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1 Algorithms (327)

Searching, Sorting, Hashing, Asymptotic worst case time and Space complexity, Algorithm design techniques: Greedy, Dynamic programming, and Divide-and-conquer, Graph search, Minimum spanning trees, Shortest paths.

Mark Distribution in Previous GATE

Year	2019	2018	2017-1	2017-2	2016-1	2016-2	Minimum	Average	Maximum
1 Mark Count	2	0	2	2	3	3	0	2	3
2 Marks Count	2	4	2	3	2	3	2	2.7	4
Total Marks	6	8	6	8	7	9	**6**	**7.3**	**9**

1.1 Algorithm Design (8)

1.1.1 Algorithm Design: GATE1992-8

https://gateoverflow.in/587

Let T be a Depth First Tree of a undirected graph G. An array P indexed by the vertices of G is given. $P[V]$ is the parent of vertex V, in T. Parent of the root is the root itself.

Give a method for finding and printing the cycle formed if the edge (u, v) of G not in T (i.e., $e \in G - T$) is now added to T.

Time taken by your method must be proportional to the length of the cycle.

Describe the algorithm in a PASCAL (C) – like language. Assume that the variables have been suitably declared.

gate1992 algorithms descriptive algorithm-design

1.1.2 Algorithm Design: GATE1994-7

https://gateoverflow.in/2503

An array A contains n integers in locations $A[0], A[1], \ldots A[n-1]$. It is required to shift the elements of the array cyclically to the left by K places, where $1 \leq K \leq n-1$. An incomplete algorithm for doing this in linear time, without using another array is given below. Complete the algorithm by filling in the blanks. Assume all variables are suitably declared.

```
min:=n;
i=0;
while _____ do
begin
    temp:=A[i];
    j:=i;
    while ____ do
    begin
        A[j]:=____;
        j:=(j+K) mod n;
       if j<min then
        min:=j;
    end;
    A[(n+i-K)mod n]:=____;
    i:=_____;
end;
```

gate1994 algorithms normal algorithm-design

1.1.3 Algorithm Design: GATE2006-17

https://gateoverflow.in/978

An element in an array X is called a leader if it is greater than all elements to the right of it in X. The best algorithm to find all leaders in an array

A. solves it in linear time using a left to right pass of the array
B. solves it in linear time using a right to left pass of the array
C. solves it using divide and conquer in time $\Theta(n \log n)$
D. solves it in time $\Theta(n^2)$

gate2006 algorithms normal algorithm-design

1.1.4 Algorithm Design: GATE2006-54

https://gateoverflow.in/1832

Given two arrays of numbers $a_1, \ldots, a_n$ and $b_1, \ldots, b_n$ where each number is 0 or 1, the fastest algorithm to find the

largest span (i, j) such that $a_i + a_{i+1} + \cdots + a_j = b_i + b_{i+1} + \cdots + b_j$ or report that there is not such span,

A. Takes $O(3^n)$ and $\Omega(2^n)$ time if hashing is permitted
B. Takes $O(n^3)$ and $\Omega(n^{2.5})$ time in the key comparison mode
C. Takes $\Theta(n)$ time and space
D. Takes $O(\sqrt{n})$ time only if the sum of the $2n$ elements is an even number

gate2006 algorithms normal algorithm-design time-complexity

1.1.5 Algorithm Design: GATE2014-1-37

https://gateoverflow.in/1915

There are 5 bags labeled 1 to 5. All the coins in a given bag have the same weight. Some bags have coins of weight 10 gm, others have coins of weight 11 gm. I pick $1, 2, 4, 8, 16$ coins respectively from bags 1 to 5 Their total weight comes out to 323 gm. Then the product of the labels of the bags having 11 gm coins is ___.

gate2014-1 algorithms numerical-answers normal algorithm-design

1.1.6 Algorithm Design: GATE2019-25

https://gateoverflow.in/302823

Consider a sequence of 14 elements: $A = [-5, -10, 6, 3, -1, -2, 13, 4, -9, -1, 4, 12, -3, 0]$. The sequence sum $S(i, j) = \Sigma_{k=i}^{j} A[k]$. Determine the maximum of $S(i, j)$, where $0 \leq i \leq j < 14$. (Divide and conquer approach may be used.)

Answer: _____

gate2019 numerical-answers algorithms algorithm-design

1.1.7 Algorithm Design: TIFR2011-B-29

https://gateoverflow.in/20576

You are given ten rings numbered from 1 to 10, and three pegs labeled A, B, and C. Initially all the rings are on peg A, arranged from top to bottom in ascending order of their numbers. The goal is to move all the rings to peg B in the minimum number of moves obeying the following constraints:

i. In one move, only one ring can be moved.
ii. A ring can only be moved from the top of its peg to the top of a new peg.
iii. At no point can a ring be placed on top of another ring with a lower number.

How many moves are required?

A. 501 B. 1023 C. 2011 D. 10079 E. None of the above.

tifr2011 algorithms algorithm-design

1.1.8 Algorithm Design: TIFR2019-A-5

https://gateoverflow.in/280505

Asha and Lata play a game in which Lata first thinks of a natural number between 1 and 1000. Asha must find out that number by asking Lata questions, but Lata can only reply by saying “Yes” or “no”. Assume that Lata always tells the truth. What is the least number of questions that Asha needs to ask within which she can always find out the number Lata has thought of?

A. 10 B. 32 C. 100 D. 999 E. None of the above

tifr2019 algorithm-design binary-search

1.2 Algorithm Design Techniques (6)

1.2.1 Algorithm Design Techniques: GATE1990-12b

https://gateoverflow.in/86146

Consider the following problem. Given n positive integers $a_1, a_2 \ldots a_n$, it is required to partition them in to two parts A and B such that

$|\sum_{i \in A} a_i - \sum_{i \in B} a_i|$ is minimised

Consider a greedy algorithm for solving this problem. The numbers are ordered so that $a_1 \geq a_2 \geq \ldots a_n$, and at i^{th} step, a_i is placed in that part whose sum in smaller at that step. Give an example with $n = 5$ for which the solution produced by the greedy algorithm is not optimal.

gate1990 descriptive algorithms algorithm-design-techniques

1.2.2 Algorithm Design Techniques: GATE1990-2-vii

https://gateoverflow.in/83991

Match the pairs in the following questions:

(a)	Strassen's matrix multiplication algorithm	(p)	Greedy method
(b)	Kruskal's minimum spanning tree algorithm	(q)	Dynamic programming
(c)	Biconnected components algorithm	(r)	Divide and Conquer
(d)	Floyd's shortest path algorithm	(s)	Depth-first search

gate1990 match-the-following algorithms algorithm-design-techniques

1.2.3 Algorithm Design Techniques: GATE1997-1.5

https://gateoverflow.in/2221

The correct matching for the following pairs is

A.	All pairs shortest path	1.	Greedy
B.	Quick Sort	2.	Depth-First Search
C.	Minimum weight spanning tree	3.	Dynamic Programming
D.	Connected Components	4.	Divide and Conquer

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

gate1997 algorithms normal algorithm-design-techniques

1.2.4 Algorithm Design Techniques: GATE2015-1-6

https://gateoverflow.in/8088

Match the following:

P.	Prim's algorithm for minimum spanning tree	i.	Backtracking
Q.	Floyd-Warshall algorithm for all pairs shortest path	ii.	Greedy method
R.	Merge sort	iii.	Dynamic programming
S.	Hamiltonian circuit	iv.	Divide and conquer

A. P-iii, Q-ii, R-iv, S-i
B. P-i, Q-ii, R-iv, S-iii
C. P-ii, Q-iii, R-iv, S-i
D. P-ii, Q-i, R-iii, S-iv

gate2015-1 algorithms normal algorithm-design-techniques

1.2.5 Algorithm Design Techniques: GATE2015-2-36

https://gateoverflow.in/8161

Given below are some algorithms, and some algorithm design paradigms.

1.	Dijkstra's Shortest Path	i.	Divide and Conquer
2.	Floyd-Warshall algorithm to compute all pairs shortest path	ii.	Dynamic Programming
3.	Binary search on a sorted array	iii.	Greedy design
4.	Backtracking search on a graph	iv.	Depth-first search
		v.	Breadth-first search

Match the above algorithms on the left to the corresponding design paradigm they follow.

A. 1-i, 2-iii, 3-i, 4-v
B. 1-iii, 2-iii, 3-i, 4-v
C. 1-iii, 2-ii, 3-i, 4-iv
D. 1-iii, 2-ii, 3-i, 4-v

gate2015-2 algorithms easy algorithm-design-techniques

1.2.6 Algorithm Design Techniques: GATE2017-1-05

https://gateoverflow.in/118707

Consider the following table:

Algorithms	Design Paradigms
P. Kruskal	i. Divide and Conquer
Q. Quicksort	ii. Greedy
R. Floyd-Warshall	iii. Dynamic Programming

Match the algorithms to the design paradigms they are based on.

A. $(P) \leftrightarrow (ii), (Q) \leftrightarrow (iii), (R) \leftrightarrow (i)$
B. $(P) \leftrightarrow (iii), (Q) \leftrightarrow (i), (R) \leftrightarrow (ii)$
C. $(P) \leftrightarrow (ii), (Q) \leftrightarrow (i), (R) \leftrightarrow (iii)$
D. $(P) \leftrightarrow (i), (Q) \leftrightarrow (ii), (R) \leftrightarrow (iii)$

gate2017-1 algorithms algorithm-design-techniques

1.3 Asymptotic Notations (20)

1.3.1 Asymptotic Notations: GATE1994-1.23

https://gateoverflow.in/2466

Consider the following two functions:

$$g_1(n) = \begin{cases} n^3 \text{ for } 0 \leq n \leq 10,000 \\ n^2 \text{ for } n \geq 10,000 \end{cases}$$

$$g_2(n) = \begin{cases} n \text{ for } 0 \leq n \leq 100 \\ n^3 \text{ for } n > 100 \end{cases}$$

Which of the following is true?

A. $g_1(n)$ is $O(g_2(n))$
B. $g_1(n)$ is $O(n^3)$
C. $g_2(n)$ is $O(g_1(n))$
D. $g_2(n)$ is $O(n)$

gate1994 algorithms asymptotic-notations normal

1.3.2 Asymptotic Notations: GATE1996-1.11

https://gateoverflow.in/2715

Which of the following is false?

A. $100n \log n = O(\frac{n \log n}{100})$
B. $\sqrt{\log n} = O(\log \log n)$
C. If $0 < x < y$ then $n^x = O(n^y)$
D. $2^n \neq O(nk)$

gate1996 algorithms asymptotic-notations normal

1.3.3 Asymptotic Notations: GATE2000-2.17

https://gateoverflow.in/664

Consider the following functions

- $f(n) = 3n^{\sqrt{n}}$
- $g(n) = 2^{\sqrt{n} \log_2 n}$
- $h(n) = n!$

Which of the following is true?

A. $h(n)$ is $O(f(n))$
B. $h(n)$ is $O(g(n))$
C. $g(n)$ is not $O(f(n))$
D. $f(n)$ is $O(g(n))$

gate2000 algorithms asymptotic-notations normal

1.3.4 Asymptotic Notations: GATE2001-1.16

https://gateoverflow.in/709

Let $f(n) = n^2 \log n$ and $g(n) = n(\log n)^{10}$ be two positive functions of n. Which of the following statements is correct?

A. $f(n) = O(g(n))$ and $g(n) \neq O(f(n))$
B. $g(n) = O(f(n))$ and $f(n) \neq O(g(n))$
C. $f(n) \neq O(g(n))$ and $g(n) \neq O(f(n))$
D. $f(n) = O(g(n))$ and $g(n) = O(f(n))$

gate2001 algorithms asymptotic-notations time-complexity normal

1.3.5 Asymptotic Notations: GATE2003-20

https://gateoverflow.in/910

Consider the following three claims:

I. $(n+k)^m = \Theta(n^m)$ where k and m are constants
II. $2^{n+1} = O(2^n)$
III. $2^{2n+1} = O(2^n)$

Which of the following claims are correct?

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

gate2003 algorithms asymptotic-notations normal

1.3.6 Asymptotic Notations: GATE2004-IT-55

https://gateoverflow.in/3698

Let $f(n)$, $g(n)$ and $h(n)$ be functions defined for positive integers such that $f(n) = O(g(n))$, $g(n) \neq O(f(n))$, $g(n) = O(h(n))$, and $h(n) = O(g(n))$.

Which one of the following statements is FALSE?

A. $f(n) + g(n) = O(h(n) + h(n))$
B. $f(n) = O(h(n))$
C. $h(n) \neq O(f(n))$
D. $f(n)h(n) \neq O(g(n)h(n))$

gate2004-it algorithms asymptotic-notations normal

1.3.7 Asymptotic Notations: GATE2008-39

https://gateoverflow.in/450

Consider the following functions:

- $f(n) = 2^n$
- $g(n) = n!$
- $h(n) = n^{\log n}$

Which of the following statements about the asymptotic behavior of $f(n)$, $g(n)$ and $h(n)$ is true?

A. $f(n) = O(g(n)); g(n) = O(h(n))$
B. $f(n) = \Omega(g(n)); g(n) = O(h(n))$
C. $g(n) = O(f(n)); h(n) = O(f(n))$
D. $h(n) = O(f(n)); g(n) = \Omega(f(n))$

gate2008 algorithms asymptotic-notations normal

1.3.8 Asymptotic Notations: GATE2008-IT-10

https://gateoverflow.in/3270

Arrange the following functions in increasing asymptotic order:

A. $n^{1/3}$
B. e^n
C. $n^{7/4}$
D. $n \log^9 n$
E. 1.0000001^n

A. a, d, c, e, b
B. d, a, c, e, b
C. a, c, d, e, b
D. a, c, d, b, e

gate2008-it algorithms asymptotic-notations normal

1.3.9 Asymptotic Notations: GATE2011-37

https://gateoverflow.in/2139

Which of the given options provides the increasing order of asymptotic complexity of functions f_1, f_2, f_3 and f_4?

- $f_1(n) = 2^n$
- $f_2(n) = n^{3/2}$
- $f_3(n) = n \log_2 n$
- $f_4(n) = n^{\log_2 n}$

A. f_3, f_2, f_4, f_1
B. f_3, f_2, f_1, f_4
C. f_2, f_3, f_1, f_4
D. f_2, f_3, f_4, f_1

gate2011 algorithms asymptotic-notations normal

1.3.10 Asymptotic Notations: GATE2012-18

https://gateoverflow.in/50

Let $W(n)$ and $A(n)$ denote respectively, the worst case and average case running time of an algorithm executed on an input of size n. Which of the following is **ALWAYS TRUE**?

A. $A(n) = \Omega(W(n))$
B. $A(n) = \Theta(W(n))$
C. $A(n) = \mathrm{O}(W(n))$
D. $A(n) = \mathrm{o}(W(n))$

gate2012 algorithms easy asymptotic-notations

1.3.11 Asymptotic Notations: GATE2015-3-4

https://gateoverflow.in/8398

Consider the equality $\sum_{i=0}^{n} i^3 = X$ and the following choices for X:

I. $\Theta(n^4)$
II. $\Theta(n^5)$
III. $O(n^5)$
IV. $\Omega(n^3)$

The equality above remains correct if X is replaced by

A. Only I
B. Only II
C. I or III or IV but not II
D. II or III or IV but not I

gate2015-3 algorithms asymptotic-notations normal

1.3.12 Asymptotic Notations: GATE2015-3-42

https://gateoverflow.in/8501

Let $f(n) = n$ and $g(n) = n^{(1+\sin\ n)}$, where n is a positive integer. Which of the following statements is/are correct?

I. $f(n) = O(g(n))$
II. $f(n) = \Omega(g(n))$

A. Only I B. Only II C. Both I and II D. Neither I nor II

gate2015-3 algorithms asymptotic-notations normal

1.3.13 Asymptotic Notations: GATE2017-1-04

https://gateoverflow.in/118703

Consider the following functions from positive integers to real numbers:

$10,\ \sqrt{n},\ n,\ \log_2 n,\ \frac{100}{n}$.
The CORRECT arrangement of the above functions in increasing order of asymptotic complexity is:

A. $\log_2 n,\ \frac{100}{n},\ 10,\ \sqrt{n},\ n$
B. $\frac{100}{n},\ 10,\ \log_2 n,\ \sqrt{n},\ n$
C. $10,\ \frac{100}{n},\ \sqrt{n},\ \log_2 n,\ n$
D. $\frac{100}{n},\ \log_2 n,\ 10,\ \sqrt{n},\ n$

gate2017-1 algorithms asymptotic-notations normal

1.3.14 Asymptotic Notations: TIFR2011-B-27

https://gateoverflow.in/20573

Let n be a large integer. Which of the following statements is **TRUE**?

A. $n^{1/\sqrt{\log_2 n}} < \sqrt{\log_2 n} < n^{1/100}$
B. $n^{1/100} < n^{1/\sqrt{\log_2 n}} < \sqrt{\log_2 n}$
C. $n^{1/\sqrt{\log_2 n}} < n^{1/100} < \sqrt{\log_2 n}$
D. $\sqrt{\log_2 n} < n^{1/\sqrt{\log_2 n}} < n^{1/100}$
E. $\sqrt{\log_2 n} < n^{1/100} < n^{1/\sqrt{\log_2 n}}$

tifr2011 asymptotic-notations

1.3.15 Asymptotic Notations: TIFR2012-B-6

https://gateoverflow.in/25106

Let n be a large integer. Which of the following statements is **TRUE**?

A. $2^{\sqrt{2\log n}} < \frac{n}{\log n} < n^{1/3}$
B. $\frac{n}{\log n} < n^{1/3} < 2^{\sqrt{2\log n}}$
C. $2\sqrt{2\log n} < n^{1/3} < \frac{n}{\log n}$
D. $n^{1/3} < 2\sqrt{2\log n} < \frac{n}{\log n}$
E. $\frac{n}{\log n} < 2\sqrt{2\log n} < n^{1/3}$

tifr2012 algorithms asymptotic-notations

1.3.16 Asymptotic Notations: TIFR2014-B-8

https://gateoverflow.in/27192

Which of these functions grows fastest with n?

A. e^n/n.
B. $e^{n-0.9\log n}$.
C. 2^n.
D. $(\log n)^{n-1}$.
E. None of the above.

tifr2014 algorithms asymptotic-notations

1.3.17 Asymptotic Notations: TIFR2016-B-7

https://gateoverflow.in/30720

Let $n = m!$. Which of the following is **TRUE**?

A. $m = \Theta(\log n/\log\log n)$
B. $m = \Omega(\log n/\log\log n)$ but not $m = O(\log n/\log\log n)$
C. $m = \Theta(\log^2 n)$
D. $m = \Omega(\log^2 n)$ but not $m = \mathrm{O}((\log^2 n)$
E. $m = \Theta(\log^{1.5} n)$

tifr2016 asymptotic-notations

1.3.18 Asymptotic Notations: TIFR2017-A-4

https://gateoverflow.in/94943

Which of the following functions asymptotically grows the fastest as n goes to infinity?

A. $(\log\ \log\ n)!$
B. $(\log\ \log\ n)^{\log\ n}$
C. $(\log\ \log\ n)^{\log\ \log\ \log\ n}$
D. $(\log\ n)^{\log\ \log\ n}$
E. $2^{\sqrt{\log\ \log\ n}}$

tifr2017 algorithms asymptotic-notations

1.3.19 Asymptotic Notations: TIFR2018-A-3

https://gateoverflow.in/179272

Which of the following statements is TRUE for all sufficiently large integers n ?

A. $2^{2^{\sqrt{\log\log n}}} < 2^{\sqrt{\log n}} < n$
B. $2^{\sqrt{\log n}} < n < 2^{2^{\sqrt{\log\log n}}}$
C. $n < 2^{\sqrt{\log n}} < 2^{2^{\sqrt{\log\log n}}}$
D. $n < 2^{2^{\sqrt{\log\log n}}} < 2^{\sqrt{\log n}}$
E. $2^{\sqrt{\log n}} < 2^{2^{\sqrt{\log\log n}}} < n$

tifr2018 asymptotic-notations

1.3.20 Asymptotic Notations: TIFR2019-B-5

https://gateoverflow.in/280490

Stirling's approximation for $n!$ states for some constants c_1, c_2

$$c_1 n^{n+\frac{1}{2}} e^{-n} \leq n! \leq c_2 n^{n+\frac{1}{2}} e^{-n}.$$

What are the tightest asymptotic bounds that can be placed on $n!$?

A. $n! = \Omega(n^n)$ and $n! = \mathcal{O}(n^{n+\frac{1}{2}})$
B. $n! = \Theta(n^{n+\frac{1}{2}})$
C. $n! = \Theta((\frac{n}{e})^n)$
D. $n! = \Theta((\frac{n}{e})^{n+\frac{1}{2}})$
E. $n! = \Theta(n^{n+\frac{1}{2}}2^{-n})$

tifr2019 algorithms asymptotic-notations

1.4 Dynamic Programming (12)

1.4.1 Dynamic Programming: GATE2008-80

https://gateoverflow.in/498

The subset-sum problem is defined as follows. Given a set of n positive integers, $S = \{a_1, a_2, a_3, \ldots, a_n\}$, and positive integer W, is there a subset of S whose elements sum to W? A dynamic program for solving this problem uses a 2-dimensional Boolean array, X, with n rows and $W+1$ columns. $X[i,j], 1 \leq i \leq n, 0 \leq j \leq W$, is TRUE, if and only if there is a subset of $\{a_1, a_2, \ldots, a_i\}$ whose elements sum to j.

Which of the following is valid for $2 \leq i \leq n$, and $a_i \leq j \leq W$?

A. $X[i,j] = X[i-1,j] \vee X[i, j-a_i]$

B. $X[i,j] = X[i-1,j] \vee X[i-1,j-a_i]$
C. $X[i,j] = X[i-1,j] \wedge X[i,j-a_i]$
D. $X[i,j] = X[i-1,j] \wedge X[i-1,j-a_i]$

gate2008 algorithms normal dynamic-programming

1.4.2 Dynamic Programming: GATE2008-81

https://gateoverflow.in/43484

The subset-sum problem is defined as follows. Given a set of n positive integers, $S = \{a_1, a_2, a_3, \ldots, a_n\}$, and positive integer W, is there a subset of S whose elements sum to W? A dynamic program for solving this problem uses a 2-dimensional Boolean array, X, with n rows and $W+1$ columns. $X[i,j], 1 \leq i \leq n, 0 \leq j \leq W$, is TRUE, if and only if there is a subset of $\{a_1, a_2, \ldots, a_i\}$ whose elements sum to j.

Which entry of the array X, if TRUE, implies that there is a subset whose elements sum to W?

A. $X[1,W]$ B. $X[n,0]$ C. $X[n,W]$ D. $X[n-1,n]$

gate2008 algorithms normal dynamic-programming

1.4.3 Dynamic Programming: GATE2009-53

https://gateoverflow.in/1338

A sub-sequence of a given sequence is just the given sequence with some elements (possibly none or all) left out. We are given two sequences $X[m]$ and $Y[n]$ of lengths m and n, respectively with indexes of X and Y starting from 0.

We wish to find the length of the longest common sub-sequence (LCS) of $X[m]$ and $Y[n]$ as $l(m,n)$, where an incomplete recursive definition for the function $I(i,j)$ to compute the length of the LCS of $X[m]$ and $Y[n]$ is given below:

```
l(i,j)  = 0, if either i = 0 or j = 0
        = expr1, if i,j > 0 and X[i-1] = Y[j-1]
        = expr2, if i,j > 0 and X[i-1] ≠ Y[j-1]
```

Which one of the following options is correct?

A. $\text{expr1} = l(i-1,j)+1$
B. $\text{expr1} = l(i,j-1)$
C. $\text{expr2} = \max(l(i-1,j), l(i,j-1))$
D. $\text{expr2} = \max(l(i-1,j-1), l(i,j))$

gate2009 algorithms normal dynamic-programming recursion

1.4.4 Dynamic Programming: GATE2009-54

https://gateoverflow.in/43476

A sub-sequence of a given sequence is just the given sequence with some elements (possibly none or all) left out. We are given two sequences $X[m]$ and $Y[n]$ of lengths m and n, respectively with indexes of X and Y starting from 0.

We wish to find the length of the longest common sub-sequence (LCS) of $X[m]$ and $Y[n]$ as $l(m,n)$, where an incomplete recursive definition for the function $I(i,j)$ to compute the length of the LCS of $X[m]$ and $Y[n]$ is given below:

$l(i,j) = 0$, if either $i = 0$ or $j = 0$
$= expr1$, if $i,j > 0$ and $X[i-1] = Y[j-1]$
$= expr2$, if $i,j > 0$ and $X[i-1] \neq Y[j-1]$

The value of $l(i,j)$ could be obtained by dynamic programming based on the correct recursive definition of $l(i,j)$ of the form given above, using an array $L[M,N]$, where $M = m+1$ and $N = n+1$, such that $L[i,j] = l(i,j)$.

Which one of the following statements would be TRUE regarding the dynamic programming solution for the recursive definition of $l(i,j)$?

A. All elements of L should be initialized to 0 for the values of $l(i,j)$ to be properly computed.
B. The values of $l(i,j)$ may be computed in a row major order or column major order of $L[M,N]$.
C. The values of $l(i,j)$ cannot be computed in either row major order or column major order of $L[M,N]$.
D. $L[p,q]$ needs to be computed before $L[r,s]$ if either $p < r$ or $q < s$.

gate2009 normal algorithms dynamic-programming recursion

1.4.5 Dynamic Programming: GATE2010-34

https://gateoverflow.in/2208

The weight of a sequence $a_0, a_1, \ldots, a_{n-1}$ of real numbers is defined as $a_0 + a_1/2 + \cdots + a_{n-1}/2^{n-1}$. A subsequence of a sequence is obtained by deleting some elements from the sequence, keeping the order of the remaining elements the same. Let X denote the maximum possible weight of a subsequence of $a_o, a_1, \ldots, a_{n-1}$ and Y the maximum possible weight of a subsequence of $a_1, a_2, \ldots, a_{n-1}$. Then X is equal to

A. $max(Y, a_0 + Y)$
B. $max(Y, a_0 + Y/2)$
C. $max(Y, a_0 + 2Y)$
D. $a_0 + Y/2$

gate2010 algorithms dynamic-programming normal

1.4.6 Dynamic Programming: GATE2011-25

https://gateoverflow.in/2127

An algorithm to find the length of the longest monotonically increasing sequence of numbers in an array $A[0 : n-1]$ is given below.

Let L_i, denote the length of the longest monotonically increasing sequence starting at index i in the array.

Initialize $L_{n-1} = 1$.

For all i such that $0 \leq i \leq n-2$

$$L_i = \begin{cases} 1 + L_{i+1} & \text{if A[i] < A[i+1]} \\ 1 & \text{Otherwise} \end{cases}$$

Finally, the length of the longest monotonically increasing sequence is $\max(L_0, L_1, \ldots, L_{n-1})$.

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

A. The algorithm uses dynamic programming paradigm
B. The algorithm has a linear complexity and uses branch and bound paradigm
C. The algorithm has a non-linear polynomial complexity and uses branch and bound paradigm
D. The algorithm uses divide and conquer paradigm

gate2011 algorithms easy dynamic-programming

1.4.7 Dynamic Programming: GATE2011-38

https://gateoverflow.in/2140

Four Matrices M_1, M_2, M_3 and M_4 of dimensions $p \times q$, $q \times r$, $r \times s$ and $s \times t$ respectively can be multiplied in several ways with different number of total scalar multiplications. For example when multiplied as $((M_1 \times M_2) \times (M_3 \times M_4))$, the total number of scalar multiplications is $pqr + rst + prt$. When multiplied as $(((M_1 \times M_2) \times M_3) \times M_4)$, the total number of scalar multiplications is $pqr + prs + pst$.

If $p = 10, q = 100, r = 20, s = 5$ and $t = 80$, then the minimum number of scalar multiplications needed is

A. 248000 B. 44000 C. 19000 D. 25000

gate2011 algorithms dynamic-programming normal

1.4.8 Dynamic Programming: GATE2014-2-37

https://gateoverflow.in/1996

Consider two strings A="qpqrr" and B="pqprqrp". Let x be the length of the longest common subsequence *(not necessarily contiguous)* between A and B and let y be the number of such longest common subsequences between A and B. Then $x + 10y =$ ___.

gate2014-2 algorithms normal numerical-answers dynamic-programming

1.4.9 Dynamic Programming: GATE2014-3-37

https://gateoverflow.in/2071

Suppose you want to move from 0 to 100 on the number line. In each step, you either move right by a unit distance or you take a *shortcut*. A shortcut is simply a pre-specified pair of integers i, j with $i < j$. Given a shortcut (i, j), if you are at position i on the number line, you may directly move to j. Suppose $T(k)$ denotes the smallest number of steps needed to move from k to 100. Suppose further that there is at most 1 shortcut involving any number, and in particular, from 9 there is a shortcut to 15. Let y and z be such that $T(9) = 1 + \min(T(y), T(z))$. Then the value of the product yz is _____.

gate2014-3 algorithms normal numerical-answers dynamic-programming

1.4.10 Dynamic Programming: GATE2016-2-14

https://gateoverflow.in/39570

The Floyd-Warshall algorithm for all-pair shortest paths computation is based on

A. Greedy paradigm.
B. Divide-and-conquer paradigm.
C. Dynamic Programming paradigm.
D. Neither Greedy nor Divide-and-Conquer nor Dynamic Programming paradigm.

gate2016-2 algorithms dynamic-programming easy

1.4.11 Dynamic Programming: GATE2016-2-38

https://gateoverflow.in/39587

Let A_1, A_2, A_3 and A_4 be four matrices of dimensions $10 \times 5, 5 \times 20, 20 \times 10$ and 10×5, respectively. The minimum number of scalar multiplications required to find the product $A_1A_2A_3A_4$ using the basic matrix multiplication method is _____.

gate2016-2 dynamic-programming algorithms normal numerical-answers

1.4.12 Dynamic Programming: GATE2018-31

https://gateoverflow.in/204105

Assume that multiplying a matrix G_1 of dimension $p \times q$ with another matrix G_2 of dimension $q \times r$ requires pqr scalar multiplications. Computing the product of n matrices $G_1G_2G_3 \ldots G_n$ can be done by parenthesizing in different ways. Define G_iG_{i+1} as an **explicitly computed pair** for a given paranthesization if they are directly multiplied. Fr example, in the matrix multiplication chain $G_1G_2G_3G_4G_5G_6$ using parenthesization $(G_1(G_2G_3))(G_4(G_5G_6)), G_2G_3$ and G_5G_6 are only explicitly computed pairs.

Consider a matrix multiplication chain $F_1F_2F_3F_4F_5$, where matrices F_1, F_2, F_3, F_4 and F_5 are of dimensions $2 \times 25, 25 \times 3, 3 \times 16, 16 \times 1$ and 1×1000, respectively. In the parenthesization of $F_1F_2F_3F_4F_5$ that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

A. F_1F_2 and F_3F_4 only
B. F_2F_3 only
C. F_3F_4 only
D. F_2F_2 and F_4F_5 only

gate2018 algorithms dynamic-programming

1.5 Graph Algorithms (48)

1.5.1 Graph Algorithms: GATE1994-1.22

https://gateoverflow.in/2465

Which of the following statements is false?

A. Optimal binary search tree construction can be performed efficiently using dynamic programming
B. Breadth-first search cannot be used to find connected components of a graph
C. Given the prefix and postfix walks over a binary tree, the binary tree cannot be uniquely constructed.
D. Depth-first search can be used to find connected components of a graph

gate1994 algorithms normal graph-algorithms

1.5.2 Graph Algorithms: GATE1994-24

https://gateoverflow.in/2520

An independent set in a graph is a subset of vertices such that no two vertices in the subset are connected by an edge. An incomplete scheme for a greedy algorithm to find a maximum independent set in a tree is given below:

```
V: Set of all vertices in the tree;
I := ϕ
while V ≠ ϕ do
begin
    select a vertex u ∈ V such that
    _______;
    V := V - {u};
    if u is such that
    _______then I := I U {u}
end;
Output(I);
```

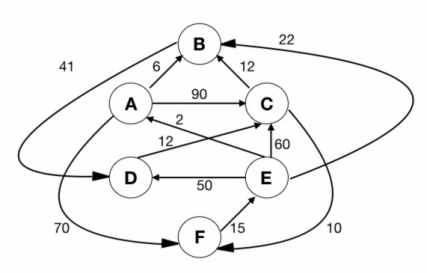
a. Complete the algorithm by specifying the property of vertex u in each case.
b. What is the time complexity of the algorithm?

gate1994 algorithms graph-algorithms normal

1.5.3 Graph Algorithms: GATE1996-17

https://gateoverflow.in/2769

Let G be the directed, weighted graph shown in below figure



We are interested in the shortest paths from A.

a. Output the sequence of vertices identified by the Dijkstra's algorithm for single source shortest path when the algorithm is started at node A
b. Write down sequence of vertices in the shortest path from A to E
c. What is the cost of the shortest path from A to E?

gate1996 algorithms graph-algorithms normal

1.5.4 Graph Algorithms: GATE1998-1.21, ISRO2008-16

https://gateoverflow.in/1658

Which one of the following algorithm design techniques is used in finding all pairs of shortest distances in a graph?

A. Dynamic programming
B. Backtracking
C. Greedy
D. Divide and Conquer

gate1998 algorithms graph-algorithms easy isro2008

1.5.5 Graph Algorithms: GATE2000-1.13

https://gateoverflow.in/636

The most appropriate matching for the following pairs

X: depth first search	1: heap
Y: breadth first search	2: queue
Z: sorting	3: stack

is:

A. X - 1, Y - 2, Z - 3
B. X - 3, Y - 1, Z - 2
C. X - 3, Y - 2, Z - 1
D. X - 2, Y - 3, Z - 1

gate2000 algorithms easy graph-algorithms

1.5.6 Graph Algorithms: GATE2001-2.14

https://gateoverflow.in/732

Consider an undirected, unweighted graph G. Let a breadth-first traversal of G be done starting from a node r. Let $d(r,u)$ and $d(r,v)$ be the lengths of the shortest paths from r to u and v respectively in G. If u is visited before v during the breadth-first traversal, which of the following statements is correct?

A. $d(r,u) < d(r,v)$
B. $d(r,u) > d(r,v)$
C. $d(r,u) \leq d(r,v)$
D. None of the above

gate2001 algorithms graph-algorithms normal

1.5.7 Graph Algorithms: GATE2002-12

https://gateoverflow.in/865

Fill in the blanks in the following template of an algorithm to compute all pairs shortest path lengths in a directed graph G with $n * n$ adjacency matrix A. $A[i,j]$ equals 1 if there is an edge in G from i to j, and 0 otherwise. Your aim in filling in the blanks is to ensure that the algorithm is correct.

```
INITIALIZATION: For i = 1 ... n
    {For j = 1 ... n
        { if a[i,j] = 0 then P[i,j] =_______ else P[i,j] =_______;}
    }

ALGORITHM: For i = 1 ... n
    {For j = 1 ... n
        {For k = 1 ... n
            {P[__,__] = min{_______,______}; }
```

```
        }
    }
```

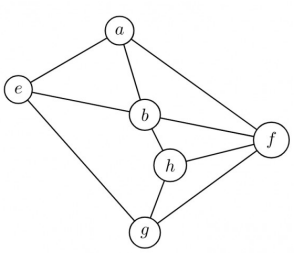
a. Copy the complete line containing the blanks in the Initialization step and fill in the blanks.
b. Copy the complete line containing the blanks in the Algorithm step and fill in the blanks.
c. Fill in the blank: The running time of the Algorithm is $O(\_\_\_)$.

gate2002 algorithms graph-algorithms time-complexity normal descriptive

1.5.8 Graph Algorithms: GATE2003-21

https://gateoverflow.in/911

Consider the following graph:



Among the following sequences:

I. abeghf
II. abfehg
III. abfhge
IV. afghbe

Which are the depth-first traversals of the above graph?

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

gate2003 algorithms graph-algorithms normal

1.5.9 Graph Algorithms: GATE2003-67

https://gateoverflow.in/954

Let $G=(V,E)$ be an undirected graph with a subgraph $G_1=(V_1,E_1)$. Weights are assigned to edges of G as follows.

$$w(e)=\begin{cases}0, & \text{if } e\in E_1\\ 1, & \text{otherwise}\end{cases}$$

A single-source shortest path algorithm is executed on the weighted graph (V,E,w) with an arbitrary vertex v_1 of V_1 as the source. Which of the following can always be inferred from the path costs computed?

A. The number of edges in the shortest paths from v_1 to all vertices of G
B. G_1 is connected
C. V_1 forms a clique in G
D. G_1 is a tree

gate2003 algorithms graph-algorithms normal

1.5.10 Graph Algorithms: GATE2003-70

https://gateoverflow.in/957

Let $G=(V,E)$ be a directed graph with n vertices. A path from v_i to v_j in G is a sequence of vertices ($v_i,v_{i+1},\ldots,v_j$) such that $(v_k,v_k+1)\in E$ for all k in i through $j-1$. A simple path is a path in which no vertex appears more than once.

Let A be an $n\times n$ array initialized as follows:

$$A[j,k]=\begin{cases}1, & \text{if } (j,k)\in E\\ 0, & \text{otherwise}\end{cases}$$

Consider the following algorithm:

```
for i=1 to n
    for j=1 to n
        for k=1 to n
            A[j,k] = max(A[j,k], A[j,i] + A[i,k]);
```

Which of the following statements is necessarily true for all j and k after termination of the above algorithm?

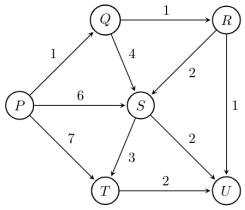
A. $A[j,k] \leq n$
B. If $A[j,j] \geq n-1$ then G has a Hamiltonian cycle
C. If there exists a path from j to k, $A[j,k]$ contains the longest path length from j to k
D. If there exists a path from j to k, every simple path from j to k contains at most $A[j,k]$ edges

gate2003 algorithms graph-algorithms normal

1.5.11 Graph Algorithms: GATE2004-44

https://gateoverflow.in/1041

Suppose we run Dijkstra's single source shortest path algorithm on the following edge-weighted directed graph with vertex P as the source.



In what order do the nodes get included into the set of vertices for which the shortest path distances are finalized?

A. P,Q,R,S,T,U B. P,Q,R,U,S,T C. P,Q,R,U,T,S D. P,Q,T,R,U,S

gate2004 algorithms graph-algorithms normal

1.5.12 Graph Algorithms: GATE2004-81

https://gateoverflow.in/1075

Let $G_1 = (V, E_1)$ and $G_2 = (V, E_2)$ be connected graphs on the same vertex set V with more than two vertices. If $G_1 \cap G_2 = (V, E_1 \cap E_2)$ is not a connected graph, then the graph $G_1 \cup G_2 = (V, E_1 \cup E_2)$

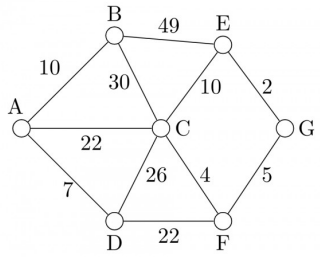
A. cannot have a cut vertex
B. must have a cycle
C. must have a cut-edge (bridge)
D. has chromatic number strictly greater than those of G_1 and G_2

gate2004 algorithms graph-algorithms normal

1.5.13 Graph Algorithms: GATE2004-IT-56

https://gateoverflow.in/3699

Consider the undirected graph below:



Using Prim's algorithm to construct a minimum spanning tree starting with node A, which one of the following sequences of edges represents a possible order in which the edges would be added to construct the minimum spanning tree?

A. (E, G), (C, F), (F, G), (A, D), (A, B), (A, C)
B. (A, D), (A, B), (A, C), (C, F), (G, E), (F, G)
C. (A, B), (A, D), (D, F), (F, G), (G, E), (F, C)
D. (A, D), (A, B), (D, F), (F, C), (F, G), (G, E)

gate2004-it algorithms graph-algorithms normal

1.5.14 Graph Algorithms: GATE2005-38

https://gateoverflow.in/1374

Let $G(V,E)$ be an undirected graph with positive edge weights. Dijkstra's single source shortest path algorithm can be implemented using the binary heap data structure with time complexity:

A. $O\left(|V|^2\right)$
B. $O(|E|+|V|\log|V|)$
C. $O(|V|\log|V|)$
D. $O((|E|+|V|)\log|V|)$

gate2005 algorithms graph-algorithms normal

1.5.15 Graph Algorithms: GATE2005-82a

https://gateoverflow.in/1404

Let s and t be two vertices in a undirected graph $G=(V,E)$ having distinct positive edge weights. Let $[X,Y]$ be a partition of V such that $s\in X$ and $t\in Y$. Consider the edge e having the minimum weight amongst all those edges that have one vertex in X and one vertex in Y.

The edge e must definitely belong to:

A. the minimum weighted spanning tree of G
B. the weighted shortest path from s to t
C. each path from s to t
D. the weighted longest path from s to t

gate2005 algorithms graph-algorithms normal

1.5.16 Graph Algorithms: GATE2005-82b

https://gateoverflow.in/82129

Let s and t be two vertices in a undirected graph $G=(V,E)$ having distinct positive edge weights. Let $[X,Y]$ be a partition of V such that $s\in X$ and $t\in Y$. Consider the edge e having the minimum weight amongst all those edges that have one vertex in X and one vertex in Y.

Let the weight of an edge e denote the congestion on that edge. The congestion on a path is defined to be the maximum of the congestions on the edges of the path. We wish to find the path from s to t having minimum congestion. Which of the following paths is always such a path of minimum congestion?

A. a path from s to t in the minimum weighted spanning tree
B. a weighted shortest path from s to t
C. an Euler walk from s to t
D. a Hamiltonian path from s to t

gate2005 algorithms graph-algorithms normal

1.5.17 Graph Algorithms: GATE2005-IT-14

https://gateoverflow.in/3759

In a depth-first traversal of a graph G with n vertices, k edges are marked as tree edges. The number of connected components in G is

A. k
B. $k+1$
C. $n-k-1$
D. $n-k$

gate2005-it algorithms graph-algorithms normal

1.5.18 Graph Algorithms: GATE2005-IT-15

https://gateoverflow.in/3760

In the following table, the left column contains the names of standard graph algorithms and the right column contains the time complexities of the algorithms. Match each algorithm with its time complexity.

1. Bellman-Ford algorithm	A: $O(m\log n)$
2. Kruskal's algorithm	B: $O(n^3)$
3. Floyd-Warshall algorithm	C: $O(nm)$
4. Topological sorting	D: $O(n+m)$

A. $1\rightarrow$ C, $2\rightarrow$ A, $3\rightarrow$ B, $4\rightarrow$ D
B. $1\rightarrow$ B, $2\rightarrow$ D, $3\rightarrow$ C, $4\rightarrow$ A
C. $1\rightarrow$ C, $2\rightarrow$ D, $3\rightarrow$ A, $4\rightarrow$ B
D. $1\rightarrow$ B, $2\rightarrow$ A, $3\rightarrow$ C, $4\rightarrow$ D

gate2005-it algorithms graph-algorithms normal

1.5.19 Graph Algorithms: GATE2005-IT-84a

https://gateoverflow.in/3856

A sink in a directed graph is a vertex i such that there is an edge from every vertex $j\neq i$ to i and there is no edge from i to any other vertex. A directed graph G with n vertices is represented by its adjacency matrix A, where $A[i][j]=1$ if there is an edge directed from vertex i to j and 0 otherwise. The following algorithm determines whether there is a sink in the graph G.

```
i = 0;
do {
    j = i + 1;
    while ((j < n) && E1) j++;
    if (j < n) E2;
} while (j < n);
flag = 1;
for (j = 0; j < n; j++)
    if ((j! = i) && E3) flag = 0;
if (flag) printf("Sink exists");
else printf ("Sink does not exist");
```

Choose the correct expressions for E_1 and E_2

A. $E_1 : A[i][j]$ and $E_2 : i = j$;
B. $E_1 : !A[i][j]$ and $E_2 : i = j+1$;
C. $E_1 : !A[i][j]$ and $E_2 : i = j$;
D. $E_1 : A[i][j]$ and $E_2 : i = j+1$;

gate2005-it algorithms graph-algorithms normal

1.5.20 Graph Algorithms: GATE2005-IT-84b

https://gateoverflow.in/3857

A sink in a directed graph is a vertex i such that there is an edge from every vertex $j \neq i$ to i and there is no edge from i to any other vertex. A directed graph G with n vertices is represented by its adjacency matrix A, where $A[i][j] = 1$ if there is an edge directed from vertex i to j and 0 otherwise. The following algorithm determines whether there is a sink in the graph G.

```
i = 0;
do {
    j = i + 1;
    while ((j < n) && E1) j++;
    if (j < n) E2;
} while (j < n);
flag = 1;
for (j = 0; j < n; j++)
    if ((j! = i) && E3) flag = 0;
if (flag) printf("Sink exists") ;
else printf ("Sink does not exist");
```

Choose the correct expression for E_3

A. $(A[i][j]$ && $!A[j][i])$
B. $(!A[i][j]$ && $A[j][i])$
C. $(!A[i][j]$ || $A[j][i])$
D. $(A[i][j]$ || $!A[j][i])$

gate2005-it algorithms graph-algorithms normal

1.5.21 Graph Algorithms: GATE2006-12

https://gateoverflow.in/891

To implement Dijkstra's shortest path algorithm on unweighted graphs so that it runs in linear time, the data structure to be used is:

A. Queue B. Stack C. Heap D. B-Tree

gate2006 algorithms graph-algorithms easy

1.5.22 Graph Algorithms: GATE2006-48

https://gateoverflow.in/1824

Let T be a depth first search tree in an undirected graph G. Vertices u and v are leaves of this tree T. The degrees of both u and v in G are at least 2. which one of the following statements is true?

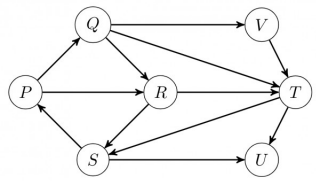
A. There must exist a vertex w adjacent to both u and v in G
B. There must exist a vertex w whose removal disconnects u and v in G
C. There must exist a cycle in G containing u and v
D. There must exist a cycle in G containing u and all its neighbours in G

gate2006 algorithms graph-algorithms normal

1.5.23 Graph Algorithms: GATE2006-IT-46

https://gateoverflow.in/3589

Which of the following is the correct decomposition of the directed graph given below into its strongly connected components?



A. $\{P,Q,R,S\},\{T\},\{U\},\{V\}$
B. $\{P,Q,R,S,T,V\},\{U\}$
C. $\{P,Q,S,T,V\},\{R\},\{U\}$
D. $\{P,Q,R,S,T,U,V\}$

gate2006-it algorithms graph-algorithms normal

1.5.24 Graph Algorithms: GATE2006-IT-47

https://gateoverflow.in/3590

Consider the depth-first-search of an undirected graph with 3 vertices P, Q, and R. Let discovery time $d(u)$ represent the time instant when the vertex u is first visited, and finish time $f(u)$ represent the time instant when the vertex u is last visited. Given that

$d(P) = 5$ units	$f(P) = 12$ units
$d(Q) = 6$ units	$f(Q) = 10$ units
$d(R) = 14$ unit	$f(R) = 18$ units

Which one of the following statements is TRUE about the graph?

A. There is only one connected component
B. There are two connected components, and P and R are connected
C. There are two connected components, and Q and R are connected
D. There are two connected components, and P and Q are connected

gate2006-it algorithms graph-algorithms normal

1.5.25 Graph Algorithms: GATE2007-41

https://gateoverflow.in/1239

In an unweighted, undirected connected graph, the shortest path from a node S to every other node is computed most efficiently, in terms of *time complexity*, by

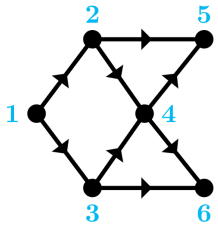
A. Dijkstra's algorithm starting from S.
B. Warshall's algorithm.
C. Performing a DFS starting from S.
D. Performing a BFS starting from S.

gate2007 algorithms graph-algorithms easy

1.5.26 Graph Algorithms: GATE2007-5

https://gateoverflow.in/31821

Consider the DAG with $V = \{1,2,3,4,5,6\}$ shown below.



Which of the following is not a topological ordering?

A. $1\,2\,3\,4\,5\,6$ B. $1\,3\,2\,4\,5\,6$ C. $1\,3\,2\,4\,6\,5$ D. $3\,2\,4\,1\,6\,5$

gate2007 algorithms graph-algorithms

1.5.27 Graph Algorithms: GATE2007-IT-24

https://gateoverflow.in/3457

A depth-first search is performed on a directed acyclic graph. Let $d[u]$ denote the time at which vertex u is visited for the first time and $f[u]$ the time at which the DFS call to the vertex u terminates. Which of the following statements is always TRUE for all edges (u,v) in the graph ?

A. $d[u] < d[v]$
B. $d[u] < f[v]$
C. $f[u] < f[v]$
D. $f[u] > f[v]$

gate2007-it algorithms graph-algorithms normal

1.5.28 Graph Algorithms: GATE2007-IT-3, UGCNET-June2012-III-34

https://gateoverflow.in/3434

Consider a weighted, undirected graph with positive edge weights and let uv be an edge in the graph. It is known that the shortest path from the source vertex s to u has weight 53 and the shortest path from s to v has weight 65. Which one of the following statements is always TRUE?

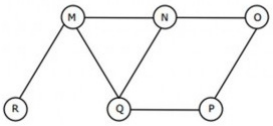
A. Weight $(u,v) \leq 12$
B. Weight $(u,v) = 12$
C. Weight $(u,v) \geq 12$
D. Weight $(u,v) > 12$

gate2007-it algorithms graph-algorithms normal ugcnetjune2012iii

1.5.29 Graph Algorithms: GATE2008-19

https://gateoverflow.in/417

The Breadth First Search algorithm has been implemented using the queue data structure. One possible order of visiting the nodes of the following graph is:

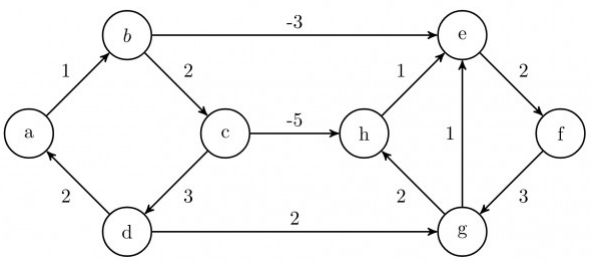


A. $MNOPQR$ B. $NQMPOR$ C. $QMNPRO$ D. $QMNPOR$

gate2008 normal algorithms graph-algorithms

1.5.30 Graph Algorithms: GATE2008-45

https://gateoverflow.in/457



Dijkstra's single source shortest path algorithm when run from vertex a in the above graph, computes the correct shortest path distance to

A. only vertex a
B. only vertices a, e, f, g, h
C. only vertices a, b, c, d
D. all the vertices

gate2008 algorithms graph-algorithms normal

1.5.31 Graph Algorithms: GATE2008-7

https://gateoverflow.in/405

The most efficient algorithm for finding the number of connected components in an undirected graph on n vertices and m edges has time complexity

A. $\Theta(n)$ B. $\Theta(m)$ C. $\Theta(m+n)$ D. $\Theta(mn)$

gate2008 algorithms graph-algorithms time-complexity normal

1.5.32 Graph Algorithms: GATE2008-IT-47

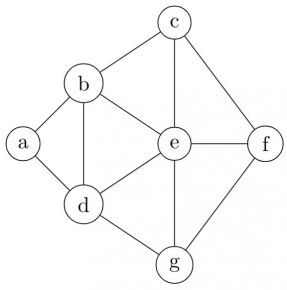
https://gateoverflow.in/3357

Consider the following sequence of nodes for the undirected graph given below:

1. $a\ b\ e\ f\ d\ g\ c$

2. $a\,b\,e\,f\,c\,g\,d$
3. $a\,d\,g\,e\,b\,c\,f$
4. $a\,d\,b\,c\,g\,e\,f$

A Depth First Search (DFS) is started at node a. The nodes are listed in the order they are first visited. Which of the above is/are possible output(s)?



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

gate2008-it algorithms graph-algorithms normal

1.5.33 Graph Algorithms: GATE2009-13

https://gateoverflow.in/1305

Which of the following statement(s) is/are correct regarding Bellman-Ford shortest path algorithm?

P: Always finds a negative weighted cycle, if one exists.

Q: Finds whether any negative weighted cycle is reachable from the source.

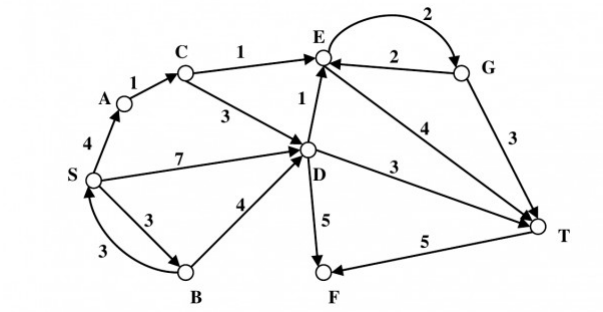
A. P only B. Q only C. Both P and Q D. Neither P nor Q

gate2009 algorithms graph-algorithms normal

1.5.34 Graph Algorithms: GATE2012-40

https://gateoverflow.in/1765

Consider the directed graph shown in the figure below. There are multiple shortest paths between vertices S and T. Which one will be reported by Dijkstra's shortest path algorithm? Assume that, in any iteration, the shortest path to a vertex v is updated only when a strictly shorter path to v is discovered.



A. SDT B. SBDT C. SACDT D. SACET

gate2012 algorithms graph-algorithms normal

1.5.35 Graph Algorithms: GATE2013-19

https://gateoverflow.in/1441

What is the time complexity of Bellman-Ford single-source shortest path algorithm on a complete graph of n vertices?

A. $\theta(n^2)$ B. $\theta(n^2 \log n)$
C. $\theta(n^3)$ D. $\theta(n^3 \log n)$

gate2013 algorithms graph-algorithms normal

1.5.36 Graph Algorithms: GATE2014-1-11

https://gateoverflow.in/1771

Let G be a graph with n vertices and m edges.What is the tightest upper bound on the running time of Depth First Search on G, when G is represented as an adjacency matrix?

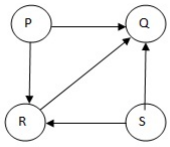
A. $\Theta(n)$ B. $\Theta(n+m)$ C. $\Theta(n^2)$ D. $\Theta(m^2)$

gate2014-1 algorithms graph-algorithms normal

1.5.37 Graph Algorithms: GATE2014-1-13

https://gateoverflow.in/1779

Consider the directed graph below given.



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

A. The graph does not have any topological ordering.
B. Both PQRS and SRQP are topological orderings.
C. Both PSRQ and SPRQ are topological orderings.
D. PSRQ is the only topological ordering.

gate2014-1 graph-algorithms easy

1.5.38 Graph Algorithms: GATE2014-2-14

https://gateoverflow.in/1969

Consider the tree arcs of a BFS traversal from a source node W in an unweighted, connected, undirected graph. The tree T formed by the tree arcs is a data structure for computing

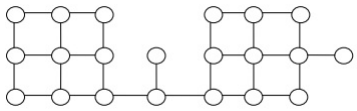
A. the shortest path between every pair of vertices.
B. the shortest path from W to every vertex in the graph.
C. the shortest paths from W to only those nodes that are leaves of T.
D. the longest path in the graph.

gate2014-2 algorithms graph-algorithms normal

1.5.39 Graph Algorithms: GATE2014-3-13

https://gateoverflow.in/2047

Suppose depth first search is executed on the graph below starting at some unknown vertex. Assume that a recursive call to visit a vertex is made only after first checking that the vertex has not been visited earlier. Then the maximum possible recursion depth (including the initial call) is _____.



gate2014-3 algorithms graph-algorithms numerical-answers normal

1.5.40 Graph Algorithms: GATE2015-1-45

https://gateoverflow.in/8321

Let $G = (V, E)$ be a simple undirected graph, and s be a particular vertex in it called the source. For $x \in V$, let $d(x)$ denote the shortest distance in G from s to x. A breadth first search (BFS) is performed starting at s. Let T be the resultant BFS tree. If (u, v) is an edge of G that is not in T, then which one of the following CANNOT be the value of $d(u) - d(v)$?

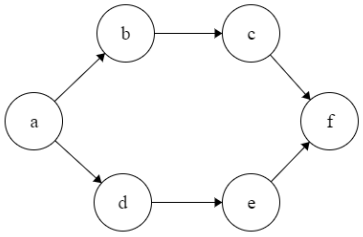
A. -1 B. 0 C. 1 D. 2

gate2015-1 algorithms graph-algorithms normal

1.5.41 Graph Algorithms: GATE2016-1-11

https://gateoverflow.in/39669

Consider the following directed graph:



The number of different topological orderings of the vertices of the graph is _____.

gate2016-1 algorithms graph-algorithms normal numerical-answers

1.5.42 Graph Algorithms: GATE2016-2-11

https://gateoverflow.in/39563

Breadth First Search (BFS) is started on a binary tree beginning from the root vertex. There is a vertex t at a distance four from the root. If t is the n^{th} vertex in this BFS traversal, then the maximum possible value of n is _____

gate2016-2 algorithms graph-algorithms normal numerical-answers

1.5.43 Graph Algorithms: GATE2016-2-41

https://gateoverflow.in/39620

In an adjacency list representation of an undirected simple graph $G = (V, E)$, each edge (u, v) has two adjacency list entries: $[v]$ in the adjacency list of u, and $[u]$ in the adjacency list of v. These are called twins of each other. A twin pointer is a pointer from an adjacency list entry to its twin. If $|E| = m$ and $|V| = n$, and the memory size is not a constraint, what is the time complexity of the most efficient algorithm to set the twin pointer in each entry in each adjacency list?

A. $\Theta(n^2)$
B. $\Theta(n+m)$
C. $\Theta(m^2)$
D. $\Theta(n^4)$

gate2016-2 algorithms graph-algorithms normal

1.5.44 Graph Algorithms: GATE2017-1-26

https://gateoverflow.in/118306

Let $G = (V, E)$ be *any* connected, undirected, edge-weighted graph. The weights of the edges in E are positive and distinct. Consider the following statements:

I. Minimum Spanning Tree of G is always unique.
II. Shortest path between any two vertices of G is always unique.

Which of the above statements is/are necessarily true?

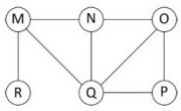
A. I only B. II only C. both I and II D. neither I nor II

gate2017-1 algorithms graph-algorithms normal

1.5.45 Graph Algorithms: GATE2017-2-15

https://gateoverflow.in/118196

The Breadth First Search (BFS) algorithm has been implemented using the queue data structure. Which one of the following is a possible order of visiting the nodes in the graph below?



A. MNOPQR B. NQMPOR C. QMNROP D. POQNMR

gate2017-2 algorithms graph-algorithms

1.5.46 Graph Algorithms: Gate2000-2.19

https://gateoverflow.in/4208

Let G be an undirected graph. Consider a depth-first traversal of G, and let T be the resulting depth-first search tree. Let u be a vertex in G and let v be the first new (unvisited) vertex visited after visiting u in the traversal. Which of the following statement is always true?

