regular then L' is regular.
B. If L is regular then L/L' is regular.
C. If L/L' is regular then L is regular.
D. L/L' is a subset of L.
E. If L/L' and L' are regular, then L is regular.

tifr2013 theory-of-computation regular-languages

5.16.31 Regular Languages: TIFR2013-B-8 https://gateoverflow.in/25670

Which one of the following languages over the alphabet $0,1$ is regular?

A. The language of balanced parentheses where $0, 1$ are thought of as $(,)$ respectively.
B. The language of palindromes, i.e. bit strings x that read the same from left to right as well as right to left.
C. $L = \left\{0^{m^2} : 3 \leq m\right\}$
D. The Kleene closure L^*, where L is the language in (c) above.
E. $\{0^m 1^n \mid 1 \leq m \leq n\}$

tifr2013 theory-of-computation regular-languages

5.16.32 Regular Languages: TIFR2014-B-12 https://gateoverflow.in/27314

Consider the following three statements:

i. Intersection of infinitely many regular languages must be regular.
ii. Every subset of a regular language is regular.
iii. If L is regular and M is not regular then $L \bullet M$ is necessarily not regular.

Which of the following gives the correct true/false evaluation of the above?

A. true, false, true.
B. false, false, true.
C. true, false, true.
D. false, false, false.
E. true, true, true.

tifr2014 theory-of-computation regular-languages

5.16.33 Regular Languages: TIFR2015-B-10 https://gateoverflow.in/30039

Consider the languages

$L_1 = \{a^m b^n c^p \mid (m = n \vee n = p) \wedge m + n + p \geq 10\}$

$L_2 = \{a^m b^n c^p \mid (m = n \vee n = p) \wedge m + n + p \leq 10\}$

State which of the following is true?

A. L_1 and L_2 are both regular.
B. Neither L_1 nor L_2 is regular.
C. L_1 is regular and L_2 is not regular.
D. L_1 is not regular and L_2 is regular.
E. Both L_1 and L_2 are infinite.

tifr2015 regular-languages

5.16.34 Regular Languages: TIFR2015-B-6 https://gateoverflow.in/29860

Let B consist of all binary strings beginning with a 1 whose value when converted to decimal is divisible by 7.

A. B can be recognized by a deterministic finite state automaton.
B. B can be recognized by a non-deterministic finite state automaton but not by a deterministic finite state automaton.
C. B can be recognized by a deterministic push-down automaton but not by a non-deterministic finite state automaton.
D. B can be recognized by a non-deterministic push-down automaton but not by a deterministic push-down automaton.
E. B cannot be recognized by any push down automaton, deterministic or non-deterministic.

tifr2015 theory-of-computation regular-languages

5.16.35 Regular Languages: TIFR2018-B-12 https://gateoverflow.in/179296

Consider the following statements:

i. For every positive integer n, let $\#n$ be the product of all primes less than or equal to n. Then, $\#p+1$ is a prime, for every prime p.
ii. π is a universal constant with value $\frac{22}{7}$.
iii. No polynomial time algorithm exists that can find the greatest common divisor of two integers given as input in binary.
iv. Let $L \equiv \{x \in \{0,1\}^* \mid x \text{ is the binary encoding of an integer that is divisible by } 31\}$ Then, L is a regular language.

Then which of the following is TRUE ?

1. Only statement **(i)** is correct.
2. Only statement **(ii)** is correct.
3. Only statement **(iii)** is correct.
4. Only statement **(iv)** is correct.
5. None of the statements are correct.

tifr2018 regular-languages

5.17 Turing Machine (4)

5.17.1 Turing Machine: GATE2003-53 https://gateoverflow.in/941

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 page 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 strings ending in a 0
D. M halts on all strings ending in a 1

gate2003 theory-of-computation turing-machine normal

5.17.2 Turing Machine: GATE2003-54 https://gateoverflow.in/355

Define languages L_0 and L_1 as follows :

$$L_0 = \{\langle M,w,0\rangle \mid M \text{ halts on } w\}$$

$$L_1 = \{\langle M,w,1\rangle \mid M \text{ does not halts on } w\}$$

Here $\langle M,w,i\rangle$ 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 $L = L_0 \cup L_1$. 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

theory-of-computation turing-machine gate2003 difficult

5.17.3 Turing Machine: GATE2004-89 https://gateoverflow.in/1083

L_1 is a recursively enumerable language over Σ. An algorithm A effectively enumerates its words as $\omega_1, \omega_2, \omega_3, \dots$. Define another language L_2 over $\Sigma \cup \{\#\}$ as $\{w_i \# w_j \mid w_i, w_j \in L_1, i < j\}$. Here # is new symbol. Consider the following assertions.

- $S_1 : L_1$ is recursive implies L_2 is recursive
- $S_2 : L_2$ is recursive implies L_1 is recursive

Which of the following statements is true?

A. Both S_1 and S_2 are true
B. S_1 is true but S_2 is not necessarily true
C. S_2 is true but S_1 is not necessarily true
D. Neither is necessarily true

gate2004 theory-of-computation turing-machine difficult

5.17.4 Turing Machine: GATE2014-2-35 https://gateoverflow.in/1994

Let $\langle M \rangle$ be the encoding of a Turing machine as a string over $\Sigma = \{0, 1\}$. Let

$$L = \{\langle M \rangle \mid M \text{ is a Turing machine that accepts a string of length } 2014\}.$$

Then L is:

A. decidable and recursively enumerable
B. undecidable but recursively enumerable
C. undecidable and not recursively enumerable
D. decidable but not recursively enumerable

gate2014-2 theory-of-computation turing-machine normal