A. $\{u, v\}$ must be an edge in G, and u is a descendant of v in T
B. $\{u, v\}$ must be an edge in G, and v is a descendant of u in T

C. If $\{u,v\}$ is not an edge in G then u is a leaf in T
D. If $\{u,v\}$ is not an edge in G then u and v must have the same parent in T

gate2000 algorithms graph-algorithms normal

1.5.47 Graph Algorithms: TIFR2013-B-5

https://gateoverflow.in/25666

Given a weighted directed graph with n vertices where edge weights are integers (positive, zero, or negative), determining whether there are paths of arbitrarily large weight can be performed in time

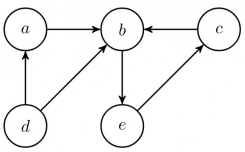
A. $O(n)$
B. $O(n.\log(n))$ but not $O(n)$
C. $O(n^{1.5})$ but not $O(n \log n)$
D. $O(n^3)$ but not $O(n^{1.5})$
E. $O(2^n)$ but not $O(n^3)$

tifr2013 algorithms graph-algorithms

1.5.48 Graph Algorithms: TIFR2014-B-3

https://gateoverflow.in/27137

Consider the following directed graph.



Suppose a depth-first traversal of this graph is performed, assuming that whenever there is a choice, the vertex earlier in the alphabetical order is to be chosen. Suppose the number of tree edges is T, the number of back edges is B and the number of cross edges is C. Then

a. $B = 1$, $C = 1$, and $T = 4$.
b. $B = 0$, $C = 2$, and $T = 4$.
c. $B = 2$, $C = 1$, and $T = 3$.
d. $B = 1$, $C = 2$, and $T = 3$.
e. $B = 2$, $C = 2$, and $T = 1$.

tifr2014 algorithms graph-algorithms

1.6 Graph Connectivity (1)

1.6.1 Graph Connectivity: GATE2018-43

https://gateoverflow.in/204117

Let G be a graph with 100! vertices, with each vertex labelled by a distinct permutation of the numbers $1,2,\ldots,100$. There is an edge between vertices u and v if and only if the label of u can be obtained by swapping two adjacent numbers in the label of v. Let y denote the degree of a vertex in G, and z denote the number of connected components in G. Then, $y + 10z =$ ____

gate2018 algorithms graph-algorithms graph-connectivity numerical-answers

1.7 Greedy Algorithm (7)

1.7.1 Greedy Algorithm: GATE1999-2.20

https://gateoverflow.in/466

The minimum number of record movements required to merge five files A (with 10 records), B (with 20 records), C (with 15 records), D (with 5 records) and E (with 25 records) is:

A. 165 B. 90 C. 75 D. 65

gate1999 algorithms normal greedy-algorithm

1.7.2 Greedy Algorithm: GATE2003-69

https://gateoverflow.in/956

The following are the starting and ending times of activities A,B,C,D,E,F,G and H respectively in chronological order: "$a_s\ b_s\ c_s\ a_e\ d_s\ c_e\ e_s\ f_s\ b_e\ d_e\ g_s\ e_e\ f_e\ h_s\ g_e\ h_e$" . Here, x_s denotes the starting time and x_e denotes the ending time of activity X. We need to schedule the activities in a set of rooms available to us. An activity can be scheduled in a room only if the room is reserved for the activity for its entire duration. What is the minimum number of rooms required?

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

gate2003 algorithms normal greedy-algorithm

1.7.3 Greedy Algorithm: GATE2005-84a

https://gateoverflow.in/1406

We are given 9 tasks $T_1, T_2, \ldots, T_9$. The execution of each task requires one unit of time. We can execute one task at a time. Each task T_i has a profit P_i and a deadline d_i. Profit P_i is earned if the task is completed before the end of the d_i^{th} unit of time.

Task	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Profit	15	20	30	18	18	10	23	16	25
Deadline	7	2	5	3	4	5	2	7	3

Are all tasks completed in the schedule that gives maximum profit?

A. All tasks are completed
B. T_1 and T_6 are left out
C. T_1 and T_8 are left out
D. T_4 and T_6 are left out

gate2005 algorithms greedy-algorithm process-schedule normal

1.7.4 Greedy Algorithm: GATE2005-84b

https://gateoverflow.in/82514

We are given 9 tasks $T_1, T_2, \ldots, T_9$. The execution of each task requires one unit of time. We can execute one task at a time. Each task T_i has a profit P_i and a deadline d_i. Profit P_i is earned if the task is completed before the end of the d_i^{th} unit of time.

Task	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Profit	15	20	30	18	18	10	23	16	25
Deadline	7	2	5	3	4	5	2	7	3

What is the maximum profit earned?

A. 147 B. 165 C. 167 D. 175

gate2005 algorithms greedy-algorithm process-schedule normal

1.7.5 Greedy Algorithm: GATE2006-IT-48

https://gateoverflow.in/3591

The characters a to h have the set of frequencies based on the first 8 Fibonacci numbers as follows

$a : 1, b : 1, c : 2, d : 3, e : 5, f : 8, g : 13, h : 21$

A Huffman code is used to represent the characters. What is the sequence of characters corresponding to the following code?

110111100111010

A. $fdheg$ B. $ecgdf$ C. $dchfg$ D. $fehdg$

gate2006-it algorithms greedy-algorithm normal

1.7.6 Greedy Algorithm: GATE2007-76

https://gateoverflow.in/1271

Suppose the letters a, b, c, d, e, f have probabilities $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \frac{1}{32}$, respectively.

Which of the following is the Huffman code for the letter a, b, c, d, e, f ?

A. 0, 10, 110, 1110, 11110, 11111
B. 11, 10, 011, 010, 001, 000
C. 11, 10, 01, 001, 0001, 0000
D. 110, 100, 010, 000, 001, 111

gate2007 algorithms greedy-algorithm normal

1.7.7 Greedy Algorithm: GATE2018-48

https://gateoverflow.in/204123

Consider the weights and values of items listed below. Note that there is only one unit of each item.

Item number	Weight (in Kgs)	Value (in rupees)
1	10	60
2	7	28
3	4	20
4	2	24

The task is to pick a subset of these items such that their total weight is no more than 11 Kgs and their total value is maximized. Moreover, no item may be split. The total value of items picked by an optimal algorithm is denoted by V_{opt}. A greedy algorithm sorts the items by their value-to-weight ratios in descending order and packs them greedily, starting from the first item in the ordered list. The total value of items picked by the greedy algorithm is denoted by V_{greedy}.

The value of $V_{opt} - V_{greedy}$ is ____

gate2018 algorithms greedy-algorithm numerical-answers

1.8 Hashing (1)

1.8.1 Hashing: GATE1990-13b

https://gateoverflow.in/86225

Consider a hash table with chaining scheme for overflow handling:

i. What is the worst-case timing complexity of inserting n elements into such a table?
ii. For what type of instance does this hashing scheme take the worst-case time for insertion?

gate1990 hashing algorithms

1.9 Huffman Code (3)

1.9.1 Huffman Code: GATE1989-13a

https://gateoverflow.in/93172

A language uses an alphabet of six letters, $\{a,b,c,d,e,f\}$. The relative frequency of use of each letter of the alphabet in the language is as given below:

LETTER	RELATIVE FREQUENCY OF USE
a	0.19
b	0.05
c	0.17
d	0.08
e	0.40
f	0.11

Design a prefix binary code for the language which would minimize the average length of the encoded words of the language.

descriptive gate1989 algorithms huffman-code

1.9.2 Huffman Code: GATE2007-77

https://gateoverflow.in/43513

Suppose the letters a, b, c, d, e, f have probabilities $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \frac{1}{32}$, respectively.

What is the average length of the Huffman code for the letters a, b, c, d, e, f ?

A. 3 B. 2.1875 C. 2.25 D. 1.9375

gate2007 algorithms greedy-algorithm normal huffman-code

1.9.3 Huffman Code: GATE2017-2-50

https://gateoverflow.in/118395

A message is made up entirely of characters from the set $X = \{P,Q,R,S,T\}$. The table of probabilities for each of the characters is shown below:

Character	Probability
P	0.22
Q	0.34
R	0.17
S	0.19
T	0.08
Total	1.00

If a message of 100 characters over X is encoded using Huffman coding, then the expected length of the encoded message in bits is _____.

gate2017-2 huffman-code numerical-answers algorithms

1.10 Identify Function (38)

1.10.1 Identify Function: GATE1989-8a

https://gateoverflow.in/89080

What is the output produced by the following program, when the input is "HTGATE"

```
Function what (s:string): string;
var n:integer;
begin
     n = s.length
     if n <= 1
     then what := s
     else what :=contact (what (substring (s, 2, n)), s.C [1])
end;
```

Note

i. type string=record
   length:integer;
   C:array[1..100] of char
   end
ii. Substring (s, i, j): this yields the string made up of the i^{th} through j^{th} characters in s; for appropriately defined in i and j.
iii. Contact (s_1, s_2): this function yields a string of length s_1 length + s_2 - length obtained by concatenating s_1 with s_2 such that s_1 precedes s_2.

gate1989 descriptive algorithms identify-function

1.10.2 Identify Function: GATE1990-11b

https://gateoverflow.in/85987

The following program computes values of a mathematical function $f(x)$. Determine the form of $f(x)$.

```
main ()
{
    int m, n; float x, y, t;
    scanf ("%f%d", &x, &n);
    t = 1; y = 0; m = 1;
    do
    {
        t *= (-x/m);
        y += t;
    } while (m++ < n);
    printf ("The value of y is %f", y);
}
```

gate1990 descriptive algorithms identify-function

1.10.3 Identify Function: GATE1991-03-viii

https://gateoverflow.in/523

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

Consider the following Pascal function:

```
Function X(M:integer):integer;
Var i:integer;
Begin
    i := 0;
    while i*i < M
    do i:= i+1
    X := i
 end
```

The function call $X(N)$, if N is positive, will return

A. $\lfloor \sqrt{N} \rfloor$
B. $\lfloor \sqrt{N} \rfloor + 1$
C. $\lceil \sqrt{N} \rceil$
D. $\lceil \sqrt{N} \rceil + 1$
E. None of the above

gate1991 algorithms easy identify-function

1.10.4 Identify Function: GATE1993-7.4

https://gateoverflow.in/2292

What does the following code do?

```
var a, b: integer;
begin
    a:=a+b;
    b:=a-b;
    a:a-b;
end;
```

A. exchanges a and b
B. doubles a and stores in b
C. doubles b and stores in a
D. leaves a and b unchanged
E. none of the above

gate1993 algorithms identify-function easy

1.10.5 Identify Function: GATE1994-6

https://gateoverflow.in/2502

What function of x, n is computed by this program?

```
Function what(x, n:integer): integer:
Var
    value : integer
begin
    value := 1
    if n > 0 then
    begin
        if n mod 2 =1 then
            value := value * x;
        value := value * what(x*x, n div 2);
    end;
    what := value;
end;
```

gate1994 algorithms identify-function normal

1.10.6 Identify Function: GATE1995-1.4

https://gateoverflow.in/2591

In the following Pascal program segment, what is the value of X after the execution of the program segment?

```
X := -10; Y := 20;
If X > Y then if X < 0 then X := abs(X) else X := 2*X;
```

A. 10 B. -20 C. -10 D. None

gate1995 algorithms identify-function easy

1.10.7 Identify Function: GATE1995-2.3

https://gateoverflow.in/2615

Assume that X and Y are non-zero positive integers. What does the following Pascal program segment do?

```
while X <> Y do
if  X > Y then
    X := X - Y
else
    Y := Y - X;
write(X);
```

A. Computes the LCM of two numbers
B. Divides the larger number by the smaller number
C. Computes the GCD of two numbers
D. None of the above

gate1995 algorithms identify-function normal

1.10.8 Identify Function: GATE1995-4

https://gateoverflow.in/2640

a. Consider the following Pascal function where A and B are non-zero positive integers. What is the value of $GET(3,2)$?

```
function GET(A,B:integer): integer;
begin
    if B=0 then
        GET:= 1
    else if A < B then
```

```
        GET:= 0
    else
        GET:= GET(A-1, B) + GET(A-1, B-1)
end;
```

b. The Pascal procedure given for computing the transpose of an $N \times N, (N > 1)$ matrix A of integers has an error. Find the error and correct it. Assume that the following declaration are made in the main program

```
const
    MAXSIZE=20;
type
    INTARR=array [1..MAXSIZE,1..MAXSIZE] of integer;
Procedure TRANSPOSE (var A: INTARR; N : integer);
var
    I, J, TMP: integer;
begin
    for I:=1 to N - 1 do
    for J:=1 to N do
    begin
        TMP:= A[I, J];
        A[I, J]:= A[J, I];
        A[J, I]:= TMP
    end
end;
```

gate1995 algorithms identify-function normal

1.10.9 Identify Function: GATE1998-2.12

https://gateoverflow.in/1684

What value would the following function return for the input $x = 95$?

```
Function fun (x:integer):integer;
Begin
    If x > 100 then fun = x - 10
    Else fun = fun(fun (x+11))
End;
```

A. 89 B. 90 C. 91 D. 92

gate1998 algorithms recursion identify-function normal

1.10.10 Identify Function: GATE1999-2.24

https://gateoverflow.in/1501

Consider the following C function definition

```
int Trial (int a, int b, int c)
{
    if ((a>=b) && (c<b)) return b;
    else if (a>=b) return Trial(a, c, b);
    else return Trial(b, a, c);
}
```

The functional Trial:

A. Finds the maximum of a, b, and c
B. Finds the minimum of a, b, and c
C. Finds the middle number of a, b, c
D. None of the above

gate1999 algorithms identify-function normal

1.10.11 Identify Function: GATE2000-2.15

https://gateoverflow.in/662

Suppose you are given an array $s[1...n]$ and a procedure reverse (s, i, j) which reverses the order of elements in s between positions i and j (both inclusive). What does the following sequence do, where $1 \leqslant k \leqslant n$:

```
        reverse (s, 1, k);
        reverse (s, k+1, n);
        reverse (s, 1, n);
```

A. Rotates s left by k positions
B. Leaves s unchanged
C. Reverses all elements of s
D. None of the above

gate2000 algorithms normal identify-function

1.10.12 Identify Function: GATE2003-1

https://gateoverflow.in/892

Consider the following C function.

For large values of y, the return value of the function f best approximates

```
float f,(float x, int y) {
    float p, s; int i;
    for (s=1,p=1,i=1; i<y; i++) {
        p *= x/i;
        s += p;
    }
    return s;
}
```

A. x^y B. e^x C. $\ln(1+x)$ D. x^x

gate2003 algorithms identify-function normal

1.10.13 Identify Function: GATE2003-88

https://gateoverflow.in/971

In the following C program fragment, j, k, n and TwoLog_n are integer variables, and A is an array of integers. The variable n is initialized to an integer ≥ 3, and TwoLog_n is initialized to the value of $2^{*}\lceil \log_2(n) \rceil$

```
for (k = 3;  k <= n; k++)
        A[k] = 0;
for (k = 2; k <= TwoLog_n; k++)
    for (j = k+1; j <= n; j++)
        A[j] = A[j] || (j%k);
for (j = 3; j <= n; j++)
    if (!A[j]) printf("%d", j);
```

The set of numbers printed by this program fragment is

A. $\{m \mid m \leq n, (\exists i)\, [m = i!]\}$

B. $\{m \mid m \leq n, (\exists i)\, [m = i^2]\}$

C. $\{m \mid m \leq n, \text{m is prime}\}$

D. $\{\,\}$

gate2003 algorithms identify-function normal

1.10.14 Identify Function: GATE2004-41

https://gateoverflow.in/1038

Consider the following C program

```
main()
{
    int x, y, m, n;
    scanf("%d %d", &x, &y);
    /* Assume x>0 and y>0*/
    m = x; n = y;
    while(m != n)
        {
            if (m > n)
                m = m-n;
            else
                n = n-m;
        }
    printf("%d", n);
}
```

The program computes

A. $x+y$ using repeated subtraction

B. $x \mod y$ using repeated subtraction

C. the greatest common divisor of x and y

D. the least common multiple of x and y

gate2004 algorithms normal identify-function

1.10.15 Identify Function: GATE2004-42

https://gateoverflow.in/1039

What does the following algorithm approximate? (Assume $m > 1, \epsilon > 0$).

```
x = m;
y = 1;
While (x-y > ϵ)
{
     x = (x+y)/2;
     y = m/x;
```

```
}
print(x);
```

A. $\log m$ B. m^2 C. $m^{\frac{1}{2}}$ D. $m^{\frac{1}{3}}$

gate2004 algorithms identify-function normal

1.10.16 Identify Function: GATE2005-31

https://gateoverflow.in/1367

Consider the following C-program:

```
void foo (int n, int sum) {
    int k = 0, j = 0;
    if (n == 0) return;
    k = n % 10; j = n/10;
    sum = sum + k;
    foo (j, sum);
    printf ("%d,",k);
}

int main() {
    int a = 2048, sum = 0;
    foo(a, sum);
    printf("%d\n", sum);
}
```

What does the above program print?

A. $8, 4, 0, 2, 14$ B. $8, 4, 0, 2, 0$
C. $2, 0, 4, 8, 14$ D. $2, 0, 4, 8, 0$

gate2005 algorithms identify-function recursion normal

1.10.17 Identify Function: GATE2005-IT-57

https://gateoverflow.in/3818

What is the output printed by the following program?

```
#include <stdio.h>

int f(int n, int k) {
    if (n == 0) return 0;
    else if (n % 2) return f(n/2, 2*k) + k;
    else return f(n/2, 2*k) - k;
}

int main () {
    printf("%d", f(20, 1));
    return 0;
}
```

A. 5 B. 8 C. 9 D. 20

gate2005-it algorithms identify-function normal

1.10.18 Identify Function: GATE2006-50

https://gateoverflow.in/1828

A set X can be represented by an array $x[n]$ as follows:

$$x[i] = \begin{cases} 1 & \text{if } i \in X \\ 0 & \text{otherwise} \end{cases}$$

Consider the following algorithm in which x, y, and z are Boolean arrays of size n:

```
algorithm zzz(x[], y[], z[]) {
    int i;

    for(i=0; i<n; ++i)
        z[i] = (x[i] ∧ ~y[i]) ∨ (~x[i] ∧ y[i]);
}
```

The set Z computed by the algorithm is:

A. $(X \cup Y)$ B. $(X \cap Y)$ C. $(X - Y) \cap (Y - X)$ D. $(X - Y) \cup (Y - X)$

gate2006 algorithms identify-function normal

1.10.19 Identify Function: GATE2006-53

https://gateoverflow.in/1831

Consider the following C-function in which $a[n]$ and $b[m]$ are two sorted integer arrays and $c[n+m]$ be another integer array,

```
void xyz(int a[], int b [], int c []){
    int i,j,k;
    i=j=k=0;
    while ((i<n) && (j<m))
        if (a[i] < b[j]) c[k++] = a[i++];
        else c[k++] = b[j++];
}
```

Which of the following condition(s) hold(s) after the termination of the while loop?

i. $j<m, k=n+j-1$ and $a[n-1]<b[j]$ if $i=n$
ii. $i<n, k=m+i-1$ and $b[m-1]\leq a[i]$ if $j=m$

A. only (i)
B. only (ii)
C. either (i) or (ii) but not both
D. neither (i) nor (ii)

gate2006 algorithms identify-function normal

1.10.20 Identify Function: GATE2006-IT-52

https://gateoverflow.in/3595

The following function computes the value of $\binom{m}{n}$ correctly for all legal values m and n ($m \geq 1, n \geq 0$ and $m > n$)

```
int func(int m, int n)
{
    if (E) return 1;
    else return(func(m -1, n) + func(m - 1, n - 1));
}
```

In the above function, which of the following is the correct expression for E?

A. $(n == 0) || (m == 1)$
B. $(n == 0)$ && $(m == 1)$
C. $(n == 0) || (m == n)$
D. $(n == 0)$ && $(m == n)$

gate2006-it algorithms identify-function normal

1.10.21 Identify Function: GATE2008-IT-82

https://gateoverflow.in/3406

Consider the code fragment written in C below :

```
void f (int n)
{
  if (n <=1)  {
   printf ("%d", n);
  }
  else {
   f (n/2);
   printf ("%d", n%2);
  }
}
```

What does f(173) print?

A. 010110101
B. 010101101
C. 10110101
D. 10101101

gate2008-it algorithms recursion identify-function normal

1.10.22 Identify Function: GATE2008-IT-83

https://gateoverflow.in/3407

Consider the code fragment written in C below :

```
void f (int n)
{
    if (n <= 1)  {
        printf ("%d", n);
    }
    else {
        f (n/2);
        printf ("%d", n%2);
    }
}
```

Which of the following implementations will produce the same output for $f(173)$ as the above code?

P1

```
void f (int n)
{
    if (n/2)  {
        f(n/2);
    }
    printf ("%d", n%2);
}
```

P2

```
void f (int n)
{
    if (n <=1)  {
        printf ("%d", n);
    }
    else {
        printf ("%d", n%2);
        f (n/2);
    }
}
```

A. Both $P1$ and $P2$ B. $P2$ only C. $P1$ only D. Neither $P1$ nor $P2$

gate2008-it algorithms recursion identify-function normal

1.10.23 Identify Function: GATE2009-18

https://gateoverflow.in/1310

Consider the program below:

```
#include <stdio.h>
int fun(int n, int *f_p) {
    int t, f;
    if (n <= 1) {
        *f_p = 1;
        return 1;
    }
    t = fun(n-1, f_p);
    f = t + *f_p;
    *f_p = t;
    return f;
}

int main() {
    int x = 15;
    printf("%d/n", fun(5, &x));
    return 0;
}
```

The value printed is:

A. 6 B. 8 C. 14 D. 15

gate2009 algorithms recursion identify-function normal

1.10.24 Identify Function: GATE2010-35

https://gateoverflow.in/2336

What is the value printed by the following C program?

```
#include<stdio.h>

int f(int *a, int n)
{
    if (n <= 0) return 0;
    else if (*a % 2 == 0) return *a+f(a+1, n-1);
    else return *a - f(a+1, n-1);
}

int main()
{
    int a[] = (12, 7, 13, 4, 11, 6);
    printf("%d", f(a, 6));
    return 0;
}
```

A. -9 B. 5 C. 15 D. 19

gate2010 algorithms recursion identify-function normal

1.10.25 Identify Function: GATE2011-48

https://gateoverflow.in/2154

Consider the following recursive C function that takes two arguments.

```
unsigned int foo(unsigned int n, unsigned int r) {
```

```
    if (n>0) return ((n%r) + foo(n/r, r));
    else return 0;
}
```

What is the return value of the function foo when it is called as $\text{foo}(345, 10)$?

A. 345 B. 12 C. 5 D. 3

gate2011 algorithms recursion identify-function normal

1.10.26 Identify Function: GATE2011-49

https://gateoverflow.in/43324

Consider the following recursive C function that takes two arguments.

```
unsigned int foo(unsigned int n, unsigned int r) {
    if (n>0) return ((n%r) + foo(n/r, r));
    else return 0;
}
```

What is the return value of the function foo when it is called as $\text{foo}(513, 2)$?

A. 9 B. 8 C. 5 D. 2

gate2011 algorithms recursion identify-function normal

1.10.27 Identify Function: GATE2013-31

https://gateoverflow.in/1542

Consider the following function:

```
int unknown(int n){

int i, j, k=0;
for (i=n/2; i<=n; i++)
    for (j=2; j<=n; j=j*2)
        k = k + n/2;
 return (k);

}
```

The return value of the function is

A. $\Theta(n^2)$
B. $\Theta(n^2 \log n)$
C. $\Theta(n^3)$
D. $\Theta(n^3 \log n)$

gate2013 algorithms identify-function normal

1.10.28 Identify Function: GATE2014-1-41

https://gateoverflow.in/1919

Consider the following C function in which **size** is the number of elements in the array **E**:

```
int MyX(int *E, unsigned int size)
{
   int Y = 0;
   int Z;
   int i, j, k;

   for(i = 0; i< size; i++)
          Y = Y + E[i];

    for(i=0; i < size; i++)
        for(j = i; j < size; j++)
        {
            Z = 0;
            for(k = i; k <= j; k++)
               Z = Z + E[k];
            if(Z > Y)
               Y = Z;
        }
   return Y;
}
```

The value returned by the function **MyX** is the

A. maximum possible sum of elements in any sub-array of array **E**.
B. maximum element in any sub-array of array **E.**
C. sum of the maximum elements in all possible sub-arrays of array **E**.
D. the sum of all the elements in the array **E.**

gate2014-1 algorithms identify-function normal

1.10.29 Identify Function: GATE2014-2-10

https://gateoverflow.in/1964

Consider the function func shown below:

```
int func(int num) {
   int count = 0;
   while (num) {
     count++;
     num>>= 1;
   }
   return (count);
}
```

The value returned by func(435) is _____

gate2014-2 algorithms identify-function numerical-answers easy

1.10.30 Identify Function: GATE2014-3-10

https://gateoverflow.in/2044

Let A be the square matrix of size $n \times n$. Consider the following pseudocode. What is the expected output?

```
C=100;
for i=1 to n do
    for j=1 to n do
    {
        Temp = A[i][j]+C;
        A[i][j] = A[j][i];
        A[j][i] = Temp -C;
    }
for i=1 to n do
    for j=1 to n do
        output (A[i][j]);
```

A. The matrix A itself
B. Transpose of the matrix A
C. Adding 100 to the upper diagonal elements and subtracting 100 from lower diagonal elements of A
D. None of the above

gate2014-3 algorithms identify-function easy

1.10.31 Identify Function: GATE2015-1-31

https://gateoverflow.in/8263

Consider the following C function.

```
int fun1 (int n) {
     int i, j, k, p, q = 0;
     for (i = 1; i < n; ++i)
     {
        p = 0;
       for (j = n; j > 1; j = j/2)
           ++p;
       for (k = 1; k < p; k = k * 2)
           ++q;
     }
     return q;
}
```

Which one of the following most closely approximates the return value of the function fun1?

A. n^3 B. $n(\log n)^2$ C. $n \log n$ D. $n \log(\log n)$

gate2015-1 algorithms normal identify-function

1.10.32 Identify Function: GATE2015-2-11

https://gateoverflow.in/8060

Consider the following C function.

```
int fun(int n) {
    int x=1, k;
    if (n==1) return x;
    for (k=1; k<n; ++k)
        x = x + fun(k) * fun (n-k);
    return x;
```

```
}
```

The return value of $fun(5)$ is _____.

gate2015-2 algorithms identify-function recurrence normal numerical-answers

1.10.33 Identify Function: GATE2015-3-49

https://gateoverflow.in/8558

Suppose $c = \langle c[0], \ldots, c[k-1] \rangle$ is an array of length k, where all the entries are from the set $\{0,1\}$. For any positive integers a and n, consider the following pseudocode.

DOSOMETHING (*c, a, n)*

$z \leftarrow 1$
for $i \leftarrow 0$ to $k-1$
  do $z \leftarrow z^2 \bmod n$
  if *c*[i]=1
    then $z \leftarrow (z \times a) \bmod n$
return z

If $k = 4, c = \langle 1,0,1,1 \rangle, a = 2,$ and $n = 8$, then the output of DOSOMETHING(*c, a, n)* is _____.

gate2015-3 algorithms identify-function normal numerical-answers

1.10.34 Identify Function: GATE2019-26

https://gateoverflow.in/302822

Consider the following C function.

```
void convert (int n ) {
        if (n<0)
            printf{"%d", n);
        else {
            convert(n/2);
            printf("%d", n%2);
        }
}
```

Which one of the following will happen when the function *convert* is called with any positive integer n as argument?

A. It will print the binary representation of n and terminate
B. It will print the binary representation of n in the reverse order and terminate
C. It will print the binary representation of n but will not terminate
D. It will not print anything and will not terminate

gate2019 algorithms identify-function

1.10.35 Identify Function: TIFR2010-B-24

https://gateoverflow.in/18742

Consider the following program operating on four variables u, v, x, y, and two constants X and Y.

```
x, y, u, v:= X, Y, Y, X;
While (x ≠ y)
do
    if (x > y) then x, v := x - y, v + u;
    else if (y > x) then y, u:= y - x, u + v;
od;
print ((x + y) / 2);  print ((u + v) / 2);
```

Given $X > 0 \wedge Y > 0$, pick the true statement out of the following:

A. The program prints $\gcd(X,Y)$ and the first prime larger than both X and Y.
B. The program prints $\gcd(X,Y)$ followed by $\text{lcm}(X,Y)$.
C. The program prints $\gcd(X,Y)$ followed by $\frac{1}{2} \times \text{lcm}(X,Y)$.
D. The program prints $\frac{1}{2} \times \gcd(X,Y)$ followed by $\frac{1}{2} \times \text{lcm}(X,Y)$.
E. The program does none of the above.

tifr2010 algorithms identify-function

1.10.36 Identify Function: TIFR2014-B-2

https://gateoverflow.in/27136

Consider the following code.

```
def brian(n):
    count = 0

    while ( n ! = 0 )
          n = n & ( n-1 )
         count = count + 1

  return count
```

Here n is meant to be an unsigned integer. The operator & considers its arguments in binary and computes their bit wise AND. For example, 22 & 15 gives 6, because the binary (say 8-bit) representation of 22 is 00010110 and the binary representation of 15 is 00001111, and the bit-wise AND of these binary strings is 00000110, which is the binary representation of 6. What does the function brian return?

a. The highest power of 2 dividing n, but zero if n is zero.
b. The number obtained by complementing the binary representation of n.
c. The number of ones in the binary representation of n.
d. The code might go into an infinite loop for some n.
e. The result depends on the number of bits used to store unsigned integers.

tifr2014 algorithms identify-function

1.10.37 Identify Function: TIFR2014-B-20

https://gateoverflow.in/27354

Consider the following game. There is a list of distinct numbers. At any round, a player arbitrarily chooses two numbers a, b from the list and generates a new number c by subtracting the smaller number from the larger one. The numbers a and b are put back in the list. If the number c is non-zero and is not yet in the list, c is added to the list. The player is allowed to play as many rounds as the player wants. The score of a player at the end is the size of the final list.

Suppose at the beginning of the game the list contains the following numbers: $48, 99, 120, 165$ and 273. What is the score of the best player for this game?

A. 40 B. 16 C. 33 D. 91 E. 123

tifr2014 algorithms identify-function

1.10.38 Identify Function: TIFR2017-A-12

https://gateoverflow.in/95299

Consider the following program modifying an $n \times n$ square matrix A:

```
for i=1 to n:
    for j=1 to n:
        temp=A[i][j]+10
        A[i][j]=A[j][i]
        A[j][i]=temp-10
    end for
end for
```

Which of the following statements about the contents of matrix A at the end of this program must be TRUE?

A. the new A is the transpose of the old A
B. all elements above the diagonal have their values increased by 10 and all the values below have their values decreased by 10
C. all elements above the diagonal have their values decreased by 10 and all the values below have their values increased by 10
D. the new matrix A is symmetric, that is, $A[i][j] = A[j][i]$ for all $1 \leq i, j \leq n$
E. A remains unchanged

tifr2017 algorithms identify-function

1.11 Minimum Maximum (4)

1.11.1 Minimum Maximum: GATE2014-1-39

https://gateoverflow.in/1917

The minimum number of comparisons required to find the minimum and the maximum of 100 numbers is _____

gate2014-1 algorithms numerical-answers normal minimum-maximum

1.11.2 Minimum Maximum: TIFR2014-B-10

https://gateoverflow.in/27198

Given a set of n distinct numbers, we would like to determine both the smallest and the largest number. Which of the following statements is TRUE?

A. These two elements can be determined using $O\left(\log^{100} n\right)$ comparisons.
B. $O\left(\log^{100} n\right)$ comparisons do not suffice, however these two elements can be determined using $n + O(\log n)$ comparisons.
C. $n + O(\log n)$ comparisons do not suffice, however these two elements can be determined using $3\lceil n/2 \rceil$ comparisons.
D. $3\lceil n/2 \rceil$ comparisons do not suffice, however these two elements can be determined using $2(n-1)$ comparisons.
E. None of the above.

tifr2014 algorithms minimum-maximum

1.11.3 Minimum Maximum: TIFR2014-B-6

https://gateoverflow.in/27183

Consider the problem of computing the minimum of a set of n distinct numbers. We choose a permutation uniformly at random (i.e., each of the n! permutations of $\langle 1, \ldots, n \rangle$ is chosen with probability $(1/n!)$ and we inspect the numbers in the order given by this permutation. We maintain a variable MIN that holds the minimum value seen so far. MIN is initialized to ∞ and if we see a value smaller than MIN during our inspection, then MIN is updated. For example, in the inspection given by the following sequence, MIN is updated four times.

5 9 4 2 6 8 0 3 1 7

What is the expected number of times MIN is updated?

A. $O(1)$ B. $H_n = \sum_{i=1}^{n} 1/i$ C. $\sqrt{n}$ D. $n/2$ E. n

tifr2014 algorithms minimum-maximum

1.11.4 Minimum Maximum: TIFR2014-B-9

https://gateoverflow.in/27194

Given a set of n distinct numbers, we would like to determine the smallest three numbers in this set using comparisons. Which of the following statements is TRUE?

A. These three elements can be determined using $O\left(\log^2 n\right)$ comparisons.
B. $O\left(\log^2 n\right)$ comparisons do not suffice, however these three elements can be determined using $n + O(1)$ comparisons.
C. $n + O(1)$ comparisons do not suffice, however these three elements can be determined using $n + O(\log n)$ comparisons.
D. $n + O(\log n)$ comparisons do not suffice, however these three elements can be determined using $O(n)$ comparisons.
E. None of the above.

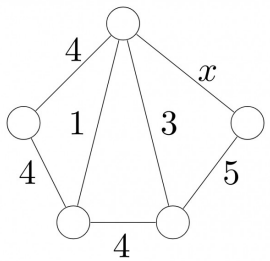
tifr2014 algorithms minimum-maximum

1.12 Minimum Spanning Trees (3)

1.12.1 Minimum Spanning Trees: GATE2018-47

https://gateoverflow.in/204122

Consider the following undirected graph G:



Choose a value for x that will maximize the number of minimum weight spanning trees (MWSTs) of G. The number of MWSTs of G for this value of x is ____.

gate2018 algorithms graph-algorithms minimum-spanning-trees numerical-answers

1.12.2 Minimum Spanning Trees: TIFR2018-B-13

https://gateoverflow.in/179297

Let $n \geq 3$, and let G be a simple, connected, undirected graph with the same number n of vertices and edges. Each edge of G has a distinct real weight associated with it. Let T be the minimum weight spanning tree of G. Which of the following statements is NOT ALWAYS TRUE ?

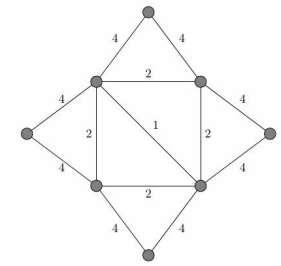
A. The minimum weight edge of G is in T.
B. The maximum weight edge of G is not in T.
C. G has a unique cycle C and the minimum weight edge of C is also in T.
D. G has a unique cycle C and the maximum weight edge of C is not in T.
E. T can be found in $O(n)$ time from the adjacency list representation of G.

tifr2018 graph-algorithms minimum-spanning-trees

1.12.3 Minimum Spanning Trees: TIFR2019-B-2

https://gateoverflow.in/280493

How many distinct minimum weight spanning trees does the following undirected, weighted graph have ?



A. 8 B. 16 C. 32 D. 64 E. None of the above

tifr2019 algorithms minimum-spanning-trees

1.13 P Np Npc Nph (12)

1.13.1 P Np Npc Nph: GATE1992-02,vi

https://gateoverflow.in/561

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

Which of the following problems is not NP-hard?

a. Hamiltonian circuit problem
b. The $0/1$ Knapsack problem
c. Finding bi-connected components of a graph
d. The graph coloring problem

gate1992 p-np-npc-nph algorithms

1.13.2 P Np Npc Nph: GATE2003-12

https://gateoverflow.in/903

Ram and Shyam have been asked to show that a certain problem Π is NP-complete. Ram shows a polynomial time reduction from the 3-SAT problem to Π, and Shyam shows a polynomial time reduction from Π to 3-SAT. Which of the following can be inferred from these reductions?

A. Π is NP-hard but not NP-complete
B. Π is in NP, but is not NP-complete
C. Π is NP-complete
D. Π is neither NP-hard, nor in NP

gate2003 algorithms p-np-npc-nph normal

1.13.3 P Np Npc Nph: GATE2004-30, ISRO2017-10

https://gateoverflow.in/1027

The problem 3-SAT and 2-SAT are

A. both in P
B. both NP complete
C. NP-complete and in P respectively
D. undecidable and NP complete respectively

gate2004 algorithms p-np-npc-nph easy isro2017

1.13.4 P Np Npc Nph: GATE2006-16, ISRO-DEC2017-27

https://gateoverflow.in/977

Let S be an NP-complete problem and Q and R be two other problems not known to be in NP. Q is polynomial time reducible to S and S is polynomial-time reducible to R. Which one of the following statements is true?

A. R is NP-complete
B. R is NP-hard
C. Q is NP-complete
D. Q is NP-hard

gate2006 algorithms p-np-npc-nph normal isrodec2017

1.13.5 P Np Npc Nph: GATE2008-44

https://gateoverflow.in/456

The subset-sum problem is defined as follows: Given a set S of n positive integers and a positive integer W, determine whether there is a subset of S whose elements sum to W. An algorithm Q solves this problem in $O(nW)$ time. Which of the following statements is false?

A. Q solves the subset-sum problem in polynomial time when the input is encoded in unary
B. Q solves the subset-sum problem in polynomial time when the input is encoded in binary
C. The subset sum problem belongs to the class NP
D. The subset sum problem is NP-hard

gate2008 algorithms p-np-npc-nph normal

1.13.6 P Np Npc Nph: TIFR2010-B-39

https://gateoverflow.in/18754

Suppose a language L is $\mathbf{NP}$ complete. Then which of the following is FALSE?

A. $L \in \mathbf{NP}$
B. Every problem in $\mathbf{P}$ is polynomial time reducible to L.
C. Every problem in $\mathbf{NP}$ is polynomial time reducible to L.
D. The Hamilton cycle problem is polynomial time reducible to L.
E. $\mathbf{P} \neq \mathbf{NP}$ and $L \in \mathbf{P}$.

tifr2010 algorithms p-np-npc-nph

1.13.7 P Np Npc Nph: TIFR2011-B-37

https://gateoverflow.in/20922

Given an integer $n \geq 3$, consider the problem of determining if there exist integers $a, b \geq 2$ such that $n = a^b$. Call this the forward problem. The reverse problem is: given a and b, compute a^b (mod b). Note that the input length for the forward problem is $\lfloor \log n \rfloor + 1$, while the input length for the reverse problem is $\lfloor \log a \rfloor + \lfloor \log b \rfloor + 2$. Which of the following statements is TRUE?

a. Both the forward and reverse problems can be solved in time polynomial in the lengths of their respective inputs.
b. The forward problem can be solved in polynomial time, however the reverse problem is NP-hard.
c. The reverse problem can be solved in polynomial time, however the forward problem is NP-hard.
d. Both the forward and reverse problem are NP-hard.
e. None of the above.

tifr2011 algorithms p-np-npc-nph

1.13.8 P Np Npc Nph: TIFR2012-B-20

https://gateoverflow.in/26480

This question concerns the classes P and NP. If you are familiar with them, you may skip the definitions and go directly to the question.

Let L be a set. We say that L is in P if there is some algorithm which given input x decides if x is in L or not in time bounded by a polynomial in the length of x. For example, the set of all connected graphs is in P, because there is an algorithm which, given a graph graph, can decide if it is connected or not in time roughly proportional to the number of edges of the graph.

The class NP is a superset of class P. It contains those sets that have membership witnesses that can be verified in polynomial time. For example, the set of composite numbers is in NP. To see this take the witness for a composite number to be one of its divisors. Then the verification process consists of performing just one division using two reasonable size numbers. Similarly, the set of those graphs that have a Hamilton cycle, i.e. a cycle containing all the vertices of the graph, is in in NP. To verify that the graph has a Hamilton cycle we just check if the witnessing sequence of vertices indeed a cycle of the graph that passes through all the vertices of the graph. This can be done in time that is polynomial in the size of the graph.

More precisely, if L is a set in P consisting of elements of the form (x, w), then the set

$M = \{x :$ $\exists$

is in N P .

Let $G = (V, E)$ be a graph. G is said to have perfect matching if there is a subset M of the edges of G so that

i. No two edges in M intersect (have a vertex in common); and
ii. Every vertex of G has an edge in M.

Let MATCH be the set of all graphs that have a perfect matching. Let $\overline{\text{MATCH}}$ be the set of graphs that do not have a perfect matching. Let $o(G)$ be the number of components of G that have an odd number of vertices.

Tutte's Theorem: $G \in \text{MATCH}$ if and only if for all subsets S of V, the number of components in $G - S$ (the graph formed by deleting the vertices in S) with an odd number of vertices is at most $|S|$. That is,

$G \in \text{MATCH} \leftrightarrow \qquad \forall$

Which of the following is true?

A. $\text{MATCH} \in NP$ and $\overline{\text{MATCH}} \notin NP$
B. $\overline{\text{MATCH}} \in NP$ and $\text{MATCH} \notin NP$
C. $\text{MATCH} \in NP$ and $\overline{\text{MATCH}} \in NP$
D. $\text{MATCH} \notin P$ and $\overline{\text{MATCH}} \notin P$
E. none of the above

tifr2012 algorithms p-np-npc-nph

1.13.9 P Np Npc Nph: TIFR2013-B-7

https://gateoverflow.in/25668

Which of the following is not implied by $P = NP$?

a. 3SAT can be solved in polynomial time.
b. Halting problem can be solved in polynomial time.
c. Factoring can be solved in polynomial time.
d. Graph isomorphism can be solved in polynomial time.
e. Travelling salesman problem can be solved in polynomial time.

tifr2013 algorithms p-np-npc-nph

1.13.10 P Np Npc Nph: TIFR2017-B-15

https://gateoverflow.in/95828

A multivariate polynomial in n variables with integer coefficients has a binary root if it is possible to assign each variable either 0 or 1, so that the polynomial evaluates to 0. For example, the multivariate polynomial $-2x_1^3 - x_1x_2 + 2$ has the binary root $(x_1 = 1, x_2 = 0)$. Then determining whether a multivariate polynomial, given as the sum of monimials, has a binary root:

A. is trivial: every polynomial has a binary root
B. can be done in polynomial time
C. is NP-hard, but not in NP
D. is in NP, but not in P and not NP-hard
E. is both in NP and NP-hard

tifr2017 algorithms p-np-npc-nph

1.13.11 P Np Npc Nph: TIFR2017-B-2

https://gateoverflow.in/95673

Consider the following statements:

i. Checking if a given *undirected* graph has a cycle is in P
ii. Checking if a given *undirected* graph has a cycle is in NP
iii. Checking if a given *directed* graph has a cycle is in P
iv. Checking if a given *directed* graph has a cycle is in NP

Which of the above statements is/are TRUE? Choose from the following options.

A. Only i and ii B. Only ii and iv C. Only ii, iii, and iv D. Only i, ii and iv E. All of them

tifr2017 algorithms p-np-npc-nph

1.13.12 P Np Npc Nph: TIFR2019-B-7

https://gateoverflow.in/280488

A formula is said to be a 3-CF-formula if it is a conjunction (i.e., an AND) of clauses, and each clause has at most 3 literals. Analogously, a formula is said to be a 3-DF-formula if it is a disjunction (i.e., an OR) of clauses of at most 3 literals each.

Define the languages 3-CF-SAT and 3-DF-SAT as follows:

$$\text{3-CF-SAT} = \{\Phi \mid \Phi \text{ is a } \textit{satisfiable} \text{ 3-CF formula}\}$$

$$\text{3-DF-SAT} = \{\Phi \mid \Phi \text{ is a } \textit{satisfiable} \text{3-DF formula}\}$$

Which of the following best represents our current knowledge of these languages ?

A. Both 3-CF-SAT and 3-DF-SAT are in NP but only 3-CF-SAT is NP-complete
B. Both 3-CF-SAT and 3-DF-SAT are in NP-complete
C. Both 3-CF-SAT and 3-DF-SAT are in P
D. Both 3-CF-SAT and 3-DF-SAT are in NP but only 3-DF-SAT is NP-complete
E. Neither 3-CF-SAT nor 3-DF-SAT are in P

tifr2019 algorithms p-np-npc-nph

1.14 Quicksort (2)

1.14.1 Quicksort: GATE2019-20 https://gateoverflow.in/302828

An array of 25 distinct elements is to be sorted using quicksort. Assume that the pivot element is chosen uniformly at random. The probability that the pivot element gets placed in the worst possible location in the first round of partitioning (rounded off to 2 decimal places) is _____

gate2019 numerical-answers algorithms quicksort probability

1.14.2 Quicksort: TIFR2018-B-7 https://gateoverflow.in/179291

Consider the recursive quicksort algorithm with "random pivoting". That is, in each recursive call, a pivot is chosen uniformly at random from the sub-array being sorted.When this randomized algorithm is applied to an array of size n all whose elements are distinct, what is the probability that the smallest and the largest elements in the array are compared during a run of the algorithm ?

A. $\left(\frac{1}{n}\right)$ B. $\left(\frac{2}{n}\right)$ C. $\Theta\left(\frac{1}{n \log n}\right)$ D. $O\left(\frac{1}{n^2}\right)$ E. $\Theta\left(\frac{1}{n \log^2 n}\right)$

tifr2018 algorithms sorting quicksort

1.15 Recurrence (37)

1.15.1 Recurrence: GATE1987-10a https://gateoverflow.in/82450

Solve the recurrence equations:

- $T(n) = T(n-1) + n$
- $T(1) = 1$

gate1987 algorithms recurrence

1.15.2 Recurrence: GATE1988-13iv https://gateoverflow.in/94637

Solve the recurrence equations:

- $T(n) = T(\frac{n}{2}) + 1$
- $T(1) = 1$

gate1988 descriptive algorithms recurrence

1.15.3 Recurrence: GATE1989-13b https://gateoverflow.in/93175

Find a solution to the following recurrence equation:

$T(n) = \sqrt{n} + T(\frac{n}{2})$

$T(1) = 1$

gate1989 descriptive algorithms recurrence

1.15.4 Recurrence: GATE1990-17a

https://gateoverflow.in/86878

Express $T(n)$ in terms of the harmonic number $H_n = \sum_{t=1}^{n} 1/i, n \geq 1$, where $T(n)$ satisfies the recurrence relation,

$T(n) = \frac{n+1}{n} T(n-1) + 1$, for $n \geq \sum$ and $T(1) = 1$

What is the asymptotic behaviour of $T(n)$ as a function of n ?

gate1990 descriptive algorithms recurrence

1.15.5 Recurrence: GATE1992-07a

https://gateoverflow.in/586

Consider the function $F(n)$ for which the pseudocode is given below :

```
Function F(n)
begin
F1 ← 1
if(n=1) then F ← 3
 else
   For i = 1 to n do
        begin
            C ← 0
           For j = 1 to n - 1 do
           begin C ← C + 1 end
           F1 = F1 * C
       end
 F = F1
end
```

[n is a positive integer greater than zero]

(a) Derive a recurrence relation for $F(n)$

gate1992 algorithms recurrence descriptive

1.15.6 Recurrence: GATE1992-07b

https://gateoverflow.in/43600

Consider the function $F(n)$ for which the pseudocode is given below :

```
Function F(n)
begin
F1 ← 1
if(n=1) then F ← 3
 else
   For i = 1 to n do
        begin
            C ← 0
           For j = 1 to n - 1 do
           begin C ← C + 1 end
           F1 = F1 * C
       end
 F = F1
end
```

[n is a positive integer greater than zero]

Solve the recurrence relation for a closed form solution of $F(n)$.

gate1992 algorithms recurrence descriptive

1.15.7 Recurrence: GATE1993-15

https://gateoverflow.in/2312

Consider the recursive algorithm given below:

```
procedure bubblesort (n);
var i,j: index; temp : item;
begin
    for i:=1 to n-1 do
        if A[i] > A[i+1] then
        begin
            temp := A[i];
            A[i] := A[i+1];
            A[i+1] := temp;
        end;
    bubblesort (n-1)
end
```

Let a_n be the number of times the 'if…then…' statement gets executed when the algorithm is run with value n. Set up the recurrence relation by defining a_n in terms of a_{n-1}. Solve for a_n.

gate1993 algorithms recurrence normal

1.15.8 Recurrence: GATE1994-1.7, ISRO2017-14

https://gateoverflow.in/2444

The recurrence relation that arises in relation with the complexity of binary search is:

A. $T(n) = 2T\left(\frac{n}{2}\right) + k$, k is a constant
B. $T(n) = T\left(\frac{n}{2}\right) + k$, k is a constant
C. $T(n) = T\left(\frac{n}{2}\right) + \log n$
D. $T(n) = T\left(\frac{n}{2}\right) + n$

gate1994 algorithms recurrence easy isro2017

1.15.9 Recurrence: GATE1996-2.12

https://gateoverflow.in/2741

The recurrence relation

- $T(1) = 2$
- $T(n) = 3T(\frac{n}{4}) + n$

has the solution $T(n)$ equal to

A. $O(n)$
B. $O(\log n)$
C. $O\left(n^{\frac{3}{4}}\right)$
D. None of the above

gate1996 algorithms recurrence normal

1.15.10 Recurrence: GATE1997-15

https://gateoverflow.in/2275

Consider the following function.

```
Function F(n, m:integer):integer;
begin
    If (n<=0 or (m<=0) then F:=1
    else
      F:F(n-1, m) + F(n, m-1);
    end;
```

Use the recurrence relation $\binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1}$ to answer the following questions. Assume that n, m are positive integers. Write only the answers without any explanation.

a. What is the value of $F(n,2)$?
b. What is the value of $F(n,m)$?
c. How many recursive calls are made to the function F, including the original call, when evaluating $F(n,m)$.

gate1997 algorithms recurrence normal

1.15.11 Recurrence: GATE1997-4.6

https://gateoverflow.in/2247

Let $T(n)$ be the function defined by $T(1) = 1$, $T(n) = 2T(\lfloor \frac{n}{2} \rfloor) + \sqrt{n}$ for $n \geq 2$.

Which of the following statements is true?

A. $T(n) = O\sqrt{n}$
B. $T(n) = O(n)$
C. $T(n) = O(\log n)$
D. None of the above

gate1997 algorithms recurrence normal

1.15.12 Recurrence: GATE1998-6a

https://gateoverflow.in/44584

Solve the following recurrence relation

$x_n = 2x_{n-1} - 1, n > 1$

$x_1 = 2$

gate1998 algorithms recurrence descriptive

1.15.13 Recurrence: GATE1999-2.21

https://gateoverflow.in/1498

If $T_1 = O(1)$, give the correct matching for the following pairs:

(M) $T_n = T_{n-1} + n$	(U) $T_n = O(n)$
(N) $T_n = T_{n/2} + n$	(V) $T_n = O(n \log n)$
(O) $T_n = T_{n/2} + n \log n$	(W) $T_n = O(n^2)$
(P) $T_n = T_{n-1} + \log n$	(X) $T_n = O(\log^2 n)$

A. M-W, N-V, O-U, P-X
B. M-W, N-U, O-X, P-V
C. M-V, N-W, O-X, P-U
D. M-W, N-U, O-V, P-X

gate1999 algorithms recurrence asymptotic-notations normal

1.15.14 Recurrence: GATE2002-1.3

https://gateoverflow.in/807

The solution to the recurrence equation $T(2^k) = 3T(2^{k-1}) + 1, T(1) = 1$ is

A. 2^k
B. $\frac{(3^{k+1}-1)}{2}$
C. $3^{\log_2 k}$
D. $2^{\log_3 k}$

gate2002 algorithms recurrence normal

1.15.15 Recurrence: GATE2002-2.11

https://gateoverflow.in/841

The running time of the following algorithm

Procedure $A(n)$

If $n \leqslant 2$ return (1) else return $(A(\lceil \sqrt{n} \rceil))$;

is best described by

A. $O(n)$
B. $O(\log n)$
C. $O(\log \log n)$
D. $O(1)$

gate2002 algorithms recurrence normal

1.15.16 Recurrence: GATE2003-35

https://gateoverflow.in/925

Consider the following recurrence relation

$T(1) = 1$

$T(n+1) = T(n) + \lfloor \sqrt{n+1} \rfloor$ for all $n \geq 1$

The value of $T(m^2)$ for $m \geq 1$ is

A. $\frac{m}{6}(21m - 39) + 4$
B. $\frac{m}{6}(4m^2 - 3m + 5)$
C. $\frac{m}{2}(3m^{2.5} - 11m + 20) - 5$
D. $\frac{m}{6}(5m^3 - 34m^2 + 137m - 104) + \frac{5}{6}$

gate2003 algorithms time-complexity recurrence difficult

1.15.17 Recurrence: GATE2004-83, ISRO2015-40

https://gateoverflow.in/1077

The time complexity of the following C function is (assume $n > 0$)

```
int recursive (int n) {
    if(n == 1)
        return (1);
    else
        return (recursive (n-1) + recursive (n-1));
}
```

A. $O(n)$
B. $O(n \log n)$
C. $O(n^2)$
D. $O(2^n)$

gate2004 algorithms recurrence time-complexity normal isro2015

1.15.18 Recurrence: GATE2004-84

https://gateoverflow.in/1078

The recurrence equation

$T(1) = 1$

$T(n) = 2T(n-1) + n, n \geq 2$

evaluates to

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

gate2004 algorithms recurrence normal

1.15.19 Recurrence: GATE2004-IT-57

https://gateoverflow.in/3700

Consider a list of recursive algorithms and a list of recurrence relations as shown below. Each recurrence relation corresponds to exactly one algorithm and is used to derive the time complexity of the algorithm.

	Recursive Algorithm		Recurrence Relation
P	Binary search	I.	$T(n)=T(n-k)+T(k)+cn$
Q.	Merge sort	II.	$T(n)=2T(n-1)+1$
R.	Quick sort	III.	$T(n)=2T(n/2)+cn$
S.	Tower of Hanoi	IV.	$T(n)=T(n/2)+1$

Which of the following is the correct match between the algorithms and their recurrence relations?

A. P-II, Q-III, R-IV, S-I
B. P-IV, Q-III, R-I, S-II
C. P-III, Q-II, R-IV, S-I
D. P-IV, Q-II, R-I, S-III

gate2004-it algorithms recurrence normal

1.15.20 Recurrence: GATE2005-37

https://gateoverflow.in/1373

Suppose $T(n)=2T(\frac{n}{2})+n$, $T(0)=T(1)=1$

Which one of the following is FALSE?

A. $T(n)=O(n^2)$
B. $T(n)=\Theta(n\log n)$
C. $T(n)=\Omega(n^2)$
D. $T(n)=O(n\log n)$

gate2005 algorithms asymptotic-notations recurrence normal

1.15.21 Recurrence: GATE2005-IT-51

https://gateoverflow.in/3812

Let $T(n)$ be a function defined by the recurrence
$T(n)=2T(n/2)+\sqrt{n}$ for $n\geq 2$ and
$T(1)=1$

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

A. $T(n)=\Theta(\log n)$
B. $T(n)=\Theta(\sqrt{n})$
C. $T(n)=\Theta(n)$
D. $T(n)=\Theta(n\log n)$

gate2005-it algorithms recurrence easy

1.15.22 Recurrence: GATE2006-51, ISRO2016-34

https://gateoverflow.in/1829

Consider the following recurrence:

$$T(n)=2T\left(\sqrt{n}\right)+1,\ T(1)=1$$

Which one of the following is true?

A. $T(n)=\Theta(\log\log n)$
B. $T(n)=\Theta(\log n)$
C. $T(n)=\Theta(\sqrt{n})$
D. $T(n)=\Theta(n)$

algorithms recurrence isro2016 gate2006

1.15.23 Recurrence: GATE2008-78

https://gateoverflow.in/497

Let x_n denote the number of binary strings of length n that contain no consecutive 0s.

Which of the following recurrences does x_n satisfy?

A. $x_n=2x_{n-1}$
B. $x_n=x_{\lfloor n/2\rfloor}+1$
C. $x_n=x_{\lfloor n/2\rfloor}+n$
D. $x_n=x_{n-1}+x_{n-2}$

gate2008 algorithms recurrence normal

1.15.24 Recurrence: GATE2008-79

https://gateoverflow.in/43485

Let x_n denote the number of binary strings of length n that contain no consecutive 0s.
The value of x_5 is

A. 5 B. 7 C. 8 D. 16

gate2008 algorithms recurrence normal

1.15.25 Recurrence: GATE2008-IT-44

https://gateoverflow.in/3354

When $n = 2^{2k}$ for some $k \geqslant 0$, the recurrence relation
$T(n) = \sqrt{(2)}T(n/2) + \sqrt{n}$, $T(1) = 1$
evaluates to :

A. $\sqrt{(n)}(\log n + 1)$
B. $\sqrt{(n)} \log n$
C. $\sqrt{(n)} \log \sqrt{(n)}$
D. $n \log \sqrt{n}$

gate2008-it algorithms recurrence normal

1.15.26 Recurrence: GATE2009-35

https://gateoverflow.in/1321

The running time of an algorithm is represented by the following recurrence relation:

$$T(n) = \begin{cases} n & n \leq 3 \\ T(\frac{n}{3}) + cn & \text{otherwise} \end{cases}$$

Which one of the following represents the time complexity of the algorithm?

A. $\Theta(n)$
B. $\Theta(n \log n)$
C. $\Theta(n^2)$
D. $\Theta(n^2 \log n)$

gate2009 algorithms recurrence time-complexity normal

1.15.27 Recurrence: GATE2012-16

https://gateoverflow.in/48

The recurrence relation capturing the optimal execution time of the $Towers\ of\ Hanoi$ problem with n discs is

A. $T(n) = 2T(n-2) + 2$
B. $T(n) = 2T(n-1) + n$
C. $T(n) = 2T(n/2) + 1$
D. $T(n) = 2T(n-1) + 1$

gate2012 algorithms easy recurrence

1.15.28 Recurrence: GATE2014-2-13

https://gateoverflow.in/1968

Which one of the following correctly determines the solution of the recurrence relation with $T(1) = 1$?

$$T(n) = 2T\left(\frac{n}{2}\right) + \log n$$

A. $\Theta(n)$ B. $\Theta(n \log n)$ C. $\Theta(n^2)$ D. $\Theta(\log n)$

gate2014-2 algorithms recurrence normal

1.15.29 Recurrence: GATE2015-1-2

https://gateoverflow.in/8017

Which one of the following is the recurrence equation for the worst case time complexity of the quick sort algorithm for sorting n (≥ 2) numbers? In the recurrence equations given in the options below, c is a constant.

A. $T(n) = 2T(n/2) + cn$
B. $T(n) = T(n-1) + T(1) + cn$
C. $T(n) = 2T(n-1) + cn$
D. $T(n) = T(n/2) + cn$

gate2015-1 algorithms recurrence sorting easy

1.15.30 Recurrence: GATE2015-1-49

https://gateoverflow.in/8355

Let a_n represent the number of bit strings of length n containing two consecutive 1s. What is the recurrence relation for a_n?

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

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

gate2015-1 algorithms recurrence normal

1.15.31 Recurrence: GATE2015-3-39

https://gateoverflow.in/8498

Consider the following recursive C function.

```
void get(int n)
{
    if (n<1) return;
    get (n-1);
    get (n-3);
    printf("%d", n);
}
```

If $get(6)$ function is being called in $main()$ then how many times will the $get()$ function be invoked before returning to the $main()$?

A. 15 B. 25 C. 35 D. 45

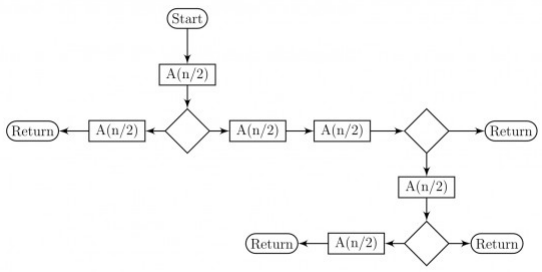
gate2015-3 algorithms recurrence normal

1.15.32 Recurrence: GATE2016-2-39

https://gateoverflow.in/39581

The given diagram shows the flowchart for a recursive function $A(n)$. Assume that all statements, except for the recursive calls, have $O(1)$ time complexity. If the worst case time complexity of this function is $O(n^{\alpha})$, then the least possible value (accurate up to two decimal positions) of α is _____.

Flow chart for Recursive Function $A(n)$.



gate2016-2 algorithms time-complexity recurrence normal numerical-answers

1.15.33 Recurrence: GATE2017-2-30

https://gateoverflow.in/118623

Consider the recurrence function

$$T(n)=\begin{cases}2T(\sqrt{n})+1, & n>2\\ 2, & 0<n\leq 2\end{cases}$$

Then $T(n)$ in terms of Θ notation is

A. $\Theta(\log\log n)$ B. $\Theta(\log n)$
C. $\Theta(\sqrt{n})$ D. $\Theta(n)$

gate2017-2 algorithms recurrence

1.15.34 Recurrence: TIFR2014-B-11

https://gateoverflow.in/27308

Consider the following recurrence relation:

$$T(n)=\begin{cases}T\left(\frac{n}{k}\right)+T\left(\frac{3n}{4}\right)+n & \text{if } n\geq 2\\ 1 & \text{if } n=1\end{cases}$$

Which of the following statements is FALSE?

a. $T(n)$ is $O(n^{3/2})$ when $k=3$. b. $T(n)$ is $O(n\log n)$ when $k=3$.
c. $T(n)$ is $O(n\log n)$ when $k=4$. d. $T(n)$ is $O(n\log n)$ when $k=5$.
e. $T(n)$ is $O(n)$ when $k=5$.

tifr2014 algorithms recurrence

1.15.35 Recurrence: TIFR2015-B-1

https://gateoverflow.in/29657

Consider the following recurrence relation:

$$T(n) = \begin{cases} 2T(\lfloor \sqrt{n} \rfloor) + \log n & \text{if } n \geq 2 \\ 1 & \text{if } n = 1 \end{cases}$$

Which of the following statements is TRUE?

a. $T(n)$ is $O(\log n)$.
b. $T(n)$ is $O(\log n. \log\log n)$ but not $O(\log n)$.
c. $T(n)$ is $O(\log^{3/2} n)$ but not $O(\log n. \log\log n)$.
d. $T(n)$ is $O(\log^2 n)$ but not $O(\log^{3/2} n)$.
e. $T(n)$ is $O(\log^2 n. \log\log n)$ but not $O(\log^2 n)$.

tifr2015 algorithms recurrence time-complexity

1.15.36 Recurrence: TIFR2017-A-15

https://gateoverflow.in/95664

Let $T(a,b)$ be the function with two arguments (both nonnegative integral powers of 2) defined by the following reccurence:

- $T(a,b) = T\left(\frac{a}{2}, b\right) + T\left(a, \frac{b}{2}\right) \qquad \text{if } a,b \geq 2$;
- $T(a,1) = T\left(\frac{a}{2}, 1\right) \qquad \text{if } a \geq 2$;
- $T(1,b) = T\left(1, \frac{b}{2}\right) \qquad \text{if } b \geq 2$;
- $T(1,1) = 1$.

What is $T(2^r, 2^s)$?

A. rs
B. $r+s$
C. $\binom{2^r + 2^s}{2^r}$
D. $\binom{r+s}{r}$
E. 2^{r-s} if $r \geq s$, otherwise 2^{s-r}

tifr2017 algorithms recurrence

1.15.37 Recurrence: TIFR2018-B-5

https://gateoverflow.in/179289

Which of the following functions, given by there recurrence, grows the fastest asymptotically ?

A. $T(n) = 4T\left(\frac{n}{2}\right) + 10n$
B. $T(n) = 8T\left(\frac{n}{3}\right) + 24n^2$
C. $T(n) = 16T\left(\frac{n}{4}\right) + 10n^2$
D. $T(n) = 25T\left(\frac{n}{5}\right) + 20(nlogn)^{1.99}$
E. They all are asymptotically the same

tifr2018 asymptotic-notations recurrence

1.16 Searching (8)

1.16.1 Searching: GATE1996-18

https://gateoverflow.in/2770

Consider the following program that attempts to locate an element x in an array $a[]$ using binary search. Assume $N > 1$. The program is erroneous. Under what conditions does the program fail?

```
var i,j,k: integer; x: integer;
    a: array; [1..N] of integer;
begin i:= 1; j:= n;
repeat
    k:(i+j) div 2;
    if a[k] < x then i:= k
    else j:= k
until (a[k] = x) or (i >= j);

if (a[k] = x) then
    writeln ('x is in the array')
else
    writeln ('x is not in the array')
end;
```

gate1996 algorithms searching normal

1.16.2 Searching: GATE1996-2.13, ISRO2016-28

https://gateoverflow.in/2742

The average number of key comparisons required for a successful search for sequential search on n items is

A. $\frac{n}{2}$ B. $\frac{n-1}{2}$ C. $\frac{n+1}{2}$ D. None of the above

gate1996 algorithms easy isro2016 searching

1.16.3 Searching: GATE2002-2.10

https://gateoverflow.in/840

Consider the following algorithm for searching for a given number x in an unsorted array $A[1..n]$ having n distinct values:

1. Choose an i at random from $1..n$
2. If $A[i] = x$, then Stop else Goto 1;

Assuming that x is present in A, what is the expected number of comparisons made by the algorithm before it terminates?

A. n B. $n-1$ C. $2n$ D. $\frac{n}{2}$

gate2002 searching normal

1.16.4 Searching: GATE2008-84

https://gateoverflow.in/394

Consider the following C program that attempts to locate an element x in an array $Y[\,]$ using binary search. The program is erroneous.

```
f (int Y[10] , int x) {
   int u, j, k;
   i= 0; j = 9;
   do {
        k = (i+ j) / 2;
        if( Y[k] < x) i = k;else j = k;
        } while (Y[k] != x) && (i < j)) ;
   if(Y[k] == x) printf(" x is in the array ") ;
   else printf(" x is not in the array ") ;
}
```

On which of the following contents of Y and x does the program fail?

A. Y is $[1\,2\,3\,4\,5\,6\,7\,8\,9\,10]$ and $x < 10$
B. Y is $[1\,3\,5\,7\,9\,11\,13\,15\,17\,19]$ and $x < 1$
C. Y is $[2\,2\,2\,2\,2\,2\,2\,2\,2\,2]$ and $x > 2$
D. Y is $[2\,4\,6\,8\,10\,12\,14\,16\,18\,20]$ and $2 < x < 20$ and x is even

gate2008 algorithms searching normal

1.16.5 Searching: GATE2008-85

https://gateoverflow.in/43508

Consider the following C program that attempts to locate an element x in an array $Y[\,]$ using binary search. The program is erroneous.

```
f (int Y[10] , int x) {
   int u, j, k;
   i= 0; j = 9;
   do {
        k = (i+ j) / 2;
        if( Y[k] < x) i = k;else j = k;
        } while (Y[k] != x) && (i < j)) ;
   if(Y[k] == x) printf(" x is in the array ") ;
   else printf(" x is not in the array ") ;
}
```

The correction needed in the program to make it work properly is

A. Change line 6 to: if $(Y[k] < x) i = k+1$; else $j = k-1$;
B. Change line 6 to: if $(Y[k] < x) i = k-1$; else $j = k+1$;
C. Change line 6 to: if $(Y[k] < x) i = k$; else $j = k$;
D. Change line 7 to: } while $((Y[k] == x) \&\& (i < j))$;

gate2008 algorithms searching normal

1.16.6 Searching: GATE2017-1-48

https://gateoverflow.in/118331

Let A be an array of 31 numbers consisting of a sequence of 0's followed by a sequence of 1's. The problem is to find the smallest index i such that $A[i]$ is 1 by probing the minimum number of locations in A. The *worst case* number of probes performed by an *optimal* algorithm is _____.

gate2017-1 algorithms normal numerical-answers searching

1.16.7 Searching: TIFR2010-B-29

https://gateoverflow.in/18752

Suppose you are given an array A with $2n$ numbers.

The numbers in odd positions are sorted in ascending order, that is, $A[1] \leq A[3] \leq \ldots \leq A[2n-1]$.

The numbers in even positions are sorted in descending order, that is, $A[2] \geq A[4] \geq \ldots \geq A[2n]$.

What is the method you would recommend for determining if a given number is in the array?

A. Sort the array using quick-sort and then use binary search.
B. Merge the sorted lists and perform binary search.
C. Perform a single binary search on the entire array.
D. Perform separate binary searches on the odd positions and the even positions.
E. Search sequentially from the end of the array.

tifr2010 searching

1.16.8 Searching: TIFR2012-B-11

https://gateoverflow.in/25140

Consider the following three version of the binary search program. Assume that the elements of type T can be compared with each other; also assume that the array is sorted.

```
i, j, k : integer;
a : array [1....N] of T;
x : T;

Program 1 :   i := 1; j := N;
              repeat
                    k := (i + j) div 2;
                    if a[k] < x then i := k else j := k
              until (a[k] = x) or (i > j)
Program 2 :   i := 1; j := N;
              repeat
                    k := (i + j) div 2;
                   if x < a[k] then j := k - 1;
                   if a[k] < x then i := k + 1;
              until i > j
Program 3 :  i := 1; j := N
              repeat
                    k := (i + j) div 2;
                   if x < a[k] then j := k else i := k + 1
              until i > j
```

A binary search program is called correct provided it terminates with $a[k] = x$ whenever such an element exists, or it terminates with $a[k] \neq x$ if there exists no array element with value x. Which of the following statements is correct?

A. Only Program 1 is correct
B. Only Program 2 is correct
C. Only Program 1 and 2 are correct.
D. Both Program 2 and 3 are correct
E. All the three programs are wrong

tifr2012 algorithms searching

1.17 Shortest Path (1)

1.17.1 Shortest Path: TIFR2018-B-9

https://gateoverflow.in/179293

Let $G = (V, E)$ be a DIRECTED graph, where each edge e has a positive weight $\omega(e)$, and all vertices can be reached from vertex s. For each vertex v, let $\phi(v)$ be the length of the shortest path from s to v. Let $G' = (V, E)$ be a new weighted graph with the same vertices and edges, but with the edge weight of every edge $e = (u \rightarrow v)$ changed to $\omega'(e) = \omega(e) + \phi(v) - \phi(u)$. Let P be a path from s to a vertex v, and let $\omega(P) = \sum_{e \in P} \omega_e$, and $\omega'(P) = \sum_{e \in P} \omega'_e$.

Which of the following options is NOT NECESSARILY TRUE ?

A. If P is a shortest path in G, then P is a shortest path in G'.
B. If P is a shortest path in F', then P is a shortest path in G.
C. If P is a shortest path in G, then $\omega'(P) = 2 \times \omega(P)$.
D. If P is NOT a shortest path in G, then $\omega'(P) < 2 \times \omega(P)$.
E. All of the above options are necessarily TRUE.

tifr2018 graph-algorithms shortest-path

1.18 Sorting (52)

1.18.1 Sorting: GATE1987-1-xviii

https://gateoverflow.in/80366

Let P be a quicksort program to sort numbers in ascending order. Let t_1 and t_2 be the time taken by the program for the inputs $[1\,2\,3\,4]$ and $[5\,4\,3\,2\,1]$, respectively. Which of the following holds?

A. $t_1 = t_2$
B. $t_1 > t_2$
C. $t_1 < t_2$
D. $t_1 = t_2 + 5 \log 5$

gate1987 algorithms sorting

1.18.2 Sorting: GATE1988-1iii

https://gateoverflow.in/91338

Quicksort is _____ efficient than heapsort in the worst case.

gate1988 algorithms sorting

1.18.3 Sorting: GATE1989-9

https://gateoverflow.in/89083

An input files has 10 records with keys as given below:

$25 \quad 7 \quad 34 \quad 2 \quad 70 \quad 9 \quad 61 \quad 16 \quad 49 \quad 19$

This is to be sorted in non-decreasing order.

i. Sort the input file using QUICKSORT by correctly positioning the first element of the file/subfile. Show the subfiles obtained at all intermediate steps. Use square brackets to demarcate subfiles.
ii. Sort the input file using 2-way- MERGESORT showing all major intermediate steps. Use square brackets to demarcate subfiles.

gate1989 descriptive algorithms sorting

1.18.4 Sorting: GATE1990-3-v

https://gateoverflow.in/84830

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

The complexity of comparision based sorting algorithms is:

A. $\Theta(n \log n)$
B. $\Theta(n)$
C. $\Theta\left(n^2\right)$
D. $\Theta(n\sqrt{n})$

gate1990 normal algorithms sorting

1.18.5 Sorting: GATE1991-01,vii

https://gateoverflow.in/505

The minimum number of comparisons required to sort 5 elements is ____

gate1991 normal algorithms sorting

1.18.6 Sorting: GATE1991-13

https://gateoverflow.in/540

Give an optimal algorithm in pseudo-code for sorting a sequence of n numbers which has only k distinct numbers (k is not known a Priori). Give a brief analysis for the time-complexity of your algorithm.

gate1991 sorting time-complexity algorithms difficult

1.18.7 Sorting: GATE1992-02,ix

https://gateoverflow.in/559

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

Following algorithm(s) can be used to sort n in the range $[1 \ldots n^3]$ in $O(n)$ time

a. Heap sort b. Quick sort c. Merge sort d. Radix sort

gate1992 easy algorithms sorting

1.18.8 Sorting: GATE1992-03,iv

https://gateoverflow.in/581

Assume that the last element of the set is used as partition element in Quicksort. If n distinct elements from the set $[1 \ldots n]$ are to be sorted, give an input for which Quicksort takes maximum time.

gate1992 algorithms sorting easy

1.18.9 Sorting: GATE1994-1.19, ISRO2016-31

https://gateoverflow.in/2462

Algorithm design technique used in quicksort algorithm is?

A. Dynamic programming
B. Backtracking
C. Divide and conquer
D. Greedy method

gate1994 algorithms sorting easy isro2016

1.18.10 Sorting: GATE1995-1.16

https://gateoverflow.in/2603

For merging two sorted lists of sizes m and n into a sorted list of size $m+n$, we require comparisons of

A. $O(m)$ B. $O(n)$ C. $O(m+n)$ D. $O(\log m + \log n)$

gate1995 algorithms sorting normal

1.18.11 Sorting: GATE1995-1.5

https://gateoverflow.in/2592

Merge sort uses:

A. Divide and conquer strategy
B. Backtracking approach
C. Heuristic search
D. Greedy approach

gate1995 algorithms sorting easy

1.18.12 Sorting: GATE1995-12

https://gateoverflow.in/2648

Consider the following sequence of numbers:

$$92, 37, 52, 12, 11, 25$$

Use Bubble sort to arrange the sequence in ascending order. Give the sequence at the end of each of the first five passes.

gate1995 algorithms sorting easy

1.18.13 Sorting: GATE1996-14

https://gateoverflow.in/2766

A two dimensional array $A[1..n][1..n]$ of integers is partially sorted if $\forall i, j \in [1..n-1], A[i][j] < A[i][j+1]$ and $A[i][j] < A[i+1][j]$

Fill in the blanks:

a. The smallest item in the array is at $A[i][j]$ where i=__ and j=__.
b. The smallest item is deleted. Complete the following $O(n)$ procedure to insert item x (which is guaranteed to be smaller than any item in the last row or column) still keeping A partially sorted.

```
procedure insert (x: integer);
var i,j: integer;
begin
    i:=1; j:=1, A[i][j]:=x;
    while (x > __ or x > __) do
        if A[i+1][j] < A[i][j] ___ then begin
            A[i][j]:=A[i+1][j]; i:=i+1;
        end
        else begin
            _____
        end
    A[i][j]:= ____
```

```
end
```

gate1996 algorithms sorting normal

1.18.14 Sorting: GATE1996-2.15

https://gateoverflow.in/2744

Quick-sort is run on two inputs shown below to sort in ascending order taking first element as pivot

i. $1,2,3,\ldots n$
ii. $n,n-1,n-2,\ldots,2,1$

Let C_1 and C_2 be the number of comparisons made for the inputs (i) and (ii) respectively. Then,

A. $C_1 < C_2$
B. $C_1 > C_2$
C. $C_1 = C_2$
D. we cannot say anything for arbitrary n

gate1996 algorithms sorting normal

1.18.15 Sorting: GATE1998-1.22

https://gateoverflow.in/1659

Give the correct matching for the following pairs:

(A)	$O(\log n)$	(P)	Selection sort
(B)	$O(n)$	(Q)	Insertion sort
(C)	$O(n \log n)$	(R)	Binary search
(D)	$O(n^2)$	(S)	Merge sort

A. A-R B-P C-Q D-S
B. A-R B-P C-S D-Q
C. A-P B-R C-S D-Q
D. A-P B-S C-R D-Q

gate1998 algorithms sorting easy

1.18.16 Sorting: GATE1999-1.12

https://gateoverflow.in/1465

A sorting technique is called stable if

A. it takes $O(n \log n)$ time
B. it maintains the relative order of occurrence of non-distinct elements
C. it uses divide and conquer paradigm
D. it takes $O(n)$ space

gate1999 algorithms sorting easy

1.18.17 Sorting: GATE1999-1.14, ISRO2015-42

https://gateoverflow.in/1467

If one uses straight two-way merge sort algorithm to sort the following elements in ascending order:

20, 47, 15, 8, 9, 4, 40, 30, 12, 17

then the order of these elements after second pass of the algorithm is:

A. 8, 9, 15, 20, 47, 4, 12, 17, 30, 40
B. 8, 15, 20, 47, 4, 9, 30, 40, 12, 17
C. 15, 20, 47, 4, 8, 9, 12, 30, 40, 17
D. 4, 8, 9, 15, 20, 47, 12, 17, 30, 40

gate1999 algorithms sorting normal isro2015

1.18.18 Sorting: GATE1999-8

https://gateoverflow.in/1507

Let A be an $n \times n$ matrix such that the elements in each row and each column are arranged in ascending order. Draw a decision tree, which finds 1^{st}, 2^{nd} and 3^{rd} smallest elements in minimum number of comparisons.

gate1999 algorithms sorting normal descriptive

1.18.19 Sorting: GATE2000-17

https://gateoverflow.in/688

An array contains four occurrences of 0, five occurrences of 1, and three occurrences of 2 in any order. The array is to be sorted using swap operations (elements that are swapped need to be adjacent).

a. What is the minimum number of swaps needed to sort such an array in the worst case?
b. Give an ordering of elements in the above array so that the minimum number of swaps needed to sort the array is maximum.

gate2000 algorithms sorting normal descriptive

1.18.20 Sorting: GATE2001-1.14

https://gateoverflow.in/707

Randomized quicksort is an extension of quicksort where the pivot is chosen randomly. What is the worst case complexity of sorting n numbers using Randomized quicksort?

A. $O(n)$ B. $O(n \log n)$ C. $O(n^2)$ D. $O(n!)$

gate2001 algorithms sorting time-complexity easy

1.18.21 Sorting: GATE2003-22

https://gateoverflow.in/912

The unusual $\Theta(n^2)$ implementation of Insertion Sort to sort an array uses linear search to identify the position where an element is to be inserted into the already sorted part of the array. If, instead, we use binary search to identify the position, the worst case running time will

A. remain $\Theta(n^2)$
B. become $\Theta(n(\log n)^2)$
C. become $\Theta(n \log n)$
D. become $\Theta(n)$

gate2003 algorithms sorting time-complexity normal

1.18.22 Sorting: GATE2003-61

https://gateoverflow.in/949

In a permutation $a_1 \ldots a_n$, of n distinct integers, an inversion is a pair (a_i, a_j) such that $i < j$ and $a_i > a_j$.

If all permutations are equally likely, what is the expected number of inversions in a randomly chosen permutation of $1 \ldots n$?

A. $\frac{n(n-1)}{2}$ B. $\frac{n(n-1)}{4}$ C. $\frac{n(n+1)}{4}$ D. $2n\lceil \log_2 n \rceil$

gate2003 algorithms sorting normal

1.18.23 Sorting: GATE2003-62

https://gateoverflow.in/43576

In a permutation $a_1 \ldots a_n$, of n distinct integers, an inversion is a pair (a_i, a_j) such that $i < j$ and $a_i > a_j$.

What would be the worst case time complexity of the Insertion Sort algorithm, if the inputs are restricted to permutations of $1 \ldots n$ with at most n inversions?

A. $\Theta(n^2)$
B. $\Theta(n \log n)$
C. $\Theta(n^{1.5})$
D. $\Theta(n)$

gate2003 algorithms sorting normal

1.18.24 Sorting: GATE2004-29

https://gateoverflow.in/1026

The tightest lower bound on the number of comparisons, in the worst case, for comparison-based sorting is of the order of

A. n B. n^2 C. $n \log n$ D. $n \log^2 n$

gate2004 algorithms sorting asymptotic-notations easy

1.18.25 Sorting: GATE2005-39

https://gateoverflow.in/784

Suppose there are $\lceil \log n \rceil$ sorted lists of $\lfloor n / \log n \rfloor$ elements each. The time complexity of producing a sorted list of all these elements is: (Hint:Use a heap data structure)

A. $O(n \log \log n)$
B. $\Theta(n \log n)$
C. $\Omega(n \log n)$
D. $\Omega\left(n^{3/2}\right)$

gate2005 algorithms sorting normal

1.18.26 Sorting: GATE2005-IT-59

https://gateoverflow.in/3820

Let a and b be two sorted arrays containing n integers each, in non-decreasing order. Let c be a sorted array containing $2n$ integers obtained by merging the two arrays a and b. Assuming the arrays are indexed starting from 0, consider the following four statements

I. $a[i] \geq b[i] \Rightarrow c[2i] \geq a[i]$
II. $a[i] \geq b[i] \Rightarrow c[2i] \geq b[i]$
III. $a[i] \geq b[i] \Rightarrow c[2i] \leq a[i]$
IV. $a[i] \geq b[i] \Rightarrow c[2i] \leq b[i]$

Which of the following is TRUE?

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

gate2005-it algorithms sorting normal

1.18.27 Sorting: GATE2006-14, ISRO2011-14

https://gateoverflow.in/975

Which one of the following in place sorting algorithms needs the minimum number of swaps?

A. Quick sort B. Insertion sort C. Selection sort D. Heap sort

gate2006 algorithms sorting easy isro2011

1.18.28 Sorting: GATE2006-52

https://gateoverflow.in/1830

The median of n elements can be found in $O(n)$ time. Which one of the following is correct about the complexity of quick sort, in which median is selected as pivot?

A. $\Theta(n)$
B. $\Theta(n \log n)$
C. $\Theta(n^2)$
D. $\Theta(n^3)$

gate2006 algorithms sorting easy

1.18.29 Sorting: GATE2007-14

https://gateoverflow.in/1212

Which of the following sorting algorithms has the lowest worse-case complexity?

A. Merge sort B. Bubble sort C. Quick sort D. Selection sort

gate2007 algorithms sorting time-complexity easy

1.18.30 Sorting: GATE2008-43

https://gateoverflow.in/455

Consider the Quicksort algorithm. Suppose there is a procedure for finding a pivot element which splits the list into two sub-lists each of which contains at least one-fifth of the elements. Let $T(n)$ be the number of comparisons required to sort n elements. Then

A. $T(n) \leq 2T(n/5) + n$
B. $T(n) \leq T(n/5) + T(4n/5) + n$
C. $T(n) \leq 2T(4n/5) + n$
D. $T(n) \leq 2T(n/2) + n$

gate2008 algorithms sorting easy

1.18.31 Sorting: GATE2008-IT-43

https://gateoverflow.in/3353

If we use Radix Sort to sort n integers in the range $\left(n^{k/2}, n^k\right]$, for some $k > 0$ which is independent of n, the time taken would be?

A. $\Theta(n)$ B. $\Theta(kn)$ C. $\Theta(n \log n)$ D. $\Theta(n^2)$

gate2008-it algorithms sorting normal

1.18.32 Sorting: GATE2009-11

https://gateoverflow.in/1303

What is the number of swaps required to sort n elements using selection sort, in the worst case?

A. $\Theta(n)$
B. $\Theta(n \log n)$
C. $\Theta(n^2)$
D. $\Theta(n^2 \log n)$

gate2009 algorithms sorting easy

1.18.33 Sorting: GATE2009-39

https://gateoverflow.in/1325

In quick-sort, for sorting n elements, the $(n/4)^{th}$ smallest element is selected as pivot using an $O(n)$ time algorithm. What is the worst case time complexity of the quick sort?

A. $\Theta(n)$
B. $\Theta(n \log n)$
C. $\Theta(n^2)$
D. $\Theta(n^2 \log n)$

gate2009 algorithms sorting normal

1.18.34 Sorting: GATE2012-39

https://gateoverflow.in/1762

A list of n strings, each of length n, is sorted into lexicographic order using the merge-sort algorithm. The worst case running time of this computation is

A. $O(n \log n)$ B. $O(n^2 \log n)$ C. $O(n^2 + \log n)$ D. $O(n^2)$

gate2012 algorithms sorting normal

1.18.35 Sorting: GATE2013-30

https://gateoverflow.in/1541

The number of elements that can be sorted in $\Theta(\log n)$ time using heap sort is

A. $\Theta(1)$
B. $\Theta(\sqrt{\log n})$
C. $\Theta(\frac{\log n}{\log \log n})$
D. $\Theta(\log n)$

gate2013 algorithms sorting normal

1.18.36 Sorting: GATE2013-6

https://gateoverflow.in/1415

Which one of the following is the tightest upper bound that represents the number of swaps required to sort n numbers using selection sort?

A. $O(\log n)$ B. $O(n)$ C. $O(n \log n)$ D. $O(n^2)$

gate2013 algorithms sorting easy

1.18.37 Sorting: GATE2014-1-14

https://gateoverflow.in/1780

Let P be quicksort program to sort numbers in ascending order using the first element as the pivot. Let t_1 and t_2 be the number of comparisons made by P for the inputs $[1\,2\,3\,4\,5]$ and $[4\,1\,5\,3\,2]$ respectively. Which one of the following holds?

A. $t_1 = 5$ B. $t_1 < t_2$ C. $t_1 > t_2$ D. $t_1 = t_2$

gate2014-1 algorithms sorting easy

1.18.38 Sorting: GATE2014-2-38

https://gateoverflow.in/1997

Suppose P, Q, R, S, T are sorted sequences having lengths $20, 24, 30, 35, 50$ respectively. They are to be merged into a single sequence by merging together two sequences at a time. The number of comparisons that will be needed in the worst case by the optimal algorithm for doing this is ____.

gate2014-2 algorithms sorting normal numerical-answers

1.18.39 Sorting: GATE2014-3-14

https://gateoverflow.in/2048

You have an array of n elements. Suppose you implement quicksort by always choosing the central element of the array as the pivot. Then the tightest upper bound for the worst case performance is

A. $O(n^2)$ B. $O(n \log n)$ C. $\Theta(n \log n)$ D. $O(n^3)$

gate2014-3 algorithms sorting easy

1.18.40 Sorting: GATE2015-2-45

https://gateoverflow.in/8243

Suppose you are provided with the following function declaration in the C programming language.

```
int partition(int a[], int n);
```

The function treats the first element of $a[\,]$ as a pivot and rearranges the array so that all elements less than or equal to the pivot is in the left part of the array, and all elements greater than the pivot is in the right part. In addition, it moves the pivot so that the pivot is the last element of the left part. The return value is the number of elements in the left part.

The following partially given function in the C programming language is used to find the k^{th} smallest element in an array $a[\,]$ of size n using the partition function. We assume $k \leq n$.

```
int kth_smallest (int a[], int n, int k)
{
    int left_end = partition (a, n);
    if (left_end+1==k) {
        return a[left_end];
    }
    if (left_end+1 > k) {
        return kth_smallest (___________);
    } else {
        return kth_smallest (___________);
    }
}
```

The missing arguments lists are respectively

A. $(a,$ left_end$,k)$ and $(a+$left_end$+1, n-$left_end$-1, k-$left_end$-1)$
B. $(a,$ left_end$,k)$ and $(a, n-$left_end$-1, k-$left_end$-1)$
C. $(a+$ left_end$+1, n-$left_end$-1, k-$left_end$-1)$ and $(a,$ left_end$,k)$
D. $(a, n-$left_end$-1, k-$left_end$-1)$ and $(a,$left_end$,k)$

gate2015-2 algorithms normal sorting

1.18.41 Sorting: GATE2015-3-27

https://gateoverflow.in/8480

Assume that a mergesort algorithm in the worst case takes 30 seconds for an input of size 64. Which of the following most closely approximates the maximum input size of a problem that can be solved in 6 minutes?

A. 256 B. 512 C. 1024 D. 2018

gate2015-3 algorithms sorting

1.18.42 Sorting: GATE2016-1-13

https://gateoverflow.in/39660

The worst case running times of *Insertion sort* , *Merge sort* and *Quick sort*, respectively are:

A. $\Theta(n \log n)$, $\Theta(n \log n)$ and $\Theta(n^2)$
B. $\Theta(n^2)$, $\Theta(n^2)$ and $\Theta(n \log n)$
C. $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n \log n)$
D. $\Theta(n^2)$, $\Theta(n \log n)$ and $\Theta(n^2)$

gate2016-1 algorithms sorting easy

1.18.43 Sorting: GATE2016-2-13

https://gateoverflow.in/39561

Assume that the algorithms considered here sort the input sequences in ascending order. If the input is already in the ascending order, which of the following are **TRUE**?

I. Quicksort runs in $\Theta(n^2)$ time
II. Bubblesort runs in $\Theta(n^2)$ time
III. Mergesort runs in $\Theta(n)$ time
IV. Insertion sort runs in $\Theta(n)$ time

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

gate2016-2 algorithms sorting time-complexity normal ambiguous

1.18.44 Sorting: TIFR2010-B-23

https://gateoverflow.in/18623

Suppose you are given n numbers and you sort them in descending order as follows:

First find the maximum. Remove this element from the list and find the maximum of the remaining elements, remove this element, and so on, until all elements are exhausted. How many comparisons does this method require in the worst case?

A. Linear in n.
B. $O\left(n^2\right)$ but not better.
C. $O(n \log n)$
D. Same as heap sort.
E. $O\left(n^{1.5}\right)$ but not better.

tifr2010 algorithms time-complexity sorting

1.18.45 Sorting: TIFR2010-B-27

https://gateoverflow.in/19036

Consider the Insertion Sort procedure given below, which sorts an array L of size $n (\geq 2)$ in ascending order:

```
begin
    for xindex:= 2 to n do
        x := L [xindex];
        j:= xindex - 1;
        while j > 0 and L[j] > x do
            L[j + 1]:= L[j];
            j:= j - 1;
        end {while}
        L [j + 1]:=X;
    end{for}
end
```

It is known that insertion sort makes at most $n(n-1)/2$ comparisons. Which of the following is true?

A. There is no input on which insertion Sort makes $n(n-1)/2$ comparisons.
B. Insertion Sort makes $n(n-1)/2$ comparisons when the input is already sorted in ascending order.
C. Insertion Sort makes $n(n-1)/2$ comparisons only when the input is sorted in descending order.
D. There are more than one input orderings where insertion sort makes $n(n-1)/2$ comparisons.
E. Insertion Sort makes $n(n-1)/2$ comparisons whenever all the elements of L are not distinct.

tifr2010 algorithms sorting

1.18.46 Sorting: TIFR2011-B-21

https://gateoverflow.in/20324

Let $S = \{x_1, \ldots, x_n\}$ be a set of n numbers. Consider the problem of storing the elements of S in an array $A[1 \ldots n]$ such that the following min-heap property is maintained for all $2 \leq i \leq n : A[\lfloor i/2 \rfloor] \leq A[i]$. (Note that $\lfloor x \rfloor$ is the largest integer that is at most x). Which of the following statements is TRUE?

A. This problem can be solved in $O(\log n)$ time.
B. This problem can be solved in $O(n)$ time but not in $O(\log n)$ time.
C. This problem can be solved in $O(n \log n)$ time but not in $O(n)$ time.
D. This problem can be solved in $O\left(n^2\right)$ time but not in $O(n \log n)$ time.
E. None of the above.

tifr2011 algorithms sorting

1.18.47 Sorting: TIFR2011-B-31

https://gateoverflow.in/20617

Given a set of $n = 2^k$ distinct numbers, we would like to determine the smallest and the second smallest using comparisons. Which of the following statements is TRUE?

A. Both these elements can be determined using $2k$ comparisons.
B. Both these elements can be determined using $n-2$ comparisons.
C. Both these elements can be determined using $n+k-2$ comparisons.
D. $2n-3$ comparisons are necessary to determine these two elements.
E. nk comparisons are necessary to determine these two elements.

tifr2011 algorithms sorting

1.18.48 Sorting: TIFR2011-B-39

https://gateoverflow.in/20935

The first n cells of an array L contain positive integers sorted in decreasing order, and the remaining $m-n$ cells all contain 0. Then, given an integer x, in how many comparisons can one find the position of x in L?

A. At least n comparisons are necessary in the worst case.
B. At least $\log m$ comparisons are necessary in the worst case.
C. $O(\log(m-n))$ comparisons suffice.
D. $O(\log n)$ comparisons suffice.
E. $O(\log(m/n))$ comparisons suffice.

tifr2011 algorithms sorting

1.18.49 Sorting: TIFR2012-B-13

https://gateoverflow.in/25207

An array A contains n integers. We wish to sort A in ascending order. We are told that initially no element of A is more than a distance k away from its final position in the sorted list. Assume that n and k are large and k is much smaller than n. Which of the following is true for the worst case complexity of sorting A?

A. A can be sorted with constant $.kn$ comparison but not with fewer comparisons.
B. A cannot be sorted with less than constant $.n\log n$ comparisons.
C. A can be sorted with constant $.n$ comparisons.
D. A can be sorted with constant $.n\log k$ comparisons but not with fewer comparisons.
E. A can be sorted with constant $.k^2n$ comparisons but not fewer.

tifr2012 algorithms sorting

1.18.50 Sorting: TIFR2012-B-14

https://gateoverflow.in/25209

Consider the quick sort algorithm on a set of n numbers, where in every recursive subroutine of the algorithm, the algorithm chooses the median of that set as the pivot. Then which of the following statements is TRUE?

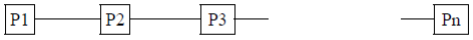
A. The running time of the algorithm is $\Theta(n)$.
B. The running time of the algorithm is $\Theta(n\log n)$.
C. The running time of the algorithm is $\Theta(n^{1.5})$.
D. The running time of the algorithm is $\Theta(n^2)$.
E. None of the above.

tifr2012 algorithms sorting

1.18.51 Sorting: TIFR2013-B-20

https://gateoverflow.in/25878

Suppose n processors are connected in a linear array as shown below. Each processor has a number. The processors need to exchange numbers so that the numbers eventually appear in ascending order (the processor $\mathrm{P1}$ should have the minimum value and the the processor Pn should have the maximum value).



The algorithm to be employed is the following. Odd numbered processors and even numbered processors are activated alternate steps; assume that in the first step all the even numbered processors are activated. When a processor is activated, the number it holds is compared with the number held by its right-hand neighbour (if one exists) and the smaller of the two numbers is retained by the activated processor and the bigger stored in its right hand neighbour.
How long does it take for the processors to sort the values?

A. $n\log n$ steps
B. n^2 steps
C. n steps
D. $n^{1.5}$ steps
E. The algorithm is not guaranteed to sort

tifr2013 algorithms sorting

1.18.52 Sorting: TIFR2017-B-7

https://gateoverflow.in/95699

An array of n distinct elements is said to be un-sorted if for every index i such that $2 \leq i \leq n-1$, either $A[i] > max\{A[i-1], A[i+1]\}$, or $A[i] < min\{A[i-1], A[i+1]\}$. What is the time-complexity of the fastest algorithm that takes as input a sorted array A with n distinct elements, and un-sorts A?

A. $O(n \log n)$ but not $O(n)$
B. $O(n)$ but not $O(\sqrt{n})$
C. $O(\sqrt{n})$ but not $O(\log n)$
D. $O(\log n)$ but not $O(1)$
E. $O(1)$

tifr2017 algorithms sorting

1.19 Spanning Tree (31)

1.19.1 Spanning Tree: GATE1991-03,vi

https://gateoverflow.in/521

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

Kruskal's algorithm for finding a minimum spanning tree of a weighted graph G with n vertices and m edges has the time complexity of:

A. $O(n^2)$ B. $O(mn)$ C. $O(m+n)$ D. $O(m \log n)$ E. $O(m^2)$

gate1991 algorithms spanning-tree

1.19.2 Spanning Tree: GATE1992-01,ix

https://gateoverflow.in/549

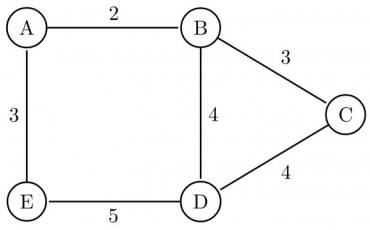
Complexity of Kruskal's algorithm for finding the minimum spanning tree of an undirected graph containing n vertices and m edges if the edges are sorted is _____

gate1992 spanning-tree algorithms time-complexity easy

1.19.3 Spanning Tree: GATE1995-22

https://gateoverflow.in/2660

How many minimum spanning trees does the following graph have? Draw them. (Weights are assigned to edges).



gate1995 algorithms graph-algorithms spanning-tree easy

1.19.4 Spanning Tree: GATE1996-16

https://gateoverflow.in/2768

A complete, undirected, weighted graph G is given on the vertex $\{0,1,\ldots,n-1\}$ for any fixed 'n'. Draw the minimum spanning tree of G if

A. the weight of the edge (u,v) is $|u-v|$
B. the weight of the edge (u,v) is $u+v$

gate1996 algorithms graph-algorithms spanning-tree normal

1.19.5 Spanning Tree: GATE1997-9

https://gateoverflow.in/2269

Consider a graph whose vertices are points in the plane with integer co-ordinates (x,y) such that $1 \leq x \leq n$ and $1 \leq y \leq n$, where $n \geq 2$ is an integer. Two vertices (x_1,y_1) and (x_2,y_2) are adjacent iff $|x_1 - x_2| \leq 1$ and $|y_1 - y_2| \leq 1$. The weight of an edge $\{(x_1,y_1),(x_2,y_2)\}$ is $\sqrt{(x_1-x_2)^2+(y_1-y_2)^2}$

A. What is the weight of a minimum weight-spanning tree in this graph? Write only the answer without any explanations.
B. What is the weight of a maximum weight-spanning tree in this graph? Write only the answer without any explanations.

gate1997 algorithms spanning-tree normal

1.19.6 Spanning Tree: GATE2000-2.18

https://gateoverflow.in/665

Let G be an undirected connected graph with distinct edge weights. Let e_{max} be the edge with maximum weight and

e_{min} the edge with minimum weight. Which of the following statements is false?

A. Every minimum spanning tree of G must contain e_{min}
B. If e_{max} is in a minimum spanning tree, then its removal must disconnect G
C. No minimum spanning tree contains e_{max}
D. G has a unique minimum spanning tree

gate2000 algorithms spanning-tree normal

1.19.7 Spanning Tree: GATE2001-15

https://gateoverflow.in/756

Consider a weighted undirected graph with vertex set $V = \{n1, n2, n3, n4, n5, n6\}$ and edge set $E = \{(n1, n2, 2), (n1, n3, 8), (n1, n6, 3), (n2, n4, 4), (n2, n5, 12), (n3, n4, 7), (n4, n5, 9), (n4, n6, 4)\}$. The third value in each tuple represents the weight of the edge specified in the tuple.

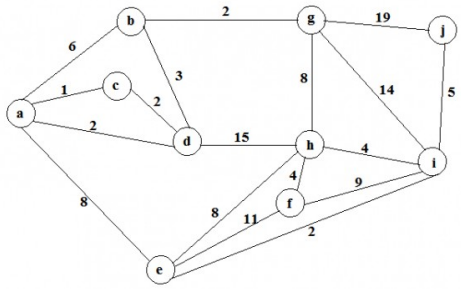
A. List the edges of a minimum spanning tree of the graph.
B. How many distinct minimum spanning trees does this graph have?
C. Is the minimum among the edge weights of a minimum spanning tree unique over all possible minimum spanning trees of a graph?
D. Is the maximum among the edge weights of a minimum spanning tree unique over all possible minimum spanning tree of a graph?

gate2001 algorithms spanning-tree normal descriptive

1.19.8 Spanning Tree: GATE2003-68

https://gateoverflow.in/955

What is the weight of a minimum spanning tree of the following graph?



A. 29 B. 31 C. 38 D. 41

gate2003 algorithms spanning-tree normal

1.19.9 Spanning Tree: GATE2005-6

https://gateoverflow.in/1348

An undirected graph G has n nodes. its adjacency matrix is given by an $n \times n$ square matrix whose (i) diagonal elements are 0's and (ii) non-diagonal elements are 1's. Which one of the following is TRUE?

A. Graph G has no minimum spanning tree (MST)
B. Graph G has unique MST of cost $n-1$
C. Graph G has multiple distinct MSTs, each of cost $n-1$
D. Graph G has multiple spanning trees of different costs

gate2005 algorithms spanning-tree normal

1.19.10 Spanning Tree: GATE2005-IT-52

https://gateoverflow.in/3813

Let G be a weighted undirected graph and e be an edge with maximum weight in G. Suppose there is a minimum weight spanning tree in G containing the edge e. Which of the following statements is always TRUE?

A. There exists a cutset in G having all edges of maximum weight.
B. There exists a cycle in G having all edges of maximum weight.
C. Edge e cannot be contained in a cycle.

D. All edges in G have the same weight.

gate2005-it algorithms spanning-tree normal

1.19.11 Spanning Tree: GATE2006-11

https://gateoverflow.in/890

Consider a weighted complete graph G on the vertex set $\{v_1, v_2, \ldots . v_n\}$ such that the weight of the edge (v_i, v_j) is $2|i-j|$. The weight of a minimum spanning tree of G is:

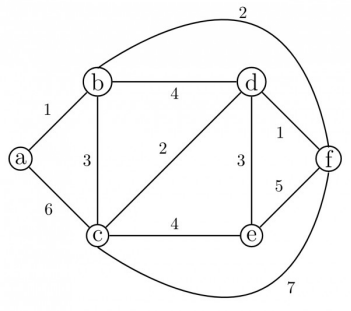
A. $n-1$ B. $2n-2$ C. $\binom{n}{2}$ D. n^2

gate2006 algorithms spanning-tree normal

1.19.12 Spanning Tree: GATE2006-47

https://gateoverflow.in/1823

Consider the following graph:



Which one of the following cannot be the sequence of edges added, **in that order**, to a minimum spanning tree using Kruskal's algorithm?

A. $(a-b),(d-f),(b-f),(d-c),(d-e)$
B. $(a-b),(d-f),(d-c),(b-f),(d-e)$
C. $(d-f),(a-b),(d-c),(b-f),(d-e)$
D. $(d-f),(a-b),(b-f),(d-e),(d-c)$

gate2006 algorithms graph-algorithms spanning-tree normal

1.19.13 Spanning Tree: GATE2007-49

https://gateoverflow.in/1247

Let w be the minimum weight among all edge weights in an undirected connected graph. Let e be a specific edge of weight w. Which of the following is FALSE?

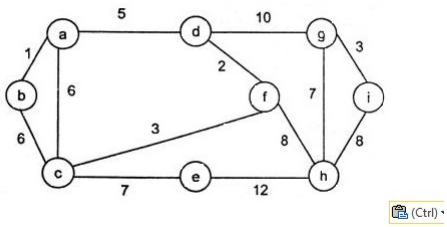
A. There is a minimum spanning tree containing e
B. If e is not in a minimum spanning tree T, then in the cycle formed by adding e to T, all edges have the same weight.
C. Every minimum spanning tree has an edge of weight w
D. e is present in every minimum spanning tree

gate2007 algorithms spanning-tree normal

1.19.14 Spanning Tree: GATE2008-IT-45

https://gateoverflow.in/3355

For the undirected, weighted graph given below, which of the following sequences of edges represents a correct execution of Prim's algorithm to construct a Minimum Spanning Tree?



A. (a, b), (d, f), (f, c), (g, i), (d, a), (g, h), (c, e), (f, h)

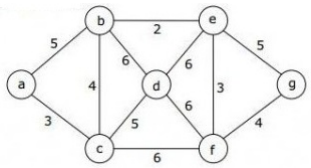
B. $(c, e), (c, f), (f, d), (d, a), (a, b), (g, h), (h, f), (g, i)$
C. $(d, f), (f, c), (d, a), (a, b), (c, e), (f, h), (g, h), (g, i)$
D. $(h, g), (g, i), (h, f), (f, c), (f, d), (d, a), (a, b), (c, e)$

gate2008-it algorithms graph-algorithms spanning-tree normal

1.19.15 Spanning Tree: GATE2009-38

https://gateoverflow.in/1324

Consider the following graph:



Which one of the following is NOT the sequence of edges added to the minimum spanning tree using Kruskal's algorithm?

A. $(b, e)\ (e, f)\ (a, c)\ (b, c)\ (f, g)\ (c, d)$
B. $(b, e)\ (e, f)\ (a, c)\ (f, g)\ (b, c)\ (c, d)$
C. $(b, e)\ (a, c)\ (e, f)\ (b, c)\ (f, g)\ (c, d)$
D. $(b, e)\ (e, f)\ (b, c)\ (a, c)\ (f, g)\ (c, d)$

gate2009 algorithms spanning-tree normal

1.19.16 Spanning Tree: GATE2010-50

https://gateoverflow.in/2355

Consider a complete undirected graph with vertex set $\{0,1,2,3,4\}$. Entry W_{ij} in the matrix W below is the weight of the edge $\{i,j\}$

$$W = \begin{pmatrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{pmatrix}$$

What is the minimum possible weight of a spanning tree T in this graph such that vertex 0 is a leaf node in the tree T?

A. 7 B. 8 C. 9 D. 10

gate2010 algorithms spanning-tree normal

1.19.17 Spanning Tree: GATE2010-51

https://gateoverflow.in/43328

Consider a complete undirected graph with vertex set $\{0,1,2,3,4\}$. Entry W_{ij} in the matrix W below is the weight of the edge $\{i,j\}$

$$W = \begin{pmatrix} 0 & 1 & 8 & 1 & 4 \\ 1 & 0 & 12 & 4 & 9 \\ 8 & 12 & 0 & 7 & 3 \\ 1 & 4 & 7 & 0 & 2 \\ 4 & 9 & 3 & 2 & 0 \end{pmatrix}$$

What is the minimum possible weight of a path P from vertex 1 to vertex 2 in this graph such that P contains at most 3 edges?

A. 7 B. 8 C. 9 D. 10

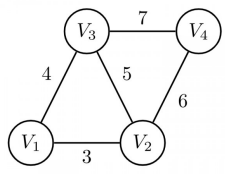
gate2010 normal algorithms spanning-tree

1.19.18 Spanning Tree: GATE2011-54

https://gateoverflow.in/2162

An undirected graph $G(V, E)$ contains $n\ (n > 2)$ nodes named $v_1, v_2, \ldots, v_n$. Two nodes v_i, v_j are connected if and

only if $0 < | i-j | \leq 2$. Each edge (v_i, v_j) is assigned a weight $i+j$. A sample graph with $n=4$ is shown below.



What will be the cost of the minimum spanning tree (MST) of such a graph with n nodes?

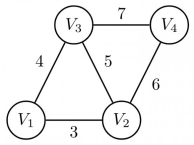
A. $\frac{1}{12}(11n^2-5n)$ B. n^2-n+1 C. $6n-11$ D. $2n+1$

gate2011 algorithms graph-algorithms spanning-tree normal

1.19.19 Spanning Tree: GATE2011-55

https://gateoverflow.in/43325

An undirected graph $G(V,E)$ contains $n\,(n>2)$ nodes named $v_1, v_2, \ldots, v_n$. Two nodes v_i, v_j are connected if and only if $0 < | i-j | \leq 2$. Each edge (v_i, v_j) is assigned a weight $i+j$. A sample graph with $n=4$ is shown below.



The length of the path from v_5 to v_6 in the MST of previous question with $n=10$ is

A. 11 B. 25 C. 31 D. 41

gate2011 algorithms graph-algorithms spanning-tree normal

1.19.20 Spanning Tree: GATE2012-29

https://gateoverflow.in/786

Let G be a weighted graph with edge weights greater than one and G' be the graph constructed by squaring the weights of edges in G. Let T and T' be the minimum spanning trees of G and G', respectively, with total weights t and t'. Which of the following statements is **TRUE**?

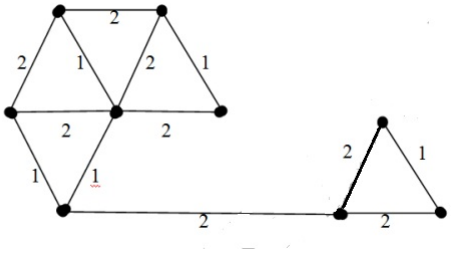
A. $T' = T$ with total weight $t' = t^2$
B. $T' = T$ with total weight $t' < t^2$
C. $T' \neq T$ but total weight $t' = t^2$
D. None of the above

gate2012 algorithms spanning-tree normal marks-to-all

1.19.21 Spanning Tree: GATE2014-2-52

https://gateoverflow.in/2019

The number of distinct minimum spanning trees for the weighted graph below is _____

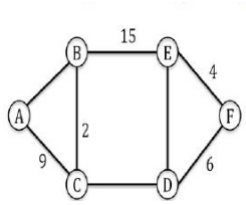


gate2014-2 algorithms spanning-tree numerical-answers normal

1.19.22 Spanning Tree: GATE2015-1-43

https://gateoverflow.in/8313

The graph shown below has 8 edges with distinct integer edge weights. The minimum spanning tree (**MST**) is of weight 36 and contains the edges: $\{(A,C),(B,C),(B,E),(E,F),(D,F)\}$. The edge weights of only those edges which are in the **MST** are given in the figure shown below. The minimum possible sum of weights of all 8 edges of this graph is_____.



gate2015-1 algorithms spanning-tree normal numerical-answers

1.19.23 Spanning Tree: GATE2015-3-40

https://gateoverflow.in/8499

Let G be a connected undirected graph of 100 vertices and 300 edges. The weight of a minimum spanning tree of G is 500. When the weight of each edge of G is increased by five, the weight of a minimum spanning tree becomes _____.

gate2015-3 algorithms spanning-tree easy numerical-answers

1.19.24 Spanning Tree: GATE2016-1-14

https://gateoverflow.in/39673

Let G be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are TRUE?

- P: Minimum spanning tree of G does not change.
- Q: Shortest path between any pair of vertices does not change.

A. P only B. Q only C. Neither P nor Q D. Both P and Q

gate2016-1 algorithms spanning-tree normal

1.19.25 Spanning Tree: GATE2016-1-39

https://gateoverflow.in/39725

Let G be a complete undirected graph on 4 vertices, having 6 edges with weights being $1,2,3,4,5,$ and 6. The maximum possible weight that a minimum weight spanning tree of G can have is _____

gate2016-1 algorithms spanning-tree normal numerical-answers

1.19.26 Spanning Tree: GATE2016-1-40

https://gateoverflow.in/39727

$G=(V,E)$ is an undirected simple graph in which each edge has a distinct weight, and e is a particular edge of G. Which of the following statements about the minimum spanning trees $(MSTs)$ of G is/are TRUE?

I. If e is the lightest edge of some cycle in G, then every MST of G includes e.
II. If e is the heaviest edge of some cycle in G, then every MST of G excludes e.

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

gate2016-1 algorithms spanning-tree normal

1.19.27 Spanning Tree: TIFR2011-B-35

https://gateoverflow.in/20842

Let G be a connected simple graph (no self-loops or parallel edges) on $n \geq 3$ vertices, with distinct edge weights. Let $e_1, e_2, \ldots, e_m$ be an ordering of the edges in decreasing order of weight. Which of the following statements is FALSE?

A. The edge e_1 has to be present in every maximum weight spanning tree.
B. Both e_1 and e_2 have to be present in every maximum weight spanning tree.
C. The edge e_m has to be present in every minimum weight spanning tree.
D. The edge e_m is never present in any maximum weight spanning tree.
E. G has a unique maximum weight spanning tree.

tifr2011 algorithms graph-algorithms spanning-tree

1.19.28 Spanning Tree: TIFR2013-B-17

https://gateoverflow.in/25860

In a connected weighted graph with n vertices, all the edges have distinct positive integer weights. Then, the maximum number of minimum weight spanning trees in the graph is

a. 1 b. n

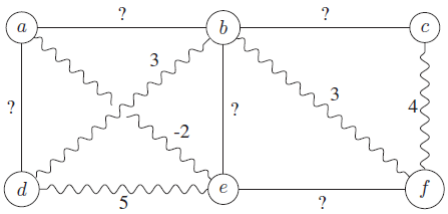
c. equal to number of edges in the graph.
d. equal to maximum weight of an edge of the graph.
e. n^{n-2}

tifr2013 spanning-tree

1.19.29 Spanning Tree: TIFR2014-B-4

https://gateoverflow.in/27174

Consider the following undirected graph with some edge costs missing.



Suppose the wavy edges form a Minimum Cost Spanning Tree for G. Then, which of the following inequalities NEED NOT hold?

a. $\text{cost}(a,b) \geq 6$.
b. $\text{cost}(b,e) \geq 5$.
c. $\text{cost}(e,f) \geq 5$.
d. $\text{cost}(a,d) \geq 4$.
e. $\text{cost}(b,c) \geq 4$.

tifr2014 algorithms graph-algorithms spanning-tree

1.19.30 Spanning Tree: TIFR2014-B-5

https://gateoverflow.in/27180

Let $G = (V,E)$ be an undirected connected simple (i.e., no parallel edges or self-loops) graph with the weight function $w : E \to \mathbb{R}$ on its edge set. Let $w(e_1) < w(e_2) < \cdots < w(e_m)$, where $E = \{e_1, e_2, \ldots, e_m\}$. Suppose T is a minimum spanning tree of G. Which of the following statements is FALSE?

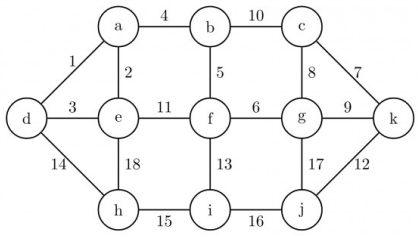
A. The tree T has to contain the edge e_1.
B. The tree T has to contain the edge e_2.
C. The minimum weight edge incident on each vertex has to be present in T.
D. T is the unique minimum spanning tree in G.
E. If we replace each edge weight $w_i = w(e_i)$ by its square w_i^2 , then T must still be a minimum spanning tree of this new instance.

tifr2014 algorithms spanning-tree

1.19.31 Spanning Tree: TIFR2015-B-2

https://gateoverflow.in/29844

Consider the following undirected connected graph G with weights on its edges as given in the figure below. A minimum spanning tree is a spanning tree of least weight and a maximum spanning tree is one with largest weight. A second best minimum spanning tree whose weight is the smallest among all spanning trees that are not minimum spanning trees in G.



Which of the following statements is TRUE in the above graph? (Note that all the edge weights are distinct in the above graph)

A. There is more than one minimum spanning tree and similarly, there is more than one maximum spanning tree here.
B. There is a unique minimum spanning tree, however there is more than one maximum spanning tree here.
C. There is more than one minimum spanning tree, however there is a unique maximum spanning tree here.
D. There is more than one minimum spanning tree and similarly, there is more than one second-best minimum spanning tree here.
E. There is unique minimum spanning tree, however there is more than one second-best minimum spanning tree here.

tifr2015 spanning-tree algorithms graph-algorithms

1.20 Time Complexity (33)

1.20.1 Time Complexity: GATE1988-6i

https://gateoverflow.in/94363

Given below is the sketch of a program that represents the path in a two-person game tree by the sequence of active procedure calls at any time. The program assumes that the payoffs are real number in a limited range; that the constant INF is larger than any positive payoff and its negation is smaller than any negative payoff and that there is a function “payoff” and that computes the payoff for any board that is a leaf. The type “boardtype” has been suitably declared to represent board positions. It is player-1’s move if mode = MAX and player-2’s move if mode=MIN. The type modetype =(MAX, MIN). The functions “min” and “max” find the minimum and maximum of two real numbers.

```
function search(B: boardtype; mode: modetype): real;
    var
        C:boardtype; {a child of board B}
        value:real;
    begin
        if B is a leaf then
            return (payoff(B))
        else
            begin
            if mode = MAX then value :=-INF
            else
                value:INF;
            for each child C of board B do
            if mode = MAX then
                value:=max (value, search (C, MIN))
            else
                value:=min(value, search(C, MAX))
            return(value)
            end
    end; (search)
```

Comment on the working principle of the above program. Suggest a possible mechanism for reducing the amount of search.

gate1988 normal descriptive algorithms time-complexity

1.20.2 Time Complexity: GATE1989-2-iii

https://gateoverflow.in/87080

Match the pairs in the following:

(A)	$O(\log n)$	(p)	Heapsort
(B)	$O(n)$	(q)	Depth-first search
(C)	$O(n \log n)$	(r)	Binary search
(D)	$O(n^2)$	(s)	Selection of the k^{th} smallest element in a set of n elements

gate1989 match-the-following algorithms time-complexity

1.20.3 Time Complexity: GATE1993-8.7

https://gateoverflow.in/2305

$\sum_{1 \leq k \leq n} O(n)$, where $O(n)$ stands for order n is:

A. $O(n)$ B. $O(n^2)$ C. $O(n^3)$ D. $O(3n^2)$ E. $O(1.5n^2)$

gate1993 algorithms time-complexity easy

1.20.4 Time Complexity: GATE1999-1.13

https://gateoverflow.in/1466

Suppose we want to arrange the n numbers stored in any array such that all negative values occur before all positive ones. Minimum number of exchanges required in the worst case is

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

gate1999 algorithms time-complexity normal

1.20.5 Time Complexity: GATE1999-1.16

https://gateoverflow.in/1469

If n is a power of 2, then the minimum number of multiplications needed to compute a^n is

A. $\log_2 n$ B. $\sqrt{n}$ C. $n-1$ D. n

gate1999 algorithms time-complexity normal

1.20.6 Time Complexity: GATE1999-11a

https://gateoverflow.in/1510

Consider the following algorithms. Assume, procedure A and procedure B take $O(1)$ and $O(1/n)$ unit of time respectively. Derive the time complexity of the algorithm in O-notation.

```
algorithm what (n)
begin
    if n = 1 then call A
    else
        begin
            what (n-1);
            call B(n)
        end
end.
```

gate1999 algorithms time-complexity normal

1.20.7 Time Complexity: GATE2000-1.15

https://gateoverflow.in/638

Let S be a sorted array of n integers. Let $T(n)$ denote the time taken for the most efficient algorithm to determined if there are two elements with sum less than 1000 in S. Which of the following statement is true?

A. $T(n)$ is $O(1)$
B. $n \leq T(n) \leq n \log_2 n$
C. $n \log_2 n \leq T(n) < \frac{n}{2}$
D. $T(n) = \left(\frac{n}{2}\right)$

gate2000 easy algorithms time-complexity

1.20.8 Time Complexity: GATE2003-66

https://gateoverflow.in/258

The cube root of a natural number n is defined as the largest natural number m such that $(m^3 \leq n)$. The complexity of computing the cube root of n (n is represented by binary notation) is

A. $O(n)$ but not $O(n^{0.5})$
B. $O(n^{0.5})$ but not $O((\log n)^k)$ for any constant $k > 0$
C. $O((\log n)^k)$ for some constant $k > 0$, but not $O((\log \log n)^m)$ for any constant $m > 0$
D. $O((\log \log n)^k)$ for some constant $k > 0.5$, but not $O((\log \log n)^{0.5})$

gate2003 algorithms time-complexity normal

1.20.9 Time Complexity: GATE2004-39

https://gateoverflow.in/1036

Two matrices M_1 and M_2 are to be stored in arrays A and B respectively. Each array can be stored either in row-major or column-major order in contiguous memory locations. The time complexity of an algorithm to compute $M_1 \times M_2$ will be

A. best if A is in row-major, and B is in column-major order
B. best if both are in row-major order
C. best if both are in column-major order
D. independent of the storage scheme

gate2004 algorithms time-complexity easy

1.20.10 Time Complexity: GATE2004-82

https://gateoverflow.in/1076

Let $A[1,\ldots,n]$ be an array storing a bit (1 or 0) at each location, and $f(m)$ is a function whose time complexity is $\Theta(m)$. Consider the following program fragment written in a C like language:

```
counter = 0;
for (i=1; i<=n; i++)
{
    if a[i] == 1) counter++;
```

```
        else {f (counter); counter = 0;}
    }
```

The complexity of this program fragment is

A. $\Omega(n^2)$
B. $\Omega(n \log n)$ and $O(n^2)$
C. $\Theta(n)$
D. $o(n)$

gate2004 algorithms time-complexity normal

1.20.11 Time Complexity: GATE2006-15

https://gateoverflow.in/976

Consider the following C-program fragment in which i, j and n are integer variables.

```
for( i = n, j = 0; i > 0; i /= 2, j +=i );
```

Let $val(j)$ denote the value stored in the variable j after termination of the for loop. Which one of the following is true?

A. $val(j) = \Theta(\log n)$
B. $val(j) = \Theta(\sqrt{n})$
C. $val(j) = \Theta(n)$
D. $val(j) = \Theta(n \log n)$

gate2006 algorithms normal time-complexity

1.20.12 Time Complexity: GATE2007-15,ISRO2016-26

https://gateoverflow.in/56129

Consider the following segment of C-code:

```
int j, n;
j = 1;
while (j <= n)
    j = j * 2;
```

The number of comparisons made in the execution of the loop for any $n > 0$ is:

A. $\lceil \log_2 n \rceil + 1$
B. n
C. $\lceil \log_2 n \rceil$
D. $\lfloor \log_2 n \rfloor + 1$

gate2007 algorithms time-complexity normal isro2016

1.20.13 Time Complexity: GATE2007-44

https://gateoverflow.in/1242

In the following C function, let $n \geq m$.

```
int gcd(n,m)  {
    if (n%m == 0) return m;
    n = n%m;
    return gcd(m,n);
}
```

How many recursive calls are made by this function?

A. $\Theta(\log_2 n)$
B. $\Omega(n)$
C. $\Theta(\log_2 \log_2 n)$
D. $\Theta(\sqrt{n})$

gate2007 algorithms time-complexity normal

1.20.14 Time Complexity: GATE2007-45

https://gateoverflow.in/1243

What is the time complexity of the following recursive function?

```
int  DoSomething (int n) {
    if (n <= 2)
        return 1;
    else
        return (DoSomething (floor (sqrt(n))) + n);
}
```

A. $\Theta(n^2)$
B. $\Theta(n \log_2 n)$
C. $\Theta(\log_2 n)$
D. $\Theta(\log_2 \log_2 n)$

gate2007 algorithms time-complexity normal

1.20.15 Time Complexity: GATE2007-50

https://gateoverflow.in/1248

An array of n numbers is given, where n is an even number. The maximum as well as the minimum of these n numbers needs to be determined. Which of the following is **TRUE** about the number of comparisons needed?

A. At least $2n - c$ comparisons, for some constant c are needed.
B. At most $1.5n - 2$ comparisons are needed.
C. At least $n \log_2 n$ comparisons are needed
D. None of the above

gate2007 algorithms time-complexity easy

1.20.16 Time Complexity: GATE2007-51

https://gateoverflow.in/1249

Consider the following C program segment:

```
int IsPrime (n)
    {
        int i, n;
        for (i=2; i<=sqrt(n);i++)
            if(n%i == 0)
                {printf("Not Prime \n"); return 0;}
        return 1;
    }
```

Let $T(n)$ denote number of times the for loop is executed by the program on input n. Which of the following is TRUE?

A. $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(\sqrt{n})$
B. $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(1)$
C. $T(n) = O(n)$ and $T(n) = \Omega(\sqrt{n})$
D. None of the above

gate2007 algorithms time-complexity normal

1.20.17 Time Complexity: GATE2007-IT-17

https://gateoverflow.in/3450

Exponentiation is a heavily used operation in public key cryptography. Which of the following options is the tightest upper bound on the number of multiplications required to compute $b^n \bmod m, 0 \leq b, n \leq m$?

A. $O(\log n)$
B. $O(\sqrt{n})$
C. $O\left(\frac{n}{\log n}\right)$
D. $O(n)$

gate2007-it algorithms time-complexity normal

1.20.18 Time Complexity: GATE2007-IT-81

https://gateoverflow.in/3533

Let $P_1, P_2, \ldots, P_n$ be n points in the xy-plane such that no three of them are collinear. For every pair of points P_i and P_j, let L_{ij} be the line passing through them. Let L_{ab} be the line with the steepest gradient among all $n(n-1)/2$ lines.

The time complexity of the best algorithm for finding P_a and P_b is

A. $\Theta(n)$
B. $\Theta(n \log n)$
C. $\Theta(n \log^2 n)$
D. $\Theta(n^2)$

gate2007-it algorithms time-complexity normal

1.20.19 Time Complexity: GATE2008-40

https://gateoverflow.in/452

The minimum number of comparisons required to determine if an integer appears more than $\frac{n}{2}$ times in a sorted array of n integers is

A. $\Theta(n)$ B. $\Theta(\log n)$ C. $\Theta(\log^* n)$ D. $\Theta(1)$

gate2008 normal algorithms time-complexity

1.20.20 Time Complexity: GATE2008-47

https://gateoverflow.in/459

We have a binary heap on n elements and wish to insert n more elements (not necessarily one after another) into this heap. The total time required for this is

A. $\Theta(\log n)$ B. $\Theta(n)$ C. $\Theta(n \log n)$ D. $\Theta(n^2)$

gate2008 algorithms time-complexity normal

1.20.21 Time Complexity: GATE2008-74

https://gateoverflow.in/495

Consider the following C functions:

```
int f1 (int n)
{
    if(n == 0 || n == 1)
        return n;
    else
        return (2 * f1(n-1) + 3 * f1(n-2));
}
int f2(int n)
{
    int i;
    int X[N], Y[N], Z[N];
    X[0] = Y[0] = Z[0] = 0;
    X[1] = 1; Y[1] = 2; Z[1] = 3;
    for(i = 2; i <= n; i++){
        X[i] = Y[i-1] + Z[i-2];
        Y[i] = 2 * X[i];
        Z[i] = 3 * X[i];
    }
    return X[n];
}
```

The running time of $f1(n)$ and $f2(n)$ are

A. $\Theta(n)$ and $\Theta(n)$
B. $\Theta(2^n)$ and $\Theta(n)$
C. $\Theta(n)$ and $\Theta(2^n)$
D. $\Theta(2^n)$ and $\Theta(2^n)$

gate2008 algorithms time-complexity normal

1.20.22 Time Complexity: GATE2008-75

https://gateoverflow.in/43489

Consider the following C functions:

```
int f1 (int n)
{
    if(n == 0 || n == 1)
        return n;
    else
        return (2 * f1(n-1) + 3 * f1(n-2));
}
int f2(int n)
{
    int i;
    int X[N], Y[N], Z[N];
    X[0] = Y[0] = Z[0] = 0;
    X[1] = 1; Y[1] = 2; Z[1] = 3;
    for(i = 2; i <= n; i++){
        X[i] = Y[i-1] + Z[i-2];
        Y[i] = 2 * X[i];
        Z[i] = 3 * X[i];
    }
    return X[n];
}
```

$f1(8)$ and $f2(8)$ return the values

A. 1661 and 1640 B. 59 and 59 C. 1640 and 1640 D. 1640 and 1661

gate2008 normal algorithms time-complexity

1.20.23 Time Complexity: GATE2010-12

https://gateoverflow.in/2185

Two alternative packages A and B are available for processing a database having 10^k records. Package A requires $0.0001n^2$ time units and package B requires $10n \log_{10} n$ time units to process n records. What is the smallest value of k for which package B will be preferred over A?

A. 12 B. 10 C. 6 D. 5

gate2010 algorithms time-complexity easy

1.20.24 Time Complexity: GATE2014-1-42

https://gateoverflow.in/1920

Consider the following pseudo code. What is the total number of multiplications to be performed?

```
D = 2
for i = 1 to n do
    for j = i to n do
        for k = j + 1 to n do
            D = D * 3
```

A. Half of the product of the 3 consecutive integers.
B. One-third of the product of the 3 consecutive integers.
C. One-sixth of the product of the 3 consecutive integers.
D. None of the above.

gate2014-1 algorithms time-complexity normal

1.20.25 Time Complexity: GATE2015-1-40

https://gateoverflow.in/8299

An algorithm performs $(\log N)^{\frac{1}{2}}$ find operations , N insert operations, $(\log N)^{\frac{1}{2}}$ delete operations, and $(\log N)^{\frac{1}{2}}$ decrease-key operations on a set of data items with keys drawn from a linearly ordered set . For a delete operation, a pointer is provided to the record that must be deleted . For the decrease-key operation, a pointer is provided to the record that has its key decreased. Which one of the following data structures is the most suited for the algorithm to use, if the goal is to achieve the best total asymptotic complexity considering all the operations?

A. Unsorted array
B. Min - heap
C. Sorted array
D. Sorted doubly linked list

gate2015-1 algorithms data-structure normal time-complexity

1.20.26 Time Complexity: GATE2015-2-22

https://gateoverflow.in/8113

An unordered list contains n distinct elements. The number of comparisons to find an element in this list that is neither maximum nor minimum is

A. $\Theta(n \log n)$ B. $\Theta(n)$ C. $\Theta(\log n)$ D. $\Theta(1)$

gate2015-2 algorithms time-complexity easy

1.20.27 Time Complexity: GATE2017-2-03

https://gateoverflow.in/118156

Match the algorithms with their time complexities:

Algorithms	Time Complexity
P. Tower of Hanoi with n disks	i. $\Theta(n^2)$
Q. Binary Search given n sorted numbers	ii. $\Theta(n \log n)$
R. Heap sort given n numbers at the worst case	iii. $\Theta(2^n)$
S. Addition of two $n \times n$ matrices	iv. $\Theta(\log n)$

A. $P \rightarrow (iii)$ $Q \rightarrow (iv)$ $r \rightarrow (i)$ $S \rightarrow (ii)$
B. $P \rightarrow (iv)$ $Q \rightarrow (iii)$ $r \rightarrow (i)$ $S \rightarrow (ii)$
C. $P \rightarrow (iii)$ $Q \rightarrow (iv)$ $r \rightarrow (ii)$ $S \rightarrow (i)$
D. $P \rightarrow (iv)$ $Q \rightarrow (iii)$ $r \rightarrow (ii)$ $S \rightarrow (i)$

gate2017-2 algorithms time-complexity

1.20.28 Time Complexity: GATE2017-2-38

https://gateoverflow.in/118283

Consider the following C function

```
int fun(int n) {
    int I, j;
    for(i=1; i<=n; i++) {
        for (j=1; j<n; j+=i) {
            printf("%d %d", I, j);
        }
    }
}
```

Time complexity of fun in terms of Θ notation is

A. $\Theta(n\sqrt{n})$
B. $\Theta(n^2)$
C. $\Theta(n \log n)$
D. $\Theta(n^2 \log n)$

gate2017-2 algorithms time-complexity

1.20.29 Time Complexity: GATE2019-37

https://gateoverflow.in/302811

There are n unsorted arrays: $A_1, A_2, \ldots, A_n$. Assume that n is odd.Each of $A_1, A_2, \ldots, A_n$ contains n distinct elements. There are no common elements between any two arrays. The worst-case time complexity of computing the median of the medians of $A_1, A_2, \ldots, A_n$ is

A. $O(n)$
B. $O(n \log n)$
C. $O(n^2)$
D. $\Omega(n^2 \log n)$

gate2019 algorithms time-complexity

1.20.30 Time Complexity: TIFR2013-B-12

https://gateoverflow.in/25774

It takes $O(n)$ time to find the median in a list of n elements, which are not necessarily in sorted order while it takes only $O(1)$ time to find the median in a list of n sorted elements. How much time does it take to find the median of $2n$ elements which are given as two lists of n sorted elements each?

A. $O(1)$
B. $O(\log n)$ but not $O(1)$
C. $O(\sqrt{n})$ but not $O(\log n)$
D. $O(n)$ but not $O(\sqrt{n})$
E. $O(n \log n)$ but not $O(n)$

tifr2013 algorithms time-complexity

1.20.31 Time Complexity: TIFR2013-B-18

https://gateoverflow.in/25865

Let S be a set of numbers. For $x \in S$, the rank of x is the number of elements in S that are less than or equal to x. The procedure Select(S,r) takes a set S of numbers and a rank $r\,(1 \leq r \leq |S|)$ and returns the element in S of rank r. The procedure MultiSelect(S,R) takes a set of numbers S and a list of ranks $R = \{r_1 < r_2 < \ldots < r_k\}$, and returns the list $\{x_1 < x_2 < \ldots < x_k\}$ of elements of S, such that the rank of x_i is r_i. Suppose there is an implementation for Select(S,r) that uses at most "constant $\cdot |S|$" binary comparisons between elements of S. The minimum number of comparisons needed to implement MultiSelect(S,R) is

a. constant $\cdot |S| \log |S|$
b. constant $\cdot |S|$
c. constant $\cdot |S||R|$
d. constant $\cdot |R| \log |S|$
e. constant $\cdot |S|(1 + \log |R|)$

tifr2013 algorithms time-complexity

1.20.32 Time Complexity: TIFR2014-B-7

https://gateoverflow.in/27189

Which of the following statements is TRUE for all sufficiently large n?

A. $(\log n)^{\log \log n} < 2^{\sqrt{\log n}} < n^{1/4}$

B. $2^{\sqrt{\log n}} < n^{1/4} < (\log n)^{\log \log n}$

C. $n^{1/4} < (\log n)^{\log \log n} < 2^{\sqrt{\log n}}$

D. $(\log n)^{\log \log n} < n^{1/4} < 2^{\sqrt{\log n}}$

E. $2^{\sqrt{\log n}} < (\log n)^{\log \log n} < n^{1/4}$

tifr2014 algorithms time-complexity

1.20.33 Time Complexity: TIFR2015-B-3

https://gateoverflow.in/29846

Consider the following code fragment in the C programming language when run on a non-negative integer n.

```
int f (int n)
{
     if (n==0 || n==1)
         return 1;
     else
```

```
        return f (n - 1) + f(n - 2);
}
```

Assuming a typical implementation of the language, what is the running time of this algorithm and how does it compare to the optimal running time for this problem?

A. This algorithm runs in polynomial time in n but the optimal running time is exponential in n.
B. This algorithm runs in exponential time in n and the optimal running time is exponential in n.
C. This algorithm runs in exponential time in n but the optimal running time is polynomial in n.
D. This algorithm runs in polynomial time in n and the optimal running time is polynomial in n.
E. The algorithm does not terminate.

tifr2015 time-complexity

2 Compiler Design (186)

Lexical analysis, Parsing, Syntax-directed translation, Runtime environments, Intermediate code generation.

Mark Distribution in Previous GATE

Year	2019	2018	2017-1	2017-2	2016-1	2016-2	Minimum	Average	Maximum
1 Mark Count	2	1	2	2	1	1	1	1.5	2
2 Marks Count	2	2	2	1	3	2	1	2	3
Total Marks	6	5	6	4	7	5	**4**	**5.5**	**6**

2.1 Abstract Syntax Tree (1)

2.1.1 Abstract Syntax Tree: GATE2015-2-14

https://gateoverflow.in/8084

In the context of abstract-syntax-tree (AST) and control-flow-graph (CFG), which one of the following is TRUE?

A. In both AST and CFG, let node N_2 be the successor of node N_1. In the input program, the code corresponding to N_2 is present after the code corresponding to N_1
B. For any input program, neither AST nor CFG will contain a cycle
C. The maximum number of successors of a node in an AST and a CFG depends on the input program
D. Each node in AST and CFG corresponds to at most one statement in the input program

gate2015-2 compiler-design easy abstract-syntax-tree

2.2 Assembler (7)

2.2.1 Assembler: GATE1992-01,viii

https://gateoverflow.in/553

The purpose of instruction location counter in an assembler is _____

gate1992 compiler-design assembler normal

2.2.2 Assembler: GATE1992-03,ii

https://gateoverflow.in/579

Mention the pass number for each of the following activities that occur in a two pass assembler:

A. object code generation
B. literals added to literal table
C. listing printed
D. address resolution of local symbols

gate1992 compiler-design assembler easy

2.2.3 Assembler: GATE1992-3,i

https://gateoverflow.in/578

Write short answers to the following:

(i). Which of the following macros can put a macro assembler into an infinite loop?

```
.MACRO MI,X
.IF EQ,X
M1 X+1
.ENDC
.IF NE,X
.WORD X
.ENDC
.ENDM
```

```
.MACRO M2,X
.IF EQ,X
M2 X
.ENDC
.IF NE,X
.WORD X+1
.ENDC
.ENDM
```

Give an example call that does so.

gate1992 compiler-design assembler normal

2.2.4 Assembler: GATE1993-7.6

https://gateoverflow.in/2294

A simple two-pass assembler does the following in the first pass:

A. It allocates space for the literals.
B. It computes the total length of the program.
C. It builds the symbol table for the symbols and their values.

D. It generates code for all the load and store register instructions.
E. None of the above.

gate1993 compiler-design assembler easy

2.2.5 Assembler: GATE1994-17

https://gateoverflow.in/2513

State whether the following statements are True or False with reasons for your answer:

A. Coroutine is just another name for a subroutine.
B. A two pass assembler uses its machine opcode table in the first pass of assembly.

gate1994 compiler-design normal assembler

2.2.6 Assembler: GATE1994-18

https://gateoverflow.in/2514

State whether the following statements are True or False with reasons for your answer

A. A subroutine cannot always be used to replace a macro in an assembly language program.
B. A symbol declared as 'external' in an assembly language program is assigned an address outside the program by the assembler itself.

gate1994 compiler-design normal assembler true-false

2.2.7 Assembler: GATE1996-1.17

https://gateoverflow.in/2721

The pass numbers for each of the following activities

i. object code generation
ii. literals added to literal table
iii. listing printed
iv. address resolution of local symbols that occur in a two pass assembler

respectively are

A. $1,2,1,2$ B. $2,1,2,1$ C. $2,1,1,2$ D. $1,2,2,2$

gate1996 compiler-design normal assembler

2.3 Code Optimization (4)

2.3.1 Code Optimization: GATE2008-12

https://gateoverflow.in/410

Some code optimizations are carried out on the intermediate code because

A. They enhance the portability of the compiler to the target processor
B. Program analysis is more accurate on intermediate code than on machine code
C. The information from dataflow analysis cannot otherwise be used for optimization
D. The information from the front end cannot otherwise be used for optimization

gate2008 normal code-optimization compiler-design

2.3.2 Code Optimization: GATE2014-1-17

https://gateoverflow.in/1784

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

A. A basic block is a sequence of instructions where control enters the sequence at the beginning and exits at the end.
B. Available expression analysis can be used for common subexpression elimination.
C. Live variable analysis can be used for dead code elimination.
D. $x = 4 * 5 \Rightarrow x = 20$ is an example of common subexpression elimination.

gate2014-1 compiler-design code-optimization normal

2.3.3 Code Optimization: GATE2014-3-11

https://gateoverflow.in/2045

The minimum number of arithmetic operations required to evaluate the polynomial $P(X) = X^5 + 4X^3 + 6X + 5$ for a given value of X, using only one temporary variable is _____.

gate2014-3 compiler-design numerical-answers normal code-optimization

2.3.4 Code Optimization: GATE2014-3-34

https://gateoverflow.in/2068

Consider the basic block given below.

```
a = b + c
c = a + d
d = b + c
e = d - b
a = e + b
```

The minimum number of nodes and edges present in the DAG representation of the above basic block respectively are

A. 6 and 6 B. 8 and 10 C. 9 and 12 D. 4 and 4

gate2014-3 compiler-design code-optimization normal

2.4 Compilation Phases (8)

2.4.1 Compilation Phases: GATE1987-1-xi

https://gateoverflow.in/80282

In a compiler the module the checks every character of the source text is called:

A. The code generator.
B. The code optimiser.
C. The lexical analyser.
D. The syntax analyser.

gate1987 compiler-design compilation-phases

2.4.2 Compilation Phases: GATE1990-2-ix

https://gateoverflow.in/84033

Match the pairs in the following questions:

(a)	Lexical analysis	(p)	DAG's
(b)	Code optimization	(q)	Syntax trees
(c)	Code generation	(r)	Push down automaton
(d)	Abelian groups	(s)	Finite automaton

gate1990 match-the-following compiler-design compilation-phases

2.4.3 Compilation Phases: GATE2005-61

https://gateoverflow.in/4066

Consider line number 3 of the following C-program.

```
int main() {                /*Line 1 */
    int I, N;               /*Line 2 */
    fro (I=0, I<N, I++); /*Line 3 */
}
```

Identify the compiler's response about this line while creating the object-module:

A. No compilation error
B. Only a lexical error
C. Only syntactic errors
D. Both lexical and syntactic errors

gate2005 compiler-design compilation-phases normal

2.4.4 Compilation Phases: GATE2009-17

https://gateoverflow.in/1309

Match all items in Group 1 with the correct options from those given in Group 2.Syntax analysis

Group 1		Group 2	
P.	Regular Expression	1.	Syntax analysis
Q.	Pushdown automata	2.	Code generation
R.	Dataflow analysis	3.	Lexical analysis
S.	Register allocation	4.	Code optimization

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

gate2009 compiler-design easy compilation-phases

2.4.5 Compilation Phases: GATE2015-2-19

https://gateoverflow.in/8098

Match the following:

P.	Lexical analysis	1.	Graph coloring
Q.	Parsing	2.	DFA minimization
R.	Register allocation	3.	Post-order traversal
S.	Expression evaluation	4.	Production tree

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

gate2015-2 compiler-design normal compilation-phases

2.4.6 Compilation Phases: GATE2016-2-19

https://gateoverflow.in/39548

Match the following:

(P)	Lexical analysis	(i)	Leftmost derivation
(Q)	Top down parsing	(ii)	Type checking
(R)	Semantic analysis	(iii)	Regular expressions
(S)	Runtime environment	(iv)	Activation records

A. P $\leftrightarrow$ i, Q $\leftrightarrow$ ii, R $\leftrightarrow$ iv, S $\leftrightarrow$ iii
B. P $\leftrightarrow$ iii, Q $\leftrightarrow$ i, R $\leftrightarrow$ ii, S $\leftrightarrow$ iv
C. P $\leftrightarrow$ ii, Q $\leftrightarrow$ iii, R $\leftrightarrow$ i, S $\leftrightarrow$ iv
D. P $\leftrightarrow$ iv, Q $\leftrightarrow$ i, R $\leftrightarrow$ ii, S $\leftrightarrow$ iii

gate2016-2 compiler-design easy compilation-phases

2.4.7 Compilation Phases: GATE2017-2-05

https://gateoverflow.in/118592

Match the following according to input (from the left column) to the compiler phase (in the right column) that processes it:

P. Syntax tree	i. Code generator
Q. Character stream	ii. Syntax analyser
R. Intermediate representation	iii. Semantic analyser
S. Token stream	iv. Lexical analyser

A. P-ii; Q-iii; R-iv; S-i
B. P-ii; Q-i; R-iii; S-iv
C. P-iii; Q-iv; R-i; S-ii
D. P-i; Q-iv; R-ii; S-iii

gate2017-2 compiler-design compilation-phases easy

2.4.8 Compilation Phases: GATE2018-8

https://gateoverflow.in/204082

Which one of the following statements is FALSE?

A. Context-free grammar can be used to specify both lexical and syntax rules
B. Type checking is done before parsing
C. High-level language programs can be translated to different Intermediate Representations

D. Arguments to a function can be passed using the program stack

gate2018 compiler-design easy compilation-phases

2.5 Expression Evaluation (2)

2.5.1 Expression Evaluation: GATE2002-2.19

https://gateoverflow.in/849

To evaluate an expression without any embedded function calls

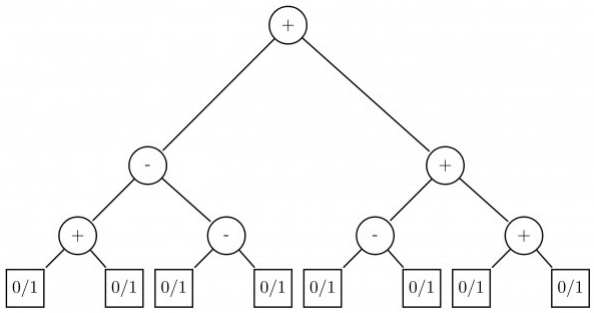
A. One stack is enough
B. Two stacks are needed
C. As many stacks as the height of the expression tree are needed
D. A Turing machine is needed in the general case

gate2002 compiler-design expression-evaluation easy

2.5.2 Expression Evaluation: GATE2014-2-39

https://gateoverflow.in/1999

Consider the expression tree shown. Each leaf represents a numerical value, which can either be 0 or 1. Over all possible choices of the values at the leaves, the maximum possible value of the expression represented by the tree is ___.



gate2014-2 compiler-design normal expression-evaluation numerical-answers

2.6 Grammar (41)

2.6.1 Grammar: GATE1990-16a

https://gateoverflow.in/86869

Show that grammar $G1$ is ambiguous using parse trees:

G_1 : $S \rightarrow$ if S then S else S

$S \rightarrow$ if S then S

gate1990 descriptive compiler-design grammar

2.6.2 Grammar: GATE1991-10a

https://gateoverflow.in/537

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

$$E \rightarrow E - T \mid T$$

$$T \rightarrow T/F \mid F$$

$$F \rightarrow (E) \mid id$$

(E is the start symbol)

Is the grammar unambiguous? Is so, what is the relative precedence between $-$ and $/$? If not, give an unambiguous grammar that gives $/$ precedence over $-$.

gate1991 grammar compiler-design normal descriptive

2.6.3 Grammar: GATE1991-10b

https://gateoverflow.in/43604

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

$E \rightarrow E - T \mid T$

$T \rightarrow T/F \mid F$

$F \rightarrow (E) \mid id$

(E is the start symbol)

Does the grammar allow expressions with redundant parentheses as in (id/id) or in $id - (id/id)$? If so, convert the grammar into one which does not generate expressions with redundant parentheses. Do this with minimum number of changes to the given production rules and adding at most one more production rule.

gate1991 grammar compiler-design normal descriptive

2.6.4 Grammar: GATE1991-10c

https://gateoverflow.in/43605

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

- $E \rightarrow E - T \mid T$
- $T \rightarrow T/F \mid F$
- $F \rightarrow (E) \mid id$

(E is the start symbol)

Does the grammar allow expressions with redundant parentheses as in (id/id) or in $id - (id/id)$? If so, convert the grammar into one which does not generate expressions with redundant parentheses. Do this with minimum number of changes to the given production rules and adding at most one more production rule.

Convert the grammar obtained above into one that is not left recursive.

gate1991 grammar compiler-design normal descriptive

2.6.5 Grammar: GATE1994-1.18

https://gateoverflow.in/2461

Which of the following features cannot be captured by context-free grammars?

A. Syntax of if-then-else statements
B. Syntax of recursive procedures
C. Whether a variable has been declared before its use
D. Variable names of arbitrary length

gate1994 compiler-design grammar normal

2.6.6 Grammar: GATE1994-20

https://gateoverflow.in/2516

A grammar G is in Chomsky-Normal Form (CNF) if all its productions are of the form $A \rightarrow BC$ or $A \rightarrow a$, where A, B and C, are non-terminals and a is a terminal. Suppose G is a CFG in CNF and w is a string in $L(G)$ of length n, then how long is a derivation of w in G?

gate1994 compiler-design grammar normal

2.6.7 Grammar: GATE1994-3.5

https://gateoverflow.in/2482

Match the following items

(i)	Backus-Naur form	(a)	Regular expressions
(ii)	Lexical analysis	(b)	LALR(1) grammar
(iii)	YACC	(c)	LL(1) grammars
(iv)	Recursive descent parsing	(d)	General context-free grammars

gate1994 compiler-design grammar normal

2.6.8 Grammar: GATE1995-1.10

https://gateoverflow.in/2597

Consider a grammar with the following productions

- $S \rightarrow a\alpha b \mid b\alpha c \mid aB$
- $S \rightarrow \alpha S \mid b$
- $S \rightarrow \alpha bb \mid ab$
- $S\alpha \rightarrow bdb \mid b$

The above grammar is:

A. Context free B. Regular C. Context sensitive D. $LR(k)$

gate1995 compiler-design grammar normal

2.6.9 Grammar: GATE1995-9

https://gateoverflow.in/2644

A. Translate the arithmetic expression $a^* - (b + c)$ into syntax tree.
B. A grammar is said to have cycles if it is the case that

$A \Rightarrow^+ A$

Show that no grammar that has cycles can be LL(1).

gate1995 compiler-design grammar normal

2.6.10 Grammar: GATE1996-11

https://gateoverflow.in/2763

Let G be a context-free grammar where $G = (\{S, A, B, C\}, \{a, b, d\}, P, S)$ with the productions in P given below.

$S \rightarrow ABAC$

$A \rightarrow aA \mid \varepsilon$

$B \rightarrow bB \mid \varepsilon$

$C \rightarrow d$

(ε denotes the null string). Transform the grammar G to an equivalent context-free grammar G' that has no ε productions and no unit productions. (A unit production is of the form $x \rightarrow y$, and x and y are non terminals).

gate1996 compiler-design grammar normal

2.6.11 Grammar: GATE1996-2.10

https://gateoverflow.in/2739

The grammar whose productions are

- $\langle \text{stmt} \rangle \rightarrow \text{if id then } \langle \text{stmt} \rangle$
- $\langle \text{stmt} \rangle \rightarrow \text{if id then } \langle \text{stmt} \rangle \text{ else } \langle \text{stmt} \rangle$
- $\langle \text{stmt} \rangle \rightarrow \text{id} := \text{id}$

is ambiguous because

(a) the sentence

```
if a then if b then c:= d
```

has more than two parse trees

(b) the left most and right most derivations of the sentence

```
if a then if b then c:= d
```

give rise to different parse trees

(c) the sentence

```
if a then if b then c:= d else c:= f
```

has more than two parse trees

(d) the sentence

```
if a then if b then c:= d else c:= f
```

has two parse trees

gate1996 compiler-design grammar normal

2.6.12 Grammar: GATE1997-1.6

https://gateoverflow.in/2222

In the following grammar

$$\begin{aligned} X &::= X \oplus Y \mid Y \\ Y &::= Z * Y \mid Z \\ Z &::= id \end{aligned}$$

Which of the following is true?

A. '$\oplus$' is left associative while '$*$' is right associative
B. Both '$\oplus$' and '$*$' are left associative
C. '$\oplus$' is right associative while '$*$' is left associative
D. None of the above

gate1997 compiler-design grammar normal

2.6.13 Grammar: GATE1997-11

https://gateoverflow.in/2271

Consider the grammar

- $S \rightarrow bSe$
- $S \rightarrow PQR$
- $P \rightarrow bPc$
- $P \rightarrow \varepsilon$
- $Q \rightarrow cQd$
- $Q \rightarrow \varepsilon$
- $R \rightarrow dRe$
- $R \rightarrow \varepsilon$

where S,P,Q,R are non-terminal symbols with S being the start symbol; b,c,d,e are terminal symbols and 'ε' is the empty string. This grammar generates strings of the form b^i,c^j,d^k,e^m for some $i,j,k,m \geq 0$.

a. What is the condition on the values of i,j,k,m?
b. Find the smallest string that has two parse trees.

gate1997 compiler-design grammar normal theory-of-computation

2.6.14 Grammar: GATE1998-14

https://gateoverflow.in/1728

A. Let $G_1 = (N,T,P,S_1)$ be a CFG where, $N = \{S_1, A, B\}, T = \{a,b\}$ and P is given by

$S_1 \rightarrow aS_1b$	$S_1 \rightarrow aBb$
$S_1 \rightarrow aAb$	$B \rightarrow Bb$
$A \rightarrow aA$	$B \rightarrow b$
$A \rightarrow a$	

What is $L(G_1)$?

B. Use the grammar in Part(a) to give a CFG for $L_2 = \{a^ib^ja^kb^l \mid i,j,k,l \geq 1, i = j \text{ or } k = l\}$ by adding not more than 5 production rules.

C. Is L_2 inherently ambiguous?

gate1998 compiler-design grammar descriptive

2.6.15 Grammar: GATE1998-6b

https://gateoverflow.in/1697

Consider the grammar

- S $\rightarrow Aa \mid b$
- A $\rightarrow Ac \mid Sd \mid \epsilon$

Construct an equivalent grammar with no left recursion and with minimum number of production rules.

gate1998 compiler-design grammar descriptive

2.6.16 Grammar: GATE1999-2.15

https://gateoverflow.in/1493

A grammar that is both left and right recursive for a non-terminal, is

A. Ambiguous
B. Unambiguous
C. Information is not sufficient to decide whether it is ambiguous or unambiguous
D. None of the above

gate1999 compiler-design grammar normal

2.6.17 Grammar: GATE2000-2.21, ISRO2015-24

https://gateoverflow.in/668

Given the following expression grammar:

$$E \rightarrow E * F \mid F + E \mid F$$

$$F \quad \rightarrow F - F \mid id$$

Which of the following is true?

A. $*$ has higher precedence than $+$
B. $-$ has higher precedence than $*$
C. $+$ and $-$ have same precedence
D. $+$ has higher precedence than $*$

gate2000 grammar normal compiler-design isro2015

2.6.18 Grammar: GATE2001-1.18

https://gateoverflow.in/711

Which of the following statements is false?

A. An unambiguous grammar has same leftmost and rightmost derivation
B. An LL(1) parser is a top-down parser
C. LALR is more powerful than SLR
D. An ambiguous grammar can never be LR(k) for any k

gate2001 compiler-design grammar normal

2.6.19 Grammar: GATE2001-18

https://gateoverflow.in/759

A. Remove left-recursion from the following grammar: $S \rightarrow Sa \mid Sb \mid a \mid b$
B. Consider the following grammar:

$$S \rightarrow aSbS \mid bSaS \mid \epsilon$$

Construct all possible parse trees for the string abab. Is the grammar ambiguous?

gate2001 compiler-design grammar descriptive

2.6.20 Grammar: GATE2003-56

https://gateoverflow.in/944

Consider the grammar shown below

- $S \rightarrow iEtSS' \mid a$
- $S' \rightarrow eS \mid \epsilon$

- $E \rightarrow b$

In the predictive parse table, M, of this grammar, the entries $M[S', e]$ and $M[S', \$]$ respectively are

A. $\{S' \rightarrow eS\}$ and $\{S' \rightarrow \epsilon\}$
B. $\{S' \rightarrow eS\}$ and $\{\}$
C. $\{S' \rightarrow \epsilon\}$ and $\{S' \rightarrow \epsilon\}$
D. $\{S' \rightarrow eS, S' \rightarrow \varepsilon\}$ and $\{S' \rightarrow \epsilon\}$

gate2003 compiler-design grammar normal

2.6.21 Grammar: GATE2003-58

https://gateoverflow.in/946

Consider the translation scheme shown below.

S $\rightarrow$ T R

R $\rightarrow$ + T {*print*('+');} R$|\varepsilon$

T $\rightarrow$ **num** {*print*(**num.**val);}

Here **num** is a token that represents an integer and **num**.val represents the corresponding integer value. For an input string '$9 + 5 + 2$', this translation scheme will print

A. $9 + 5 + 2$ B. $9\,5 + 2+$ C. $9\,5\,2 + +$ D. $+ + 9\,5\,2$

gate2003 compiler-design grammar normal

2.6.22 Grammar: GATE2004-45

https://gateoverflow.in/1042

Consider the grammar with the following translation rules and E as the start symbol

$$\begin{array}{ll} E \rightarrow E_1 \# T & \{E.value = E_1.value * T.value\} \\ \quad |T & \{E.value = T.value\} \\ T \rightarrow T_1 \& F & \{T.value = T_1.value + F.value\} \\ \quad |F & \{T.value = F.value\} \\ F \rightarrow \text{num} & \{F.value = num.value\} \end{array}$$

Compute E.value for the root of the parse tree for the expression: $2 \# 3 \,\&\, 5 \# 6 \,\&\, 4$

A. 200 B. 180 C. 160 D. 40

gate2004 compiler-design grammar normal

2.6.23 Grammar: GATE2004-8

https://gateoverflow.in/1005

Which of the following grammar rules violate the requirements of an operator grammar? P, Q, R are nonterminals, and r, s, t are terminals.

I. P $\rightarrow$ Q R
II. P $\rightarrow$ Q s R
III. P $\rightarrow$ ε
IV. P $\rightarrow$ Q t R r

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

gate2004 compiler-design grammar normal

2.6.24 Grammar: GATE2004-88

https://gateoverflow.in/1082

Consider the following grammar G:

$S \rightarrow bS \mid aA \mid b$

$A \rightarrow bA \mid aB$

$B \rightarrow bB \mid aS \mid a$

Let $N_a(w)$ and $N_b(w)$ denote the number of a's and b's in a string ω respectively.

The language $L(G)$ over $\{a,b\}^+$ generated by G is

A. $\{w \mid N_a(w) > 3N_b(w)\}$
B. $\{w \mid N_b(w) > 3N_a(w)\}$
C. $\{w \mid N_a(w) = 3k, k \in \{0,1,2,\ldots\}\}$
D. $\{w \mid N_b(w) = 3k, k \in \{0,1,2,\ldots\}\}$

gate2004 compiler-design grammar normal

2.6.25 Grammar: GATE2005-59

https://gateoverflow.in/1382

Consider the grammar:

$$E \rightarrow E + n \mid E \times n \mid n$$

For a sentence $n + n \times n$, the handles in the right-sentential form of the reduction are:

A. $n, E + n$ and $E + n \times n$
B. $n, E + n$ and $E + E \times n$
C. $n, n + n$ and $n + n \times n$
D. $n, E + n$ and $E \times n$

gate2005 compiler-design grammar normal

2.6.26 Grammar: GATE2006-32, ISRO2016-35

https://gateoverflow.in/995

Consider the following statements about the context free grammar

$$G = \{S \rightarrow SS, S \rightarrow ab, S \rightarrow ba, S \rightarrow \epsilon\}$$

I. G is ambiguous
II. G produces all strings with equal number of a's and b's
III. G can be accepted by a deterministic PDA.

Which combination below expresses all the true statements about G?

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

gate2006 compiler-design grammar normal isro2016

2.6.27 Grammar: GATE2006-59

https://gateoverflow.in/1837

Consider the following translation scheme.

- $S \rightarrow ER$
- $R \rightarrow^* E\{print('*');\}R \mid \varepsilon$
- $E \rightarrow F + E\{print('+');\} \mid F$
- $F \rightarrow (S) \mid id\{print(id.value);\}$

Here *id* is a token that represents an integer and *id.value* represents the corresponding integer value. For an input '$2 * 3 + 4$', this translation scheme prints

A. $2 * 3 + 4$
B. $2 * + 3\ 4$
C. $2\ 3 * 4 +$
D. $2\ 3\ 4 + *$

gate2006 compiler-design grammar normal

2.6.28 Grammar: GATE2006-84

https://gateoverflow.in/1856

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

A. $S \rightarrow AC \mid CB$
$C \rightarrow aCb \mid a \mid b$
$A \rightarrow aA \mid \varepsilon$
$B \rightarrow Bb \mid \varepsilon$

B. $S \rightarrow aS \mid Sb \mid a \mid b$

C. $S \rightarrow AC \mid CB$
$C \rightarrow aCb \mid \varepsilon$
$A \rightarrow aA \mid \varepsilon$
$B \rightarrow Bb \mid \varepsilon$

D. $S \rightarrow AC \mid CB$
$C \rightarrow aCb \mid \varepsilon$
$A \rightarrow aA \mid a$
$B \rightarrow Bb \mid b$

gate2006 compiler-design grammar normal theory-of-computation

2.6.29 Grammar: GATE2006-85

https://gateoverflow.in/79799

Find the grammar that generates the language $L = \{a^i b^j \mid i \neq j\}$. In that grammar what is the length of the derivation (number of steps starring from S) to generate the string $a^l b^m$ with $l \neq m$

A. $max(l,m)+2$ B. $l+m+2$ C. $l+m+3$ D. $max(l,m)+3$

gate2006 compiler-design grammar normal

2.6.30 Grammar: GATE2006-85

https://gateoverflow.in/79801

The grammar

- $S \rightarrow AC \mid CB$
- $C \rightarrow aCb \mid \varepsilon$
- $A \rightarrow aA \mid a$
- $B \rightarrow Bb \mid b$

generates the language $L = \{a^i b^j \mid i \neq j\}$. In that grammar what is the length of the derivation (number of steps starting from S) to generate the string $a^l b^m$ with $l \neq m$

A. $max(l,m)+2$ B. $l+m+2$ C. $l+m+3$ D. $max(l,m)+3$

gate2006 compiler-design grammar normal

2.6.31 Grammar: GATE2007-52

https://gateoverflow.in/1250

Consider the grammar with non-terminals $N = \{S, C, S_1\}$, terminals $T = \{a, b, i, t, e\}$, with S as the start symbol, and the following set of rules:

$S \rightarrow iCtSS_1 \mid a$

$S_1 \rightarrow eS \mid \epsilon$

$C \rightarrow b$

The grammar is NOT LL(1) because:

A. it is left recursive
B. it is right recursive
C. it is ambiguous
D. it is not context-free

gate2007 compiler-design grammar normal

2.6.32 Grammar: GATE2007-53

https://gateoverflow.in/1251

Consider the following two statements:

- P: Every regular grammar is LL(1)
- Q: Every regular set has a LR(1) grammar

Which 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

gate2007 compiler-design grammar normal

2.6.33 Grammar: GATE2007-78

https://gateoverflow.in/1272

Consider the CFG with $\{S, A, B\}$ as the non-terminal alphabet, $\{a, b\}$ as the terminal alphabet, S as the start symbol and the following set of production rules:

$S \rightarrow aB \qquad S \rightarrow bA$
$B \rightarrow b \qquad A \rightarrow a$
$B \rightarrow bS \qquad A \rightarrow aS$
$B \rightarrow aBB \qquad S \rightarrow bAA$

Which of the following strings is generated by the grammar?

A. $aaaabb$ B. $aabbbb$ C. $aabbab$ D. $abbbba$

gate2007 compiler-design grammar normal

2.6.34 Grammar: GATE2007-79

https://gateoverflow.in/43512

Consider the CFG with $\{S, A, B\}$ as the non-terminal alphabet, $\{a, b\}$ as the terminal alphabet, S as the start symbol and the following set of production rules:

$S \rightarrow aB \qquad S \rightarrow bA$
$B \rightarrow b \qquad A \rightarrow a$
$B \rightarrow bS \qquad A \rightarrow aS$
$B \rightarrow aBB \qquad S \rightarrow bAA$

For the string $aabbab$, how many derivation trees are there?

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

gate2007 compiler-design grammar normal

2.6.35 Grammar: GATE2007-IT-9

https://gateoverflow.in/3442

Consider an ambiguous grammar G and its disambiguated version D. Let the language recognized by the two grammars be denoted by $L(G)$ and $L(D)$ respectively. Which one of the following is true?

A. $L(D) \subset L(G)$
B. $L(D) \supset L(G)$
C. $L(D) = L(G)$
D. $L(D)$ is empty

gate2007-it compiler-design grammar normal

2.6.36 Grammar: GATE2008-50

https://gateoverflow.in/395

Which of the following statements are true?

I. Every left-recursive grammar can be converted to a right-recursive grammar and vice-versa
II. All ϵ-productions can be removed from any context-free grammar by suitable transformations
III. The language generated by a context-free grammar all of whose productions are of the form $X \rightarrow w$ or $X \rightarrow wY$ (where, w is a string of terminals and Y is a non-terminal), is always regular
IV. The derivation trees of strings generated by a context-free grammar in Chomsky Normal Form are always binary trees

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

gate2008 normal compiler-design grammar

2.6.37 Grammar: GATE2010-38

https://gateoverflow.in/2339

The grammar $S \rightarrow aSa \mid bS \mid c$ is

A. LL(1) but not LR(1)
B. LR(1) but not LL(1)
C. Both LL(1) and LR(1)
D. Neither LL(1) nor LR(1)

gate2010 compiler-design grammar normal

2.6.38 Grammar: GATE2014-2-17

https://gateoverflow.in/1973

Consider the grammar defined by the following production rules, with two operators $*$ and $+$

- $S \rightarrow T * P$

- $T \rightarrow U \mid T * U$
- $P \rightarrow Q + P \mid Q$
- $Q \rightarrow Id$
- $U \rightarrow Id$

Which one of the following is TRUE?

A. $+$ is left associative, while $*$ is right associative
B. $+$ is right associative, while $*$ is left associative
C. Both $+$ and $*$ are right associative
D. Both $+$ and $*$ are left associative

gate2014-2 compiler-design grammar normal

2.6.39 Grammar: GATE2016-2-45 https://gateoverflow.in/39594

Which one of the following grammars is free from left recursion?

A. $S \rightarrow AB$, $A \rightarrow Aa \mid b$, $B \rightarrow c$

B. $S \rightarrow Ab \mid Bb \mid c$, $A \rightarrow Bd \mid \epsilon$, $B \rightarrow e$

C. $S \rightarrow Aa \mid B$, $A \rightarrow Bb \mid Sc \mid \epsilon$, $B \rightarrow d$

D. $S \rightarrow Aa \mid Bb \mid c$, $A \rightarrow Bd \mid \epsilon$, $B \rightarrow Ae \mid \epsilon$

gate2016-2 compiler-design grammar easy

2.6.40 Grammar: GATE2016-2-46 https://gateoverflow.in/39598

A student wrote two context-free grammars G1 and G2 for generating a single C-like array declaration. The dimension of the array is at least one. For example,

```
int a[10] [3];
```

The grammars use D as the start symbol, and use six terminal symbols **int ; id [ ] num.**

Grammar **G1**	Grammar **G2**
D $\rightarrow$ **int L;**	D $\rightarrow$ **int L;**
L $\rightarrow$ **id** [**E**	L $\rightarrow$ **id E**
E $\rightarrow$ **num**]	E $\rightarrow$ **E** [**num**]
E $\rightarrow$ **num**] [**E**	E $\rightarrow$ [**num**]

Which of the grammars correctly generate the declaration mentioned above?

A. Both **G1** and **G2** B. Only **G1** C. Only **G2** D. Neither **G1** nor **G2**

gate2016-2 compiler-design grammar normal

2.6.41 Grammar: GATE2019-43 https://gateoverflow.in/302805

Consider the augmented grammar given below:

- $S' \rightarrow S$
- $S \rightarrow \langle L \rangle \mid id$
- $L \rightarrow L, S \mid S$

Let $I_0 = \text{CLOSURE}(\{[S' \rightarrow \cdot S]\})$. The number of items in the set $\text{GOTO}(I_0, \langle)$ is_____

gate2019 numerical-answers compiler-design grammar

2.7 Infix Postfix (1)

2.7.1 Infix Postfix: GATE1989-4-ii https://gateoverflow.in/87881

Provide short answers to the following questions:

Compute the postfix equivalent of the following infix arithmetic expression

$a + b * c + d * e \uparrow f$

where $\uparrow$ represents exponentiation. Assume normal operator precedences.

gate1989 descriptive compiler-design infix-postfix intermediate-code

2.8 Intermediate Code (8)

2.8.1 Intermediate Code: GATE1988-2xvii

https://gateoverflow.in/94350

Construct a DAG for the following set of quadruples:

- E:=A+B
- F:=E-C
- G:=F*D
- H:=A+B
- I:=I-C
- J:=I+G

gate1988 descriptive compiler-design intermediate-code

2.8.2 Intermediate Code: GATE1989-4-v

https://gateoverflow.in/87885

Is the following code template for the if-then-else statement correct? if not, correct it.

if expression then statement 1

else statement 2

Template:

Code for expression

(*result in $E, E > O$ indicates true *)

Branch on $E > O$ to $L1$

Code for statement 1

$L1$: Code for statement 2

descriptive gate1989 compiler-design intermediate-code

2.8.3 Intermediate Code: GATE1992-11b

https://gateoverflow.in/43583

Write 3 address intermediate code (quadruples) for the following boolean expression in the sequence as it would be generated by a compiler. Partial evaluation of boolean expressions is not permitted. Assume the usual rules of precedence of the operators.

$$(a + b) > (c + d) \text{ or } a > c \text{ and } b < d$$

gate1992 compiler-design syntax-directed-translation intermediate-code descriptive

2.8.4 Intermediate Code: GATE1994-1.12

https://gateoverflow.in/2453

Generation of intermediate code based on an abstract machine model is useful in compilers because

A. it makes implementation of lexical analysis and syntax analysis easier
B. syntax-directed translations can be written for intermediate code generation
C. it enhances the portability of the front end of the compiler
D. it is not possible to generate code for real machines directly from high level language programs

gate1994 compiler-design intermediate-code easy

2.8.5 Intermediate Code: GATE2014-2-34

https://gateoverflow.in/1993

For a C program accessing $\mathbf{X[i][j][k]}$, the following intermediate code is generated by a compiler. Assume that the size of an **integer** is 32 bits and the size of a **character** is 8 bits.

```
t0 = i * 1024
t1 = j * 32
t2 = k * 4
t3 = t1 + t0
t4 = t3 + t2
t5 = X[t4]
```

Which one of the following statements about the source code for the C program is CORRECT?

A. $\mathbf{X}$ is declared as **"int $\mathbf{X[32][32][8]}$ "**.
B. $\mathbf{X}$ is declared as **"int $\mathbf{X[4][1024][32]}$ "**.
C. $\mathbf{X}$ is declared as **"char $\mathbf{X[4][32][8]}$ "**.
D. $\mathbf{X}$ is declared as **"char $\mathbf{X[32][16][2]}$ "**.

gate2014-2 compiler-design intermediate-code programming-in-c normal

2.8.6 Intermediate Code: GATE2014-3-17

https://gateoverflow.in/2051

One of the purposes of using intermediate code in compilers is to

A. make parsing and semantic analysis simpler.
B. improve error recovery and error reporting.
C. increase the chances of reusing the machine-independent code optimizer in other compilers.
D. improve the register allocation.

gate2014-3 compiler-design intermediate-code easy

2.8.7 Intermediate Code: GATE2015-1-55

https://gateoverflow.in/8365

The least number of temporary variables required to create a three-address code in static single assignment form for the expression $q + r/3 + s - t * 5 + u * v/w$ is_____.

gate2015-1 compiler-design intermediate-code normal numerical-answers

2.8.8 Intermediate Code: GATE2015-1-8

https://gateoverflow.in/8096

For computer based on three-address instruction formats, each address field can be used to specify which of the following:

(S1) A memory operand

(S2) A processor register

(S3) An implied accumulator register

A. Either $S1$ or $S2$
B. Either $S2$ or $S3$
C. Only $S2$ and $S3$
D. All of $S1$, $S2$ and $S3$

gate2015-1 compiler-design intermediate-code normal

2.9 Left Recursion (1)

2.9.1 Left Recursion: GATE2017-2-32

https://gateoverflow.in/118374

Consider the following expression grammar G:

- $E \rightarrow E - T \mid T$
- $T \rightarrow T + F \mid F$
- $F \rightarrow (E) \mid id$

Which of the following grammars is not left recursive, but is equivalent to G?

A. $E \rightarrow E - T \mid T$ B. $E \rightarrow TE'$ C. $E \rightarrow TX$ D. $E \rightarrow TX \mid (TX)$

$T \rightarrow T + F \mid F$
$F \rightarrow (E) \mid id$

$E' \rightarrow -TE' \mid \epsilon$
$T \rightarrow T + F \mid F$
$F \rightarrow (E) \mid id$

$X \rightarrow -TX \mid \epsilon$
$T \rightarrow FY$
$Y \rightarrow +FY \mid \epsilon$
$F \rightarrow (E) \mid id$

$X \rightarrow -TX \mid +TX \mid \epsilon$
$T \rightarrow id$

gate2017-2 grammar left-recursion

2.10 Lexical Analysis (6)

2.10.1 Lexical Analysis: GATE1987-1-xvii

https://gateoverflow.in/80364

Using longer identifiers in a program will necessarily lead to:

A. Somewhat slower compilation
B. A program that is easier to understand
C. An incorrect program
D. None of the above

gate1987 compiler-design lexical-analysis

2.10.2 Lexical Analysis: GATE2000-1.18, ISRO2015-25

https://gateoverflow.in/641

The number of tokens in the following C statement is

```
printf("i=%d, &i=%x", i, &i);
```

A. 3 B. 26 C. 10 D. 21

gate2000 compiler-design lexical-analysis easy isro2015

2.10.3 Lexical Analysis: GATE2010-13

https://gateoverflow.in/2186

Which data structure in a compiler is used for managing information about variables and their attributes?

A. Abstract syntax tree
B. Symbol table
C. Semantic stack
D. Parse table

gate2010 compiler-design lexical-analysis easy

2.10.4 Lexical Analysis: GATE2011-1

https://gateoverflow.in/2103

In a compiler, keywords of a language are recognized during

A. parsing of the program
B. the code generation
C. the lexical analysis of the program
D. dataflow analysis

gate2011 compiler-design lexical-analysis easy

2.10.5 Lexical Analysis: GATE2011-19

https://gateoverflow.in/2121

The lexical analysis for a modern computer language such as Java needs the power of which one of the following machine models in a necessary and sufficient sense?

A. Finite state automata
B. Deterministic pushdown automata
C. Non-deterministic pushdown automata
D. Turing machine

gate2011 compiler-design lexical-analysis easy

2.10.6 Lexical Analysis: GATE2018-37

https://gateoverflow.in/204111

A lexical analyzer uses the following patterns to recognize three tokens T_1, T_2, and T_3 over the alphabet $\{a,b,c\}$.

T_1: $a?(b \mid c)^*a$

T_2: $b?(a \mid c)^*b$

T_3: $c?(b \mid a)^*c$

Note that 'x?' means 0 or 1 occurrence of the symbol x. Note also that the analyzer outputs the token that matches the longest possible prefix.

If the string bbaacabc is processes by the analyzer, which one of the following is the sequence of tokens it outputs?

A. $T_1T_2T_3$ B. $T_1T_1T_3$ C. $T_2T_1T_3$ D. T_3T_3

gate2018 compiler-design lexical-analysis normal

2.11 Linking (3)

2.11.1 Linking: GATE1991-03,ix

https://gateoverflow.in/519

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

A “link editor” is a program that:

A. matches the parameters of the macro-definition with locations of the parameters of the macro call
B. matches external names of one program with their location in other programs
C. matches the parameters of subroutine definition with the location of parameters of subroutine call.
D. acts as a link between text editor and the user
E. acts as a link between compiler and the user program

gate1991 compiler-design normal linking

2.11.2 Linking: GATE2003-76

https://gateoverflow.in/962

Which of the following is NOT an advantage of using shared, dynamically linked libraries as opposed to using statistically linked libraries?

A. Smaller sizes of executable files
B. Lesser overall page fault rate in the system
C. Faster program startup
D. Existing programs need not be re-linked to take advantage of newer versions of libraries

gate2003 compiler-design runtime-environments linking easy

2.11.3 Linking: GATE2004-9

https://gateoverflow.in/1006

Consider a program P that consists of two source modules M_1 and M_2 contained in two different files. If M_1 contains a reference to a function defined in M_2 the reference will be resolved at

A. Edit time B. Compile time C. Link time D. Load time

gate2004 compiler-design easy linking

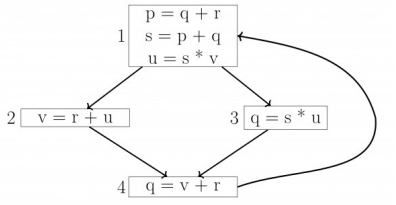
2.12 Live Variable (1)

2.12.1 Live Variable: GATE2015-1-50

https://gateoverflow.in/8356

A variable x is said to be live at a statement s_i in a program if the following three conditions hold simultaneously:

i. There exists a statement S_j that uses x
ii. There is a path from S_i to S_j in the flow graph corresponding to the program
iii. The path has no intervening assignment to x including at S_i and S_j



The variables which are live both at the statement in basic block 2 and at the statement in basic block 3 of the above control flow graph are

A. p, s, u B. r, s, u C. r, u D. q, v

gate2015-1 compiler-design live-variable normal

2.13 Macros (4)

2.13.1 Macros: GATE1992-01,vii

https://gateoverflow.in/552

Macro expansion is done in pass one instead of pass two in a two pass macro assembler because _____

gate1992 compiler-design macros easy

2.13.2 Macros: GATE1995-1.11

https://gateoverflow.in/2598

What are x and y in the following macro definition?

```
macro Add x, y
        Load y
        Mul x
        Store y
end macro
```

A. Variables
B. Identifiers
C. Actual parameters
D. Formal parameters

gate1995 compiler-design macros easy

2.13.3 Macros: GATE1996-2.16

https://gateoverflow.in/2745

Which of the following macros can put a macro assembler into an infinite loop?

i.
```
.MACRO M1, X
.IF EQ, X   ;if X=0 then
M1 X + 1
.ENDC
.IF NE, X   ;if X ≠ 0 then
.WORD X  ;address (X) is stored here
.ENDC
.ENDM
```

ii.
```
.MACRO M2, X
.IF EQ, X
M2 X
.ENDC
.IF NE, X
.WORD X + 1
.ENDC
.ENDM
```

A. (ii) only
B. (i) only
C. both (i) and (ii)
D. None of the above

gate1996 compiler-design macros normal

2.13.4 Macros: GATE1997-1.9

https://gateoverflow.in/2225

The conditional expansion facility of macro processor is provided to

A. test a condition during the execution of the expanded program
B. to expand certain model statements depending upon the value of a condition during the execution of the expanded program
C. to implement recursion
D. to expand certain model statements depending upon the value of a condition during the process of macro expansion

gate1997 compiler-design macros easy

2.14 Parameter Passing (13)

2.14.1 Parameter Passing: GATE1988-2xv

https://gateoverflow.in/94333

What is printed by following program, assuming call-by reference method of passing parameters for all variables in the parameter list of procedure P?

```
program     Main(inout, output);
var     a, b:integer;
        procedure P(x, y, z:integer);
        begin
            y:=y+1
            z:=x+x
        end P;
begin
    a:=2; b:=3;
```

```
    p(a+b, a, a);
    Write(a)
end.
```

gate1988 descriptive compiler-design runtime-environments parameter-passing numerical-answers

2.14.2 Parameter Passing: GATE1988-8i

https://gateoverflow.in/94371

Consider the procedure declaration:

```
Procedure
P (k: integer)
```

where the parameter passing mechanism is call-by-value-result. Is it correct if the call, P (A[i]), where A is an array and i an integer, is implemented as below.

a. create a new local variable, say z;
b. assign to z, the value of A [i];
c. execute the body of P using z for k;
d. set A [i] to z;

Explain your answer. If this is incorrect implementation, suggest a correct one.

gate1988 descriptive compiler-design runtime-environments parameter-passing

2.14.3 Parameter Passing: GATE1989-3-viii

https://gateoverflow.in/37264

In which of the following case(s) is it possible to obtain different results for call-by-reference and call-by-name parameter passing?

A. Passing an expression as a parameter
B. Passing an array as a parameter
C. Passing a pointer as a parameter
D. Passing as array element as a parameter

gate1989 parameter-passing runtime-environments compiler-design

2.14.4 Parameter Passing: GATE1990-11a

https://gateoverflow.in/85981

What does the following program output?

```
program module (input, output);
var
    a:array [1...5] of integer;
    i, j: integer;
procedure unknown (var b: integer, var c: integer);
var
    i:integer;
begin
    for i := 1 to 5 do a[i] := i;
    b:= 0; c := 0
    for i := 1 to 5 do write (a[i]);
    writeln();
    a[3]:=11; a[1]:=11;
    for i:=1 to 5 do a [i] := sqr(i);
    writeln(c,b); b := 5; c := 6;
end;
begin
  i:=1; j:=3; unknown (a[i], a[j]);
  for i:=1 to 5 do write (a[i]);
end;
```

gate1990 descriptive compiler-design runtime-environments parameter-passing

2.14.5 Parameter Passing: GATE1991-03,x

https://gateoverflow.in/524

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

Indicate all the true statements from the following:

A. Recursive descent parsing cannot be used for grammar with left recursion.
B. The intermediate form for representing expressions which is best suited for code optimization is the postfix form.
C. A programming language not supporting either recursion or pointer type does not need the support of dynamic memory allocation.
D. Although C does not support call-by-name parameter passing, the effect can be correctly simulated in C
E. No feature of Pascal typing violates strong typing in Pascal.

gate1991 compiler-design parameter-passing programming difficult

2.14.6 Parameter Passing: GATE1991-09a

https://gateoverflow.in/536

Consider the following pseudo-code (all data items are of type integer):

```
procedure P(a, b, c);
    a := 2;
    c := a + b;
end {P}

begin
    x := 1;
    y := 5;
    z := 100;
    P(x, x*y, z);
    Write ('x = ', x, 'z = ', z);
end
```

Determine its output, if the parameters are passed to the Procedure P by

i. value
ii. reference
iii. name

gate1991 compiler-design parameter-passing normal runtime-environments

2.14.7 Parameter Passing: GATE1991-09b

https://gateoverflow.in/43603

For the following code, indicate the output if

a. static scope rules
b. dynamic scope rules

are used

```
var a,b : integer;

procedure P;
    a := 5;
    b := 10;
end {P};

procedure Q;
    var a, b : integer;
    P;
end {Q};

begin
    a := 1;
    b := 2;
    Q;
    Write ('a = ', a, 'b = ', b);
end
```

gate1991 runtime-environments normal compiler-design parameter-passing

2.14.8 Parameter Passing: GATE1993-26

https://gateoverflow.in/2322

A stack is used to pass parameters to procedures in a procedure call.

A. If a procedure P has two parameters as described in procedure definition:

```
procedure P (var x :integer; y: integer);
```

and if P is called by ; $P(a,b)$

State precisely in a sentence what is pushed on stack for parameters a and b

B. In the generated code for the body of procedure P, how will the addressing of formal parameters x and y differ?

gate1993 compiler-design parameter-passing runtime-environments normal

2.14.9 Parameter Passing: GATE1995-2.4

https://gateoverflow.in/2616

What is the value of X printed by the following program?

```
program COMPUTE (input, output);
var X:integer;
procedure FIND (X:real);
    begin
        X:=sqrt(X);
    end;
begin
    X:=2
    FIND(X);
    writeln(X);
end.
```

A. 2 B. $\sqrt{2}$ C. Run time error D. None of the above

gate1995 programming parameter-passing runtime-environments easy

2.14.10 Parameter Passing: GATE2003-74

https://gateoverflow.in/43575

The following program fragment is written in a programming language that allows global variables and does not allow nested declarations of functions.

```
global int i=100, j=5;
void P(x) {
 int i=10;
    print(x+10);
    i=200;
    j=20;
    print (x);
}
main() {P(i+j);}
```

If the programming language uses dynamic scoping and call by name parameter passing mechanism, the values printed by the above program are

A. $115, 220$ B. $25, 220$ C. $25, 15$ D. $115, 105$

gate2003 programming compiler-design parameter-passing runtime-environments normal

2.14.11 Parameter Passing: GATE2004-2,ISRO2017-54

https://gateoverflow.in/999

Consider the following function

```
void swap(int a, int b)
{
    int temp;
    temp = a;
    a = b;
    b = temp;
}
```

In order to exchange the values of two variables x and y.

A. call $swap(x, y)$
B. call $swap(\&x, \&y)$
C. $swap(x, y)$ cannot be used as it does not return any value
D. $swap(x, y)$ cannot be used as the parameters are passed by value

gate2004 compiler-design programming-in-c parameter-passing easy isro2017 runtime-environments

2.14.12 Parameter Passing: GATE2007-IT-33

https://gateoverflow.in/3466

Consider the program below in a hypothetical language which allows global variable and a choice of call by reference or call by value methods of parameter passing.

```
int i ;
program main ()
{
    int j = 60;
    i = 50;
    call f (i, j);
```

```
    print i, j;
}
procedure f (x, y)
{
    i = 100;
    x = 10;
    y = y + i ;
}
```

Which one of the following options represents the correct output of the program for the two parameter passing mechanisms?

A. Call by value : $i = 70, j = 10$; Call by reference :$i = 60, j = 70$
B. Call by value : $i = 50, j = 60$; Call by reference :$i = 50, j = 70$
C. Call by value : $i = 10, j = 70$; Call by reference :$i = 100, j = 60$
D. Call by value : $i = 100, j = 60$; Call by reference :$i = 10, j = 70$

gate2007-it programming parameter-passing normal compiler-design runtime-environments

2.14.13 Parameter Passing: GATE2016-1-36

https://gateoverflow.in/39701

What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

```
a = 3;
void n(x) { x = x * a; print (x); }
void m(y) { a = 1 ; a = y - a;  n(a); print (a); }
void main () { m(a); }
```

A. $6,2$ B. $6,6$ C. $4,2$ D. $4,4$

gate2016-1 parameter-passing normal

2.15 Parsing (48)

2.15.1 Parsing: GATE1987-1-xiv

https://gateoverflow.in/80295

An operator precedence parser is a

A. Bottom-up parser.
B. Top-down parser.
C. Back tracking parser.
D. None of the above.

gate1987 compiler-design parsing

2.15.2 Parsing: GATE1988-10ia

https://gateoverflow.in/94390

Consider the following grammar:

- $S \rightarrow S$
- $S \rightarrow SS \mid a \mid \epsilon$

Construct the collection of sets of LR (0) items for this grammar and draw its goto graph.

gate1988 descriptive grammar parsing

2.15.3 Parsing: GATE1989-1-iii

https://gateoverflow.in/87046

Merging states with a common core may produce _____ conflicts and does not produce _____ conflicts in an LALR purser.

gate1989 descriptive compiler-design parsing

2.15.4 Parsing: GATE1992-02,xiii

https://gateoverflow.in/570

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

For a context free grammar, FOLLOW(A) is the set of terminals that can appear immediately to the right of non-terminal A in some "sentential" form. We define two sets LFOLLOW(A) and RFOLLOW(A) by replacing the word "sentential" by "left sentential" and "right most sentential" respectively in the definition of FOLLOW (A).

A. FOLLOW(A) and LFOLLOW(A) may be different.
B. FOLLOW(A) and RFOLLOW(A) are always the same.
C. All the three sets are identical.
D. All the three sets are different.

gate1992 parsing compiler-design normal

2.15.5 Parsing: GATE1992-02,xiv

https://gateoverflow.in/571

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

Consider the $SLR(1)$ and $LALR(1)$ parsing tables for a context free grammar. Which of the following statement is/are true?

A. The *goto* part of both tables may be different.
B. The *shift* entries are identical in both the tables.
C. The *reduce* entries in the tables may be different.
D. The *error* entries in tables may be different

gate1992 compiler-design normal parsing

2.15.6 Parsing: GATE1993-25

https://gateoverflow.in/2321

A simple Pascal like language has only three statements.

i. assignment statement e.g. x:=expression
ii. loop construct e.g. for i:=expression to expression do statement
iii. sequencing e.g. begin statement ;…; statement end

A. Write a context-free grammar (CFG) for statements in the above language. Assume that expression has already been defined. Do not use optional parenthesis and * operator in CFG.
B. Show the parse tree for the following statements:

```
for j:=2 to 10 do
begin
    x:=expr1;
    y:=expr2;
end
```

gate1993 compiler-design parsing normal

2.15.7 Parsing: GATE1995-8

https://gateoverflow.in/2643

Construct the LL(1) table for the following grammar.

1. $Expr \rightarrow \_Expr$
2. $Expr \rightarrow (Expr)$
3. $Expr \rightarrow Var\ ExprTail$
4. $ExprTail \rightarrow \_Expr$
5. $Expr \rightarrow \lambda$
6. $Var \rightarrow Id\ VarTail$
7. $VarTail \rightarrow (Expr)$
8. $VarTail \rightarrow \lambda$
9. $Goal \rightarrow Expr\ \$$

gate1995 compiler-design parsing normal

2.15.8 Parsing: GATE1998-1.26

https://gateoverflow.in/1663

Which of the following statements is true?

A. SLR parser is more powerful than LALR
B. LALR parser is more powerful than Canonical LR parser
C. Canonical LR parser is more powerful than LALR parser
D. The parsers SLR, Canonical CR, and LALR have the same power

gate1998 compiler-design parsing normal

2.15.9 Parsing: GATE1998-1.27

https://gateoverflow.in/1664

Type checking is normally done during

A. lexical analysis
B. syntax analysis
C. syntax directed translation
D. code optimization

gate1998 compiler-design parsing easy

2.15.10 Parsing: GATE1998-22

https://gateoverflow.in/1737

A. An identifier in a programming language consists of up to six letters and digits of which the first character must be a letter. Derive a regular expression for the identifier.
B. Build an $LL(1)$ parsing table for the language defined by the $LL(1)$ grammar with productions

$\text{Program} \rightarrow \text{ begin } d \text{ semi } X \text{ end}$
$X \rightarrow d \text{ semi } X \mid sY$
$Y \rightarrow \text{ semi } sY \mid \epsilon$

gate1998 compiler-design parsing descriptive

2.15.11 Parsing: GATE1999-1.17

https://gateoverflow.in/1470

Which of the following is the most powerful parsing method?

A. LL (1) B. Canonical LR C. SLR D. LALR

gate1999 compiler-design parsing easy

2.15.12 Parsing: GATE2000-1.19, UGCNET-Dec2013-II-30

https://gateoverflow.in/642

Which of the following derivations does a top-down parser use while parsing an input string? The input is assumed to be scanned in left to right order.

A. Leftmost derivation
B. Leftmost derivation traced out in reverse
C. Rightmost derivation
D. Rightmost derivation traced out in reverse

gate2000 compiler-design parsing normal ugcnetdec2013ii

2.15.13 Parsing: GATE2001-16

https://gateoverflow.in/757

Consider the following grammar with terminal alphabet $\Sigma = \{a, (,), +, *\}$ and start symbol E. The production rules of the grammar are:

- $E \rightarrow aA$
- $E \rightarrow (E)$
- $A \rightarrow +E$
- $A \rightarrow *E$
- $A \rightarrow \epsilon$

a. Compute the FIRST and FOLLOW sets for E and A.
b. Complete the LL(1) parse table for the grammar.

gate2001 compiler-design parsing normal

2.15.14 Parsing: GATE2002-22

https://gateoverflow.in/875

A. Construct all the parse trees corresponding to $i + j * k$ for the grammar
$E \rightarrow E + E$
$E \rightarrow E * E$
$E \rightarrow id$
B. In this grammar, what is the precedence of the two operators $*$ and $+$?

C. If only one parse tree is desired for any string in the same language, what changes are to be made so that the resulting LALR(1) grammar is unambiguous?

gate2002 compiler-design parsing normal descriptive

2.15.15 Parsing: GATE2003-16

https://gateoverflow.in/906

Which of the following suffices to convert an arbitrary CFG to an LL(1) grammar?

A. Removing left recursion alone
B. Factoring the grammar alone
C. Removing left recursion and factoring the grammar
D. None of the above

gate2003 compiler-design parsing easy

2.15.16 Parsing: GATE2003-17

https://gateoverflow.in/907

Assume that the SLR parser for a grammar G has n_1 states and the LALR parser for G has n_2 states. The relationship between n_1 and n_2 is

A. n_1 is necessarily less than n_2
B. n_1 is necessarily equal to n_2
C. n_1 is necessarily greater than n_2
D. None of the above

gate2003 compiler-design parsing easy

2.15.17 Parsing: GATE2003-57

https://gateoverflow.in/945

Consider the grammar shown below.

$S \rightarrow C\,C$

$C \rightarrow c\,C \mid d$

This grammar is

A. LL(1)
B. SLR(1) but not LL(1)
C. LALR(1) but not SLR(1)
D. LR(I) but not LALR(1)

gate2003 compiler-design grammar parsing normal

2.15.18 Parsing: GATE2005-14

https://gateoverflow.in/1350

The grammar $A \rightarrow AA \mid (A) \mid \epsilon$ is not suitable for predictive-parsing because the grammar is:

A. ambiguous B. left-recursive C. right-recursive D. an operator-grammar

gate2005 compiler-design parsing grammar easy

2.15.19 Parsing: GATE2005-60

https://gateoverflow.in/1383

Consider the grammar:

$$S \rightarrow (S) \mid a$$

Let the number of states in SLR (1), LR(1) and LALR(1) parsers for the grammar be n_1, n_2 and n_3 respectively. The following relationship holds good:

A. $n_1 < n_2 < n_3$
B. $n_1 = n_3 < n_2$
C. $n_1 = n_2 = n_3$
D. $n_1 \geq n_3 \geq n_2$

gate2005 compiler-design parsing normal

2.15.20 Parsing: GATE2005-83a

https://gateoverflow.in/1405

Statement for Linked Answer Questions 83a & 83b:

Consider the following expression grammar. The semantic rules for expression evaluation are stated next to each grammar production.

$$\begin{array}{l|l} E \rightarrow number & E.val = number.val \\ \mid E \text{ `+' } E & E^{(1)}.val = E^{(2)}.val + E^{(3)}.val \\ \mid E \text{ `}\times\text{' } E & E^{(1)}.val = E^{(2)}.val \times E^{(3)}.val \end{array}$$

The above grammar and the semantic rules are fed to a *yaac* tool (which is an LALR(1) parser generator) for parsing and evaluating arithmetic expressions. Which one of the following is true about the action of *yaac* for the given grammar?

A. It detects *recursion* and eliminates recursion
B. It detects *reduce-reduce* conflict, and resolves
C. It detects *shift-reduce* conflict, and resolves the conflict in favor of a *shift* over a *reduce* action
D. It detects *shift-reduce* conflict, and resolves the conflict in favor of a *reduce* over a *shift* action

gate2005 compiler-design parsing difficult

2.15.21 Parsing: GATE2005-83b

https://gateoverflow.in/87037

Consider the following expression grammar. The semantic rules for expression evaluation are stated next to each grammar production.

$$\begin{array}{l|l} E \rightarrow number & E.val = number.val \\ \mid E \text{ `+' } E & E^{(1)}.val = E^{(2)}.val + E^{(3)}.val \\ \mid E \text{ `}\times\text{' } E & E^{(1)}.val = E^{(2)}.val \times E^{(3)}.val \end{array}$$

Assume the conflicts of this question are resolved using yacc tool and an LALR(1) parser is generated for parsing arithmetic expressions as per the given grammar. Consider an expression $3 \times 2 + 1$. What precedence and associativity properties does the generated parser realize?

A. Equal precedence and left associativity; expression is evaluated to 7
B. Equal precedence and right associativity; expression is evaluated to 9
C. Precedence of '$\times$' is higher than that of '$+$', and both operators are left associative; expression is evaluated to 7
D. Precedence of '$+$' is higher than that of '$\times$', and both operators are left associative; expression is evaluated to 9

gate2005 compiler-design parsing normal

2.15.22 Parsing: GATE2005-IT-83a

https://gateoverflow.in/3849

Consider the context-free grammar

$E \rightarrow E + E$
$E \rightarrow (E * E)$
$E \rightarrow id$

where E is the starting symbol, the set of terminals is $\{id, (, +,), *\}$, and the set of nonterminals is $\{E\}$.

Which of the following terminal strings has more than one parse tree when parsed according to the above grammar?

A. $id + id + id + id$
B. $id + (id * (id * id))$
C. $(id * (id * id)) + id$
D. $((id * id + id) * id)$

gate2005-it compiler-design grammar parsing easy

2.15.23 Parsing: GATE2005-IT-83b

https://gateoverflow.in/3850

Consider the context-free grammar

- $E \rightarrow E + E$
- $E \rightarrow (E * E)$
- $E \rightarrow \text{id}$

where E is the starting symbol, the set of terminals is $\{id, (, +,), *\}$, and the set of non-terminals is $\{E\}$.

For the terminal string $id + id + id + id$, how many parse trees are possible?

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

gate2005-it compiler-design parsing normal

2.15.24 Parsing: GATE2006-58

https://gateoverflow.in/1836

Consider the following grammar:

$S \rightarrow FR$

$R \rightarrow *S \mid \varepsilon$

$F \rightarrow id$

In the predictive parser table, M, of the grammar the entries M[S,id] and M[R,$] respectively are

A. $\{S \rightarrow FR\}$ and $\{R \rightarrow \varepsilon\}$
B. $\{S \rightarrow FR\}$ and $\{\}$
C. $\{S \rightarrow FR\}$ and $\{R \rightarrow *S\}$
D. $\{F \rightarrow id\}$ and $\{R \rightarrow \varepsilon\}$

gate2006 compiler-design parsing normal

2.15.25 Parsing: GATE2006-7

https://gateoverflow.in/886

Consider the following grammar

- $S \rightarrow S * E$
- $S \rightarrow E$
- $E \rightarrow F + E$
- $E \rightarrow F$
- $F \rightarrow id$

Consider the following LR(0) items corresponding to the grammar above

i. $S \rightarrow S*.E$
ii. $E \rightarrow F.+E$
iii. $E \rightarrow F+.E$

Given the items above, which two of them will appear in the same set in the canonical sets-of-items for the grammar?

A. i and ii B. ii and iii C. i and iii D. None of the above

gate2006 compiler-design parsing normal

2.15.26 Parsing: GATE2007-18

https://gateoverflow.in/1216

Which one of the following is a top-down parser?

A. Recursive descent parser.
B. Operator precedence parser.
C. An LR(k) parser.
D. An LALR(k) parser.

gate2007 compiler-design parsing normal

2.15.27 Parsing: GATE2008-11

https://gateoverflow.in/409

Which of the following describes a handle (as applicable to LR-parsing) appropriately?

A. It is the position in a sentential form where the next shift or reduce operation will occur
B. It is non-terminal whose production will be used for reduction in the next step
C. It is a production that may be used for reduction in a future step along with a position in the sentential form where the next shift or reduce operation will occur
D. It is the production p that will be used for reduction in the next step along with a position in the sentential form where the right hand side of the production may be found

gate2008 compiler-design parsing normal

2.15.28 Parsing: GATE2008-55

https://gateoverflow.in/478

An LALR(1) parser for a grammar G can have shift-reduce (S-R) conflicts if and only if

A. The SLR(1) parser for G has S-R conflicts
B. The LR(1) parser for G has S-R conflicts
C. The LR(0) parser for G has S-R conflicts
D. The LALR(1) parser for G has reduce-reduce conflicts

gate2008 compiler-design parsing normal

2.15.29 Parsing: GATE2008-IT-79

https://gateoverflow.in/3393

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.

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

For the string "$aabbaab$" how many steps are required to derive the string and how many parse trees are there?

A. 6 and 1 B. 6 and 2 C. 7 and 2 D. 4 and 2

gate2008-it compiler-design context-free-language parsing normal

2.15.30 Parsing: GATE2009-42

https://gateoverflow.in/1328

Which of the following statements are TRUE?

I. There exist parsing algorithms for some programming languages whose complexities are less than $\Theta(n^3)$
II. A programming language which allows recursion can be implemented with static storage allocation.
III. No L-attributed definition can be evaluated in the framework of bottom-up parsing.
IV. Code improving transformations can be performed at both source language and intermediate code level.

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

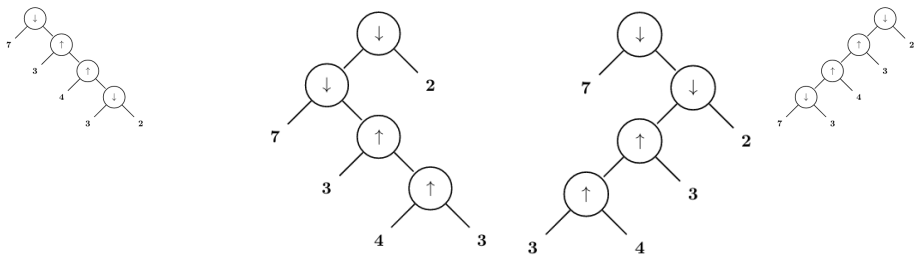
gate2009 compiler-design parsing normal

2.15.31 Parsing: GATE2011-27

https://gateoverflow.in/2129

Consider two binary operators '$\uparrow$' and '$\downarrow$' with the precedence of operator $\downarrow$ being lower than that of the operator $\uparrow$. Operator $\uparrow$ is right associative while operator $\downarrow$ is left associative. Which one of the following represents the parse tree for expression $(7 \downarrow 3 \uparrow 4 \uparrow 3 \downarrow 2)$

A. B. C. D.



gate2011 compiler-design parsing normal

2.15.32 Parsing: GATE2012-52

https://gateoverflow.in/2181

For the grammar below, a partial $LL(1)$ parsing table is also presented along with the grammar. Entries that need to be filled are indicated as $E1, E2,$ and $E3$. ε is the empty string, \$ indicates end of input, and, $\mid$ separates alternate right hand sides of productions.

- $S \rightarrow aAbB \mid bAaB \mid \varepsilon$
- $A \rightarrow S$
- $B \rightarrow S$

	a	b	$
S	E1	E2	$S \rightarrow \varepsilon$
A	$A \rightarrow S$	$A \rightarrow S$	error
B	$B \rightarrow S$	$B \rightarrow S$	$E3$

The FIRST and FOLLOW sets for the non-terminals A and B are

A. $\text{FIRST}(A) = \{a, b, \varepsilon\} = \text{FIRST}(B)$
$\text{FOLLOW}(A) = \{a, b\}$
$\text{FOLLOW}(B) = \{a, b, \$\}$

B. $\text{FIRST}(A) = \{a, b, \$\}$
$\text{FIRST}(B) = \{a, b, \varepsilon\}$
$\text{FOLLOW}(A) = \{a, b\}$
$\text{FOLLOW}(B) = \{\$\}$

C. $\text{FIRST}(A) = \{a, b, \varepsilon\} = \text{FIRST}(B)$
$\text{FOLLOW}(A) = \{a, b\}$
$\text{FOLLOW}(B) = \varnothing$

D. $\text{FIRST}(A) = \{a, b\} = \text{FIRST}(B)$
$\text{FOLLOW}(A) = \{a, b\}$
$\text{FOLLOW}(B) = \{a, b\}$

gate2012 compiler-design parsing normal

2.15.33 Parsing: GATE2012-53

https://gateoverflow.in/43312

For the grammar below, a partial $LL(1)$ parsing table is also presented along with the grammar. Entries that need to be filled are indicated as $E1, E2,$ and $E3$. ε is the empty string, $ indicates end of input, and, $\mid$ separates alternate right hand sides of productions.

- $S \rightarrow aAbB \mid bAaB \mid \varepsilon$
- $A \rightarrow S$
- $B \rightarrow S$

	a	b	$
S	E1	E2	$S \rightarrow \varepsilon$
A	$A \rightarrow S$	$A \rightarrow S$	error
B	$B \rightarrow S$	$B \rightarrow S$	$E3$

The appropriate entries for $E1, E2,$ and $E3$ are

A. $E1 : S \rightarrow aAbB, A \rightarrow S$
$E2 : S \rightarrow bAaB, B \rightarrow S$
$E1 : B \rightarrow S$

B. $E1 : S \rightarrow aAbB, S \rightarrow \varepsilon$
$E2 : S \rightarrow bAaB, S \rightarrow \varepsilon$
$E3 : S \rightarrow \varepsilon$

C. $E1 : S \rightarrow aAbB, S \rightarrow \varepsilon$
$E2 : S \rightarrow bAaB, S \rightarrow \varepsilon$
$E3 : B \rightarrow S$

D. $E1 : A \rightarrow S, S \rightarrow \varepsilon$
$E2 : B \rightarrow S, S \rightarrow \varepsilon$
$E3 : B \rightarrow S$

normal gate2012 compiler-design parsing

2.15.34 Parsing: GATE2013-40

https://gateoverflow.in/1551

Consider the following two sets of LR(1) items of an LR(1) grammar.

$X \rightarrow c.X, c$	$X \rightarrow c.X, \$$
$X \rightarrow .cX, c$	$X \rightarrow .cX, \$$
$X \rightarrow .d, c$	$X \rightarrow .d, \$$

Which of the following statements related to merging of the two sets in the corresponding LALR parser is/are **FALSE**?

1. Cannot be merged since look aheads are different.
2. Can be merged but will result in S-R conflict.
3. Can be merged but will result in R-R conflict.
4. Cannot be merged since goto on c will lead to two different sets.

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

gate2013 compiler-design parsing normal

2.15.35 Parsing: GATE2013-9

https://gateoverflow.in/1418

What is the maximum number of reduce moves that can be taken by a bottom-up parser for a grammar with no epsilon and unit-production (i.e., of type $A \rightarrow \epsilon$ and $A \rightarrow a$) to parse a string with n tokens?

A. $n/2$ B. $n-1$ C. $2n-1$ D. 2^n

gate2013 compiler-design parsing normal

2.15.36 Parsing: GATE2014-1-34

https://gateoverflow.in/1807

A canonical set of items is given below

$S \rightarrow L. > R$

$Q \rightarrow R.$

On input symbol $<$ the set has

A. a shift-reduce conflict and a reduce-reduce conflict.
B. a shift-reduce conflict but not a reduce-reduce conflict.
C. a reduce-reduce conflict but not a shift-reduce conflict.
D. neither a shift-reduce nor a reduce-reduce conflict.

gate2014-1 compiler-design parsing normal

2.15.37 Parsing: GATE2015-3-16

https://gateoverflow.in/8413

Among simple LR (SLR), canonical LR, and look-ahead LR (LALR), which of the following pairs identify the method that is very easy to implement and the method that is the most powerful, in that order?

A. SLR, LALR
B. Canonical LR, LALR
C. SLR, canonical LR
D. LALR, canonical LR

gate2015-3 compiler-design parsing normal

2.15.38 Parsing: GATE2015-3-31

https://gateoverflow.in/8488

Consider the following grammar G

$S \rightarrow F \mid H$

$F \rightarrow p \mid c$

$H \rightarrow d \mid c$

Where S, F, and H are non-terminal symbols, p, d, and c are terminal symbols. Which of the following statement(s) is/are correct?

S1: LL(1) can parse all strings that are generated using grammar G

S2: LR(1) can parse all strings that are generated using grammar G

A. Only S1 B. Only S2 C. Both S1 and S2 D. Neither S1 and S2

gate2015-3 compiler-design parsing normal

2.15.39 Parsing: GATE2016-1-45

https://gateoverflow.in/39697

The attribute of three arithmetic operators in some programming language are given below.

OPERATOR	PRECEDENCE	ASSOCIATIVITY	ARITY
$+$	High	Left	Binary
$-$	Medium	Right	Binary
$*$	Low	Left	Binary

The value of the expression $2-5+1-7*3$ in this language is _____.

gate2016-1 compiler-design parsing normal numerical-answers

2.15.40 Parsing: GATE2017-1-17

https://gateoverflow.in/118297

Consider the following grammar:

- $P \rightarrow xQRS$
- $Q \rightarrow yz \mid z$
- $R \rightarrow w \mid \varepsilon$
- $S \rightarrow y$

What is FOLLOW(Q)?

A. $\{R\}$ B. $\{w\}$ C. $\{w, y\}$ D. $\{w, \$\}$

gate2017-1 compiler-design parsing

2.15.41 Parsing: GATE2017-1-43

https://gateoverflow.in/118326

Consider the following grammar:

- stmt $\rightarrow$ **if** expr **then** expr **else** expr; stmt | 0
- expr $\rightarrow$ term **relop** term | term
- term $\rightarrow$ id | number
- id $\rightarrow$ **a** | **b** | **c**
- number $\rightarrow [0-9]$

where **relop** is a relational operator (e.g.. $<$. $>$ ...). 0 refers to the empty statement, and **if**, **then**, **else** are terminals.
Consider a program P following the above grammar containing ten **if** terminals. The number of control flow paths in P is_____ . For example. the program
if e_1 **then** e_2 **else** e_3
has 2 control flow paths. $e_1 \rightarrow e_2$ and $e_1 \rightarrow e_3$.

gate2017-1 compiler-design parsing normal numerical-answers

2.15.42 Parsing: GATE2017-2-6

https://gateoverflow.in/118343

Which of the following statements about parser is/are CORRECT?

I. Canonical LR is more powerful than SLR
II. SLR is more powerful than LALR
III. SLR is more powerful than Canonical LR

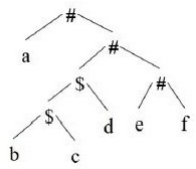
A. I only B. II only C. III only D. II and III only

gate2017-2 compiler-design parsing

2.15.43 Parsing: GATE2018-38

https://gateoverflow.in/204112

Consider the following parse tree for the expression a#b cd#e#f, involving two binary operators $ and #.



Which one of the following is correct for the given parse tree?

A. $ has higher precedence and is left associative; # is right associative
B. # has higher precedence and is left associative; $ is right associative
C. $ has higher precedence and is left associative; # is left associative
D. $ has higher precedence and is right associative; # is left associative

gate2018 compiler-design parsing normal

2.15.44 Parsing: GATE2019-19

https://gateoverflow.in/302829

Consider the grammar given below:

- $S \rightarrow Aa$
- $A \rightarrow BD$
- $B \rightarrow b \mid \epsilon$
- $D \rightarrow d \mid \epsilon$

Let a, b, d and $\$$ be indexed as follows:

a	b	d	$\$$
3	2	1	0

Compute the FOLLOW set of the non-terminal B and write the index values for the symbols in the FOLLOW set in the descending order.(For example, if the FOLLOW set is $(a, b, d, \$)$, then the answer should be 3210)

gate2019 numerical-answers compiler-design parsing

2.15.45 Parsing: GATE2019-3

https://gateoverflow.in/302845

Which one of the following kinds of derivation is used by LR parsers?

A. Leftmost
B. Leftmost in reverse
C. Rightmost
D. Rightmost in reverse

gate2019 compiler-design parsing

2.15.46 Parsing: TIFR2012-B-17

https://gateoverflow.in/25215

Which of the following correctly describes $LR(k)$ parsing?

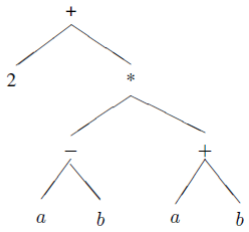
A. The input string is alternately scanned left to right and right to left with k reversals.
B. Input string is scanned once left to right with rightmost derivation and k symbol look-ahead.
C. $LR(k)$ grammers are expressively as powerful as context-free grammers.
D. Parser makes k left-to-right passes over input string.
E. Input string is scanned from left to right once with k symbol to the right as look-ahead to give left-most derivation.

tifr2012 compiler-design parsing

2.15.47 Parsing: TIFR2012-B-8

https://gateoverflow.in/25108

Consider the parse tree



Assume that $*$ has higher precedence than $+$, $-$ and operators associate right to left (i.e $(a+b+c=(a+(b+c))$. Consider

i. $2+a-b$
ii. $2+a-b*a+b$
iii. $2+((a-b)*(a+b)))$
iv. $2+(a-b)*(a+b)$

The parse tree corresponds to

A. Expression (i)
B. Expression (ii)
C. Expression (iv) only
D. Expression (ii), (iii), and (iv)
E. Expression (iii) and (iv) only

tifr2012 compiler-design parsing

2.15.48 Parsing: TIFR2015-B-15

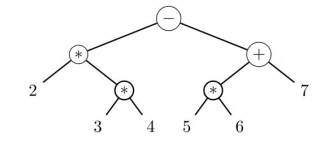
https://gateoverflow.in/30079

Consider the following grammar (the start symbol is E) for generating expressions.

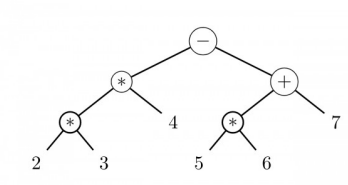
- $E \rightarrow T - E \mid T + E \mid T$
- $T \rightarrow T * F \mid F$
- $F \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

With respect to this grammar, which of the following trees is the valid evaluation tree for the expression $2 * 3 * 4 - 5 * 6 + 7$?

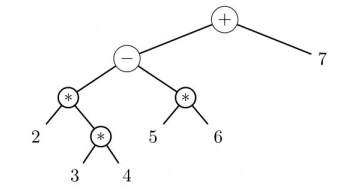
a.



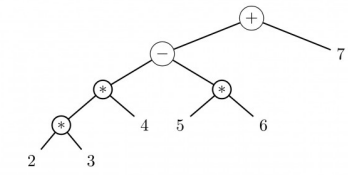
b.



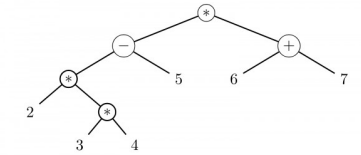
c.



d.



e.



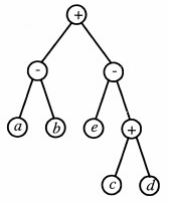
tifr2015 parsing

2.16 Register Allocation (2)

2.16.1 Register Allocation: GATE2011-36

https://gateoverflow.in/2138

Consider evaluating the following expression tree on a machine with load-store architecture in which memory can be accessed only through load and store instructions. The variables $a, b, c, d,$ and e are initially stored in memory. The binary operators used in this expression tree can be evaluated by the machine only when operands are in registers. The instructions produce result only in a register. If no intermediate results can be stored in memory, what is the minimum number of registers needed to evaluate this expression?



A. 2 B. 9 C. 5 D. 3

gate2011 compiler-design register-allocation normal

2.16.2 Register Allocation: GATE2017-1-52

https://gateoverflow.in/118746

Consider the expression $(a-1) * (((b+c)/3)+d)$. Let X be the minimum number of registers required by an *optimal* code generation (without any register spill) algorithm for a load/store architecture, in which

A. only load and store instructions can have memory operands and
B. arithmetic instructions can have only register or immediate operands. The value of X is _____ .

gate2017-1 compiler-design register-allocation normal numerical-answers

2.17 Runtime Environments (18)

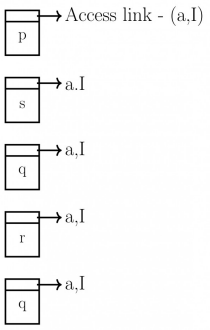
2.17.1 Runtime Environments: GATE1988-2xii

https://gateoverflow.in/93966

Consider the following program skeleton and below figure which shows activation records of procedures involved in the calling sequence.

$$p \rightarrow s \rightarrow q \rightarrow r \rightarrow q.$$

Write the access links of the activation records to enable correct access and variables in the procedures from other procedures involved in the calling sequence




```
procedure p;
  procedure q;
    procedure r;
      begin
        q
      end r;
    begin
    r
    end q;
    procedure s;
      begin
        q
      end s;
  begin
    s
  end p;
```

gate1988 normal descriptive runtime-environments compiler-design

2.17.2 Runtime Environments: GATE1989-10a

https://gateoverflow.in/89636

Will recursion work correctly in a language with static allocation of all variables? Explain.

gate1989 descriptive compiler-design runtime-environments

2.17.3 Runtime Environments: GATE1989-8b

https://gateoverflow.in/89082

Indicate the result of the following program if the language uses (i) static scope rules and (ii) dynamic scope rules.

```
        var x, y:integer;
        procedure A (var z:integer);
        var x:integer;
        begin x:=1; B; z:= x end;
        procedure B;
        begin x:=x+1 end;
        begin
        x:=5; A(y); write (y)
...end.
```

gate1989 descriptive compiler-design runtime-environments

2.17.4 Runtime Environments: GATE1990-2-v

https://gateoverflow.in/83980

Match the pairs in the following questions:

(a)	Pointer data type	(p)	Type conversion
(b)	Activation record	(q)	Dynamic data structure
(c)	Repeat-until	(r)	Recursion
(d)	Coercion	(s)	Nondeterministic loop

gate1990 match-the-following compiler-design runtime-environments recursion

2.17.5 Runtime Environments: GATE1990-4-v

https://gateoverflow.in/85394

State whether the following statements are TRUE or FALSE with reason:

The Link-load-and-go loading scheme required less storage space than the link-and-go loading scheme.

gate1990 true-false compiler-design runtime-environments

2.17.6 Runtime Environments: GATE1993-7.7

https://gateoverflow.in/2295

A part of the system software which under all circumstances must reside in the main memory is:

A. text editor B. assembler C. linker D. loader E. none of the above

gate1993 compiler-design runtime-environments easy

2.17.7 Runtime Environments: GATE1995-1.14

https://gateoverflow.in/2601

A linker is given object modules for a set of programs that were compiled separately. What information need to be included in an object module?

A. Object code
B. Relocation bits
C. Names and locations of all external symbols defined in the object module
D. Absolute addresses of internal symbols

gate1995 compiler-design runtime-environments normal

2.17.8 Runtime Environments: GATE1997-1.10

https://gateoverflow.in/2226

Heap allocation is required for languages.

A. that support recursion
B. that support dynamic data structure
C. that use dynamic scope rules
D. None of the above

gate1997 compiler-design easy runtime-environments

2.17.9 Runtime Environments: GATE1997-1.8

https://gateoverflow.in/2224

A language L allows declaration of arrays whose sizes are not known during compilation. It is required to make efficient use of memory. Which one of the following is true?

A. A compiler using static memory allocation can be written for L
B. A compiler cannot be written for L; an interpreter must be used
C. A compiler using dynamic memory allocation can be written for L
D. None of the above

gate1997 compiler-design easy runtime-environments

2.17.10 Runtime Environments: GATE1998-1.25, ISRO2008-41

https://gateoverflow.in/1662

In a resident – OS computer, which of the following systems must reside in the main memory under all situations?

A. Assembler B. Linker C. Loader D. Compiler

gate1998 compiler-design runtime-environments normal isro2008

2.17.11 Runtime Environments: GATE1998-1.28

https://gateoverflow.in/1665

A linker reads four modules whose lengths are $200, 800, 600$ and 500 words, respectively. If they are loaded in that order, what are the relocation constants?

A. $0, 200, 500, 600$
B. $0, 200, 1000, 1600$
C. $200, 500, 600, 800$
D. $200, 700, 1300, 2100$

gate1998 compiler-design runtime-environments normal

2.17.12 Runtime Environments: GATE1998-2.15

https://gateoverflow.in/1687

Faster access to non-local variables is achieved using an array of pointers to activation records called a

A. stack
B. heap
C. display
D. activation tree

gate1998 programming compiler-design normal runtime-environments

2.17.13 Runtime Environments: GATE2001-1.17

https://gateoverflow.in/710

The process of assigning load addresses to the various parts of the program and adjusting the code and the data in the program to reflect the assigned addresses is called

A. Assembly
B. parsing
C. Relocation
D. Symbol resolution

gate2001 compiler-design runtime-environments easy

2.17.14 Runtime Environments: GATE2008-54

https://gateoverflow.in/477

Which of the following are true?

I. A programming language which does not permit global variables of any kind and has no nesting of procedures/functions, but permits recursion can be implemented with static storage allocation
II. Multi-level access link (or display) arrangement is needed to arrange activation records only if the programming language being implemented has nesting of procedures/functions
III. Recursion in programming languages cannot be implemented with dynamic storage allocation
IV. Nesting procedures/functions and recursion require a dynamic heap allocation scheme and cannot be implemented with a stack-based allocation scheme for activation records
V. Programming languages which permit a function to return a function as its result cannot be implemented with a stack-based storage allocation scheme for activation records

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

gate2008 compiler-design difficult runtime-environments

2.17.15 Runtime Environments: GATE2010-14

https://gateoverflow.in/2187

Which languages necessarily need heap allocation in the runtime environment?

A. Those that support recursion.
B. Those that use dynamic scoping.
C. Those that allow dynamic data structure.
D. Those that use global variables.

gate2010 compiler-design easy runtime-environments

2.17.16 Runtime Environments: GATE2012-36

https://gateoverflow.in/1758

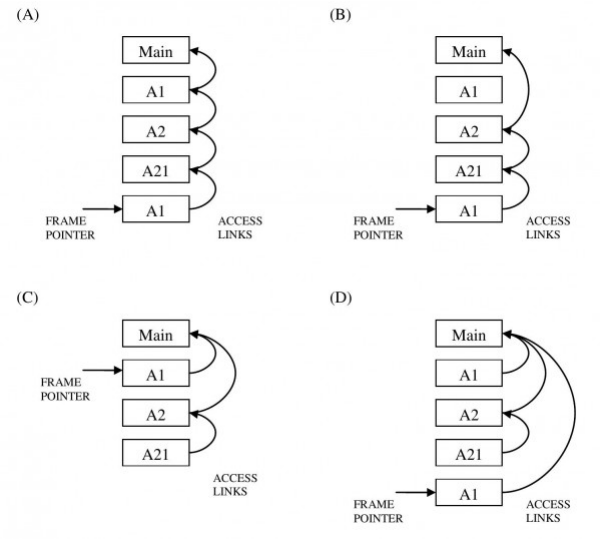
Consider the program given below, in a block-structured pseudo-language with lexical scoping and nesting of procedures permitted.

```
Program main;
  Var ...

  Procedure A1;
    Var ...
    Call A2;
  End A1

  Procedure A2;
```

```
    Var ...

    Procedure A21;
      Var ...
      Call A1;
    End A21

    Call A21;
  End A2

  Call A1;
End main.
```

Consider the calling chain: $Main \rightarrow A1 \rightarrow A2 \rightarrow A21 \rightarrow A1$

The correct set of activation records along with their access links is given by:



gate2012 compiler-design runtime-environments normal

2.17.17 Runtime Environments: GATE2014-2-18

https://gateoverflow.in/1975

Which one of the following is **NOT** performed during compilation?

A. Dynamic memory allocation
B. Type checking
C. Symbol table management
D. Inline expansion

gate2014-2 compiler-design easy runtime-environments

2.17.18 Runtime Environments: GATE2014-3-18

https://gateoverflow.in/2052

Which of the following statements are CORRECT?

1. Static allocation of all data areas by a compiler makes it impossible to implement recursion.
2. Automatic garbage collection is essential to implement recursion.
3. Dynamic allocation of activation records is essential to implement recursion.
4. Both heap and stack are essential to implement recursion.

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

gate2014-3 compiler-design runtime-environments normal

2.18 Static Single Assignment (2)

2.18.1 Static Single Assignment: GATE2016-1-19

https://gateoverflow.in/39675

Consider the following code segment.

```
x = u - t;
y = x * v;
x = y + w;
y = t - z;
y = x * y;
```

The minimum number of *total* variables required to convert the above code segment to *static single assignment* form is

_____.

gate2016-1 compiler-design static-single-assignment normal numerical-answers

2.18.2 Static Single Assignment: GATE2017-1-12

https://gateoverflow.in/118292

Consider the following intermediate program in three address code

```
p = a - b
q = p * c
p = u * v
q = p + q
```

Which one of the following corresponds to a *static single assignment* form of the above code?

A.
```
p1 = a  - b
q1 = p1 * c
p1 = u  * v
q1 = p1 + q1
```

B.
```
p3 = a  - b
q4 = p3 * c
p4 = u  * v
q5 = p4 + q4
```

C.
```
p1 = a  - b
q1 = p2 * c
p3 = u  * v
q2 = p4 + q3
```

D.
```
p1 = a - b
q1 = p * c
p2 = u * v
q2 = p + q
```

gate2017-1 compiler-design intermediate-code normal static-single-assignment

2.19 Syntax Directed Translation (9)

2.19.1 Syntax Directed Translation: GATE1992-11a

https://gateoverflow.in/590

Write syntax directed definitions (semantic rules) for the following grammar to add the type of each identifier to its entry in the symbol table during semantic analysis. Rewriting the grammar is not permitted and semantic rules are to be added to the ends of productions only.

- $D \rightarrow TL;$
- $T \rightarrow \text{int}$
- $T \rightarrow \text{real}$
- $L \rightarrow L,id$
- $L \rightarrow id$

gate1992 compiler-design syntax-directed-translation normal

2.19.2 Syntax Directed Translation: GATE1995-2.10

https://gateoverflow.in/2622

A shift reduce parser carries out the actions specified within braces immediately after reducing with the corresponding rule of grammar

- $S \rightarrow xxW$ $\{\text{print}\text{“1”}\}$
- $S \rightarrow y$ $\{\text{print}\text{“2”}\}$
- $W \rightarrow Sz$ $\{\text{print}\text{“3”}\}$

What is the translation of $xxxyzz$ using the syntax directed translation scheme described by the above rules?

A. 23131 B. 11233 C. 11231 D. 33211

gate1995 compiler-design grammar syntax-directed-translation normal

2.19.3 Syntax Directed Translation: GATE1996-20

https://gateoverflow.in/2772

Consider the syntax-directed translation schema (SDTS) shown below:

- $E \rightarrow E + E$ {print “+”}
- $E \rightarrow E * E$ {print “.”}
- $E \rightarrow id$ {print id.name}
- $E \rightarrow (E)$

An LR-parser executes the actions associated with the productions immediately after a reduction by the corresponding production. Draw the parse tree and write the translation for the sentence.

$(a+b)*(c+d)$, using SDTS given above.

gate1996 compiler-design syntax-directed-translation normal

2.19.4 Syntax Directed Translation: GATE1998-23

https://gateoverflow.in/1738

Let the attribute 'val' give the value of a binary number generated by S in the following grammar:

- $S \rightarrow L.L \mid L$
- $L \rightarrow LB \mid B$
- $B \rightarrow 0 \mid 1$

For example, an input 101.101 gives $S.val = 5.625$

Construct a syntax directed translation scheme using only synthesized attributes, to determine $S.val$.

gate1998 compiler-design syntax-directed-translation normal descriptive

2.19.5 Syntax Directed Translation: GATE2000-19

https://gateoverflow.in/690

Consider the syntax directed translation scheme (SDTS) given in the following. Assume attribute evaluation with bottom-up parsing, i.e., attributes are evaluated immediately after a reduction.

E$\rightarrow$ E_1 * T {E.val = E_1.val * T.val}

E $\rightarrow$ T {E.val = T.val}

T$\rightarrow$ F - T_1 {T.val = F.val - T_1.val}

T $\rightarrow$ F {T.val = F.val}

F $\rightarrow$2 {F.val = 2}

F $\rightarrow$4 {F.val = 4}

A. Using this SDTS, construct a parse tree for the expression $4-2-4*2$ and also compute its $E.val$.
B. It is required to compute the total number of reductions performed to parse a given input. Using synthesized attributes only, modify the SDTS given, without changing the grammar, to find $E.red$, the number of reductions performed while reducing an input to E.

gate2000 compiler-design syntax-directed-translation normal descriptive

2.19.6 Syntax Directed Translation: GATE2001-17

https://gateoverflow.in/758

The syntax of the repeat-until statement is given by the following grammar

$S \rightarrow$ repeat S_1 until E

where E stands for expressions, S and S_1 stand for statements. The non-terminals S and S_1 have an attribute code that represents generated code. The non-terminal E has two attributes. The attribute code represents generated code to evaluate the expression and store its value in a distinct variable, and the attribute varName contains the name of the variable in which the truth value is stored. The truth-value stored in the variable is 1 if E is true, 0 if E is false.

Give a syntax-directed definition to generate three-address code for the repeat-until statement. Assume that you can call a function newlabel() that returns a distinct label for a statement. Use the operator '\\' to concatenate two strings and the function gen(s) to generate a line containing the string s.

gate2001 compiler-design syntax-directed-translation normal descriptive

2.19.7 Syntax Directed Translation: GATE2003-18

https://gateoverflow.in/908

In a bottom-up evaluation of a syntax directed definition, inherited attributes can

A. always be evaluated
B. be evaluated only if the definition is L-attributed
C. be evaluated only if the definition has synthesized attributes
D. never be evaluated

gate2003 compiler-design syntax-directed-translation normal

2.19.8 Syntax Directed Translation: GATE2016-1-46

https://gateoverflow.in/39700

Consider the following Syntax Directed Translation Scheme $(SDTS)$, with non-terminals $\{S, A\}$ and terminals $\{a, b\}$.

$S \rightarrow aA \quad \{\text{print } 1\}$
$S \rightarrow a \quad \{\text{print } 2\}$
$A \rightarrow Sb \quad \{\text{print } 3\}$

Using the above $SDTS$, the output printed by a bottom-up parser, for the input aab is:

A. $1\,3\,2$
B. $2\,2\,3$
C. $2\,3\,1$
D. syntax error

gate2016-1 compiler-design syntax-directed-translation normal

2.19.9 Syntax Directed Translation: GATE2019-36

https://gateoverflow.in/302812

Consider the following grammar and the semantic actions to support that inherited type declaration attributes. Let X_1, X_2, X_3, X_4, X_5, and X_6 be the placeholders for the non-terminals D, T, L or L_1 in the following table:

Production rule	Semantic action
$D \rightarrow TL$	$X_1.\text{type} = X_2.\text{type}$
$T \rightarrow \text{int}$	$T.\text{type} = \text{int}$
$T \rightarrow \text{float}$	$T.\text{type} = \text{float}$
$L \rightarrow L_1, id$	$X_3.\text{type} = X_4.\text{type}$ $\text{addType}(id.\text{entry}, X_5.\text{type})$
$L \rightarrow id$	$\text{addType}(id.\text{entry}, X_6, \text{type})$

Which one of the following are appropriate choices for X_1, X_2, X_3 and X_4?

A. $X_1 = L,\ X_2 = T,\ X_3 = L_1,\ X_4 = L$
B. $X_1 = T,\ X_2 = L,\ X_3 = L_1,\ X_4 = T$
C. $X_1 = L,\ X_2 = L,\ X_3 = L_1,\ X_4 = T$
D. $X_1 = T,\ X_2 = L,\ X_3 = T,\ X_4 = L_1$

gate2019 compiler-design syntax-directed-translation

2.20 Target Code Generation (4)

2.20.1 Target Code Generation: GATE1997-4.9

https://gateoverflow.in/2250

The expression $(a * b) * c\ op \ldots$

where 'op' is one of '$+$', '$*$' and '$\uparrow$' (exponentiation) can be evaluated on a CPU with single register without storing the value of $(a * b)$ if

A. 'op' is '$+$' or '$*$'
B. 'op' is '$\uparrow$' or '$*$'
C. 'op' is '$\uparrow$' or '$+$'
D. not possible to evaluate without storing

gate1997 compiler-design target-code-generation register-allocation normal

2.20.2 Target Code Generation: GATE2003-59

https://gateoverflow.in/947

Consider the syntax directed definition shown below.

$$\begin{aligned} S &\rightarrow \mathbf{id} := E && \{gen(\mathbf{id}.place = E.place;);\} \\ E &\rightarrow E_1 + E_2 && \{t = newtemp(); \\ & && gen(t = E_1.place + E_2.place;); \\ & && E.place = t;\} \\ E &\rightarrow id && \{E.place = \mathbf{id}.place;\} \end{aligned}$$

Here, gen is a function that generates the output code, and $newtemp$ is a function that returns the name of a new temporary variable on every call. Assume that *ti*'s are the temporary variable names generated by $newtemp$. For the statement '$X := Y + Z$', the 3-address code sequence generated by this definition is

A. $X = Y + Z$
B. $t_1 = Y + Z; X = t_1$
C. $t_1 = Y; t_2 = t_1 + Z; X = t_2$
D. $t_1 = Y; t_2 = Z; t_3 = t_1 + t_2; X = t_3$

gate2003 compiler-design target-code-generation normal

2.20.3 Target Code Generation: GATE2004-10

https://gateoverflow.in/4069

Consider the grammar rule $E \rightarrow E1 - E2$ for arithmetic expressions. The code generated is targeted to a CPU having a single user register. The subtraction operation requires the first operand to be in the register. If $E1$ and $E2$ do not have any common sub expression, in order to get the shortest possible code

A. $E1$ should be evaluated first
B. $E2$ should be evaluated first
C. Evaluation of $E1$ and $E2$ should necessarily be interleaved
D. Order of evaluation of $E1$ and $E2$ is of no consequence

gate2004 compiler-design target-code-generation normal

2.20.4 Target Code Generation: GATE2010-37

https://gateoverflow.in/2338

The program below uses six temporary variables a, b, c, d, e, f.

```
a = 1
b = 10
c = 20
d = a + b
e = c + d
f = c + e
b = c + e
e = b + f
d = 5 + e
return d + f
```

Assuming that all operations take their operands from registers, what is the minimum number of registers needed to execute this program without spilling?

A. 2 B. 3 C. 4 D. 6

gate2010 compiler-design target-code-generation register-allocation normal

2.21 Variable Scope (2)

2.21.1 Variable Scope: GATE1987-1-xix

https://gateoverflow.in/80373

Study the following program written in a block-structured language:

```
Var x, y:interger;
procedure P(n:interger);
begin
     x:=(n+2)/(n-3);
end;

procedure Q
Var x, y:interger;
begin
    x:=3;
    y:=4;
    P(y);
    Write(x)                                  __(1)
end;

begin
    x:=7;
    y:=8;
    Q;
Write(x);                                     __(2)
end.
```

What will be printed by the write statements marked (1) and (2) in the program if the variables are statically scoped?

A. 3,6 B. 6,7 C. 3,7 D. None of the above.

gate1987 compiler-design variable-scope

2.21.2 Variable Scope: GATE1987-1-xx

https://gateoverflow.in/80374

For the program given below what will be printed by the write statements marked (1) and (2) in the program if the variables are dynamically scoped?

```
Var x, y:interger;
procedure P(n:interger);
begin
     x := (n+2)/(n-3);
end;

procedure Q
Var x, y:interger;
begin
    x:=3;
    y:=4;
    P(y);
    Write(x);                                  __(1)
end;

begin
    x:=7;
    y:=8;
    Q;
    Write(x);                                    __(2)
end.
```

A. $3,6$ B. $6,7$ C. $3,7$ D. None of the above

gate1987 compiler-design variable-scope

2.22 Viable Prefix (1)

2.22.1 Viable Prefix: GATE2015-1-13

https://gateoverflow.in/8187

Which one of the following is TRUE at any valid state in shift-reduce parsing?

A. Viable prefixes appear only at the bottom of the stack and not inside
B. Viable prefixes appear only at the top of the stack and not inside
C. The stack contains only a set of viable prefixes
D. The stack never contains viable prefixes

gate2015-1 compiler-design parsing normal viable-prefix

3 Programming and DS: DS (212)

Arrays, Stacks, Queues, Linked lists, Trees, Binary search trees, Binary heaps, Graphs.

Mark Distribution in Previous GATE

Year	2019	2018	2017-1	2017-2	2016-1	2016-2	Minimum	Average	Maximum
1 Mark Count	0	2	3	1	1	1	0	1.3	3
2 Marks Count	2	0	0	1	3	3	0	1.5	3
Total Marks	4	2	3	3	7	7	**2**	**4.3**	**7**

3.1 Abstract Data Type (1)

3.1.1 Abstract Data Type: GATE2005-2

https://gateoverflow.in/1344

An Abstract Data Type (ADT) is:

A. same as an abstract class
B. a data type that cannot be instantiated
C. a data type for which only the operations defined on it can be used, but none else
D. all of the above

gate2005 data-structure normal abstract-data-type

3.2 Arrays (13)

3.2.1 Arrays: GATE1993-12

https://gateoverflow.in/2309

The following Pascal program segments finds the largest number in a two-dimensional integer array $A[0\ldots n-1, 0\ldots n-1]$ using a single loop. Fill up the boxes to complete the program and write against $\boxed{A}, \boxed{B}, \boxed{C}$ and $\boxed{D}$ in your answer book Assume that max is a variable to store the largest value and i, j are the indices to the array.

```
begin
    max:=|A|, i:=0, j:=0;
    while |B| do
    begin
        if A[i, j]>max then max:=A[i, j];
        if |C| then j:=j+1;
        else begin
            j:=0;
            i:=|D|
        end
    end
end
```

gate1993 data-structure arrays normal

3.2.2 Arrays: GATE1994-1.11

https://gateoverflow.in/2452

In a compact single dimensional array representation for lower triangular matrices (i.e all the elements above the diagonal are zero) of size $n \times n$, non-zero elements, (i.e elements of lower triangle) of each row are stored one after another, starting from the first row, the index of the $(i,j)^{th}$ element of the lower triangular matrix in this new representation is:

A. $i+j$ B. $i+j-1$ C. $(j-1)+\frac{i(i-1)}{2}$ D. $i+\frac{j(j-1)}{2}$

gate1994 data-structure arrays normal

3.2.3 Arrays: GATE1994-25

https://gateoverflow.in/2521

An array A contains n integers in non-decreasing order, $A[1] \leq A[2] \leq \cdots \leq A[n]$. Describe, using Pascal like pseudo code, a linear time algorithm to find i, j, such that $A[i] + A[j] = a$ given integer M, if such i, j exist.

gate1994 data-structure arrays normal

3.2.4 Arrays: GATE1997-17

https://gateoverflow.in/2277

An array A contains $n \geq 1$ positive integers in the locations $A[1], A[2], \ldots A[n]$. The following program fragment

prints the length of a shortest sequence of consecutive elements of A, $A[i], A[i+1], \ldots, A[j]$ such that the sum of their values is $\geq M$, a given positive number. It prints '$n+1$' if no such sequence exists. Complete the program by filling in the boxes. In each case use the simplest possible expression. Write only the line number and the contents of the box.

```
begin
i:=1;j:=1;
sum := □
min:=n; finish:=false;
while not finish do
    if □ then
        if j=n then finish:=true
        else
        begin
            j:=j+1;
            sum:= □
        end
    else
    begin
        if(j-i) < min then min:=j-i;
        sum:=sum -A[i];
        i:=i+1;
    end
    writeln (min +1);
end.
```

gate1997 data-structure arrays normal

3.2.5 Arrays: GATE1998-2.14

https://gateoverflow.in/1686

Let A be a two dimensional array declared as follows:

```
A: array [1 …. 10] [1 ….. 15] of integer;
```

Assuming that each integer takes one memory location, the array is stored in row-major order and the first element of the array is stored at location 100, what is the address of the element $A[i][j]$?

A. $15i+j+84$ B. $15j+i+84$ C. $10i+j+89$ D. $10j+i+89$

gate1998 data-structure arrays easy

3.2.6 Arrays: GATE2000-1.2

https://gateoverflow.in/625

An $n \times n$ array v is defined as follows:

$v[i,j] = i-j$ for all $i,j, i \leq n, 1 \leq j \leq n$

The sum of the elements of the array v is

A. 0 B. $n-1$ C. n^2-3n+2 D. $n^2\frac{(n+1)}{2}$

gate2000 data-structure arrays easy

3.2.7 Arrays: GATE2000-15

https://gateoverflow.in/686

Suppose you are given arrays $p[1.....N]$ and $q[1.....N]$ both uninitialized, that is, each location may contain an arbitrary value), and a variable count, initialized to 0. Consider the following procedures set and is_set:

```
set(i) {
    count = count + 1;
    q[count] = i;
    p[i] = count;
}
is_set(i) {
    if (p[i] ≤ 0 or p[i] > count)
        return false;
    if (q[p[i]] ≠ i)
        return false;
    return true;
}
```

A. Suppose we make the following sequence of calls:
$set(7); set(3); set(9);$
After these sequence of calls, what is the value of count, and what do $q[1], q[2], q[3], p[7], p[3]$ and $p[9]$ contain?

B. Complete the following statement "The first count elements of _____contain values i such that set (_____) has been called".

C. Show that if $set(i)$ has not been called for some i, then regardless of what $p[i]$ contains, $is\_set(i)$ will return false.

gate2000 data-structure arrays easy descriptive

3.2.8 Arrays: GATE2005-5

https://gateoverflow.in/1347

A program P reads in 500 integers in the range $[0,100]$ representing the scores of 500 students. It then prints the frequency of each score above 50. What would be the best way for P to store the frequencies?

A. An array of 50 numbers
B. An array of 100 numbers
C. An array of 500 numbers
D. A dynamically allocated array of 550 numbers

gate2005 data-structure arrays easy

3.2.9 Arrays: GATE2013-50

https://gateoverflow.in/1557

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array $oldc$, while their respective replacement characters are supplied in array $newc$. Array A has a fixed length of five characters, while arrays $oldc$ and $newc$ contain three characters each. However, the procedure is flawed.

```
void find_and_replace (char *A, char *oldc, char *newc) {
    for (int i=0; i<5; i++)
        for (int j=0; j<3; j++)
            if (A[i] == oldc[j])
                A[i] = newc[j];
}
```

The procedure is tested with the following four test cases.

1. $oldc =$ "abc", $newc =$ "dab"
2. $oldc =$ "cde", $newc =$ "bcd"
3. $oldc =$ "bca", $newc =$ "cda"
4. $oldc =$ "abc", $newc =$ "bac"

The tester now tests the program on all input strings of length five consisting of characters 'a', 'b', 'c', 'd' and 'e' with duplicates allowed. If the tester carries out this testing with the four test cases given above, how many test cases will be able to capture the flaw?

A. Only one B. Only two C. Only three D. All four

gate2013 data-structure arrays normal

3.2.10 Arrays: GATE2013-51

https://gateoverflow.in/43291

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array $oldc$, while their respective replacement characters are supplied in array $newc$. Array A has a fixed length of five characters, while arrays $oldc$ and $newc$ contain three characters each. However, the procedure is flawed.

```
void find_and_replace (char *A, char *oldc, char *newc) {
    for (int i=0; i<5; i++)
        for (int j=0; j<3; j++)
            if (A[i] == oldc[j])
                A[i] = newc[j];
}
```

The procedure is tested with the following four test cases.

1. $oldc =$ "abc", $newc =$ "dab"
2. $oldc =$ "cde", $newc =$ "bcd"
3. $oldc =$ "bca", $newc =$ "cda"
4. $oldc =$ "abc", $newc =$ "bac"

If array A is made to hold the string "$abcde$", which of the above four test cases will be successful in exposing the flaw in this procedure?

A. None B. 2 only C. 3 and 4 only D. 4 only

gate2013 data-structure arrays normal

3.2.11 Arrays: GATE2014-3-42

https://gateoverflow.in/2076

Consider the C function given below. Assume that the array $listA$ contains $n(>0)$ elements, sorted in ascending order.

```
int ProcessArray(int *listA, int x, int n)
{
        int i, j, k;
        i = 0;      j = n-1;
         do {
               k = (i+j)/2;
               if (x <= listA[k]) j = k-1;
               if (listA[k] <= x) i = k+1;
             }
        while (i <= j);
        if (listA[k] == x) return(k);
        else    return -1;
}
```

Which one of the following statements about the function $ProcessArray$ is **CORRECT**?

A. It will run into an infinite loop when x is not in $listA$.
B. It is an implementation of binary search.
C. It will always find the maximum element in $listA$.
D. It will return -1 even when x is present in $listA$.

gate2014-3 data-structure arrays easy

3.2.12 Arrays: GATE2015-2-31

https://gateoverflow.in/8148

A Young tableau is a $2D$ array of integers increasing from left to right and from top to bottom. Any unfilled entries are marked with ∞, and hence there cannot be any entry to the right of, or below a ∞. The following Young tableau consists of unique entries.

1	2	5	14
3	4	6	23
10	12	18	25
31	∞	∞	∞

When an element is removed from a Young tableau, other elements should be moved into its place so that the resulting table is still a Young tableau (unfilled entries may be filled with a ∞). The minimum number of entries (other than 1) to be shifted, to remove 1 from the given Young tableau is _____.

gate2015-2 databases arrays normal numerical-answers

3.2.13 Arrays: TIFR2011-B-30

https://gateoverflow.in/20611

Consider an array $A[1...n]$. It consists of a permutation of numbers $1....n$. Now compute another array $B[1...n]$ as follows: $B[A[i]] := i$ for all i. Which of the following is true?

A. B will be a sorted array.
B. B is a permutation of array A.
C. Doing the same transformation twice will not give the same array.
D. B is not a permutation of array A.
E. None of the above.

tifr2011 data-structure arrays

3.3 Binary Search Tree (29)

3.3.1 Binary Search Tree: GATE1996-2.14

https://gateoverflow.in/2743

A binary search tree is generated by inserting in order the following integers:

$$50, 15, 62, 5, 20, 58, 91, 3, 8, 37, 60, 24$$

The number of nodes in the left subtree and right subtree of the root respectively is

A. $(4,7)$ B. $(7,4)$ C. $(8,3)$ D. $(3,8)$

gate1996 data-structure binary-search-tree normal

3.3.2 Binary Search Tree: GATE1996-4

https://gateoverflow.in/2756

A binary search tree is used to locate the number 43. Which of the following probe sequences are possible and which are not? Explain.

(a) $61\ 52\ 14\ 17\ 40\ 43$
(b) $2\ 3\ 50\ 40\ 60\ 43$
(c) $10\ 65\ 31\ 48\ 37\ 43$
(d) $81\ 61\ 52\ 14\ 41\ 43$
(e) $17\ 77\ 27\ 66\ 18\ 43$

gate1996 data-structure binary-search-tree normal

3.3.3 Binary Search Tree: GATE2001-14

https://gateoverflow.in/755

A. Insert the following keys one by one into a binary search tree in the order specified.

$$15,32,20,9,3,25,12,1$$

Show the final binary search tree after the insertions.
B. Draw the binary search tree after deleting 15 from it.
C. Complete the statements $S1$, $S2$ and $S3$ in the following function so that the function computes the depth of a binary tree rooted at t.

```
typedef struct tnode{
    int key;
    struct tnode *left, *right;
} *Tree;

int depth (Tree t)
{
    int x, y;
    if (t == NULL) return 0;
    x = depth (t -> left);
S1:     ____________;

S2:     if (x > y) return ___________;

S3:     else return _______;

}
```

gate2001 data-structure binary-search-tree normal descriptive

3.3.4 Binary Search Tree: GATE2003-19, ISRO2009-24

https://gateoverflow.in/909

Suppose the numbers $7,5,1,8,3,6,0,9,4,2$ are inserted in that order into an initially empty binary search tree. The binary search tree uses the usual ordering on natural numbers. What is the in-order traversal sequence of the resultant tree?

A. $7\ 5\ 1\ 0\ 3\ 2\ 4\ 6\ 8\ 9$
B. $0\ 2\ 4\ 3\ 1\ 6\ 5\ 9\ 8\ 7$
C. $0\ 1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9$
D. $9\ 8\ 6\ 4\ 2\ 3\ 0\ 1\ 5\ 7$

gate2003 binary-search-tree easy isro2009

3.3.5 Binary Search Tree: GATE2003-6

https://gateoverflow.in/897

Let $T(n)$ be the number of different binary search trees on n distinct elements.
Then $T(n) = \sum_{k=1}^{n} T(k-1)T(x)$, where x is

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

gate2003 normal binary-search-tree

3.3.6 Binary Search Tree: GATE2003-63, ISRO2009-25

https://gateoverflow.in/950

A data structure is required for storing a set of integers such that each of the following operations can be done in $O(\log n)$ time, where n is the number of elements in the set.

I. Deletion of the smallest element

II. Insertion of an element if it is not already present in the set

Which of the following data structures can be used for this purpose?

A. A heap can be used but not a balanced binary search tree
B. A balanced binary search tree can be used but not a heap
C. Both balanced binary search tree and heap can be used
D. Neither balanced search tree nor heap can be used

gate2003 data-structure easy isro2009 binary-search-tree

3.3.7 Binary Search Tree: GATE2004-4, ISRO2009-26

https://gateoverflow.in/1001

The following numbers are inserted into an empty binary search tree in the given order: $10,1,3,5,15,12,16$. What is the height of the binary search tree (the height is the maximum distance of a leaf node from the root)?

A. 2 B. 3 C. 4 D. 6

gate2004 data-structure binary-search-tree easy isro2009

3.3.8 Binary Search Tree: GATE2004-85

https://gateoverflow.in/1079

A program takes as input a balanced binary search tree with n leaf nodes and computes the value of a function $g(x)$ for each node x. If the cost of computing $g(x)$ is:

$$\min\left(\begin{array}{c}\text{number of leaf-nodes}\\ \text{in left-subtree of } x\end{array}, \begin{array}{c}\text{number of leaf-nodes}\\ \text{in right-subtree of } x\end{array}\right)$$

Then the worst-case time complexity of the program is?

A. $\Theta(n)$ B. $\Theta(n\log n)$
C. $\Theta(n^2)$ D. $\Theta(n^2\log n)$

gate2004 binary-search-tree normal data-structure

3.3.9 Binary Search Tree: GATE2005-IT-12

https://gateoverflow.in/3757

The numbers $1,2,\ldots.n$ are inserted in a binary search tree in some order. In the resulting tree, the right subtree of the root contains p nodes. The first number to be inserted in the tree must be

A. p B. $p+1$ C. $n-p$ D. $n-p+1$

gate2005-it data-structure normal binary-search-tree

3.3.10 Binary Search Tree: GATE2005-IT-55

https://gateoverflow.in/3816

A binary search tree contains the numbers $1,2,3,4,5,6,7,8.$ When the tree is traversed in pre-order and the values in each node printed out, the sequence of values obtained is $5,3,1,2,4,6,8,7.$ If the tree is traversed in post-order, the sequence obtained would be

A. $8,7,6,5,4,3,2,1$ B. $1,2,3,4,8,7,6,5$
C. $2,1,4,3,6,7,8,5$ D. $2,1,4,3,7,8,6,5$

gate2005-it data-structure binary-search-tree normal

3.3.11 Binary Search Tree: GATE2006-IT-45

https://gateoverflow.in/3588

Suppose that we have numbers between 1 and 100 in a binary search tree and want to search for the number 55. Which of the following sequences CANNOT be the sequence of nodes examined?

A. $\{10, 75, 64, 43, 60, 57, 55\}$
B. $\{90, 12, 68, 34, 62, 45, 55\}$
C. $\{9, 85, 47, 68, 43, 57, 55\}$
D. $\{79, 14, 72, 56, 16, 53, 55\}$

gate2006-it data-structure binary-search-tree normal

3.3.12 Binary Search Tree: GATE2007-IT-29

https://gateoverflow.in/3462

When searching for the key value 60 in a binary search tree, nodes containing the key values $10, 20, 40, 50, 70, 80, 90$ are traversed, not necessarily in the order given. How many different orders are possible in which these key values can occur on the search path from the root to the node containing the value 60?

A. 35 B. 64 C. 128 D. 5040

gate2007-it data-structure binary-search-tree normal

3.3.13 Binary Search Tree: GATE2008-46

https://gateoverflow.in/458

You are given the postorder traversal, P, of a binary search tree on the n elements $1, 2, \ldots, n$. You have to determine the unique binary search tree that has P as its postorder traversal. What is the time complexity of the most efficient algorithm for doing this?

A. $\Theta(\log n)$
B. $\Theta(n)$
C. $\Theta(n \log n)$
D. None of the above, as the tree cannot be uniquely determined

gate2008 data-structure binary-search-tree normal

3.3.14 Binary Search Tree: GATE2008-IT-12

https://gateoverflow.in/3272

Which of the following is TRUE?

A. The cost of searching an AVL tree is $\Theta(\log n)$ but that of a binary search tree is $O(n)$
B. The cost of searching an AVL tree is $\Theta(\log n)$ but that of a complete binary tree is $\Theta(n \log n)$
C. The cost of searching a binary search tree is $O(\log n)$ but that of an AVL tree is $\Theta(n)$
D. The cost of searching an AVL tree is $\Theta(n \log n)$ but that of a binary search tree is $O(n)$

gate2008-it data-structure binary-search-tree easy

3.3.15 Binary Search Tree: GATE2008-IT-71

https://gateoverflow.in/3385

A Binary Search Tree (BST) stores values in the range 37 to 573. Consider the following sequence of keys.

I. $81, 537, 102, 439, 285, 376, 305$
II. $52, 97, 121, 195, 242, 381, 472$
III. $142, 248, 520, 386, 345, 270, 307$
IV. $550, 149, 507, 395, 463, 402, 270$

Suppose the BST has been unsuccessfully searched for key 273. Which all of the above sequences list nodes in the order in which we could have encountered them in the search?

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

gate2008-it data-structure binary-search-tree normal

3.3.16 Binary Search Tree: GATE2008-IT-72

https://gateoverflow.in/3386

A Binary Search Tree (BST) stores values in the range 37 to 573. Consider the following sequence of keys.

I. $81, 537, 102, 439, 285, 376, 305$
II. $52, 97, 121, 195, 242, 381, 472$
III. $142, 248, 520, 386, 345, 270, 307$
IV. $550, 149, 507, 395, 463, 402, 270$

Which of the following statements is TRUE?

A. I, II and IV are inorder sequences of three different BSTs
B. I is a preorder sequence of some BST with 439 as the root
C. II is an inorder sequence of some BST where 121 is the root and 52 is a leaf
D. IV is a postorder sequence of some BST with 149 as the root

gate2008-it data-structure binary-search-tree easy

3.3.17 Binary Search Tree: GATE2008-IT-73

https://gateoverflow.in/3387

How many distinct BSTs can be constructed with 3 distinct keys?

A. 4 B. 5 C. 6 D. 9

gate2008-it data-structure binary-search-tree normal

3.3.18 Binary Search Tree: GATE2009-37,ISRO-DEC2017-55

https://gateoverflow.in/1323

What is the maximum height of any AVL-tree with 7 nodes? Assume that the height of a tree with a single node is 0.

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

gate2009 data-structure binary-search-tree normal isrodec2017

3.3.19 Binary Search Tree: GATE2012-5

https://gateoverflow.in/37

The worst case running time to search for an element in a balanced binary search tree with $n2^n$ elements is

A. $\Theta(n \log n)$
B. $\Theta(n2^n)$
C. $\Theta(n)$
D. $\Theta(\log n)$

gate2012 data-structure normal binary-search-tree

3.3.20 Binary Search Tree: GATE2013-43

https://gateoverflow.in/1554

The preorder traversal sequence of a binary search tree is $30,20,10,15,25,23,39,35,42$. Which one of the following is the postorder traversal sequence of the same tree?

A. $10,20,15,23,25,35,42,39,30$
B. $15,10,25,23,20,42,35,39,30$
C. $15,20,10,23,25,42,35,39,30$
D. $15,10,23,25,20,35,42,39,30$

gate2013 data-structure binary-search-tree normal

3.3.21 Binary Search Tree: GATE2013-7

https://gateoverflow.in/1416

Which one of the following is the tightest upper bound that represents the time complexity of inserting an object into a binary search tree of n nodes?

A. $O(1)$ B. $O(\log n)$ C. $O(n)$ D. $O(n \log n)$

gate2013 data-structure easy binary-search-tree

3.3.22 Binary Search Tree: GATE2014-3-39

https://gateoverflow.in/2073

Suppose we have a balanced binary search tree T holding n numbers. We are given two numbers L and H and wish to sum up all the numbers in T that lie between L and H. Suppose there are m such numbers in T. If the tightest upper bound on the time to compute the sum is $O(n^a \log^b n + m^c \log^d n)$, the value of $a + 10b + 100c + 1000d$ is _____.

gate2014-3 data-structure binary-search-tree numerical-answers normal

3.3.23 Binary Search Tree: GATE2015-1-10

https://gateoverflow.in/8129

Which of the following is/are correct in order traversal sequence(s) of binary search tree(s)?

I. $3,5,7,8,15,19,25$
II. $5,8,9,12,10,15,25$
III. $2,7,10,8,14,16,20$
IV. $4,6,7,9,18,20,25$

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

gate2015-1 data-structure binary-search-tree easy

3.3.24 Binary Search Tree: GATE2015-1-23

https://gateoverflow.in/8221

What are the worst-case complexities of insertion and deletion of a key in a binary search tree?

A. $\Theta(\log n)$ for both insertion and deletion
B. $\Theta(n)$ for both insertion and deletion
C. $\Theta(n)$ for insertion and $\Theta(\log n)$ for deletion
D. $\Theta(\log n)$ for insertion and $\Theta(n)$ for deletion

gate2015-1 data-structure binary-search-tree easy

3.3.25 Binary Search Tree: GATE2015-3-13

https://gateoverflow.in/8409

While inserting the elements $71, 65, 84, 69, 67, 83$ in an empty binary search tree (BST) in the sequence shown, the element in the lowest level is

A. 65 B. 67 C. 69 D. 83

gate2015-3 data-structure binary-search-tree easy

3.3.26 Binary Search Tree: GATE2016-2-40

https://gateoverflow.in/39586

The number of ways in which the numbers $1, 2, 3, 4, 5, 6, 7$ can be inserted in an empty binary search tree, such that the resulting tree has height 6, is _____.

Note: The height of a tree with a single node is 0.

gate2016-2 data-structure binary-search-tree normal numerical-answers

3.3.27 Binary Search Tree: GATE2017-1-6

https://gateoverflow.in/118286

Let T be a binary search tree with 15 nodes. The minimum and maximum possible heights of T are:

Note: The height of a tree with a single node is 0.

A. 4 and 15 respectively.
B. 3 and 14 respectively.
C. 4 and 14 respectively.
D. 3 and 15 respectively.

gate2017-1 data-structure binary-search-tree easy

3.3.28 Binary Search Tree: GATE2017-2-36

https://gateoverflow.in/118378

The pre-order traversal of a binary search tree is given by $12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20$. Then the post-order traversal of this tree is

A. $2, 6, 7, 8, 9, 10, 12, 15, 16, 17, 19, 20$
B. $2, 7, 6, 10, 9, 8, 15, 17, 20, 19, 16, 12$
C. $7, 2, 6, 8, 9, 10, 20, 17, 19, 15, 16, 12$
D. $7, 6, 2, 10, 9, 8, 15, 16, 17, 20, 19, 12$

gate2017-2 data-structure binary-search-tree

3.3.29 Binary Search Tree: TIFR2010-B-26

https://gateoverflow.in/18749

Suppose there is a balanced binary search tree with n nodes, where at each node, in addition to the key, we store the number of elements in the sub tree rooted at that node.

Now, given two elements a and b, such that $a < b$, we want to find the number of elements x in the tree that lie between a and b, that is, $a \leq x \leq b$. This can be done with (choose the best solution).

A. $O(\log n)$ comparisons and $O(\log n)$ additions.
B. $O(\log n)$ comparisons but no further additions.
C. $O(\sqrt{n})$ comparisons but $O(\log n)$ additions.
D. $O(\log n)$ comparisons but a constant number of additions.
E. $O(n)$ comparisons and $O(n)$ additions, using depth-first- search.

tifr2010 binary-search-tree

3.4 Binary Tree (56)

3.4.1 Binary Tree: GATE1987-2c

https://gateoverflow.in/80579

State whether the following statements are TRUE or FALSE:

It is possible to construct a binary tree uniquely whose pre-order and post-order traversals are given?

gate1987 binary-tree data-structure normal

3.4.2 Binary Tree: GATE1987-2g

https://gateoverflow.in/80588

State whether the following statements are TRUE or FALSE:

If the number of leaves in a tree is not a power of 2, then the tree is not a binary tree.

gate1987 data-structure binary-tree

3.4.3 Binary Tree: GATE1987-7b

https://gateoverflow.in/82427

Construct a binary tree whose preorder traversal is

- K L N M P R Q S T

and inorder traversal is

- N L K P R M S Q T

gate1987 data-structure binary-tree

3.4.4 Binary Tree: GATE1988-7i

https://gateoverflow.in/94366

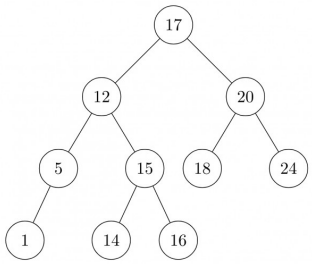
Define the height of a binary tree or subtree and also define a height-balanced (AVL) tree.

gate1988 normal descriptive data-structure binary-tree

3.4.5 Binary Tree: GATE1988-7ii

https://gateoverflow.in/94367

Mark the balance factor of each on the tree given on the below figure and state whether it is height-balanced.

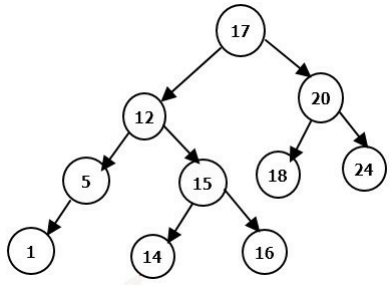


gate1988 normal descriptive binary-tree

3.4.6 Binary Tree: GATE1988-7iii

https://gateoverflow.in/94368

Consider the tree given in the below figure, insert 13 and show the new balance factors that would arise if the tree is not rebalanced. Finally, carry out the required rebalancing of the tree and show the new tree with the balance factors on each mode.



gate1988 normal descriptive data-structure binary-tree

3.4.7 Binary Tree: GATE1990-3-iv

https://gateoverflow.in/84828

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

The total external path length, EPL, of a binary tree with n external nodes is, $EPL = \sum_w Iw$, where I_w is the path length of external node w),

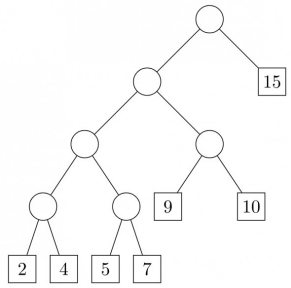
A. $\leq n^2$ always.
B. $\geq n \log_2 n$ always.
C. Equal to n^2 always.
D. $O(n)$ for some special trees.

gate1990 normal data-structure binary-tree

3.4.8 Binary Tree: GATE1991-01,viii

https://gateoverflow.in/506

The weighted external path length of the binary tree in figure is _____

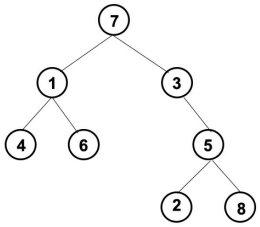


gate1991 binary-tree data-structure normal

3.4.9 Binary Tree: GATE1991-1,ix

https://gateoverflow.in/502

If the binary tree in figure is traversed in inorder, then the order in which the nodes will be visited is _____

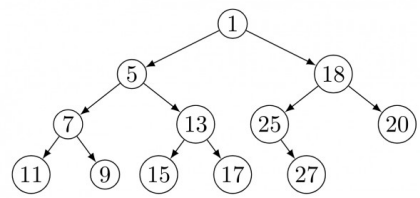


gate1991 binary-tree easy data-structure

3.4.10 Binary Tree: GATE1991-14,a

https://gateoverflow.in/541

Consider the binary tree in the figure below:



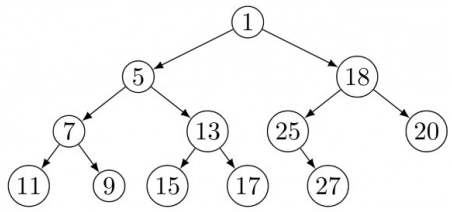
(a). What structure is represented by the binary tree?

gate1991 data-structure binary-tree time-complexity normal

3.4.11 Binary Tree: GATE1991-14,b

https://gateoverflow.in/43026

Consider the binary tree in the figure below:



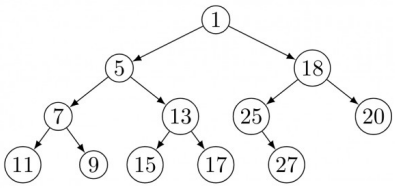
Give different steps for deleting the node with key 5 so that the structure is preserved.

gate1991 data-structure binary-tree normal

3.4.12 Binary Tree: GATE1991-14,c

https://gateoverflow.in/43027

Consider the binary tree in the figure below:



Outline a procedure in Pseudo-code to delete an arbitrary node from such a binary tree with n nodes that preserves the structures. What is the worst-case-time-complexity of your procedure?

gate1991 normal data-structure binary-tree time-complexity

3.4.13 Binary Tree: GATE1993-16

https://gateoverflow.in/2313

Prove by the principal of mathematical induction that for any binary tree, in which every non-leaf node has 2-descendants, the number of leaves in the tree is one more than the number of non-leaf nodes.

gate1993 data-structure binary-tree normal

3.4.14 Binary Tree: GATE1994-8

https://gateoverflow.in/2504

A rooted tree with 12 nodes has its nodes numbered 1 to 12 in pre-order. When the tree is traversed in post-order, the nodes are visited in the order $3,5,4,2,7,8,6,10,11,12,9,1$.

Reconstruct the original tree from this information, that is, find the parent of each node, and show the tree diagrammatically.

gate1994 data-structure binary-tree normal

3.4.15 Binary Tree: GATE1995-1.17

https://gateoverflow.in/2604

A binary tree T has n leaf nodes. The number of nodes of degree 2 in T is

A. $\log_2 n$ B. $n-1$ C. n D. 2^n

gate1995 data-structure binary-tree normal

3.4.16 Binary Tree: GATE1995-6

https://gateoverflow.in/2667

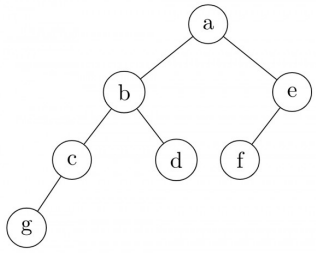
What is the number of binary trees with 3 nodes which when traversed in post-order give the sequence A,B,C? Draw all these binary trees.

gate1995 data-structure binary-tree normal

3.4.17 Binary Tree: GATE1996-1.14

https://gateoverflow.in/2718

In the balanced binary tree in the below figure, how many nodes will become unbalanced when a node is inserted as a child of the node "g"?



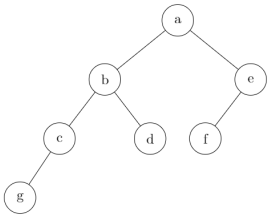
A. 1 B. 3 C. 7 D. 8

gate1996 data-structure binary-tree normal

3.4.18 Binary Tree: GATE1996-1.15

https://gateoverflow.in/2719

Which of the following sequences denotes the post order traversal sequence of the below tree?



A. $f\ e\ g\ c\ d\ b\ a$
B. $g\ c\ b\ d\ a\ f\ e$
C. $g\ c\ d\ b\ f\ e\ a$
D. $f\ e\ d\ g\ c\ b\ a$

gate1996 data-structure binary-tree easy

3.4.19 Binary Tree: GATE1997-16

https://gateoverflow.in/2276

A size-balanced binary tree is a binary tree in which for every node the difference between the number of nodes in the left and right subtree is at most 1. The distance of a node from the root is the length of the path from the root to the node. The height of a binary tree is the maximum distance of a leaf node from the root.

A. Prove, by using induction on h, that a size-balance binary tree of height h contains at least 2^h nodes.
B. In a size-balanced binary tree of height $h \geqslant 1$, how many nodes are at distance $h-1$ from the root? Write only the answer without any explanations.

gate1997 data-structure binary-tree normal

3.4.20 Binary Tree: GATE1997-4.5

https://gateoverflow.in/2246

A binary search tree contains the value $1,2,3,4,5,6,7,8$. The tree is traversed in pre-order and the values are printed out. Which of the following sequences is a valid output?

A. $5\ 3\ 1\ 2\ 4\ 7\ 8\ 6$
B. $5\ 3\ 1\ 2\ 6\ 4\ 8\ 7$
C. $5\ 3\ 2\ 4\ 1\ 6\ 7\ 8$
D. $5\ 3\ 1\ 2\ 4\ 7\ 6\ 8$

gate1997 data-structure binary-tree normal

3.4.21 Binary Tree: GATE1998-20

https://gateoverflow.in/1734

Draw the binary tree with node labels $\mathrm{a, b, c, d, e, f}$ and g for which the inorder and postorder traversals result in the following sequences:

Inorder: $\mathrm{a\ f\ b\ c\ d\ g\ e}$

Postorder: $\mathrm{a\ f\ c\ g\ e\ d\ b}$

gate1998 data-structure binary-tree descriptive

3.4.22 Binary Tree: GATE2000-1.14

https://gateoverflow.in/637

Consider the following nested representation of binary trees: $(X\,Y\,Z)$ indicates Y and Z are the left and right subtrees, respectively, of node X. Note that Y and Z may be $NULL$, or further nested. Which of the following represents a valid binary tree?

A. $(1\,2\,(4\,5\,6\,7))$
B. $(1\,(2\,3\,4)\,5\,6)\,7)$
C. $(1\,(2\,3\,4)\,(5\,6\,7))$
D. $(1\,(2\,3\,NULL)\,(4\,5))$

gate2000 data-structure binary-tree easy

3.4.23 Binary Tree: GATE2000-2.16

https://gateoverflow.in/663

Let LASTPOST, LASTIN and LASTPRE denote the last vertex visited `in a postorder, inorder and preorder traversal respectively, of a complete binary tree. Which of the following is always true?

A. LASTIN = LASTPOST
B. LASTIN = LASTPRE
C. LASTPRE = LASTPOST
D. None of the above

gate2000 data-structure binary-tree normal

3.4.24 Binary Tree: GATE2002-2.12

https://gateoverflow.in/842

A weight-balanced tree is a binary tree in which for each node, the number of nodes in the left sub tree is at least half and at most twice the number of nodes in the right sub tree. The maximum possible height (number of nodes on the path from the root to the furthest leaf) of such a tree on n nodes is best described by which of the following?

A. $\log_2 n$
B. $\log_{\frac{4}{3}} n$
C. $\log_3 n$
D. $\log_{\frac{3}{2}} n$

gate2002 data-structure binary-tree normal

3.4.25 Binary Tree: GATE2002-6

https://gateoverflow.in/859

Draw all binary trees having exactly three nodes labeled A, B and C on which preorder traversal gives the sequence C, B, A.

gate2002 data-structure binary-tree easy descriptive

3.4.26 Binary Tree: GATE2004-35

https://gateoverflow.in/1032

Consider the label sequences obtained by the following pairs of traversals on a labeled binary tree. Which of these pairs identify a tree uniquely?

I. preorder and postorder
II. inorder and postorder
III. preorder and inorder
IV. level order and postorder

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

gate2004 data-structure binary-tree normal

3.4.27 Binary Tree: GATE2004-43

https://gateoverflow.in/1040

Consider the following C program segment

```
struct CellNode{
    struct CellNode *leftChild
    int element;
    struct CellNode *rightChild;
    };

int Dosomething (struct CellNode *ptr)
{
    int value = 0;
    if(ptr != NULL)
    {
        if (ptr -> leftChild != NULL)
            value = 1 + DoSomething (ptr -> leftChild);
        if (ptr -> rightChild != NULL)
            value = max(value, 1 + Dosomething (ptr -> rightChild));
    }
    return(value);
```

```
}
```

The value returned by the function DoSomething when a pointer to the root of a non-empty tree is passed as argument is

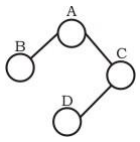
A. The number of leaf nodes in the tree
B. The number of nodes in the tree
C. The number of internal nodes in the tree
D. The height of the tree

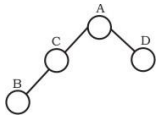
gate2004 data-structure binary-tree normal

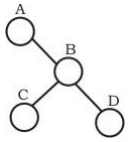
3.4.28 Binary Tree: GATE2004-IT-54

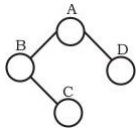
https://gateoverflow.in/3697

Which one of the following binary trees has its inorder and preorder traversals as $BCAD$ and $ABCD$, respectively?

A. 

B. 

C. 

D. 

gate2004-it binary-tree easy data-structure

3.4.29 Binary Tree: GATE2005-33

https://gateoverflow.in/1369

Postorder traversal of a given binary search tree, T produces the following sequence of keys

$10, 9, 23, 22, 27, 25, 15, 50, 95, 60, 40, 29$

Which one of the following sequences of keys can be the result of an in-order traversal of the tree T?

A. $9, 10, 15, 22, 23, 25, 27, 29, 40, 50, 60, 95$
B. $9, 10, 15, 22, 40, 50, 60, 95, 23, 25, 27, 29$
C. $29, 15, 9, 10, 25, 22, 23, 27, 40, 60, 50, 95$
D. $95, 50, 60, 40, 27, 23, 22, 25, 10, 9, 15, 29$

gate2005 data-structure binary-tree easy

3.4.30 Binary Tree: GATE2005-IT-50

https://gateoverflow.in/3811

In a binary tree, for every node the difference between the number of nodes in the left and right subtrees is at most 2. If the height of the tree is $h > 0$, then the minimum number of nodes in the tree is

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

gate2005-it data-structure binary-tree normal

3.4.31 Binary Tree: GATE2006-13

https://gateoverflow.in/974

A scheme for storing binary trees in an array X is as follows. Indexing of X starts at 1 instead of 0. the root is stored at $X[1]$. For a node stored at $X[i]$, the left child, if any, is stored in $X[2i]$ and the right child, if any, in $X[2i+1]$. To be able to store any binary tree on n vertices the minimum size of X should be

A. $\log_2 n$ B. n C. $2n+1$ D. $2^n - 1$

gate2006 data-structure binary-tree normal

3.4.32 Binary Tree: GATE2006-IT-71

https://gateoverflow.in/3615

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. The index of the parent of element $X[i], i \neq 0$, is?

A. $\left\lfloor \frac{i}{2} \right\rfloor$ B. $\left\lceil \frac{i-1}{2} \right\rceil$

C. $\left\lceil \frac{i}{2} \right\rceil$ D. $\left\lceil \frac{i}{2} \right\rceil - 1$

gate2006-it data-structure binary-tree normal

3.4.33 Binary Tree: GATE2006-IT-73

https://gateoverflow.in/3617

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. If the root node is at level 0, the level of element $X[i]$, $i \neq 0$, is

A. $\lfloor \log_2 i \rfloor$
B. $\lceil \log_2 (i+1) \rceil$
C. $\lfloor \log_2 (i+1) \rfloor$
D. $\lceil \log_2 i \rceil$

gate2006-it data-structure binary-tree normal

3.4.34 Binary Tree: GATE2006-IT-9

https://gateoverflow.in/3548

In a binary tree, the number of internal nodes of degree 1 is 5, and the number of internal nodes of degree 2 is 10. The number of leaf nodes in the binary tree is

A. 10 B. 11 C. 12 D. 15

gate2006-it data-structure binary-tree normal

3.4.35 Binary Tree: GATE2007-12

https://gateoverflow.in/1210

The height of a binary tree is the maximum number of edges in any root to leaf path. The maximum number of nodes in a binary tree of height h is:

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

gate2007 data-structure binary-tree easy

3.4.36 Binary Tree: GATE2007-13

https://gateoverflow.in/1211

The maximum number of binary trees that can be formed with three unlabeled nodes is:

A. 1 B. 5 C. 4 D. 3

gate2007 data-structure binary-tree normal

3.4.37 Binary Tree: GATE2007-39, UGCNET-June2015-II-22

https://gateoverflow.in/1237

The inorder and preorder traversal of a binary tree are

$d\ b\ e\ a\ f\ c\ g$ and $a\ b\ d\ e\ c\ f\ g$, respectively

The postorder traversal of the binary tree is:

A. $d\ e\ b\ f\ g\ c\ a$
B. $e\ d\ b\ g\ f\ c\ a$
C. $e\ d\ b\ f\ g\ c\ a$
D. $d\ e\ f\ g\ b\ c\ a$

gate2007 data-structure binary-tree normal ugcnetjune2015ii

3.4.38 Binary Tree: GATE2007-46

https://gateoverflow.in/1244

Consider the following C program segment where $CellNode$ represents a node in a binary tree:

```
struct CellNode {
    struct CellNode *leftChild;
    int element;
    struct CellNode *rightChild;
};

int Getvalue (struct CellNode *ptr) {
    int value = 0;
    if (ptr != NULL) {
        if ((ptr->leftChild == NULL) &&
            (ptr->rightChild == NULL))
            value = 1;
        else
            value = value + GetValue(ptr->leftChild)
                      + GetValue(ptr->rightChild);
    }
    return(value);
}
```

The value returned by $GetValue$ when a pointer to the root of a binary tree is passed as its argument is:

A. the number of nodes in the tree
B. the number of internal nodes in the tree
C. the number of leaf nodes in the tree
D. the height of the tree

gate2007 data-structure binary-tree normal

3.4.39 Binary Tree: GATE2008-IT-46

https://gateoverflow.in/3356

The following three are known to be the preorder, inorder and postorder sequences of a binary tree. But it is not known which is which.

I. $MBCAFHPYK$
II. $KAMCBYPFH$
III. $MABCKYFPH$

Pick the true statement from the following.

A. I and II are preorder and inorder sequences, respectively
B. I and III are preorder and postorder sequences, respectively
C. II is the inorder sequence, but nothing more can be said about the other two sequences
D. II and III are the preorder and inorder sequences, respectively

gate2008-it data-structure normal binary-tree

3.4.40 Binary Tree: GATE2008-IT-76

https://gateoverflow.in/3390

A binary tree with $n > 1$ nodes has n_1, n_2 and n_3 nodes of degree one, two and three respectively. The degree of a node is defined as the number of its neighbours.

n_3 can be expressed as

A. $n_1 + n_2 - 1$
B. $n_1 - 2$
C. $[((n_1 + n_2)/2)]$
D. $n_2 - 1$

gate2008-it data-structure binary-tree normal

3.4.41 Binary Tree: GATE2008-IT-77

https://gateoverflow.in/3391

A binary tree with $n > 1$ nodes has n_1, n_2 and n_3 nodes of degree one, two and three respectively. The degree of a node is defined as the number of its neighbours.

Starting with the above tree, while there remains a node v of degree two in the tree, add an edge between the two neighbours of v and then remove v from the tree. How many edges will remain at the end of the process?

A. $2 * n_1 - 3$
B. $n_2 + 2 * n_1 - 2$
C. $n_3 - n_2$
D. $n_2 + n_1 - 2$

gate2008-it data-structure binary-tree normal

3.4.42 Binary Tree: GATE2010-10

https://gateoverflow.in/2183

In a binary tree with n nodes, every node has an odd number of descendants. Every node is considered to be its own descendant. What is the number of nodes in the tree that have exactly one child?

A. 0
B. 1
C. $\frac{(n-1)}{2}$
D. $n-1$

gate2010 data-structure binary-tree normal

3.4.43 Binary Tree: GATE2011-29

https://gateoverflow.in/2131

We are given a set of n distinct elements and an unlabeled binary tree with n nodes. In how many ways can we populate the tree with the given set so that it becomes a binary search tree?

A. 0
B. 1
C. $n!$
D. $\frac{1}{n+1}.^{2n}C_n$

gate2011 binary-tree normal

3.4.44 Binary Tree: GATE2012-47

https://gateoverflow.in/2163

The height of a tree is defined as the number of edges on the longest path in the tree. The function shown in the pseudo-code below is invoked as height (root) to compute the height of a binary tree rooted at the tree pointer root.

```
int height(treeptr n)
{ if(n == NULL) return -1;
  if(n -> left == NULL)
     if(n -> right == NULL) return 0;
     else return B1; // Box 1

  else{h1 = height(n -> left);
       if(n -> right == NULL) return (1+h1);
       else{h2 = height(n -> right);
            return B2; // Box 2
            }
       }
}
```

The appropriate expressions for the two boxes **B1** and **B2** are:

A. **B1**: $(1 + \text{height}(n \rightarrow \text{right}))$; **B2**: $(1 + \max(h1, h2))$
B. **B1**: $(\text{height}(n \rightarrow \text{right}))$; **B2**: $(1 + \max(h1, h2))$
C. **B1**: $\text{height}(n \rightarrow \text{right})$; **B2**: $\max(h1, h2)$
D. **B1**: $(1 + \text{height}(n \rightarrow \text{right}))$; **B2**: $\max(h1, h2)$

gate2012 data-structure binary-tree normal

3.4.45 Binary Tree: GATE2014-1-12

https://gateoverflow.in/1776

Consider a rooted n node binary tree represented using pointers. The best upper bound on the time required to determine the number of subtrees having exactly 4 nodes is $O(n^a \log^b n)$. Then the value of $a + 10b$ is _____.

gate2014-1 data-structure binary-tree numerical-answers normal

3.4.46 Binary Tree: GATE2015-1-25

https://gateoverflow.in/8223

The height of a tree is the length of the longest root-to-leaf path in it. The maximum and minimum number of nodes in a binary tree of height 5 are

A. 63 and 6, respectively
B. 64 and 5, respectively
C. 32 and 6, respectively
D. 31 and 5, respectively

gate2015-1 data-structure binary-tree easy

3.4.47 Binary Tree: GATE2015-2-10

https://gateoverflow.in/8059

A binary tree T has 20 leaves. The number of nodes in T having two children is _____.

gate2015-2 data-structure binary-tree normal numerical-answers

3.4.48 Binary Tree: GATE2015-3-25

https://gateoverflow.in/8428

Consider a binary tree T that has 200 leaf nodes. Then the number of nodes in T that have exactly two children are _____.

gate2015-3 data-structure binary-tree normal numerical-answers

3.4.49 Binary Tree: GATE2016-2-36

https://gateoverflow.in/39597

Consider the following New-order strategy for traversing a binary tree:

- Visit the root;
- Visit the right subtree using New-order;
- Visit the left subtree using New-order;

The New-order traversal of the expression tree corresponding to the reverse polish expression

```
3 4 * 5 - 2 ^ 6 7 * 1 + -
```

is given by:

A. $+ - 1\ 6\ 7 * 2 \wedge 5\ -\ 3\ 4 *$
B. $- + 1 * 6\ 7 \wedge 2 - 5 * 3\ 4$
C. $- + 1 * 7\ 6 \wedge 2\ -\ 5\ *\ 4\ 3$
D. $1\ 7\ 6 * + 2\ 5\ 4\ 3\ *\ - \wedge -$

gate2016-2 data-structure binary-tree normal

3.4.50 Binary Tree: GATE2018-20

https://gateoverflow.in/204094

The postorder traversal of a binary tree is $8,9,6,7,4,5,2,3,1$. The inorder traversal of the same tree is $8,6,9,4,7,2,5,1,3$. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is _____

gate2018 data-structure binary-tree numerical-answers

3.4.51 Binary Tree: GATE2019-46

https://gateoverflow.in/302802

Let T be a full binary tree with 8 leaves. (A full binary tree has every level full.) Suppose two leaves a and b of T are chosen uniformly and independently at random. The expected value of the distance between a and b in T (ie., the number of edges in the unique path between a and b) is (rounded off to 2 decimal places) _____.

gate2019 numerical-answers data-structure binary-tree

3.4.52 Binary Tree: TIFR2012-B-16

https://gateoverflow.in/25214

Consider a complete binary tree of height n, where each edge is one Ohm resistor. Suppose all the leaves of the tree are tied together. Approximately how much is the effective resistance from the root to this bunch of leaves for very large n?

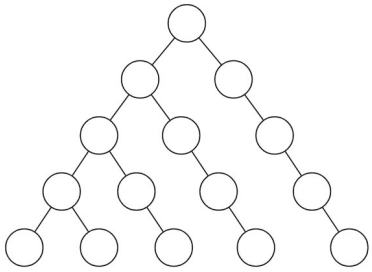
a. Exponential in n.
b. Cubic in n.
c. Linear in n.
d. Logarithmic in n.
e. Of the order square root of n.

tifr2012 binary-tree

3.4.53 Binary Tree: TIFR2013-B-13

https://gateoverflow.in/25775

Given a binary tree of the following form and having n nodes, the height of the tree is



a. $\Theta(\log n)$
b. $\Theta(n)$
c. $\Theta(\sqrt{n})$
d. $\Theta(n/\log n)$
e. None of the above.

tifr2013 binary-tree data-structure

3.4.54 Binary Tree: TIFR2014-B-1

https://gateoverflow.in/27133

Let T be a rooted binary tree whose vertices are labelled with symbols a,b,c,d,e,f,g,h,i,j,k . Suppose the in-order (visit left subtree, visit root, visit right subtree) and post-order (visit left subtree, visit right subtree, visit root) traversals of T produce the following sequences.

in-order:a,b,c,d,e,f,g,h,i,j,k

post-order:a,c,b,e,f,h,j,k,i,g,d

How many leaves does the tree have?

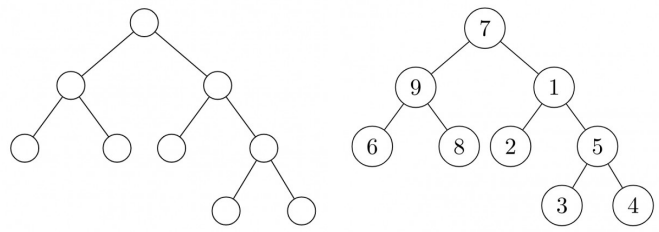
a. THREE.
b. FOUR.
c. FIVE.
d. SIX.
e. Cannot be determined uniquely from the given information.

tifr2014 binary-tree data-structure easy

3.4.55 Binary Tree: TIFR2015-B-4

https://gateoverflow.in/29849

First, consider the tree on the left.



On the right, the nine nodes of the tree have been assigned numbers from the set $\{1,2,\ldots,9\}$ so that for every node, the numbers in its left subtree and right subtree lie in disjoint intervals (that is, all numbers in one subtree are less than all numbers in the other subtree). How many such assignments are possible? Hint: Fix a value for the root and ask what values can then appear in its left and right subtrees.

A. $2^9 = 512$ B. $2^4.3^2.5.9 = 6480$ C. $2^3.3.5.9 = 1080$ D. $2^4 = 16$ E. $2^3.3^3 = 216$

tifr2015 binary-tree permutation-and-combination

3.4.56 Binary Tree: TIFR2018-B-6

https://gateoverflow.in/179290

Consider the following implementation of a binary tree data strucrure. The operator $+$ denotes list-concatenation. That is, $[a,b,c]+[d,e]=[a,b,c,d,e]$.

```
struct TreeNode:
 int value
 TreeNode leftChild
 TreeNode rightChild

function preOrder(T):
 if T == null:
  return []
 else:
  return [T.value] + preOrder(T.leftChild) + preOrder(T.rightChild)

function inOrder(T):
 if T == null:
  return []
 else:
  return inOrder(T.leftChild) + [T.value] + inOrder(T.rightChild)

function postOrder(T):
 if T == null:
  return []
 else:
  return postOrder(T.leftChild) + postOrder(T.rightChild) + [T.value]
```

For some T the functions inOrder(T) and preOrder(T) return the following:

$\text{inOrder(T)}: \quad [12,10,6,9,7,2,15,5,1,13,4,3,8,14,11]$

$\text{preOrder(T)}: \quad [5,2,10,12,9,6,7,15,13,1,3,4,14,8,11]$

What does postOrder(T) return ?

A. $[12,6,10,7,15,2,9,1,4,13,8,11,14,3,5]$
B. $[11,8,14,4,3,1,13,15,7,6,9,12,10,2,5]$
C. $[11,14,8,3,4,13,1,5,15,2,7,9,6,10,12]$
D. $[12,6,7,9,10,15,2,1,4,8,11,14,3,13,5]$
E. Cannot be uniquely determined from given information.

tifr2018 data-structure binary-tree

3.5 Graph Search (1)

3.5.1 Graph Search: GATE1989-3-ixa

https://gateoverflow.in/87143

Answer the following:

Which one of the following statements (s) is/are FALSE?

A. Overlaying is used to run a program, which is longer than the address space of the computer.
B. Optimal binary search tree construction can be performed efficiently by using dynamic programming.
C. Depth first search cannot be used to find connected components of a graph.
D. Given the prefix and postfix walls over a binary tree, the binary tree can be uniquely constructed.

normal gate1989 binary-tree graph-search

3.6 Graphs (6)

3.6.1 Graphs: GATE1992-03,iii

https://gateoverflow.in/580

How many edges can there be in a forest with p components having n vertices in all?

gate1992 data-structure graphs easy

3.6.2 Graphs: GATE1997-6.2

https://gateoverflow.in/2258

Let G be the graph with 100 vertices numbered 1 to 100. Two vertices i and j are adjacent if $|i-j|=8$ or $|i-j|=12$. The number of connected components in G is

A. 8 B. 4 C. 12 D. 25

gate1997 data-structure normal graphs

3.6.3 Graphs: GATE2008-42

https://gateoverflow.in/1872

G is a graph on n vertices and $2n-2$ edges. The edges of G can be partitioned into two edge-disjoint spanning trees. Which of the following is NOT true for G?

A. For every subset of k vertices, the induced subgraph has at most $2k-2$ edges.
B. The minimum cut in G has at least 2 edges.
C. There are at least 2 edge-disjoint paths between every pair of vertices.
D. There are at least 2 vertex-disjoint paths between every pair of vertices.

gate2008 data-structure graphs normal

3.6.4 Graphs: GATE2008-IT-4

https://gateoverflow.in/3264

What is the size of the smallest MIS (Maximal Independent Set) of a chain of nine nodes?

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

gate2008-it data-structure normal graphs

3.6.5 Graphs: GATE2014-1-3

https://gateoverflow.in/1754

Let $G=(V,E)$ be a directed graph where V is the set of vertices and E the set of edges. Then which one of the following graphs has the same strongly connected components as G ?

A. $G_1=(V,E_1)$ where $E_1=\{(u,v) \mid (u,v) \notin E\}$
B. $G_2=(V,E_2)$ where $E_2=\{(u,v) \mid (v,u) \in E\}$
C. $G_3=(V,E_3)$ where $E_3=\{(u,v) \mid$ there is a path of length ≤ 2 from u to v in $E\}$
D. $G_4=(V_4,E)$ where V_4 is the set of vertices in G which are not isolated

gate2014-1 data-structure graphs ambiguous

3.6.6 Graphs: GATE2016-1-38

https://gateoverflow.in/39731

Consider the weighted undirected graph with 4 vertices, where the weight of edge $\{i,j\}$ is given by the entry W_{ij} in the matrix W.

$$W=\begin{bmatrix} 0 & 2 & 8 & 5 \\ 2 & 0 & 5 & 8 \\ 8 & 5 & 0 & x \\ 5 & 8 & x & 0 \end{bmatrix}$$

The largest possible integer value of x, for which at least one shortest path between some pair of vertices will contain the edge with weight x is _____.

gate2016-1 data-structure graphs normal numerical-answers

3.7 Hashing (17)

3.7.1 Hashing: GATE1989-1-vii, ISRO2015-14

https://gateoverflow.in/10905

A hash table with ten buckets with one slot per bucket is shown in the following figure. The symbols $S1$ to $S7$ initially entered using a hashing function with linear probing. The maximum number of comparisons needed in searching an item that is not present is

0	S7
1	S1
2	
3	S4
4	S2
5	
6	S5
7	
8	S6
9	S3

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

hashing isro2015 gate1989 data-structure normal

3.7.2 Hashing: GATE1996-1.13

https://gateoverflow.in/2717

An advantage of chained hash table (external hashing) over the open addressing scheme is

A. Worst case complexity of search operations is less
B. Space used is less
C. Deletion is easier
D. None of the above

gate1996 data-structure hashing normal

3.7.3 Hashing: GATE1996-15

https://gateoverflow.in/2767

Insert the characters of the string $K\ R\ P\ C\ S\ N\ Y\ T\ J\ M$ into a hash table of size 10.
Use the hash function

$$h(x) = (ord(x) - ord(\text{" a "}) + 1) \mod 10$$

and linear probing to resolve collisions.

A. Which insertions cause collisions?
B. Display the final hash table.

gate1996 data-structure hashing normal

3.7.4 Hashing: GATE1997-12

https://gateoverflow.in/2272

Consider a hash table with n buckets, where external (overflow) chaining is used to resolve collisions. The hash function is such that the probability that a key value is hashed to a particular bucket is $\frac{1}{n}$. The hash table is initially empty and K distinct values are inserted in the table.

A. What is the probability that bucket number 1 is empty after the K^{th} insertion?
B. What is the probability that no collision has occurred in any of the K insertions?
C. What is the probability that the first collision occurs at the K^{th} insertion?

gate1997 data-structure hashing probability normal

3.7.5 Hashing: GATE2004-7

https://gateoverflow.in/1004

Given the following input $(4322, 1334, 1471, 9679, 1989, 6171, 6173, 4199)$ and the hash function $x \bmod 10$, which of the following statements are true?

I. $9679, 1989, 4199$ hash to the same value
II. $1471, 6171$ hash to the same value
III. All elements hash to the same value
IV. Each element hashes to a different value

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

gate2004 data-structure hashing easy

3.7.6 Hashing: GATE2005-IT-16

https://gateoverflow.in/3761

A hash table contains 10 buckets and uses linear probing to resolve collisions. The key values are integers and the hash function used is key % 10. If the values $43, 165, 62, 123, 142$ are inserted in the table, in what location would the key value 142 be inserted?

A. 2 B. 3 C. 4 D. 6

gate2005-it data-structure hashing easy

3.7.7 Hashing: GATE2006-IT-20

https://gateoverflow.in/3559

Which of the following statement(s) is TRUE?

I. A hash function takes a message of arbitrary length and generates a fixed length code.
II. A hash function takes a message of fixed length and generates a code of variable length.
III. A hash function may give the same hash value for distinct messages.

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

gate2006-it data-structure hashing normal

3.7.8 Hashing: GATE2007-40

https://gateoverflow.in/1238

Consider a hash table of size seven, with starting index zero, and a hash function $(3x + 4) \mod 7$. Assuming the hash table is initially empty, which of the following is the contents of the table when the sequence $1, 3, 8, 10$ is inserted into the table using closed hashing? Note that − denotes an empty location in the table.

A. $8, –, –, –, –, –, 10$
B. $1, 8, 10, –, –, –, 3$
C. $1, –, –, –, –, –, 3$
D. $1, 10, 8, –, –, –, 3$

gate2007 data-structure hashing easy

3.7.9 Hashing: GATE2007-IT-28

https://gateoverflow.in/3461

Consider a hash function that distributes keys uniformly. The hash table size is 20. After hashing of how many keys will the probability that any new key hashed collides with an existing one exceed 0.5.

A. 5 B. 6 C. 7 D. 10

gate2007-it data-structure hashing probability normal

3.7.10 Hashing: GATE2008-IT-48

https://gateoverflow.in/3358

Consider a hash table of size 11 that uses open addressing with linear probing. Let $h(k) = k \mod 11$ be the hash function used. A sequence of records with keys

43 36 92 87 11 4 71 13 14

is inserted into an initially empty hash table, the bins of which are indexed from zero to ten. What is the index of the bin into which the last record is inserted?

A. 3 B. 4 C. 6 D. 7

gate2008-it data-structure hashing normal

3.7.11 Hashing: GATE2009-36

https://gateoverflow.in/1322

The keys $12,18,13,2,3,23,5$ and 15 are inserted into an initially empty hash table of length 10 using open addressing with hash function $h(k) = k \mod 10$ and linear probing. What is the resultant hash table?

A.

0	
1	
2	2
3	23
4	
5	15
6	
7	
8	18
9	

B.

0	
1	
2	12
3	13
4	
5	5
6	
7	
8	18
9	

C.

0	
1	
2	12
3	13
4	2
5	3
6	23
7	5
8	18
9	15

D.

0	
1	
2	2,12
3	13,3,23
4	
5	5,15
6	
7	
8	18
9	

gate2009 data-structure hashing normal

3.7.12 Hashing: GATE2010-52

https://gateoverflow.in/2360

A hash table of length 10 uses open addressing with hash function $h(k) = k \mod 10$, and linear probing. After inserting 6 values into an empty hash table, the table is shown as below

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

Which one of the following choices gives a possible order in which the key values could have been inserted in the table?

A. $46,42,34,52,23,33$
B. $34,42,23,52,33,46$
C. $46,34,42,23,52,33$
D. $42,46,33,23,34,52$

gate2010 data-structure hashing normal

3.7.13 Hashing: GATE2010-53

https://gateoverflow.in/43327

A hash table of length 10 uses open addressing with hash function $h(k) = k \, mod \, 10$, and linear probing. After inserting 6 values into an empty hash table, the table is shown as below

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

How many different insertion sequences of the key values using the same hash function and linear probing will result in the hash table shown above?

A. 10 B. 20 C. 30 D. 40

data-structure hashing normal gate2010

3.7.14 Hashing: GATE2014-1-40

https://gateoverflow.in/1918

Consider a hash table with 9 slots. The hash function is $h(k) = k \mod 9$. The collisions are resolved by chaining. The following 9 keys are inserted in the order: $5, 28, 19, 15, 20, 33, 12, 17, 10$. The maximum, minimum, and average chain lengths in the hash table, respectively, are

A. $3, 0,$ and 1 B. $3, 3,$ and 3 C. $4, 0,$ and 1 D. $3, 0,$ and 2

gate2014-1 data-structure hashing normal

3.7.15 Hashing: GATE2014-3-40

https://gateoverflow.in/2074

Consider a hash table with 100 slots. Collisions are resolved using chaining. Assuming simple uniform hashing, what is the probability that the first 3 slots are unfilled after the first 3 insertions?

A. $(97 \times 97 \times 97)/100^3$
B. $(99 \times 98 \times 97)/100^3$
C. $(97 \times 96 \times 95)/100^3$
D. $(97 \times 96 \times 95/(3! \times 100^3)$

gate2014-3 data-structure hashing probability normal

3.7.16 Hashing: GATE2015-2-33

https://gateoverflow.in/8152

Which one of the following hash functions on integers will distribute keys most uniformly over 10 buckets numbered 0 to 9 for i ranging from 0 to 2020?

A. $h(i) = i^2 \mod 10$
B. $h(i) = i^3 \mod 10$
C. $h(i) = (11 * i^2) \mod 10$
D. $h(i) = (12 * i^2) \mod 10$

gate2015-2 data-structure hashing normal

3.7.17 Hashing: GATE2015-3-17

https://gateoverflow.in/8414

Given that hash table T with 25 slots that stores 2000 elements, the load factor a for T is _____.

gate2015-3 data-structure hashing normal numerical-answers

3.8 Heap (25)

3.8.1 Heap: GATE1990-2-viii

https://gateoverflow.in/83993

Match the pairs in the following questions:

(a)	A heap construction	(p)	$\Omega(n \log_{10} n)$
(b)	Constructing Hashtable with linear probing	(q)	$O(n)$
(c)	AVL tree construction	(r)	$O(n^2)$
(d)	Digital trie construction	(s)	$O(n \log_{10} n)$

gate1990 match-the-following data-structure heap

3.8.2 Heap: GATE1996-2.11

https://gateoverflow.in/2740

The minimum number of interchanges needed to convert the array into a max-heap is

$89, 19, 40, 17, 12, 10, 2, 5, 7, 11, 6, 9, 70$

A. 0 B. 1 C. 2 D. 3

gate1996 data-structure heap easy

3.8.3 Heap: GATE1999-12

https://gateoverflow.in/1511

A. In binary tree, a full node is defined to be a node with 2 children. Use induction on the height of the binary tree to prove that the number of full nodes plus one is equal to the number of leaves.

B. Draw the min-heap that results from insertion of the following elements in order into an initially empty min-heap: $7,6,5,4,3,2,1$. Show the result after the deletion of the root of this heap.

gate1999 data-structure heap normal

3.8.4 Heap: GATE2001-1.15

https://gateoverflow.in/708

Consider any array representation of an n element binary heap where the elements are stored from index 1 to index n of the array. For the element stored at index i of the array $(i \leq n)$, the index of the parent is

A. $i-1$ B. $\lfloor \frac{i}{2} \rfloor$ C. $\lceil \frac{i}{2} \rceil$ D. $\frac{(i+1)}{2}$

gate2001 data-structure heap easy

3.8.5 Heap: GATE2003-23

https://gateoverflow.in/1110

In a min-heap with n elements with the smallest element at the root, the 7^{th} smallest element can be found in time

A. $\Theta(n \log n)$
B. $\Theta(n)$
C. $\Theta(\log n)$
D. $\Theta(1)$

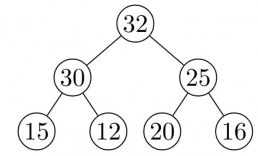
gate2003 data-structure heap

3.8.6 Heap: GATE2004-37

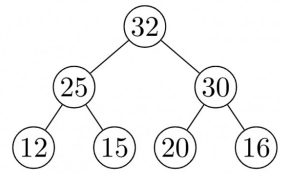
https://gateoverflow.in/1034

The elements $32,15,20,30,12,25,16,$ are inserted one by one in the given order into a maxHeap. The resultant maxHeap is

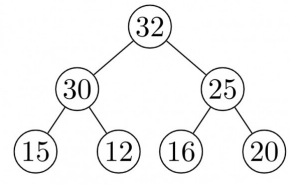
A.



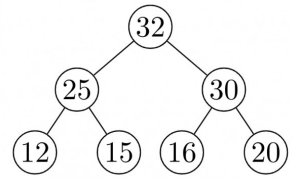
B.



C.



D.



gate2004 data-structure heap normal

3.8.7 Heap: GATE2004-IT-53

https://gateoverflow.in/3696

An array of integers of size n can be converted into a heap by adjusting the heaps rooted at each internal node of the complete binary tree starting at the node $\lfloor (n-1)/2 \rfloor$, and doing this adjustment up to the root node (root node is at index 0) in the order $\lfloor (n-1)/2 \rfloor$, $\lfloor (n-3)/2 \rfloor$, ..., 0. The time required to construct a heap in this manner is

A. $O(\log n)$ B. $O(n)$ C. $O(n \log \log n)$ D. $O(n \log n)$

gate2004-it data-structure heap normal

3.8.8 Heap: GATE2005-34

https://gateoverflow.in/1370

A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: $10,8,5,3,2$. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

A. $10,8,7,5,3,2,1$
B. $10,8,7,2,3,1,5$
C. $10,8,7,1,2,3,5$
D. $10,8,7,3,2,1,5$

gate2005 data-structure heap normal

3.8.9 Heap: GATE2006-10

https://gateoverflow.in/889

In a binary max heap containing n numbers, the smallest element can be found in time

A. $O(n)$ B. $O(\log n)$

C. $O(\log \log n)$ D. $O(1)$

gate2006 data-structure heap easy

3.8.10 Heap: GATE2006-76

https://gateoverflow.in/1852

Statement for Linked Answer Questions 76 & 77:

A 3-ary max heap is like a binary max heap, but instead of 2 children, nodes have 3 children. A 3-ary heap can be represented by an array as follows: The root is stored in the first location, $a[0]$, nodes in the next level, from left to right, is stored from $a[1]$ to $a[3]$. The nodes from the second level of the tree from left to right are stored from $a[4]$ location onward. An item x can be inserted into a 3-ary heap containing n items by placing x in the location $a[n]$ and pushing it up the tree to satisfy the heap property.

76. Which one of the following is a valid sequence of elements in an array representing 3-ary max heap?

A. $1,3,5,6,8,9$ B. $9,6,3,1,8,5$
C. $9,3,6,8,5,1$ D. $9,5,6,8,3,1$

gate2006 data-structure heap normal

3.8.11 Heap: GATE2006-77

https://gateoverflow.in/87191

Statement for Linked Answer Questions 76 & 77:

A 3-ary max heap is like a binary max heap, but instead of 2 children, nodes have 3 children. A 3-ary heap can be represented by an array as follows: The root is stored in the first location, $a[0]$, nodes in the next level, from left to right, is stored from $a[1]$ to $a[3]$. The nodes from the second level of the tree from left to right are stored from $a[4]$ location onward. An item x can be inserted into a 3-ary heap containing n items by placing x in the location $a[n]$ and pushing it up the tree to satisfy the heap property.

77. Suppose the elements $7, 2, 10$ and 4 are inserted, in that order, into the valid 3-ary max heap found in the previous question, Q.76. Which one of the following is the sequence of items in the array representing the resultant heap?

A. $10,7,9,8,3,1,5,2,6,4$ B. $10,9,8,7,6,5,4,3,2,1$
C. $10,9,4,5,7,6,8,2,1,3$ D. $10,8,6,9,7,2,3,4,1,5$

gate2006 data-structure heap normal

3.8.12 Heap: GATE2006-IT-44

https://gateoverflow.in/3587

Which of the following sequences of array elements forms a heap?

A. $\{23,17,14,6,13,10,1,12,7,5\}$ B. $\{23,17,14,6,13,10,1,5,7,12\}$
C. $\{23,17,14,7,13,10,1,5,6,12\}$ D. $\{23,17,14,7,13,10,1,12,5,7\}$

gate2006-it data-structure heap easy

3.8.13 Heap: GATE2006-IT-72

https://gateoverflow.in/3616

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. If only the root node does not satisfy the heap property, the algorithm to convert the complete binary tree into a heap has the best asymptotic time complexity of

A. $O(n)$ B. $O(\log n)$ C. $O(n \log n)$ D. $O(n \log \log n)$

gate2006-it data-structure heap easy

3.8.14 Heap: GATE2007-47

https://gateoverflow.in/1245

Consider the process of inserting an element into a $Max\ Heap$, where the $Max\ Heap$ is represented by an $array$. Suppose we perform a binary search on the path from the new leaf to the root to find the position for the newly inserted element, the number of $comparisons$ performed is:

A. $\Theta(\log_2 n)$ B. $\Theta(\log_2 \log_2 n)$
C. $\Theta(n)$ D. $\Theta(n \log_2 n)$

gate2007 data-structure heap normal

3.8.15 Heap: GATE2009-59

https://gateoverflow.in/1341

Consider a binary max-heap implemented using an array.
Which one of the following array represents a binary max-heap?

A. $\{25,12,16,13,10,8,14\}$
B. $\{25,14,13,16,10,8,12\}$
C. $\{25,14,16,13,10,8,12\}$
D. $\{25,14,12,13,10,8,16\}$

gate2009 data-structure heap normal

3.8.16 Heap: GATE2009-60

https://gateoverflow.in/43466

Consider a binary max-heap implemented using an array.
What is the content of the array after two delete operations on $\{25,14,16,13,10,8,12\}$

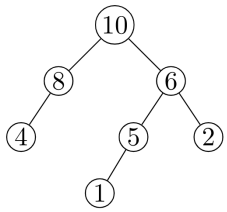
A. $\{14,13,12,10,8\}$
B. $\{14,12,13,8,10\}$
C. $\{14,13,8,12,10\}$
D. $\{14,13,12,8,10\}$

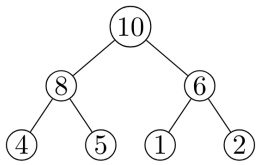
gate2009 data-structure heap normal

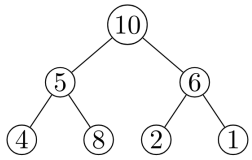
3.8.17 Heap: GATE2011-23

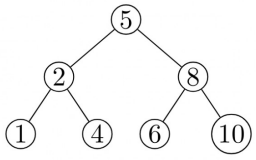
https://gateoverflow.in/2125

A max-heap is a heap where the value of each parent is greater than or equal to the value of its children. Which of the following is a max-heap?

A.


B.


C.


D.


gate2011 data-structure heap easy

3.8.18 Heap: GATE2014-2-12

https://gateoverflow.in/1967

A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: $10,8,5,3,2$. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

A. $10,8,7,3,2,1,5$
B. $10,8,7,2,3,1,5$
C. $10,8,7,1,2,3,5$
D. $10,8,7,5,3,2,1$

gate2014-2 data-structure heap normal

3.8.19 Heap: GATE2015-1-32

https://gateoverflow.in/8273

Consider a max heap, represented by the array: $40,30,20,10,15,16,17,8,4$.

Array index	1	2	3	4	5	6	7	8	9
Value	40	30	20	10	15	16	17	8	4

Now consider that a value 35 is inserted into this heap. After insertion, the new heap is

A. $40,30,20,10,15,16,17,8,4,35$
B. $40,35,20,10,30,16,17,8,4,15$
C. $40,30,20,10,35,16,17,8,4,15$
D. $40,35,20,10,15,16,17,8,4,30$

gate2015-1 data-structure heap easy

3.8.20 Heap: GATE2015-2-17

https://gateoverflow.in/8091

Consider a complete binary tree where the left and right subtrees of the root are max-heaps. The lower bound for the number of operations to convert the tree to a heap is

A. $\Omega(\log n)$
B. $\Omega(n)$
C. $\Omega(n \log n)$
D. $\Omega(n^2)$

gate2015-2 data-structure heap normal

3.8.21 Heap: GATE2015-3-19

https://gateoverflow.in/8418

Consider the following array of elements.

$\langle 89,19,50,17,12,15,2,5,7,11,6,9,100 \rangle$

The minimum number of interchanges needed to convert it into a max-heap is

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

gate2015-3 data-structure heap normal

3.8.22 Heap: GATE2016-1-37

https://gateoverflow.in/39706

An operator $delete(i)$ for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

A. $O(1)$
B. $O(d)$ but not $O(1)$
C. $O(2^d)$ but not $O(d)$
D. $O(d\,2^d)$ but not $O(2^d)$

gate2016-1 data-structure heap normal

3.8.23 Heap: GATE2016-2-34

https://gateoverflow.in/39585

A complete binary min-heap is made by including each integer in $[1,1023]$ exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is at depth 0. The maximum depth at which integer 9 can appear is _____.

gate2016-2 data-structure heap normal numerical-answers

3.8.24 Heap: GATE2019-40

https://gateoverflow.in/302808

Consider the following statements:

I. The smallest element in a max-heap is always at a leaf node
II. The second largest element in a max-heap is always a child of a root node
III. A max-heap can be constructed from a binary search tree in $\theta(n)$ time
IV. A binary search tree can be constructed from a max-heap in $\theta(n)$ time

Which of te above statements are TRUE?

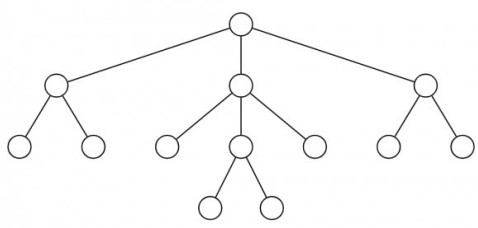
A. I, II and III B. I, II and IV C. I, III and IV D. II, III and IV

gate2019 data-structure heap

3.8.25 Heap: TIFR2014-B-19

https://gateoverflow.in/27352

Consider the following tree with 13 nodes.



Suppose the nodes of the tree are randomly assigned distinct labels from $\{1,2,\ldots,13\}$, each permutation being equally likely. What is the probability that the labels form a min-heap (i.e., every node receives the minimum label in its subtree)?

A. $\left(\frac{1}{6!}\right)\left(\frac{1}{3!}\right)^2$ B. $\left(\frac{1}{3!}\right)^2\left(\frac{1}{2!}\right)^3$ C. $\left(\frac{1}{13}\right)\left(\frac{1}{6}\right)\left(\frac{1}{3}\right)^3$ D. $\frac{2}{13}$ E. $\frac{1}{2^{13}}$

tifr2014 heap

3.9 Infix Postfix (2)

3.9.1 Infix Postfix: GATE1997-1.7

https://gateoverflow.in/2223

Which of the following is essential for converting an infix expression to the postfix form efficiently?

A. An operator stack
B. An operand stack
C. An operand stack and an operator stack
D. A parse tree

gate1997 normal infix-postfix stack data-structure

3.9.2 Infix Postfix: GATE1998-19b

https://gateoverflow.in/15708

Compute the post fix equivalent of the following expression $3^* \log(x+1) - \frac{a}{2}$

gate1998 stack infix-postfix

3.10 Linked Lists (19)

3.10.1 Linked Lists: GATE1987-1-xv

https://gateoverflow.in/80298

In a circular linked list oraganisation, insertion of a record involves modification of

A. One pointer.
B. Two pointers.
C. Multiple pointers.
D. No pointer.

gate1987 data-structure linked-lists

3.10.2 Linked Lists: GATE1987-6a

https://gateoverflow.in/82419

A list of n elements is commonly written as a sequence of n elements enclosed in a pair of square brackets. For example. $[10,20,30]$ is a list of three elements and $[]$ is a nil list. Five functions are defined below:

- $car(l)$ returns the first element of its argument list l;
- $cdr(l)$ returns the list obtained by removing the first element of the argument list l;
- $glue(a,l)$ returns a list m such that $car(m) = a$ and $cdr(m) = l$.
- $f(x,y) \equiv$ if $x = []$ then y
  else $glue(car(x), f(cdr(x),y))$;
- $g(x) \equiv$ if $x = []$ then $[]$
  else $f(g(cdr(x))\,,\, glue(car(x),[]))$

What do the following compute?

(a) $f([32,16,8],[9,11,12])$

(b) $g([5,1,8,9])$

gate1987 data-structure linked-lists

3.10.3 Linked Lists: GATE1993-13

https://gateoverflow.in/2310

Consider a singly linked list having n nodes. The data items $d_1, d_2, \ldots d_n$ are stored in these n nodes. Let X be a pointer to the j^{th} node $(1 \leq j \leq n)$ in which d_j is stored. A new data item d stored in node with address Y is to be inserted. Give an algorithm to insert d into the list to obtain a list having items $d_1, d_2, \ldots, d_j, d, \ldots, d_n$ in order without using the header.

gate1993 data-structure linked-lists normal

3.10.4 Linked Lists: GATE1994-1.17, UGCNET-Sep2013-II-32

https://gateoverflow.in/2460

Linked lists are not suitable data structures for which one of the following problems?

A. Insertion sort
B. Binary search
C. Radix sort
D. Polynomial manipulation

gate1994 data-structure linked-lists normal ugcnetsep2013ii

3.10.5 Linked Lists: GATE1995-2.22

https://gateoverflow.in/2634

Which of the following statements is true?

I. As the number of entries in a hash table increases, the number of collisions increases.
II. Recursive programs are efficient
III. The worst case complexity for Quicksort is $O(n^2)$
IV. Binary search using a linear linked list is efficient

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

gate1995 data-structure linked-lists hashing

3.10.6 Linked Lists: GATE1997-1.4

https://gateoverflow.in/2220

The concatenation of two lists is to be performed on $O(1)$ time. Which of the following implementations of a list should be used?

A. Singly linked list
B. Doubly linked list
C. Circular doubly linked list
D. Array implementation of list

gate1997 data-structure linked-lists easy

3.10.7 Linked Lists: GATE1997-18

https://gateoverflow.in/2278

Consider the following piece of 'C' code fragment that removes duplicates from an ordered list of integers.

```
Node *remove-duplicates (Node* head, int *j)
{
    Node *t1, *t2; *j=0;
    t1 = head;
    if (t1! = NULL)
        t2 = t1 ->next;
    else return head;
    *j = 1;
    if(t2 == NULL) return head;
    while (t2 != NULL)
    {
        if (t1.val != t2.val) ----------------> (S1)
        {
            (*j)++;
            t1 -> next = t2;
            t1 = t2; -----> (S2)
        }
            t2 = t2 ->next;
    }
    t1 -> next = NULL;
    return head;
}
```

Assume the list contains n elements ($n \geq 2$) in the following questions.

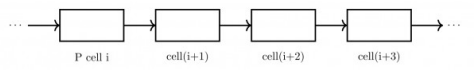
a. How many times is the comparison in statement $S1$ made?
b. What is the minimum and the maximum number of times statements marked $S2$ get executed?
c. What is the significance of the value in the integer pointed to by j when the function completes?

gate1997 data-structure linked-lists normal

3.10.8 Linked Lists: GATE1998-19a

https://gateoverflow.in/1733

a. Let p be a pointer as shown in the figure in a single linked list.



What do the following assignment statements achieve?

```
q: = p -> next
p -> next:= q -> next
```

```
q -> next:=(q -> next) -> next
(p -> next) -> next:= q
```

gate1998 data-structure linked-lists normal

3.10.9 Linked Lists: GATE1999-11b

https://gateoverflow.in/93575

Write a constant time algorithm to insert a node with data D just before the node with address p of a singly linked list.

gate1999 data-structure linked-lists

3.10.10 Linked Lists: GATE2002-1.5

https://gateoverflow.in/809

In the worst case, the number of comparisons needed to search a single linked list of length n for a given element is

A. $\log n$ B. $\frac{n}{2}$ C. $\log_2 n - 1$ D. n

gate2002 easy data-structure linked-lists

3.10.11 Linked Lists: GATE2003-90

https://gateoverflow.in/973

Consider the function f defined below.

```
struct item {
        int data;
        struct item * next;
};
int f(struct item *p) {
    return ((p == NULL) || (p->next == NULL)||
        ((p->data <= p ->next -> data) &&
        f(p->next)));
}
```

For a given linked list p, the function f returns 1 if and only if

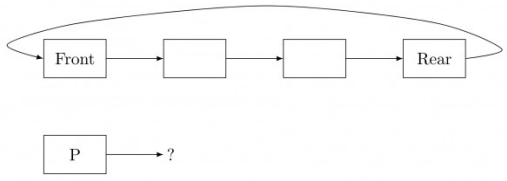
A. the list is empty or has exactly one element
B. the elements in the list are sorted in non-decreasing order of data value
C. the elements in the list are sorted in non-increasing order of data value
D. not all elements in the list have the same data value

gate2003 data-structure linked-lists normal

3.10.12 Linked Lists: GATE2004-36

https://gateoverflow.in/1033

A circularly linked list is used to represent a Queue. A single variable p is used to access the Queue. To which node should p point such that both the operations enQueue and deQueue can be performed in constant time?



A. rear node
B. front node
C. not possible with a single pointer
D. node next to front

gate2004 data-structure linked-lists normal

3.10.13 Linked Lists: GATE2004-40

https://gateoverflow.in/1037

Suppose each set is represented as a linked list with elements in arbitrary order. Which of the operations among union, intersection, membership, cardinality will be the slowest?

A. union only
B. intersection, membership
C. membership, cardinality
D. union, intersection

gate2004 data-structure linked-lists normal

3.10.14 Linked Lists: GATE2004-IT-13

https://gateoverflow.in/3654

Let P be a singly linked list. Let Q be the pointer to an intermediate node x in the list. What is the worst-case time complexity of the best-known algorithm to delete the node x from the list ?

A. $O(n)$ B. $O(\log^2 n)$ C. $O(\log n)$ D. $O(1)$

gate2004-it data-structure linked-lists normal ambiguous

3.10.15 Linked Lists: GATE2005-IT-54

https://gateoverflow.in/3815

The following C function takes a singly-linked list of integers as a parameter and rearranges the elements of the list. The list is represented as pointer to a structure. The function is called with the list containing the integers $1,2,3,4,5,6,7$ in the given order. What will be the contents of the list after the function completes execution?

```
struct node {int value; struct node *next;);
void rearrange (struct node *list) {
    struct node *p, *q;
    int temp;
    if (!list || !list -> next) return;
    p = list; q = list -> next;
    while (q) {
        temp = p -> value;
        p -> value = q -> value;
        q -> value = temp;
        p = q -> next;
        q = p ? p -> next : 0;
      }
}
```

A. $1,2,3,4,5,6,7$
B. $2,1,4,3,6,5,7$
C. $1,3,2,5,4,7,6$
D. $2,3,4,5,6,7,1$

gate2005-it data-structure linked-lists normal

3.10.16 Linked Lists: GATE2008-62

https://gateoverflow.in/485

The following C function takes a single-linked list of integers as a parameter and rearranges the elements of the list. The function is called with the list containing the integers $1,2,3,4,5,6,7$ in the given order. What will be the contents of the list after function completes execution?

```
struct node {
    int value;
    struct node *next;
};

void rearrange(struct node *list) {
    struct node *p, *q;
    int temp;
    if (!list || !list -> next) return;
    p = list; q = list -> next;
    while(q) {
        temp = p -> value; p->value =  q -> value;
        q->value = temp; p = q ->next;
        q = p? p ->next : 0;
    }
}
```

A. $1,2,3,4,5,6,7$
B. $2,1,4,3,6,5,7$
C. $1,3,2,5,4,7,6$
D. $2,3,4,5,6,7,1$

gate2008 data-structure linked-lists normal

3.10.17 Linked Lists: GATE2010-36

https://gateoverflow.in/2337

The following C function takes a singly-linked list as input argument. It modifies the list by moving the last element to the front of the list and returns the modified list. Some part of the code is left blank.

```
typedef struct node
{
    int value;
    struct node *next;
} node;
Node *move_to-front(Node *head)
{
    Node *p, *q;
    if ((head == NULL) || (head -> next == NULL))
        return head;
```

```
    q = NULL;
    p = head;
    while (p->next != NULL)
    {
        q=p;
        p=p->next;
    }
    _____________

    return head;

}
```

Choose the correct alternative to replace the blank line.

A. $q = NULL; p \rightarrow next = head; head = p$;
B. $q \rightarrow next = NULL; head = p; p \rightarrow next = head$;
C. $head = p; p \rightarrow next = q; q \rightarrow next = NULL$;
D. $q \rightarrow next = NULL; p \rightarrow next = head; head = p$;

gate2010 data-structure linked-lists normal

3.10.18 Linked Lists: GATE2016-2-15

https://gateoverflow.in/39557

N items are stored in a sorted doubly linked list. For a *delete* operation, a pointer is provided to the record to be deleted. For a *decrease-key* operation, a pointer is provided to the record on which the operation is to be performed.

An algorithm performs the following operations on the list in this order: $\Theta(N)$ *delete*, $O(\log N)$ *insert*, $O(\log N)$ *find*, and $\Theta(N)$ *decrease-key*. What is the time complexity of all these operations put together?

A. $O(\log^2 N)$ B. $O(N)$ C. $O(N^2)$ D. $\Theta(N^2 \log N)$

gate2016-2 data-structure linked-lists time-complexity normal

3.10.19 Linked Lists: GATE2017-1-08

https://gateoverflow.in/118711

Consider the C code fragment given below.

```
typedef struct node {
    int data;
    node* next;
} node;

void join(node* m, node* n) {
    node* p = n;
    while(p->next != NULL) {
        p = p->next;
    }
    p->next = m;
}
```

Assuming that m and n point to valid NULL-terminated linked lists, invocation of join will

A. append list m to the end of list n for all inputs.
B. either cause a null pointer dereference or append list m to the end of list n.
C. cause a null pointer dereference for all inputs.
D. append list n to the end of list m for all inputs.

gate2017-1 data-structure linked-lists normal

3.11 Priority Queue (1)

3.11.1 Priority Queue: GATE1997-4.7

https://gateoverflow.in/2248

A priority queue Q is used to implement a stack that stores characters. PUSH (C) is implemented as INSERT (Q, C, K) where K is an appropriate integer key chosen by the implementation. POP is implemented as DELETEMIN (Q). For a sequence of operations, the keys chosen are in

A. non-increasing order
B. non-decreasing order
C. strictly increasing order
D. strictly decreasing order

gate1997 data-structure stack normal priority-queue

3.12 Queues (12)

3.12.1 Queues: GATE1992-09

https://gateoverflow.in/588

Suggest a data structure for representing a subset S of integers from 1 to n. Following operations on the set S are to be performed in constant time (independent of cardinality of S).

i. MEMBER (X) : Check whether X is in the set S or not
ii. FIND-ONE (S) : If S is not empty, return one element of the set S (any arbitrary element will do)
iii. ADD (X) : Add integer X to set S
ii. DELETE (X) : Delete integer X from S

Give pictorial examples of your data structure. Give routines for these operations in an English like language. You may assume that the data structure has been suitable initialized. Clearly state your assumptions regarding initialization.

gate1992 data-structure normal descriptive queues

3.12.2 Queues: GATE1994-26

https://gateoverflow.in/2522

A queue Q containing n items and an empty stack S are given. It is required to transfer all the items from the queue to the stack, so that the item at the front of queue is on the TOP of the stack, and the order of all other items are preserved. Show how this can be done in $O(n)$ time using only a constant amount of additional storage. Note that the only operations which can be performed on the queue and stack are Delete, Insert, Push and Pop. Do not assume any implementation of the queue or stack.

gate1994 data-structure queues stack normal

3.12.3 Queues: GATE1996-1.12

https://gateoverflow.in/2716

Consider the following statements:

i. First-in-first out types of computations are efficiently supported by STACKS.
ii. Implementing LISTS on linked lists is more efficient than implementing LISTS on an array for almost all the basic LIST operations.
iii. Implementing QUEUES on a circular array is more efficient than implementing QUEUES on a linear array with two indices.
iv. Last-in-first-out type of computations are efficiently supported by QUEUES.

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

gate1996 data-structure easy queues stack linked-lists

3.12.4 Queues: GATE2001-2.16

https://gateoverflow.in/734

What is the minimum number of stacks of size n required to implement a queue of size n?

A. One B. Two C. Three D. Four

gate2001 data-structure easy stack queues

3.12.5 Queues: GATE2006-49

https://gateoverflow.in/1826

An implementation of a queue Q, using two stacks $S1$ and $S2$, is given below:

```
void insert (Q, x) {
    push (S1, x);
}
void delete (Q) {
    if (stack-empty(S2)) then
        if (stack-empty(S1)) then {
            print("Q is empty");
            return;
        }
        else while (!(stack-empty(S1))){
            x=pop(S1);
            push(S2,x);
        }
```

```
    x=pop(S2);
}
```

let n *insert* and $m(\leq n)$ *delete* operations be performed in an arbitrary order on an empty queue Q. Let x and y be the number of *push* and *pop* operations performed respectively in the process. Which one of the following is true for all m and n?

A. $n+m \leq x < 2n$ and $2m \leq y \leq n+m$
B. $n+m \leq x < 2n$ and $2m \leq y \leq 2n$
C. $2m \leq x < 2n$ and $2m \leq y \leq n+m$
D. $2m \leq x < 2n$ and $2m \leq y \leq 2n$

gate2006 data-structure queues stack normal

3.12.6 Queues: GATE2007-IT-30

https://gateoverflow.in/3463

Suppose you are given an implementation of a queue of integers. The operations that can be performed on the queue are:

i. $isEmpty(Q)$ — returns true if the queue is empty, false otherwise.
ii. $delete(Q)$ — deletes the element at the front of the queue and returns its value.
iii. $insert(Q,i)$ — inserts the integer i at the rear of the queue.

Consider the following function:

```
void f (queue Q) {
int i ;
if (!isEmpty(Q)) {
   i = delete(Q);
   f(Q);
   insert(Q, i);
  }
}
```

What operation is performed by the above function f?

A. Leaves the queue Q unchanged
B. Reverses the order of the elements in the queue Q
C. Deletes the element at the front of the queue Q and inserts it at the rear keeping the other elements in the same order
D. Empties the queue Q

gate2007-it data-structure queues normal

3.12.7 Queues: GATE2012-35

https://gateoverflow.in/1756

Suppose a circular queue of capacity $(n-1)$ elements is implemented with an array of n elements. Assume that the insertion and deletion operations are carried out using REAR and FRONT as array index variables, respectively. Initially, $REAR = FRONT = 0$. The conditions to detect queue full and queue empty are

A. full: $(REAR+1) \mod n == FRONT$
empty: $REAR == FRONT$

B. full: $(REAR+1) \mod n == FRONT$
empty: $(FRONT+1) \mod n == REAR$

C. full: $REAR == FRONT$
empty: $(REAR+1) \mod n == FRONT$

D. full: $(FRONT+1) \mod n == REAR$
empty: $REAR == FRONT$

gate2012 data-structure queues normal

3.12.8 Queues: GATE2013-44

https://gateoverflow.in/61

Consider the following operation along with Enqueue and Dequeue operations on queues, where k is a global parameter.

```
MultiDequeue(Q){
    m = k
    while (Q is not empty) and (m > 0) {
        Dequeue(Q)
        m = m - 1
    }
}
```

What is the worst case time complexity of a sequence of n queue operations on an initially empty

queue?

A. $\Theta(n)$ B. $\Theta(n+k)$ C. $\Theta(nk)$ D. $\Theta(n^2)$

gate2013 data-structure algorithms normal queues

3.12.9 Queues: GATE2016-1-10

https://gateoverflow.in/39667

A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is **CORRECT** (n refers to the number of items in the queue) ?

A. Both operations can be performed in $O(1)$ time.
B. At most one operation can be performed in $O(1)$ time but the worst case time for the operation will be $\Omega(n)$.
C. The worst case time complexity for both operations will be $\Omega(n)$.
D. Worst case time complexity for both operations will be $\Omega(\log n)$

gate2016-1 data-structure queues normal

3.12.10 Queues: GATE2016-1-41

https://gateoverflow.in/39684

Let Q denote a queue containing sixteen numbers and S be an empty stack. $Head(Q)$ returns the element at the head of the queue Q without removing it from Q. Similarly $Top(S)$ returns the element at the top of S without removing it from S. Consider the algorithm given below.

```
while Q is not Empty do
  if S is Empty OR Top(S) ≤ Head (Q) then
     x:= Dequeue (Q);
     Push (S, x);
  else
     x:= Pop(S);
     Enqueue (Q, x);
  end
 end
```

The maximum possible number of iterations of the **while** loop in the algorithm is _____.

gate2016-1 data-structure queues difficult numerical-answers

3.12.11 Queues: GATE2017-2-13

https://gateoverflow.in/118253

A circular queue has been implemented using a singly linked list where each node consists of a value and a single pointer pointing to the next node. We maintain exactly two external pointers FRONT and REAR pointing to the front node and the rear node of the queue, respectively. Which of the following statements is/are CORRECT for such a circular queue, so that insertion and deletion operations can be performed in $O(1)$ time?

I. Next pointer of front node points to the rear node.
II. Next pointer of rear node points to the front node.

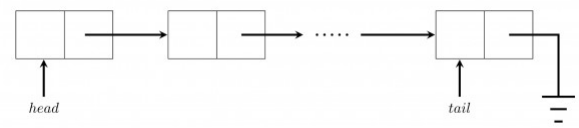
A. (I) only.
B. (II) only.
C. Both (I) and (II).
D. Neither (I) nor (II).

gate2017-2 data-structure queues

3.12.12 Queues: GATE2018-3

https://gateoverflow.in/204077

A queue is implemented using a non-circular singly linked list. The queue has a head pointer and a tail pointer, as shown in the figure. Let n denote the number of nodes in the queue. Let 'enqueue' be implemented by inserting a new node at the head, and 'dequeue' be implemented by deletion of a node from the tail.



Which one of the following is the time complexity of the most time-efficient implementation of 'enqueue' and 'dequeue, respectively, for this data structure?

A. $\Theta(1), \Theta(1)$
B. $\Theta(1), \Theta(n)$
C. $\Theta(n), \Theta(1)$
D. $\Theta(n), \Theta(n)$

gate2018 algorithms data-structure queues normal linked-lists

3.13 Stack (16)

3.13.1 Stack: GATE1991-03,vii

https://gateoverflow.in/522

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

The following sequence of operations is performed on a stack:

PUSH (10), PUSH (20), POP, PUSH (10), PUSH (20), POP, POP, POP, PUSH (20), POP

The sequence of values popped out is

A. $20, 10, 20, 10, 20$
B. $20, 20, 10, 10, 20$
C. $10, 20, 20, 10, 20$
D. $20, 20, 10, 20, 10$

gate1991 data-structure stack easy

3.13.2 Stack: GATE1994-1.14

https://gateoverflow.in/2457

Which of the following permutations can be obtained in the output (in the same order) using a stack assuming that the input is the sequence $1, 2, 3, 4, 5$ in that order?

A. $3, 4, 5, 1, 2$
B. $3, 4, 5, 2, 1$
C. $1, 5, 2, 3, 4$
D. $5, 4, 3, 1, 2$

gate1994 data-structure stack normal

3.13.3 Stack: GATE1995-2.21

https://gateoverflow.in/2633

The postfix expression for the infix expression $A + B * (C + D)/F + D * E$ is:

A. $AB + CD + *F/D + E*$
B. $ABCD + *F/DE * ++$
C. $A * B + CD/F * DE + +$
D. $A + *BCD/F * DE + +$

gate1995 data-structure stack easy

3.13.4 Stack: GATE2000-13

https://gateoverflow.in/684

Suppose a stack implementation supports, in addition to PUSH and POP, an operation REVERSE, which reverses the order of the elements on the stack.

A. To implement a queue using the above stack implementation, show how to implement ENQUEUE using a single operation and DEQUEUE using a sequence of 3 operations.
B. The following post fix expression, containing single digit operands and arithmetic operators $+$ and $*$, is evaluated using a stack.
   $5\ 2 * 3\ 4 + 5\ 2 * *+$
   Show the contents of the stack
   i. After evaluating $5\ 2 * 3\ 4+$
   ii. After evaluating $5\ 2 * 3\ 4 + 5\ 2$
   iii. At the end of evaluation

gate2000 data-structure stack normal descriptive

3.13.5 Stack: GATE2003-64

https://gateoverflow.in/951

Let **S** be a stack of size $n \geq 1$. Starting with the empty stack, suppose we push the first n natural numbers in sequence, and then perform n pop operations. Assume that Push and Pop operations take X seconds each, and Y seconds elapse between the end of one such stack operation and the start of the next operation. For $m \geq 1$, define the stack-life of m as the time elapsed from the end of $Push(m)$ to the start of the pop operation that removes m from **S**. The average stack-life of an element of this stack is

A. $n(X + Y)$
B. $3Y + 2X$
C. $n(X + Y) - X$
D. $Y + 2X$

gate2003 data-structure stack normal

3.13.6 Stack: GATE2004-3

https://gateoverflow.in/1000

A single array $A[1..MAXSIZE]$ is used to implement two stacks. The two stacks grow from opposite ends of the array. Variables $top1$ and $top2$ $(top < top2)$ point to the location of the topmost element in each of the stacks. If the

space is to be used efficiently, the condition for "stack full" is

A. $(top1 = MAXSIZE/2)$ and $(top2 = MAXSIZE/2 + 1)$ B. $top1 + top2 = MAXSIZE$
C. $(top1 = MAXSIZE/2)$ or $(top2 = MAXSIZE)$ D. $top1 = top2 - 1$

gate2004 data-structure stack easy

3.13.7 Stack: GATE2004-38, ISRO2009-27

https://gateoverflow.in/1035

Assume that the operators $+, -, \times$ are left associative and $\hat{}$ is right associative. The order of precedence (from highest to lowest) is $\hat{}, \times, +, -$. The postfix expression corresponding to the infix expression $a + b \times c - d \hat{} e \hat{} f$ is

A. $abc \times + def \hat{} \hat{} -$ B. $abc \times + de \hat{} f \hat{} -$
C. $ab + c \times d - e \hat{} f \hat{}$ D. $- + a \times bc \hat{} \hat{} def$

gate2004 stack isro2009

3.13.8 Stack: GATE2004-5

https://gateoverflow.in/1002

The best data structure to check whether an arithmetic expression has balanced parentheses is a

A. queue B. stack C. tree D. list

gate2004 data-structure easy stack

3.13.9 Stack: GATE2004-IT-52

https://gateoverflow.in/3695

A program attempts to generate as many permutations as possible of the string, ' $abcd$' by pushing the characters a, b, c, d in the same order onto a stack, but it may pop off the top character at any time. Which one of the following strings CANNOT be generated using this program?

A. $abcd$ B. $dcba$ C. $cbad$ D. $cabd$

gate2004-it data-structure normal stack

3.13.10 Stack: GATE2005-IT-13

https://gateoverflow.in/3758

A function f defined on stacks of integers satisfies the following properties. $f(\emptyset) = 0$ and $f(push(S, i)) = max(f(S), 0) + i$ for all stacks S and integers i.

If a stack S contains the integers $2, -3, 2, -1, 2$ in order from bottom to top, what is $f(S)$?

A. 6 B. 4 C. 3 D. 2

gate2005-it data-structure stack normal

3.13.11 Stack: GATE2007-38, ISRO2016-27

https://gateoverflow.in/1236

The following postfix expression with single digit operands is evaluated using a stack:

$8\ 2\ 3\ \hat{}\ \qquad\qquad /$

Note that $\hat{}$ is the exponentiation operator. The top two elements of the stack after the first $*$ is evaluated are

A. $6, 1$ B. $5, 7$ C. $3, 2$ D. $1, 5$

gate2007 data-structure stack normal isro2016

3.13.12 Stack: GATE2007-IT-32

https://gateoverflow.in/3465

Consider the following C program:

```
#include <stdio.h>
        #define EOF -1
        void push (int); /* push the argument on the stack */
        int pop  (void); /* pop the top of the stack */
        void flagError ();
        int main ()
       {         int c, m, n, r;
                  while ((c = getchar ()) != EOF)
                 { if  (isdigit (c) )
                           push (c);
```

```
                    else if ((c == '+') || (c == '*'))
                   {          m = pop ();
                               n = pop ();
                               r = (c == '+') ? n + m : n*m;
                               push (r);
                     }
                     else if (c != ' ')
                               flagError ();
            }
             printf("% c", pop ());
}
```

What is the output of the program for the following input?
$52 * 332 + *+$

A. 15 B. 25 C. 30 D. 150

gate2007-it stack normal

3.13.13 Stack: GATE2014-2-41

https://gateoverflow.in/2007

Suppose a stack implementation supports an instruction $REVERSE$, which reverses the order of elements on the stack, in addition to the $PUSH$ and POP instructions. Which one of the following statements is TRUE (*with respect to this modified stack*)?

A. A queue cannot be implemented using this stack.
B. A queue can be implemented where $ENQUEUE$ takes a single instruction and $DEQUEUE$ takes a sequence of two instructions.
C. A queue can be implemented where $ENQUEUE$ takes a sequence of three instructions and $DEQUEUE$ takes a single instruction.
D. A queue can be implemented where both $ENQUEUE$ and $DEQUEUE$ take a single instruction each.

gate2014-2 data-structure stack easy

3.13.14 Stack: GATE2015-2-38

https://gateoverflow.in/8164

Consider the C program below

```
#include <stdio.h>
int *A, stkTop;
int stkFunc (int opcode, int val)
{
    static int size=0, stkTop=0;
    switch (opcode) {
        case -1: size = val; break;
        case 0: if (stkTop < size ) A[stkTop++]=val; break;
        default: if (stkTop) return A[--stkTop];
    }
    return -1;
}
int main()
{
    int B[20]; A=B; stkTop = -1;
    stkFunc (-1, 10);
    stkFunc (0, 5);
    stkFunc (0, 10);
    printf ("%d\n", stkFunc(1, 0)+ stkFunc(1, 0));
}
```

The value printed by the above program is _____.

gate2015-2 data-structure stack easy numerical-answers

3.13.15 Stack: GATE2015-3-12

https://gateoverflow.in/8408

The result evaluating the postfix expression $10\,5 + 60\,6/ * 8-$ is

A. 284 B. 213 C. 142 D. 71

gate2015-3 data-structure stack normal

3.13.16 Stack: TIFR2017-B-3

https://gateoverflow.in/95679

We have an implementation that supports the following operations on a stack (in the instructions below, s is the name of the stack).

- isempty(s) : returns True if s is empty, and False otherwise.
- top(s) : returns the top element of the stack, but does not pop the stack; returns null if the stack is empty.
- push(s,x) : places x on top of the stack.
- pop(s) : pops the stack; does nothing if s is empty.

Consider the following code:

```
pop_ray_pop(x):
    s=empty
    for i=1 to length(x):
        if (x[i] == '('):
            push(s, x[i])
        else:
            while (top(s)=='('):
                pop(s)
            end while
            push(s, ')')
        end if
    end for
    while not isempty(s):
        print top(s)
        pop(s)
    end while
```

What is the output of this program when

```
pop_ray_pop("((((()(((())((((")
```

is executed?

A. ((((B.))) ((((C.))) D. ((()())) E. ()()

tifr2017 data-structure stack

3.14 Trees (14)

3.14.1 Trees: GATE1990-13a

https://gateoverflow.in/86224

Consider the height-balanced tree T_t with values stored at only the leaf nodes, shown in Fig.4.

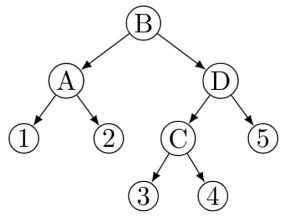


Fig.4

(i) Show how to merge to the tree, T_1 elements from tree T_2 shown in Fig.5 using node D of tree T_1.

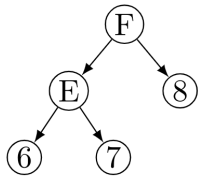


Fig.5

(ii) What is the time complexity of a merge operation of balanced trees T_1 and T_2 where T_1 and T_2 are of height h_1 and h_2 respectively, assuming that rotation schemes are given. Give reasons.

gate1990 descriptive data-structure trees

3.14.2 Trees: GATE1992-02,vii

https://gateoverflow.in/562

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

A $2-3$ tree is such that

a. All internal nodes have either 2 or 3 children
b. All paths from root to the leaves have the same length.

The number of internal nodes of a $2-3$ tree having 9 leaves could be

A. 4 B. 5 C. 6 D. 7

gate1992 trees data-structure normal

3.14.3 Trees: GATE1994-5

https://gateoverflow.in/2501

A $3-\text{ary}$ tree is a tree in which every internal node has exactly three children. Use induction to prove that the number of leaves in a $3-\text{ary}$ tree with n internal nodes is $2(n-1)$.

gate1994 data-structure trees proof

3.14.4 Trees: GATE1998-1.24

https://gateoverflow.in/1661

Which of the following statements is false?

A. A tree with a n nodes has $(n–1)$ edges
B. A labeled rooted binary tree can be uniquely constructed given its postorder and preorder traversal results.
C. A complete binary tree with n internal nodes has $(n+1)$ leaves.
D. The maximum number of nodes in a binary tree of height h is $2^{h+1}-1$

gate1998 data-structure trees normal

3.14.5 Trees: GATE1998-2.11

https://gateoverflow.in/1683

A complete n-ary tree is one in which every node has 0 or n sons. If x is the number of internal nodes of a complete n-ary tree, the number of leaves in it is given by

A. $x(n-1)+1$ B. $xn-1$ C. $xn+1$ D. $x(n+1)$

gate1998 data-structure trees normal

3.14.6 Trees: GATE1998-21

https://gateoverflow.in/1735

A. Derive a recurrence relation for the size of the smallest AVL tree with height h.
B. What is the size of the smallest AVL tree with height 8?

gate1998 data-structure trees descriptive numerical-answers

3.14.7 Trees: GATE2002-2.9

https://gateoverflow.in/839

The number of leaf nodes in a rooted tree of n nodes, with each node having 0 or 3 children is:

A. $\frac{n}{2}$ B. $\frac{(n-1)}{3}$ C. $\frac{(n-1)}{2}$ D. $\frac{(2n+1)}{3}$

gate2002 data-structure trees normal

3.14.8 Trees: GATE2004-6

https://gateoverflow.in/1003

Level order traversal of a rooted tree can be done by starting from the root and performing

A. preorder traversal
B. in-order traversal
C. depth first search
D. breadth first search

gate2004 data-structure trees easy

3.14.9 Trees: GATE2005-36

https://gateoverflow.in/1372

In a complete k-ary tree, every internal node has exactly k children. The number of leaves in such a tree with n internal node is:

A. nk B. $(n-1)k+1$ C. $n(k-1)+1$ D. $n(k-1)$

gate2005 data-structure trees normal

3.14.10 Trees: GATE2007-43

https://gateoverflow.in/1241

A complete $n-ary$ tree is a tree in which each node has n children or no children. Let I be the number of internal nodes and L be the number of leaves in a complete $n-ary$ tree. If $L=41$ and $I=10$, what is the value of n?

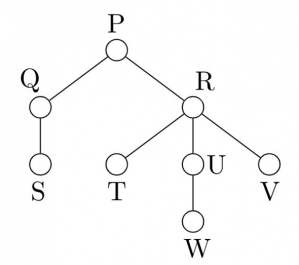
A. 3 B. 4 C. 5 D. 6

gate2007 data-structure trees normal

3.14.11 Trees: GATE2014-3-12

https://gateoverflow.in/2046

Consider the following rooted tree with the vertex labeled P as the root:



The order in which the nodes are visited during an in-order traversal of the tree is

A. $SQPTRWUV$ B. $SQPTUWRV$ C. $SQPTWUVR$ D. $SQPTRUWV$

gate2014-3 data-structure trees easy

3.14.12 Trees: GATE2014-3-41

https://gateoverflow.in/2075

Consider the pseudocode given below. The function $DoSomething()$ takes as argument a pointer to the root of an arbitrary tree represented by the $leftMostChild-rightSibling$ representation. Each node of the tree is of type $treeNode$.

```
typedef struct treeNode* treeptr;

struct treeNode
{
    treeptr leftMostChild, rightSibling;
};

int DoSomething (treeptr tree)
{
    int value=0;
    if (tree != NULL) {
        if (tree->leftMostChild == NULL)
            value = 1;
        else
        value = DoSomething(tree->leftMostChild);
        value = value + DoSomething(tree->rightSibling);
    }
    return(value);
}
```

When the pointer to the root of a tree is passed as the argument to $DoSomething$, the value returned by the function corresponds to the

A. number of internal nodes in the tree.
B. height of the tree.
C. number of nodes without a right sibling in the tree.
D. number of leaf nodes in the tree

gate2014-3 data-structure trees normal

3.14.13 Trees: GATE2017-1-20

https://gateoverflow.in/118300

Let T be a tree with 10 vertices. The sum of the degrees of all the vertices in T is _____

gate2017-1 data-structure trees numerical-answers

3.14.14 Trees: TIFR2012-B-15

https://gateoverflow.in/25212

Let T be a tree of n nodes. Consider the following algorithm, that constructs a sequence of leaves $u_1, u_2 \ldots$. Let u_1 be some leaf of tree. Let u_2 be a leaf that is farthest from u_1. Let u_3 be the leaf that is farthest from u_2, and, in general, let u_{i+1} be a leaf of T that is farthest from u_i (if there are many choices for u_{i+1}, pick one arbitrarily). The algorithm stops when some u_i is visited again. What can u say about the distance between u_i and u_{i+1}, as $i = 1, 2, \ldots ?$

A. For some trees, the distance strictly reduces in each step.
B. For some trees, the distance increases initially and then decreases.
C. For all trees, the path connecting u_2 and u_3 is a longest path in the tree.
D. For some trees, the distance reduces initially, but then stays constant.
E. For the same tree, the distance between the last two vertices visited can be different, based on the choice of the first leaf u_1.

tifr2012 data-structure trees

4 Programming and DS: Programming (118)

Programming in C. Recursion.

Mark Distribution in Previous GATE

Year	2019	2018	2017-1	2017-2	2016-1	2016-2	Minimum	Average	Maximum
1 Mark Count	2	2	1	2	2	1	1	1.7	2
2 Marks Count	3	3	4	4	2	2	2	3	4
Total Marks	8	8	9	10	6	5	**5**	**8**	**10**

4.1 Aliasing (1)

4.1.1 Aliasing: GATE2000-1.16

https://gateoverflow.in/639

Aliasing in the context of programming languages refers to

A. multiple variables having the same memory location
B. multiple variables having the same value
C. multiple variables having the same identifier
D. multiple uses of the same variable

gate2000 programming easy aliasing

4.2 Goto (2)

4.2.1 Goto: GATE1989-3-i

https://gateoverflow.in/87095

An unrestricted use of the "go to" statement is harmful because of which of the following reason (s):

A. It makes it more difficult to verify programs.
B. It makes programs more inefficient.
C. It makes it more difficult to modify existing programs.
D. It results in the compiler generating longer machine code.

gate1989 normal programming goto

4.2.2 Goto: GATE1994-1.5

https://gateoverflow.in/2442

An unrestricted use of the "*goto*" statement is harmful because

A. it makes it more difficult to verify programs
B. it increases the running time of the programs
C. it increases the memory required for the programs
D. it results in the compiler generating longer machine code

gate1994 programming easy goto

4.3 Identify Function (4)

4.3.1 Identify Function: GATE1995-3

https://gateoverflow.in/2639

Consider the following high level programming segment. Give the contents of the memory locations for variables W, X, Y and Z after the execution of the program segment. The values of the variables A and B are $5CH$ and $92H$, respectively. Also indicate error conditions if any.

```
var
    A, B, W, X, Y   :unsigned byte;
    Z               :unsigned integer, (each integer is represented by two bytes)
begin
    X               :=A+B
    Y               :=abs(A-B);
    W               :=A-B
    Z               :=A*B
end;
```

gate1995 programming identify-function descriptive

4.3.2 Identify Function: GATE1998-2.13

https://gateoverflow.in/1685

What is the result of the following program?

```
    program side-effect (input, output);
    var x, result: integer;
    function f (var x:integer:integer;
    begin
        x:x+1;f:=x;
    end
begin
    x:=5;
    result:=f(x)*f(x);
    writeln(result);
    end
```

A. 5 B. 25 C. 36 D. 42

gate1998 programming normal identify-function

4.3.3 Identify Function: GATE2004-IT-15

https://gateoverflow.in/3656

Let x be an integer which can take a value of 0 or 1. The statement

```
if (x == 0) x = 1; else x = 0;
```

is equivalent to which one of the following ?

A. $x = 1 + x;$ B. $x = 1 - x;$ C. $x = x - 1;$ D. $x = 1\%x;$

gate2004-it programming easy identify-function

4.3.4 Identify Function: GATE2017-2-43

https://gateoverflow.in/118388

Consider the following snippet of a C program. Assume that swap $(\&x, \&y)$ exchanges the content of x and y:

```
int main () {
    int array[] = {3, 5, 1, 4, 6, 2};
    int done =0;
    int i;
    while (done==0) {
        done =1;
        for (i=0; i<=4; i++) {
            if (array[i] < array[i+1]) {
                swap(&array[i], &array[i+1]);
                done=0;
            }
        }
        for (i=5; i>=1; i--) {
            if (array[i] > array[i-1]) {
                swap(&array[i], &array[i-1]);
                done =0;
            }
        }
    }
    printf("%d", array[3]);
}
```

The output of the program is _____

gate2017-2 programming algorithms numerical-answers identify-function

4.4 Loop Invariants (12)

4.4.1 Loop Invariants: GATE1987-7a

https://gateoverflow.in/82425

List the invariant assertions at points A, B, C, D and E in program given below:

```
Program division (input, output)
Const
    dividend = 81;
    divisor = 9;
Var  remainder, quotient:interger
begin
    (*(dividend >= 0) AND (divisor > 0)*)
    remainder := dividend;
    quotient := 9;
```

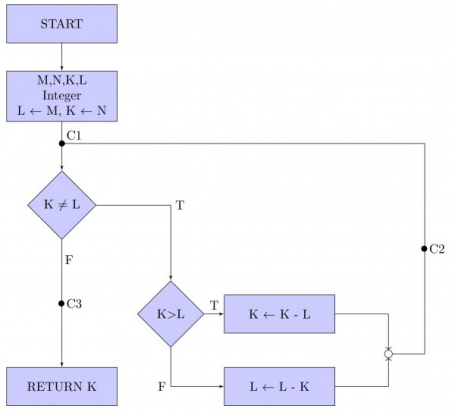
```
    (*A*)
While (remainder >= 0) do
begin (*B*)
    quotient := quotient + 1;
    remainder := remainder - divisor;
    (*C*)
end;
    (*D*)
    quotient := quotient - 1;
    remainder := remainder + divisor;
    (*E*)
end
```

gate1987 programming loop-invariants

4.4.2 Loop Invariants: GATE1988-6ii

https://gateoverflow.in/94364

Below figure is the flow-chart corresponding to a program to calculate the gcd of two integers, M and N respectively, $(M, N > 0)$. Use assertions at the cut point C_1, C_2 and C_3 to prove that the flow-chart is correct.



gate1988 normal descriptive loop-invariants

4.4.3 Loop Invariants: GATE1988-8ii

https://gateoverflow.in/94379

Consider the two program segments below:

a.
```
for
    i:=1 to f(x) by 1 do
    S
end
```

b.
```
i:=1;
While   i<=f(x) do
        S
        i:=i+1
end
```

Under what conditions are these two programs equivalent? Treat S as any sequence of statement and f as a function.

gate1988 programming descriptive loop-invariants

4.4.4 Loop Invariants: GATE1991-1,vi

https://gateoverflow.in/504

Consider the following PASCAL program segment:

```
if i mod 2 = 0 then
    while i >= 0 do
    begin
        i := i div 2;
        if i mod 2 < > 0  then i := i - 1;
        else i := i - 2;
    end;
```

An appropriate loop-invariant for the while-loop is _____

gate1991 programming loop-invariants normal

4.4.5 Loop Invariants: GATE2004-32

https://gateoverflow.in/1029

Consider the following program fragment for reversing the digits in a given integer to obtain a new integer.
Let $n = d_1\, d_2 \ldots d_m$.

```
int n, rev;
rev = 0;
while(n > 0) {
    rev = rev * 10 + n%10;
    n = n/10;
}
```

The loop invariant condition at the end of the i^{th} iteration is:

A. $n = d_1\, d_2 \ldots d_{m-i}$ **and** $\text{rev} = d_m\, d_{m-1} \ldots d_{m-i+1}$
B. $n = d_{m-i+1} \ldots d_{m-1}\, d_m$ **or** $\text{rev} = d_{m-i} \ldots d_2\, d_1$
C. $n \neq \text{rev}$
D. $n = d_1\, d_2 \ldots d_m$ **or** $\text{rev} = d_m \ldots d_2\, d_1$

gate2004 programming loop-invariants normal

4.4.6 Loop Invariants: GATE2015-1-33

https://gateoverflow.in/8276

Consider the following pseudo code, where x and y are positive integers.

```
begin
    q := 0
    r := x
   while r ≥ y do
      begin
      r := r - y
      q := q + 1
    end
end
```

The post condition that needs to be satisfied after the program terminates is

A. $\{r = qx + y \wedge r < y\}$
B. $\{x = qy + r \wedge r < y\}$
C. $\{y = qx + r \wedge 0 < r < y\}$
D. $\{q + 1 < r - y \wedge y > 0\}$

gate2015-1 programming loop-invariants normal

4.4.7 Loop Invariants: GATE2016-2-35

https://gateoverflow.in/39578

The following function computes X^Y for positive integers X and Y.

```
int exp (int X, int Y) {
     int res =1, a = X, b = Y;

     while (b != 0) {
         if (b % 2 == 0) {a = a * a; b = b/2; }
         else            {res = res * a; b = b - 1; }
     }
     return res;
}
```

Which one of the following conditions is TRUE before every iteration of the loop?

A. $X^Y = a^b$
B. $(res * a)^Y = (res * X)^b$
C. $X^Y = res * a^b$
D. $X^Y = (res * a)^b$

gate2016-2 programming loop-invariants normal

4.4.8 Loop Invariants: GATE2017-2-37

https://gateoverflow.in/118381

Consider the C program fragment below which is meant to divide x by y using repeated subtractions. The variables x, y, q and r are all unsigned int.

```
while (r >= y) {
    r=r-y;
```

```
    q=q+1;
}
```

Which of the following conditions on the variables x, y, q and r before the execution of the fragment will ensure that the loop terminated in a state satisfying the condition $x == (y * q + r)$?

A. $(q == r)\ \&\&\ (r == 0)$
B. $(x > 0)\ \&\&\ (r == x)\ \&\&\ (y > 0)$
C. $(q == 0)\ \&\&\ (r == x)\ \&\&\ (y > 0)$
D. $(q == 0)\ \&\&\ (y > 0)$

gate2017-2 programming loop-invariants

4.4.9 Loop Invariants: TIFR2010-B-30

https://gateoverflow.in/19042

Consider the following program for summing the entries of the array b: array $[0..N-1]$ of integers, where N is a positive integer. (The symbol '<>' denotes 'not equal to').

```
var
    i, s: integer;
Program
    i:= 0;
    s:= 0;
[*] while i <> N do
        s := s + b[i];
        i := i + 1;
    od
```

Which of the following gives the invariant that holds at the beginning of each loop, that is, each time the program arrives at point $[*]$?

A. $s = \sum_{j=0}^{N} b[j]\ \&\ 0 \leq i \leq N$
B. $s = \sum_{j=0}^{i-1} b[j]\ \&\ 0 \leq i < N$
C. $s = \sum_{j=0}^{i} b[j]\ \&\ 0 < i \leq N$
D. $s = \sum_{j=1}^{N} b[j]\ \&\ 0 \leq i < N$
E. $s = \sum_{j=0}^{i-1} b[j]\ \&\ 0 \leq i \leq N$

tifr2010 programming loop-invariants

4.4.10 Loop Invariants: TIFR2010-B-37

https://gateoverflow.in/19251

Consider the program where a, b are integers with $b > 0$.

```
x:=a; y:=b; z:=0;
while y > 0 do
    if odd (x) then
        z:= z + x;
        y:= y - 1;
    else y:= y % 2;
        x:= 2 * x;
    fi
```

Invariant of the loop is a condition which is true before and after every iteration of the loop. In the above program the loop invariant is given by

$$0 \leq y \text{ and } z + x * y = a * b$$

Which of the following is true of the program?

A. The program will not terminate for some values of a, b.
B. The program will terminate with $z = 2^b$
C. The program will terminate with $z = a * b$.
D. The program will not terminate for some values of a, b but when it does terminate, the condition $z = a * b$ will hold.

E. The program will terminate with $z = a^b$

tifr2010 programming loop-invariants

4.4.11 Loop Invariants: TIFR2017-B-5

https://gateoverflow.in/95683

Consider the following psuedocode fragment, where y is an integer that has been initialized.

```
int i=1
int j=1
while (i<10):
    j=j*i
    i=i+1
    if (i==y):
        break
    end if
end while
```

Consider the following statements:

i. $(i == 10)$ or $(i == y)$
ii. If $y > 10$, then $i == 10$
iii. If $j = 6$, then $y == 4$

Which of the above statements is/are TRUE at the end of the while loop? Choose from the following options.

A. i only B. iii only C. ii and iii only D. i, ii, and iii E. None of the above

tifr2017 programming loop-invariants

4.4.12 Loop Invariants: TIFR2019-B-9

https://gateoverflow.in/280486

Consider the following program fragment:

```
var x, y: integer;
x := 1; y := 0;
while y < x do
begin
   x := 2*x;
   y := y+1
end;
```

For the above fragment , which of the following is a loop invariant ?

A. $x = y + 1$
B. $x = (y + 1)^2$
C. $x = (y + 1)2^y$
D. $x = 2^y$
E. None of the above, since the loop does not terminate

tifr2019 programming loop-invariants

4.5 Parameter Passing (7)

4.5.1 Parameter Passing: GATE1999-15

https://gateoverflow.in/1514

What will be the output of the following program assuming that parameter passing is

i. call by value
ii. call by reference
iii. call by copy restore

```
procedure P{x, y, z};
begin
y:y+1;
z: x+x
end;
begin
a:= b:= 3;
P(a+b, a, a);
Print(a)
end.
```

gate1999 programming parameter-passing normal

4.5.2 Parameter Passing: GATE2001-2.17 | UGCNET-AUG2016-III-21

https://gateoverflow.in/735

What is printed by the print statements in the program $P1$ assuming call by reference parameter passing?

```
Program P1()
{
    x = 10;
    y = 3;
    func1(y,x,x);
    print x;
    print y;
}

func1(x,y,z)
{
    y = y + 4;
    z = x + y + z
}
```

A. $10, 3$ B. $31, 3$ C. $27, 7$ D. None of the above

gate2001 programming compiler-design parameter-passing normal runtime-environments ugcnetaug2016iii

4.5.3 Parameter Passing: GATE2003-73

https://gateoverflow.in/960

The following program fragment is written in a programming language that allows global variables and does not allow nested declarations of functions.

```
global int i=100, j=5;
void P(x) {
 int i=10;
    print(x+10);
    i=200;
    j=20;
    print (x);
}
main() {P(i+j);}
```

If the programming language uses static scoping and call by need parameter passing mechanism, the values printed by the above program are:

A. $115, 220$ B. $25, 220$ C. $25, 15$ D. $115, 105$

gate2003 compiler-design normal runtime-environments parameter-passing

4.5.4 Parameter Passing: GATE2013-42

https://gateoverflow.in/60

What is the return value of $f(p,p)$, if the value of p is initialized to 5 before the call? Note that the first parameter is passed by reference, whereas the second parameter is passed by value.

```
int f (int &x, int c) {
       c = c - 1;
       if (c==0) return 1;
       x = x + 1;
       return f(x,c) * x;
}
```

gate2013 compiler-design normal marks-to-all numerical-answers parameter-passing runtime-environments

4.5.5 Parameter Passing: GATE2018-29

https://gateoverflow.in/204103

```
#include<stdio.h>
void fun1(char* s1, char* s2){
    char* temp;
    temp = s1;
    s1 = s2;
    s2 = temp;
}
void fun2(char** s1, char** s2){
    char* temp;
    temp = *s1;
    *s1 = *s2;
    *s2 = temp;
}
int main(){
```

```
    char *str1="Hi", *str2 = "Bye";
    fun1(str1, str2); printf("%s %s", str1, str2);
    fun2(&str1, &str2); printf("%s %s", str1, str2);
    return 0;
}
```

The output of the program above is:

A. Hi Bye Bye Hi
B. Hi Bye Hi Bye
C. Bye Hi Hi Bye
D. Bye Hi Bye Hi

gate2018 programming-in-c pointers parameter-passing normal programming

4.5.6 Parameter Passing: TIFR2011-B-32

https://gateoverflow.in/20619

Various parameter passing mechanisms have been in used in different programming languages. Which of the following statements is true?

a. Call by value result is used in language Ada.
b. Call by value result is the same as call by name.
c. Call by value is the most robust.
d. Call by reference is the same as call by name.
e. Call by name is the most efficient.

tifr2011 programming parameter-passing

4.5.7 Parameter Passing: TIFR2019-B-8

https://gateoverflow.in/280487

Consider the following program fragment:

```
var a,b : integer;
procedure G(c,d: integer);
begin
    c:=c-d;
    d:=c+d;
    c:=d-c
end;
a:=2;
b:=3;
G(a,b);
```

If both parameters to G are passed by reference, what are the values of a and b at the end of the above program fragment ?

A. $a = 0$ and $b = 2$ B. $a = 3$ and $b = 2$ C. $a = 2$ and $b = 3$ D. $a = 1$ and $b = 5$ E. None of the above

tifr2019 programming parameter-passing

4.6 Programming Constructs (1)

4.6.1 Programming Constructs: GATE1999-2.5

https://gateoverflow.in/1483

Given the programming constructs

i. assignment
ii. for loops where the loop parameter cannot be changed within the loop
iii. if-then-else
iv. forward go to
v. arbitrary go to
vi. non-recursive procedure call
vii. recursive procedure/function call
viii. repeat loop,

which constructs will you not include in a programming language such that it should be possible to program the terminates (i.e., halting) function in the same programming language

A. (ii), (iii), (iv)
B. (v), (vii), (viii)
C. (vi), (vii), (viii)
D. (iii), (vii), (viii)

gate1999 programming normal programming-constructs

4.7 Programming In C (69)

4.7.1 Programming In C: GATE2000-1.11

https://gateoverflow.in/634

The following C declarations:

```
struct node {
    int i:
    float j;
 };
 struct node *s[10];
```

define s to be:

A. An array, each element of which is a pointer to a structure of type node
B. A structure of 2 fields, each field being a pointer to an array of 10 elements
C. A structure of 3 fields: an integer, a float, and an array of 10 elements
D. An array, each element of which is a structure of type node

gate2000 programming programming-in-c easy

4.7.2 Programming In C: GATE2000-1.12

https://gateoverflow.in/635

The most appropriate matching for the following pairs

$X:$	$\text{m} = \text{malloc}(5); \text{m} = \text{NULL};$	$1:$	using dangling pointers
$Y:$	$\text{free}(\text{n}); \text{n} \text{->} \text{value} = 5;$	$2:$	using uninitialized pointers
$Z:$	$\text{char} \text{*p}, \text{*p} = \text{'a'};$	$3:$	lost memory

is:

A. $X-1\ Y-3\ Z-2$
B. $X-2\ Y-1\ Z-3$
C. $X-3\ Y-2\ Z-1$
D. $X-3\ Y-1\ Z-2$

gate2000 programming programming-in-c normal

4.7.3 Programming In C: GATE2000-1.17, ISRO2015-79

https://gateoverflow.in/640

Consider the following C declaration:

```
struct (
    short x[5];
    union {
        float y;
        long z;
    } u;
 )t;
```

Assume that the objects of the type short, float and long occupy 2 bytes, 4 bytes and 8 bytes, respectively. The memory requirement for variable t, ignoring alignment consideration, is:

A. 22 bytes
B. 14 bytes
C. 18 bytes
D. 10 bytes

gate2000 programming programming-in-c easy isro2015

4.7.4 Programming In C: GATE2000-2.20

https://gateoverflow.in/667

The value of j at the end of the execution of the following C program:

```
int incr (int i)
{
    static int count = 0;
    count = count + i;
    return (count);
}
main () {
    int i, j;
    for (i = 0; i <= 4; i++)
       j = incr (i);
}
```

is:

A. 10
B. 4
C. 6
D. 7

gate2000 programming programming-in-c easy

4.7.5 Programming In C: GATE2001-2.18

https://gateoverflow.in/736

Consider the following three C functions:

$[P1]$

```
int *g(void)
{
    int x = 10;
    return (&x);
}
```

$[P2]$

```
int *g(void)
{
    int *px;
    *px = 10;
    return px;
}
```

$[P3]$

```
int *g(void)
{
    int *px;
    px = (int*) malloc (sizeof(int));
    *px = 10;
    return px;
}
```

Which of the above three functions are likely to cause problems with pointers?

A. Only $P3$ B. Only $P1$ and $P3$ C. Only $P1$ and $P2$ D. $P1, P2$ and $P3$

gate2001 programming programming-in-c normal

4.7.6 Programming In C: GATE2002-1.17

https://gateoverflow.in/822

In the C language:

A. At most one activation record exists between the current activation record and the activation record for the main
B. The number of activation records between the current activation record and the activation records from the main depends on the actual function calling sequence.
C. The visibility of global variables depends on the actual function calling sequence
D. Recursion requires the activation record for the recursive function to be saved in a different stack before the recursive function can be called.

gate2002 programming programming-in-c easy descriptive

4.7.7 Programming In C: GATE2002-2.18

https://gateoverflow.in/848

The C language is:

A. A context free language
B. A context sensitive language
C. A regular language
D. Parsable fully only by a Turing machine

gate2002 programming programming-in-c normal

4.7.8 Programming In C: GATE2002-2.8

https://gateoverflow.in/838

Consider the following declaration of a two-dimensional array in C:

char $a[100][100]$;

Assuming that the main memory is byte-addressable and that the array is stored starting from memory address 0, the address of $a[40][50]$ is:

A. 4040 B. 4050 C. 5040 D. 5050

gate2002 programming-in-c programming easy

4.7.9 Programming In C: GATE2003-2

https://gateoverflow.in/893

Assume the following C variable declaration:

```
int *A[10], B[10][10];
```

Of the following expressions:

I. $A[2]$
II. $A[2][3]$
III. $B[1]$
IV. $B[2][3]$

which will not give compile-time errors if used as left hand sides of assignment statements in a C program?

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

gate2003 programming programming-in-c easy

4.7.10 Programming In C: GATE2003-89

https://gateoverflow.in/972

Consider the C program shown below:

```
#include<stdio.h>
#define print(x) printf("%d", x)

int x;
void Q(int z)
{
        z+=x;
        print(z);
}

void P(int *y)
{
        int x = *y + 2;
        Q(x);
        *y = x - 1;
        print(x);
}
main(void) {
        x = 5;
        P(&x);
        print(x);
}
```

The output of this program is:

A. 12 7 6 B. 22 12 11 C. 14 6 6 D. 7 6 6

gate2003 programming programming-in-c normal

4.7.11 Programming In C: GATE2004-33

https://gateoverflow.in/1030

Consider the following C program segment:

```
char p[20]; int i;
char* s = "string";
int length = strlen(s);
for(i = 0; i < length; i++)
    p[i] = s[length-i];
printf("%s", p);
```

The output of the program is:

A. gnirts B. string C. gnirt D. no output is printed

gate2004 programming programming-in-c easy

4.7.12 Programming In C: GATE2004-IT-58

https://gateoverflow.in/3701

Consider the following C program which is supposed to compute the transpose of a given 4×4 matrix M. Note that, there is an X in the program which indicates some missing statements. Choose the correct option to replace X in the program.

```
#include<stdio.h>
#define ROW 4
#define COL 4
int M[ROW][COL] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16};
main()
{
    int i, j, t;
    for (i = 0; i < 4; ++i)
    {
        X
    }
    for (1 = 0; i < 4; ++i)
        for (j = 0; j < 4; ++j)
            printf ("%d", M[i][j]);
}
```

A.
```
for(j = 0; j < 4; ++j){
     t = M[i][j];
     M[i][j] = M[j][i];
     M[j][i] = t;
}
```

B.
```
for(j = 0; j < 4; ++j){
     M[i][j] = t;
     t = M[j][i];
     M[j][i] = M[i][j];
}
```

C.
```
for(j = i; j < 4; ++j){
     t = M[i][j];
     M[i][j] = M[j][i];
     M[j][i] = t;
}
```

D.
```
for(j = i; j < 4; ++j){
     M[i][j] = t;
     t = M[j][i];
     M[j][i] = M[i][j];
}
```

gate2004-it programming easy programming-in-c

4.7.13 Programming In C: GATE2004-IT-59

https://gateoverflow.in/3702

What is the output of the following program?

```
#include<stdio.h>
int funcf (int x);
int funcg (int y);
main ()
{
    int x = 5, y = 10, count;
    for (count = 1; count <= 2; ++count) {
        y += funcf(x) + funcg(x);
        printf ("%d", y);
    }
}
funcf (int x) {
    int y;
    y = funcg(x);
    return (y);
}
funcg (int x) {
    static int y = 10;
    y += 1;
    return (y + x);
}
```

A. 43 80 B. 42 74 C. 33 37 D. 32 32

gate2004-it programming programming-in-c normal

4.7.14 Programming In C: GATE2004-IT-60

https://gateoverflow.in/3703

Choose the correct option to fill the ?1 and ?2 so that the program prints an input string in reverse order. Assume that the input string is terminated by a new line character.

```
#include <stdio.h>
void wrt_it (void);
int main (void)
{
    printf("Enter Text");
    printf ("\n");
    wrt_it();
```

```
    printf ("\n");
    return 0;
}
void wrt_it (void)
{
    int c;
    if (?1)
        wrt_it();
    ?2
}
```

A. ?1 is $getchar() != \text{'\textbackslash n'}$
   ?2 is $getchar(c);$
B. ?1 is $(c = getchar()); != \text{'\textbackslash n'}$
   ?2 is $getchar(c);$
C. ?1 is $c != \text{'\textbackslash n'}$
   ?2 is $putchar(c);$
D. ?1 is $(c = getchar()) != \text{'\textbackslash n'}$
   ?2 is $putchar(c);$

gate2004-it programming programming-in-c normal

4.7.15 Programming In C: GATE2004-IT-61

https://gateoverflow.in/3704

Consider the following C program:

```
#include <stdio.h>
typedef struct {
    char *a;
    char *b;
    } t;
void f1 (t s);
void f2 (t *p);
main()
{
    static t s = {"A", "B"};
    printf ("%s %s\n", s.a, s.b);
    f1(s);
    printf ("%s %s\n", s.a, s.b);
    f2(&s);
}
void f1 (t s)
{
    s.a = "U";
    s.b = "V";
    printf ("%s %s\n", s.a, s.b);
    return;
}
void f2(t *p)
{
    p -> a  = "V";
    p -> b = "W";
    printf("%s %s\n", p -> a, p -> b);
    return;
}
```

What is the output generated by the program ?

A. $A\ B$
   $U\ V$
   $V\ W$
   $V\ W$
B. $A\ B$
   $U\ V$
   $A\ B$
   $V\ W$
C. $A\ B$
   $U\ V$
   $U\ V$
   $V\ W$
D. $A\ B$
   $U\ V$
   $V\ W$
   $U\ V$

gate2004-it programming programming-in-c normal

4.7.16 Programming In C: GATE2005-1, ISRO2017-55

https://gateoverflow.in/1343

What does the following C-statement declare?

```
int (*f) (int * );
```

A. A function that takes an integer pointer as argument and returns an integer
B. A function that takes an integer as argument and returns an integer pointer
C. A pointer to a function that takes an integer pointer as argument and returns an integer
D. A function that takes an integer pointer as argument and returns a function pointer

gate2005 programming programming-in-c easy isro2017

4.7.17 Programming In C: GATE2005-32

https://gateoverflow.in/1368

Consider the following C program:

```
double foo (double);  /* Line 1 */
int main() {
    double da, db;
    //input da
    db = foo(da);
}
double foo (double a) {
    return a;
}
```

The above code compiled without any error or warning. If Line 1 is deleted, the above code will show:

A. no compile warning or error
B. some compiler-warnings not leading to unintended results
C. some compiler-warnings due to type-mismatch eventually leading to unintended results
D. compiler errors

gate2005 programming programming-in-c compiler-design easy

4.7.18 Programming In C: GATE2005-IT-53

https://gateoverflow.in/3814

The following$C$ function takes two ASCII strings and determines whether one is an anagram of the other. An anagram of a string s is a string obtained by permuting the letters in s.

```
int anagram (char *a, char *b) {
    int count [128], j;
    for (j = 0;  j < 128; j++) count[j] = 0;
    j = 0;
    while (a[j] && b[j]) {
        A;
        B;
    }
    for (j = 0; j < 128; j++) if (count [j]) return 0;
    return 1;
}
```

Choose the correct alternative for statements A and B.

A. $A : count[a[j]]++ and\ B : count[b[j]]--$
B. $A : count[a[j]]++ and\ B : count[b[j]]++$
C. $A : count[a[j++]]++ and\ B : count[b[j]]--$
D. $A : count[a[j]]++ and\ B : count[b[j++]]--$

gate2005-it programming normal programming-in-c

4.7.19 Programming In C: GATE2005-IT-58

https://gateoverflow.in/3819

Let a be an array containing n integers in increasing order. The following algorithm determines whether there are two distinct numbers in the array whose difference is a specified number $S > 0$.

```
i = 0; j = 1;
while (j < n ){
        if (E) j++;
        else if (a[j] - a[i] == S) break;
        else i++;
}
if (j < n) printf("yes") else printf ("no");
```

Choose the correct expression for E.

A. $a[j]-a[i]>S$
B. $a[j]-a[i]<S$
C. $a[i]-a[j]<S$
D. $a[i]-a[j]>S$

gate2005-it programming normal programming-in-c

4.7.20 Programming In C: GATE2006-57

https://gateoverflow.in/1835

Consider this C code to swap two integers and these five statements: the code

```
void swap (int *px, int *py)
   {
      *px = *px - *py;
      *py = *px + *py;
       *px = *py - *px;
   }
```

S1: will generate a compilation error

S2: may generate a segmentation fault at runtime depending on the arguments passed

S3: correctly implements the swap procedure for all input pointers referring to integers stored in memory locations accessible to the process

S4: implements the swap procedure correctly for some but not all valid input pointers

S5: may add or subtract integers and pointers

A. S1 B. S2 and S3 C. S2 and S4 D. S2 and S5

gate2006 programming programming-in-c normal

4.7.21 Programming In C: GATE2006-IT-49

https://gateoverflow.in/3592

Which one of the choices given below would be printed when the following program is executed ?

```
#include <stdio.h>
struct test {
              int i;
              char *c;
}st[] = {5, "become", 4, "better", 6, "jungle", 8, "ancestor", 7, "brother"};
main ()
{
    struct test *p = st;
    p += 1;
    ++p -> c;
    printf("%s,", p++ -> c);
    printf("%c,", *++p -> c);
    printf("%d,", p[0].i);
    printf("%s \n", p -> c);
}
```

A. jungle, n, 8, nclastor
B. etter, u, 6, ungle
C. cetter, k, 6, jungle
D. etter, u, 8, ncestor

gate2006-it programming programming-in-c normal

4.7.22 Programming In C: GATE2006-IT-50

https://gateoverflow.in/3593

Which one of the choices given below would be printed when the following program is executed?

```
#include <stdio.h>
void swap (int *x, int *y)
{
    static int *temp;
    temp = x;
    x = y;
    y = temp;
}
void printab ()
{
    static int i, a = -3, b = -6;
    i = 0;
    while (i <= 4)
    {
        if ((i++)%2 == 1) continue;
        a = a + i;
        b = b + i;
    }
    swap (&a, &b);
```

```
    printf("a =  %d, b = %d\n", a, b);
}
main()
{
    printab();
    printab();
}
```

A. $a=0, b=3$
   $a=0, b=3$

B. $a=3, b=0$
   $a=12, b=9$

C. $a=3, b=6$
   $a=3, b=6$

D. $a=6, b=3$
   $a=15, b=12$

gate2006-it programming programming-in-c normal

4.7.23 Programming In C: GATE2006-IT-51

https://gateoverflow.in/3594

Which one of the choices given below would be printed when the following program is executed?

```
#include <stdio.h>
int a1[] = {6, 7, 8, 18, 34, 67};
int a2[] = {23, 56, 28, 29};
int a3[] = {-12, 27, -31};
int *x[] = {a1, a2, a3};
void print(int *a[])
{
            printf("%d,", a[0][2]);
            printf("%d,", *a[2]);
            printf("%d,", *++a[0]);
            printf("%d,", *(++a)[0]);
            printf("%d\n", a[-1][+1]);
}
main()
{
             print(x);
}
```

A. $8, -12, 7, 23, 8$

B. $8, 8, 7, 23, 7$

C. $-12, -12, 27, -31, 23$

D. $-12, -12, 27, -31, 56$

gate2006-it programming programming-in-c normal

4.7.24 Programming In C: GATE2007-IT-31

https://gateoverflow.in/3464

Consider the C program given below :

```
#include <stdio.h>
int main ()    {
    int sum = 0, maxsum = 0,  i,  n = 6;
    int a [] = {2, -2, -1, 3, 4, 2};
    for (i = 0; i < n; i++)    {
            if (i == 0 || a [i]  < 0  || a [i] < a [i - 1])  {
                    if (sum > maxsum) maxsum = sum;
                    sum = (a [i] > 0) ? a [i] : 0;
            }
            else sum += a [i];
    }
    if (sum > maxsum) maxsum = sum ;
    printf ("%d\n", maxsum);

}
```

What is the value printed out when this program is executed?

A. 9 B. 8 C. 7 D. 6

gate2007-it programming programming-in-c normal

4.7.25 Programming In C: GATE2008-18

https://gateoverflow.in/416

Which combination of the integer variables x, y and z makes the variable a get the value 4 in the following expression?

$$a = (x > y)?((x > z)?x : z) : ((y > z)?y : z)$$

A. $x=3, y=4, z=2$

B. $x=6, y=5, z=3$

C. $x=6, y=3, z=5$

D. $x=5, y=4, z=5$

gate2008 programming programming-in-c easy

4.7.26 Programming In C: GATE2008-60

https://gateoverflow.in/483

What is printed by the following C program?

```
int f(int x, int *py, int **ppz)
{
    int y, z;
    **ppz += 1; z = **ppz;   // corrected z = *ppz; to z = **ppz;
    *py += 2; y = *py;
    x += 3;
    return x+y+z;
}

void main()
{
    int c, *b, **a;
    c = 4; b = &c; a = &b;
    printf("%d", f(c, b, a));

}
```

A. 18 B. 19 C. 21 D. 22

gate2008 programming programming-in-c normal

4.7.27 Programming In C: GATE2008-61

https://gateoverflow.in/484

Choose the correct option to fill ?1 and ?2 so that the program below prints an input string in reverse order. Assume that the input string is terminated by a new line character.

```
void reverse(void)
{
    int c;
    if(?1) reverse();
    ?2
}
main()
{
    printf("Enter text");
    printf("\n");
    reverse();
    printf("\n");
}
```

A. ?1 is $(getchar() != '\n')$
?2 is $getchar(c);$

B. ?1 is $((c = getchar()) != '\n')$
?2 is $getchar(c);$

C. ?1 is $(c != '\n')$
?2 is $putchar(c);$

D. ?1 is $((c = getchar()) != '\n')$
?2 is $putchar(c);$

gate2008 programming normal programming-in-c

4.7.28 Programming In C: GATE2008-IT-49

https://gateoverflow.in/3359

What is the output printed by the following C code?

```
# include <stdio.h>
int main ()
{
    char a [6] = "world";
    int i, j;
    for (i = 0, j = 5; i < j; a [i++] = a [j--]);
    printf ("%s\n", a);
}
```

A. dlrow B. Null string C. dlrld D. worow

gate2008-it programming programming-in-c normal

4.7.29 Programming In C: GATE2008-IT-50

https://gateoverflow.in/3360

Consider the C program below. What does it print?

```
# include <stdio.h>
# define swapl (a, b) tmp = a; a = b; b = tmp
void swap2 ( int a, int b)
{
        int tmp;
        tmp = a; a = b; b = tmp;
 }
void swap3 (int*a, int*b)
{
        int tmp;
        tmp = *a; *a = *b; *b = tmp;
}
int main ()
{
        int num1 = 5, num2 = 4, tmp;
        if (num1 < num2) {swap1 (num1, num2);}
        if (num1 < num2) {swap2 (num1 + 1, num2);}
        if (num1 > = num2) {swap3 (&num1, &num2);}
        printf ("%d, %d", num1, num2);
}
```

A. 5,5 B. 5,4 C. 4,5 D. 4,4

gate2008-it programming programming-in-c normal

4.7.30 Programming In C: GATE2008-IT-51

https://gateoverflow.in/3361

Consider the C program given below. What does it print?

```
#include <stdio.h>
int main ()
{
        int i, j;
        int a [8] = {1, 2, 3, 4, 5, 6, 7, 8};
        for(i = 0; i < 3; i++) {
             a[i] = a[i] + 1;
             i++;
        }
        i--;
        for (j = 7; j > 4; j--) {
              int i = j/2;
              a[i] = a[i] - 1;
        }
        printf ("%d, %d", i, a[i]);
}
```

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

gate2008-it programming programming-in-c normal

4.7.31 Programming In C: GATE2008-IT-52

https://gateoverflow.in/3362

C program is given below:

```
# include <stdio.h>
int main ()
{
        int i, j;
        char a [2] [3] = {{'a', 'b', 'c'}, {'d', 'e', 'f'}};
        char b [3] [2];
        char *p = *b;
        for (i = 0; i < 2; i++) {
              for (j = 0; j < 3; j++) {
              *(p + 2*j + i) = a [i] [j];
              }
        }
}
```

What should be the contents of the array b at the end of the program?

A. a b
c d
e f

B. a d
b e
c f

C. a c
e b
d f

D. a e
d c
b f

gate2008-it programming programming-in-c normal

4.7.32 Programming In C: GATE2010-11

https://gateoverflow.in/2184

What does the following program print?

```
#include<stdio.h>

void f(int *p, int *q) {
    p=q;
    *p=2;
}

int i=0, j=1;

int main() {
    f(&i, &j);
    printf("%d %d\n", i,j);
    return 0;
}
```

A. 2 2 B. 2 1 C. 0 1 D. 0 2

gate2010 programming programming-in-c easy

4.7.33 Programming In C: GATE2011-22

https://gateoverflow.in/2124

What does the following fragment of C program print?

```
    char c[] = "GATE2011";
    char *p = c;
    printf("%s", p + p[3] - p[1]);
```

A. *GATE*2011 B. *E*2011 C. 2011 D. 011

gate2011 programming programming-in-c normal

4.7.34 Programming In C: GATE2012-3

https://gateoverflow.in/35

What will be the output of the following C program segment?

```
char inChar = 'A';
   switch ( inChar ) {
      case 'A' : printf ("Choice A \n");
      case 'B' :
      case 'C' : printf ("Choice B");
      case 'D' :
      case 'E' :
      default : printf ("No Choice");
   }
```

A. No Choice
C. Choice A
Choice B No Choice

B. Choice A
D. Program gives no output as it is erroneous

gate2012 programming easy programming-in-c

4.7.35 Programming In C: GATE2012-48

https://gateoverflow.in/2176

Consider the following C code segment.

```
int a, b, c = 0;
```

```
void prtFun(void);
main()
{
    static int a = 1;       /* Line 1 */
    prtFun();
    a += 1;
    prtFun();
    printf(" \n %d %d ", a, b);
}

void prtFun(void)
{
    static int a = 2;       /* Line 2 */
    int b = 1;
    a += ++b;
    printf(" \n %d %d ", a, b);
}
```

What output will be generated by the given code segment?

A. 3 1
4 1
4 2

B. 4 2
6 1
6 1

C. 4 2
6 2
2 0

D. 3 1
5 2
5 2

gate2012 programming programming-in-c normal

4.7.36 Programming In C: GATE2012-49

https://gateoverflow.in/43314

Consider the following C code segment.

```
int a, b, c = 0;
void prtFun(void);
main()
{
    static int a = 1;       /* Line 1 */
    prtFun();
    a += 1;
    prtFun();
    printf(" \n %d %d ", a, b);
}

void prtFun(void)
{
    static int a = 2;       /* Line 2 */
    int b = 1;
    a += ++b;
    printf(" \n %d %d ", a, b);
}
```

What output will be generated by the given code segment if:

Line 1 is replaced by **auto int** $a = 1;$

Line 2 is replaced by **register int** $a = 2;$

A. 3 1
4 1
4 2

B. 4 2
6 1
6 1

C. 4 2
6 2
2 0

D. 4 2
4 2
2 0

normal gate2012 programming-in-c programming

4.7.37 Programming In C: GATE2014-1-10

https://gateoverflow.in/1770

Consider the following program in C language:

```
#include <stdio.h>

main()
{
   int i;
   int*pi = &i;

   scanf("%d",pi);
   printf("%d\n", i+5);
}
```

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

A. Compilation fails.

B. Execution results in a run-time error.
C. On execution, the value printed is 5 more than the address of variable i.
D. On execution, the value printed is 5 more than the integer value entered.

gate2014-1 programming programming-in-c easy

4.7.38 Programming In C: GATE2014-2-11

https://gateoverflow.in/1965

Suppose n and p are unsigned int variables in a C program. We wish to set p to ${}^nC_3$. If n is large, which one of the following statements is most likely to set p correctly?

A. $p = n * (n-1) * (n-2)/6;$
B. $p = n * (n-1)/2 * (n-2)/3;$
C. $p = n * (n-1)/3 * (n-2)/2;$
D. $p = n * (n-1) * (n-2)/6.0;$

gate2014-2 programming programming-in-c normal

4.7.39 Programming In C: GATE2014-2-42

https://gateoverflow.in/2008

Consider the C function given below.

```
int f(int j)
{
    static int i = 50;
    int k;
    if (i == j)
    {
        printf("something");
        k = f(i);
        return 0;
    }
    else return 0;
}
```

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

A. The function returns 0 for all values of j.
B. The function prints the string **something** for all values of j.
C. The function returns 0 when $j = 50$.
D. The function will exhaust the runtime stack or run into an infinite loop when $j = 50$.

gate2014-2 programming programming-in-c

4.7.40 Programming In C: GATE2015-1-11

https://gateoverflow.in/8185

The output of the following C program is_____.

```
void f1 ( int a, int b)  {
                int c;
                c = a; a = b;
                 b = c;
}
void f2 ( int * a, int * b) {
               int c;
               c = * a; *a = *b; *b = c;
}
int main () {
        int a = 4, b = 5, c = 6;
        f1 ( a, b);
        f2 (&b, &c);
        printf ("%d", c - a - b);
 }
```

gate2015-1 programming programming-in-c easy numerical-answers

4.7.41 Programming In C: GATE2015-1-35

https://gateoverflow.in/8283

What is the output of the following C code? Assume that the address of x is 2000 (in decimal) and an integer requires four bytes of memory.

```
int main () {
         unsigned int x [4] [3] =
         {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}, {10, 11, 12}};
         printf ("%u, %u, %u", x + 3, *(x + 3), *(x + 2) + 3);
```

```
}
```

A. $2036, 2036, 2036$
B. $2012, 4, 2204$
C. $2036, 10, 10$
D. $2012, 4, 6$

gate2015-1 programming programming-in-c normal

4.7.42 Programming In C: GATE2015-2-15

https://gateoverflow.in/8086

Consider the following function written in the C programming langauge :

```
void foo(char *a)
 {
    if (*a && *a != ' ')
      {
       foo(a+1);
       putchar(*a);
      }
}
```

The output of the above function on input "$ABCD\ EFGH$" is

A. $ABCD\ EFGH$ B. $ABCD$ C. $HGFE\ DCBA$ D. $DCBA$

gate2015-2 programming programming-in-c normal

4.7.43 Programming In C: GATE2015-3-26

https://gateoverflow.in/8478

Consider the following C program

```
#include<stdio.h>
int main()  {
    static int a[] = {10, 20, 30, 40, 50};
    static int *p[] = {a, a+3, a+4, a+1, a+2};
    int **ptr = p;
    ptr++;
    printf("%d%d", ptr-p, **ptr);

}
```

The output of the program is _____.

gate2015-3 programming programming-in-c normal numerical-answers

4.7.44 Programming In C: GATE2015-3-30

https://gateoverflow.in/8486

Consider the following two C code segments. Y and X are one and two dimensional arrays of size n and $n \times n$ respectively, where $2 \leq n \leq 10$. Assume that in both code segments, elements of Y are initialized to 0 and each element $X[i][j]$ of array X is initialized to $i + j$. Further assume that when stored in main memory all elements of X are in same main memory page frame.

Code segment 1:

```
// initialize elements of Y to 0
// initialize elements of X[i][j] of X to i+j
for (i=0; i<n; i++)
    Y[i] += X[0][i];
```

Code segment 2:

```
// initialize elements of Y to 0
// initialize elements of X[i][j] of X to i+j
for (i=0; i<n; i++)
    Y[i] += X[i][0];
```

Which of the following statements is/are correct?

S1: Final contents of array Y will be same in both code segments

S2: Elements of array X accessed inside the for loop shown in code segment 1 are contiguous in main memory

S3: Elements of array X accessed inside the for loop shown in code segment 2 are contiguous in main memory

A. Only S2 is correct
B. Only S3 is correct
C. Only S1 and S2 are correct
D. Only S1 and S3 are correct

gate2015-3 programming-in-c normal

4.7.45 Programming In C: GATE2015-3-48

https://gateoverflow.in/8557

Consider the following C program:

```
#include<stdio.h>
int main()
{
    int i, j, k = 0;
    j=2 * 3 / 4 + 2.0 / 5 + 8 / 5;
    k-=--j;
    for (i=0; i<5; i++)
    {
        switch(i+k)
        {
            case 1:
            case 2: printf("\n%d", i+k);
            case 3: printf("\n%d", i+k);
            default: printf("\n%d", i+k);
        }
    }
    return 0;
}
```

The number of times printf statement is executed is _____.

gate2015-3 programming programming-in-c normal numerical-answers

4.7.46 Programming In C: GATE2015-3-54

https://gateoverflow.in/8563

Consider the following C program:

```
#include<stdio.h>
int f1(void);
int f2(void);
int f3(void);
int x=10;
int main()
{
    int x=1;
    x += f1() + f2 () + f3() + f2();
    printf("%d", x);
    return 0;
}
int f1() { int x = 25; x++; return x;}
int f2() { static int x = 50; x++; return x;}
int f3() { x *= 10; return x;}
```

The output of the program is _____.

gate2015-3 programming programming-in-c normal numerical-answers

4.7.47 Programming In C: GATE2015-3-7

https://gateoverflow.in/8401

Consider the following C program segment.

```
# include <stdio.h>
int main()
{
    char s1[7] = "1234", *p;
    p = s1 + 2;
    *p = '0';
    printf("%s", s1);
}
```

What will be printed by the program?

A. 12 B. 120400 C. 1204 D. 1034

gate2015-3 programming programming-in-c normal

4.7.48 Programming In C: GATE2016-1-12

https://gateoverflow.in/39638

Consider the following "C" program.

```
void f(int, short);
void main()
{
    int i = 100;
```

```
    short s = 12;
    short *p = &s;
    _____________;  // call to f()
}
```

Which one of the following expressions , when placed in the blank above, will NOT result in a type checking error?

A. $f(s, *s)$ B. $i = f(i, s)$ C. $f(i, *s)$ D. $f(i, *p)$

gate2016-1 programming-in-c easy

4.7.49 Programming In C: GATE2016-1-15 https://gateoverflow.in/39642

Consider the following C program.

```
# include <stdio.h>
void mystery (int *ptra, int *ptrb) {
     int *temp;
     temp = ptrb;
     ptrb =ptra;
     ptra = temp;
}
int main () {
    int a = 2016, b=0, c= 4, d = 42;
    mystery (&a, &b);
    if (a < c)
          mystery (&c, &a);
    mystery (&a, &d);
    print f("%d\n", a);
}
```

The output of the program is _____.

gate2016-1 programming-in-c easy numerical-answers

4.7.50 Programming In C: GATE2016-1-34 https://gateoverflow.in/39704

The following function computes the maximum value contained in an integer array $P[\,]$ of size n $(n >= 1)$.

```
int max (int *p,int n) {
    int a = 0, b=n-1;

    while (__________) {
        if (p[a]<= p[b]) {a = a+1;}
        else             {b = b-1;}
    }
    return p[a];
}
```

The missing loop condition is:

A. $a! = n$ B. $b! = 0$
C. $b > (a+1)$ D. $b! = a$

gate2016-1 programming-in-c normal

4.7.51 Programming In C: GATE2016-2-12 https://gateoverflow.in/39565

The value printed by the following program is _____.

```
      void f (int * p, int m) {
           m = m + 5;
          *p = *p + m;
           return;
      }
      void main () {
       int i=5, j=10;

       f (&i, j);
       print f ("%d", i+j);
     }
```

gate2016-2 programming-in-c normal numerical-answers

4.7.52 Programming In C: GATE2016-2-37

https://gateoverflow.in/39602

Consider the following program:

```
int f (int * p, int n)
{
    if (n <= 1) return 0;
    else return max (f (p+1, n-1), p[0] - p[1]);
}
 int main ()
{
    int a[] = {3, 5, 2, 6, 4};
    print f(" %d", f(a, 5));
}
```

Note: $max(x,y)$ returns the maximum of x and y.

The value printed by this program is _____.

gate2016-2 programming-in-c normal numerical-answers

4.7.53 Programming In C: GATE2017-1-13

https://gateoverflow.in/118293

Consider the following C code:

```
#include<stdio.h>
int *assignval (int *x, int val) {
    *x = val;
    return x;
}

void main () {
    int *x = malloc(sizeof(int));
    if (NULL == x) return;
    x = assignval (x,0);
    if (x) {
        x = (int *)malloc(sizeof(int));
        if (NULL == x) return;
        x = assignval (x,10);
    }
    printf("%d\n", *x);
    free(x);
}
```

The code suffers from which one of the following problems:

A. compiler error as the return of $malloc$ is not typecast appropriately.
B. compiler error because the comparison should be made as $x == NULL$ and not as shown.
C. compiles successfully but execution may result in dangling pointer.
D. compiles successfully but execution may result in memory leak.

gate2017-1 programming-in-c programming

4.7.54 Programming In C: GATE2017-1-36

https://gateoverflow.in/118319

Consider the C functions foo and bar given below:

```
int foo(int val) {
    int x=0;
    while(val > 0) {
        x = x + foo(val--);
    }
    return val;
}
```

```
int bar(int val) {
    int x = 0;
    while(val > 0) {
        x= x + bar(val-1);
    }
    return val;
}
```

Invocations of $foo(3)$ and $bar(3)$ will result in:

A. Return of 6 and 6 respectively.
B. Infinite loop and abnormal termination respectively.

C. Abnormal termination and infinite loop respectively.

D. Both terminating abnormally.

gate2017-1 programming-in-c programming normal

4.7.55 Programming In C: GATE2017-1-53

https://gateoverflow.in/118473

Consider the following C program.

```
#include<stdio.h>
#include<string.h>

void printlength(char *s, char *t) {
    unsigned int c=0;
    int len = ((strlen(s) - strlen(t)) > c) ? strlen(s) : strlen(t);
    printf("%d\n", len);
}

void main() {
    char *x = "abc";
    char *y = "defgh";
    printlength(x,y);
}
```

Recall that *strlen* is defined in *string.h* as returning a value of type *size_t*, which is an unsigned int. The output of the program is _____ .

gate2017-1 programming programming-in-c normal numerical-answers

4.7.56 Programming In C: GATE2017-1-55

https://gateoverflow.in/118442

The output of executing the following C program is _____ .

```
#include<stdio.h>

int total(int v) {
    static int count = 0;
    while(v) {
        count += v&1;
        v >>= 1;
    }
    return count;
}

void main() {
    static int x=0;
    int i=5;
    for(; i>0; i--) {
        x = x + total(i);
    }
    printf("%d\n", x);
}
```

gate2017-1 programming programming-in-c normal numerical-answers

4.7.57 Programming In C: GATE2017-2-14

https://gateoverflow.in/118245

Consider the following function implemented in C:

```
void printxy(int x, int y) {
    int *ptr;
    x=0;
    ptr=&x;
    y=*ptr;
    *ptr=1;
    printf("%d, %d", x, y);
}
```

The output of invoking *printxy*$(1,1)$ is:

A. $0,0$ B. $0,1$ C. $1,0$ D. $1,1$

gate2017-2 programming-in-c programming

4.7.58 Programming In C: GATE2017-2-2

https://gateoverflow.in/118171

Match the following:

P.	static char var ;	i.	Sequence of memory locations to store addresses
Q.	m = malloc(10); m =NULL ;	ii.	A variable located in data section of memory
R.	char *ptr[10] ;	iii.	Request to allocate a CPU register to store data
S.	register int varl;	iv.	A lost memory which cannot be freed

A. P-ii; Q-iv; R-i; S-iii
B. P-ii; Q-i; R-iv; S-iii
C. P-ii; Q-iv; R-iii; S-i
D. P-iii; Q-iv; R-i; S-ii

gate2017-2 programming programming-in-c

4.7.59 Programming In C: GATE2017-2-54

https://gateoverflow.in/118272

Consider the following C program.

```
#include<stdio.h>
int main () {
    int m=10;
    int n, n1;
    n=++m;
    n1=m++;
    n--;
    --n1;
    n-=n1;
    printf("%d", n);
    return 0;
}
```

The output of the program is _____

gate2017-2 programming-in-c numerical-answers

4.7.60 Programming In C: GATE2017-2-55

https://gateoverflow.in/118335

Consider the following C program.

```
#include<stdio.h>
#include<string.h>
int main() {
    char* c="GATECSIT2017";
    char* p=c;
    printf("%d", (int)strlen(c+2[p]-6[p]-1));
    return 0;
}
```

The output of the program is _____

gate2017-2 programming-in-c numerical-answers

4.7.61 Programming In C: GATE2018-32

https://gateoverflow.in/204106

Consider the following C code. Assume that unsigned long int type length is 64 bits.

```
unsigned long int fun(unsigned long int n) {
        unsigned long int i, j=0, sum = 0;
        for( i=n; i>1; i=i/2) j++;
        for( ; j>1; j=j/2) sum++;
        return sum;
}
```

The value returned when we call fun with the input 2^{40} is:

A. 4 B. 5 C. 6 D. 40

gate2018 programming-in-c normal programming

4.7.62 Programming In C: GATE2018-45

https://gateoverflow.in/204120

Consider the following program written in pseudo-code. Assume that x and y are integers.

```
Count (x, y) {
```

```
    if (y !=1 ) {
        if (x !=1) {
            print("*");
            Count (x/2, y);
        }
        else {
            y=y-1;
            Count (1024, y);
        }
    }
}
```

The number of times that the $print$ statement is executed by the call $Count(1024,1024)$ is _____

gate2018 programming-in-c numerical-answers

4.7.63 Programming In C: GATE2019-18

https://gateoverflow.in/302830

Consider the following C program :

```
#include<stdio.h>
int jumble(int x, int y){
    x = 2*x+y;
    return x;
}
int main(){
    int x=2, y=5;
    y=jumble(y,x);
    x=jumble(y,x);
    printf("%d \n",x);
    return 0;
}
```

The value printed by the program is _____.

gate2019 numerical-answers programming-in-c programming

4.7.64 Programming In C: GATE2019-24

https://gateoverflow.in/302824

Consider the following C program:

```
#include <stdio.h>
int main() {
        int arr[]={1, 2, 3, 4, 5, 6, 7, 8, 9, 0, 1, 2, 5}, *ip=arr+4;
        printf("%d\n", ip[1]);
        return 0;
}
```

The number that will be displayed on execution of the program is _____

gate2019 numerical-answers programming-in-c programming

4.7.65 Programming In C: GATE2019-27

https://gateoverflow.in/302821

Consider the following C program:

```
#include <stdio.h>
int r() {
       static int num=7;
       return num--;
}
int main() {
       for (r();r();r())
              printf("%d",r());
       return 0;
}
```

Which one of the following values will be displayed on execution of the programs?

A. 41 B. 52 C. 63 D. 630

gate2019 programming-in-c programming

4.7.66 Programming In C: GATE2019-52

https://gateoverflow.in/302796

Consider the following C program:

```c
#include <stdio.h>
int main() {
    float sum = 0.0, j=1.0, i=2.0;
    while (i/j > 0.0625) {
        j=j+j;
        sum=sum+i/j;
        printf("%f\n", sum);
    }
    return 0;
}
```

The number of times the variable sum will be printed, when the above program is executed, is _____

gate2019 numerical-answers programming-in-c programming

4.7.67 Programming In C: GATE2019-53

https://gateoverflow.in/302795

Consider the following C program:

```c
#include <stdio.h>
int main()
{
    int a[] = {2, 4, 6, 8, 10};
    int i, sum=0, *b=a+4;
    for (i=0; i<5; i++)
        sum=sum+(*b-i)-*(b-i);
    printf("%d\n", sum);
    return 0;
}
```

The output of the above C program is _____

gate2019 numerical-answers programming-in-c programming

4.7.68 Programming In C: TIFR2018-A-7

https://gateoverflow.in/179276

```c
Consider the following function definition.
void greet(int n)
{
    if(n>0)
    {
        printf("hello");
        greet(n-1);
    }
    printf("world");
}
```

If you run greet(n) for some non-negative integer n, what would it print?

A. n times "hello", followed by n+1 times "world"
B. n times "hello", followed by n times "world"
C. n times "helloworld"
D. n+1 times "helloworld"
E. n times "helloworld", followed by "world"

tifr2018 programming-in-c

4.7.69 Programming In C: TIFR2019-B-6

https://gateoverflow.in/280489

Given the following pseudocode for function printx() below, how many times is x printed if we execute printx(5)?

```c
void printx(int n)  {
    if(n==0){
        printf("x");
}
for(int i=0;i<=n-1;++i){
    printx(n-1);
}
}
```

A. 625 B. 256 C. 120 D. 24 E. 5

tifr2019 programming programming-in-c

4.8 Programming Paradigms (2)

4.8.1 Programming Paradigms: GATE2004-1

https://gateoverflow.in/998

The goal of structured programming is to:

A. have well indented programs
B. be able to infer the flow of control from the compiled code
C. be able to infer the flow of control from the program text
D. avoid the use of GOTO statements

gate2004 programming easy programming-paradigms

4.8.2 Programming Paradigms: GATE2004-90

https://gateoverflow.in/1084

Choose the best matching between the programming styles in Group 1 and their characteristics in Group 2.

Group 1		Group 2	
$P.$	Functional	1.	Common-based, procedural
$Q.$	Logic	2.	Imperative, abstract data types
$R.$	Object-oriented	3.	Side-effect free, declarative, expression evaluations
$S.$	Imperative	4.	Declarative, clausal representation, theorem proving

A. $P-2 \quad Q-3 \quad R-4 \quad S-1$
B. $P-4 \quad Q-3 \quad R-2 \quad S-1$
C. $P-3 \quad Q-4 \quad R-1 \quad S-2$
D. $P-3 \quad Q-4 \quad R-2 \quad S-1$

gate2004 programming normal programming-paradigms

4.9 Recursion (17)

4.9.1 Recursion: GATE1991-01,x

https://gateoverflow.in/507

Consider the following recursive definition of fib:

```
fib(n) :=  if n = 0 then 1
           else if n = 1 then 1
           else fib(n-1) + fib(n-2)
```

The number of times fib is called (including the first call) for evaluation of $fib(7)$ is_____.

gate1991 programming recursion normal

4.9.2 Recursion: GATE1994-21

https://gateoverflow.in/2517

Consider the following recursive function:

```
function fib (n:integer);integer;
begin
if (n=0) or (n=1) then fib := 1
else fib := fib(n-1) + fib(n-2)
end;
```

The above function is run on a computer with a stack of 64 bytes. Assuming that only return address and parameter are passed on the stack, and that an integer value and an address takes 2 bytes each, estimate the maximum value of n for which the stack will not overflow. Give reasons for your answer.

gate1994 programming recursion normal

4.9.3 Recursion: GATE1995-2.9

https://gateoverflow.in/2621

A language with string manipulation facilities uses the following operations

```
head(s): first character of a string
tail(s): all but exclude the first character of a string
```

```
concat(s1, s2): s1s2
```

For the string "$acbc$" what will be the output of

```
concat(head(s), head(tail(tail(s))))
```

A. ac B. bc C. ab D. cc

gate1995 algorithms normal recursion

4.9.4 Recursion: GATE2000-16

https://gateoverflow.in/687

A recursive program to compute Fibonacci numbers is shown below. Assume you are also given an array $f[0 \ldots m]$ with all elements initialized to 0.

```
fib(n) {
    if (n > M) error ();
    if (n == 0) return 1;
    if (n == 1)return 1;
    if (▭)_____________________(1)
        return ▭_____________(2)
    t = fib(n - 1) + fib(n - 2);
    ▭_____________________(3)
    return t;
}
```

A. Fill in the boxes with expressions/statement to make $fib()$ store and reuse computed Fibonacci values. Write the box number and the corresponding contents in your answer book.
B. What is the time complexity of the resulting program when computing $fib(n)$?

gate2000 algorithms normal descriptive recursion

4.9.5 Recursion: GATE2001-13

https://gateoverflow.in/754

Consider the following C program:

```
void abc(char*s)
{
    if(s[0]=='\0')return;
    abc(s+1);
    abc(s+1);
    printf("%c",s[0]);
}

main()
{
    abc("123");
}
```

A. What will be the output of the program?
B. If $abc(s)$ is called with a null-terminated string s of length n characters (not counting the null ('\0') character), how many characters will be printed by $abc(s)$?

gate2001 programming recursion normal descriptive

4.9.6 Recursion: GATE2002-11

https://gateoverflow.in/864

The following recursive function in C is a solution to the Towers of Hanoi problem.

```
void move(int n, char A, char B, char C)  {
    if (.....................) {
        move (..........................);
        printf("Move disk %d from pole %c to pole %c\n", n, A,C);
        move (.....................);
    }
}
```

Fill in the dotted parts of the solution.

gate2002 programming recursion normal descriptive

4.9.7 Recursion: GATE2004-31, ISRO2008-40

https://gateoverflow.in/1028

Consider the following C function:

```
int f(int n)
{
    static int i = 1;
    if(n >= 5) return n;
```

```
    n = n+i;
    i++;
    return f(n);
}
```

The value returned by $f(1)$ is:

A. 5 B. 6 C. 7 D. 8

gate2004 programming programming-in-c recursion easy isro2008

4.9.8 Recursion: GATE2005-81a

https://gateoverflow.in/1403

```
double foo(int n)
{
    int i;
    double sum;
    if(n == 0)
    {
        return 1.0;
    }
    else
    {
        sum = 0.0;
        for(i = 0; i < n; i++)
        {
            sum += foo(i);
        }
        return sum;
    }

}
```

The space complexity of the above code is?

A. $O(1)$ B. $O(n)$ C. $O(n!)$ D. n^n

gate2005 programming recursion normal

4.9.9 Recursion: GATE2005-81b

https://gateoverflow.in/82146

```
double foo(int n)
{
    int i;
    double sum;
    if(n == 0)
    {
        return 1.0;
    }
    else
    {
        sum = 0.0;
        for(i = 0; i < n; i++)
        {
            sum += foo(i);
        }
        return sum;
    }

}
```

Suppose we modify the above function $foo()$ and stores the value of $foo(i)\ 0 \leq i < n$, as and when they are computed. With this modification the time complexity for function $foo()$ is significantly reduced. The space complexity of the modified function would be:

A. $O(1)$ B. $O(n)$ C. $O(n^2)$ D. $n!$

gate2005 programming recursion normal

4.9.10 Recursion: GATE2007-42

https://gateoverflow.in/1240

Consider the following C function:

```
int f(int n)
{
    static int r = 0;
```

```
    if (n <= 0) return 1;
    if (n > 3)
    {    r = n;
         return f(n-2) + 2;
    }
    return f(n-1) + r;
}
```

What is the value of $f(5)$?

A. 5 B. 7 C. 9 D. 18

gate2007 programming recursion normal

4.9.11 Recursion: GATE2007-IT-27

https://gateoverflow.in/3460

The function f is defined as follows:

```
int f (int n) {
    if (n <= 1) return 1;
    else if (n % 2  ==  0) return f(n/2);
    else return f(3n - 1);
}
```

Assuming that arbitrarily large integers can be passed as a parameter to the function, consider the following statements.

i. The function f terminates for finitely many different values of $n \geq 1$.
ii. The function f terminates for infinitely many different values of $n \geq 1$.
iii. The function f does not terminate for finitely many different values of $n \geq 1$.
iv. The function f does not terminate for infinitely many different values of $n \geq 1$.

Which one of the following options is true of the above?

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

gate2007-it programming recursion normal

4.9.12 Recursion: GATE2014-2-40

https://gateoverflow.in/2000

Consider the following function.

```
double f(double x){
    if( abs(x*x - 3) < 0.01)
        return x;
    else
        return f(x/2 + 1.5/x);
}
```

Give a value q (to 2 decimals) such that $f(q)$ will return q:_____.

gate2014-2 programming recursion numerical-answers normal

4.9.13 Recursion: GATE2016-1-35

https://gateoverflow.in/39730

What will be the output of the following C program?

```
void count (int n) {
    static int d=1;

    printf ("%d",n);
    printf ("%d",d);
    d++;
    if (n>1) count (n-1);
    printf ("%d",d);


}

void main(){
    count (3);
}
```

A. $3\,1\,2\,2\,1\,3\,4\,4\,4$
B. $3\,1\,2\,1\,1\,1\,2\,2\,2$
C. $3\,1\,2\,2\,1\,3\,4$

D. 3121112

gate2016-1 programming-in-c recursion normal

4.9.14 Recursion: GATE2017-1-35

https://gateoverflow.in/118317

Consider the following two functions.

```
void fun1(int n) {
    if(n == 0) return;
    printf("%d", n);
    fun2(n - 2);
    printf("%d", n);
}
void fun2(int n) {
    if(n == 0) return;
    printf("%d", n);
    fun1(++n);
    printf("%d", n);
}
```

The output printed when fun1(5) is called is

A. 53423122233445
B. 53423120112233
C. 53423122132435
D. 53423120213243

gate2017-1 programming normal tricky recursion

4.9.15 Recursion: GATE2018-21

https://gateoverflow.in/204095

Consider the following C program:

```
#include<stdio.h>

int counter=0;

int calc (int a, int b) {
        int c;
        counter++;
        if(b==3) return (a*a*a);
        else {
                c = calc(a, b/3);
                return (c*c*c);
        }
}

int main() {
        calc(4, 81);
        printf("%d", counter);
}
```

The output of this program is _____.

gate2018 programming-in-c numerical-answers recursion programming

4.9.16 Recursion: TIFR2010-B-31

https://gateoverflow.in/26484

Consider the following computation rules. **Parallel-outermost rule**: Replace all the outermost occurrences of F (i.e., all occurrences of F which do not occur as arguments of other F's) simultaneously. **Parallel - innermost rule**: Replace all the innermost occurrences of F (i.e.,all occurrences of F with all arguments free of F's) simultaneously. Now consider the evaluations of the recursive program over the integers.

```
F(x, y) <== if x = 0 then 0 else
            [ F(x + 1, F(x, y)) * F(x - 1, F(x, y))]
```

where the multiplication functions * is extended as follows:

```
0 * w & w * 0 are 0
a * w & w * a are w (for any non-zero integer a)
w * w is w
```

We say that $F(x,y) =$ w when the evaluation of $F(x,y)$ does not terminate. Computing $F(1,0)$ using the parallel -

innermost and parallel - outermost rule yields

A. w and 0 respectively
B. 0 and 0 respectively
C. w and w respectively
D. w and 1 respectively
E. none of the above

tifr2010 programming recursion

4.9.17 Recursion: TIFR2011-B-38

https://gateoverflow.in/20923

Consider the class of recursive and iterative programs. Which of the following is false?

A. Recursive programs are more powerful than iterative programs.
B. For every iterative program there is an equivalent recursive program.
C. Recursive programs require dynamic memory management.
D. Recursive programs do not terminate sometimes.
E. Iterative programs and recursive programs are equally expressive.

tifr2011 recursion programming

4.10 Structures (1)

4.10.1 Structures: GATE2018-2

https://gateoverflow.in/204076

Consider the following C program:

```
#include<stdio.h>
struct Ournode{
    char x, y, z;
};
int main() {
    struct Ournode p={'1', '0', 'a'+2};
    struct Ournode *q=&p;
    printf("%c, %c", *((char*)q+1), *((char*)q+2));
    return 0;
}
```

The output of this program is:

A. 0, c B. 0, a+2 C. '0', 'a+2' D. '0', 'c'

gate2018 programming-in-c programming structures pointers normal

4.11 Type Checking (1)

4.11.1 Type Checking: GATE2003-24

https://gateoverflow.in/914

Which of the following statements is FALSE?

A. In statically typed languages, each variable in a program has a fixed type
B. In un-typed languages, values do not have any types
C. In dynamically typed languages, variables have no types
D. In all statically typed languages, each variable in a program is associated with values of only a single type during the execution of the program

gate2003 programming normal type-checking

4.12 Variable Binding (1)

4.12.1 Variable Binding: GATE2007-IT-34, UGCNET-Dec2012-III-52

https://gateoverflow.in/3467

Consider the program below in a hypothetical programming language which allows global variables and a choice of static or dynamic scoping.

```
int i ;
program main ()
{
    i = 10;
    call f();
}
```

```
procedure f()
{
    int i = 20;
    call g ();
}
procedure g ()
{
    print i;
}
```

Let x be the value printed under static scoping and y be the value printed under dynamic scoping. Then, x and y are:

A. $x = 10, y = 20$ B. $x = 20, y = 10$ C. $x = 10, y = 10$ D. $x = 20, y = 20$

gate2007-it programming variable-binding normal ugcnetdec2012iii

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 → ϵ
A → bA
A → ϵ
```

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^ib^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.

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

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
$S \rightarrow aSa \mid bSb \mid a \mid b \mid \epsilon$
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 $\{x,y,z\}$
$G1 : S \rightarrow x \mid z \mid x\,S \mid z\,S \mid y\,B$
$\quad B \rightarrow y \mid z \mid y\,B \mid z\,B$
$G2 : S \rightarrow y \mid z \mid y\,S \mid z\,S \mid x\,B$
$\quad B \rightarrow y \mid y\,S$

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:

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

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	$\rightarrow$	WHILE (expr) stmnt
	stmnt	$\rightarrow$	OTHER
	expr	$\rightarrow$	ID
$G2:$	stmnt	$\rightarrow$	WHILE (expr) stmnt
	stmnt	$\rightarrow$	OTHER
	expr	$\rightarrow$	expr + expr
	expr	$\rightarrow$	expr * expr
	expr	$\rightarrow$	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.

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

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.

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

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

A. $aabbaba$ B. $aabaaba$ C. $ababbb$ 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

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

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?

$$S \rightarrow aS \mid bS \mid \varepsilon$$

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;
$G_1 : S \rightarrow aS \mid B, B \rightarrow b \mid bB$
$G_2 : S \rightarrow aA \mid bB, A \rightarrow aA \mid B \mid \varepsilon, B \rightarrow bB \mid \varepsilon$
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. $\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots, m_n \geq 1\}$
C. $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$
D. $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

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 $\{M \mid M$ 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 $\{M', x \mid M'$ 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 $(\forall x)[x \in L_1$ 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?

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:

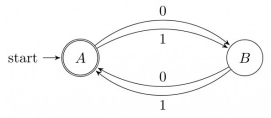
A. 01 B. 10 C. 101 D. 110

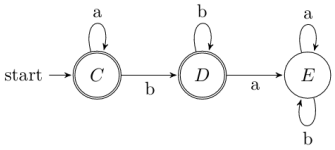
gate1995 theory-of-computation finite-automata normal

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 $1,2,4,8,\ldots 2^n,\ldots$ written in binary
B. The numbers $1,2,4,8,\ldots 2^n,\ldots$ 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 $\{1,101,11011,1110111,\ldots\}$

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:

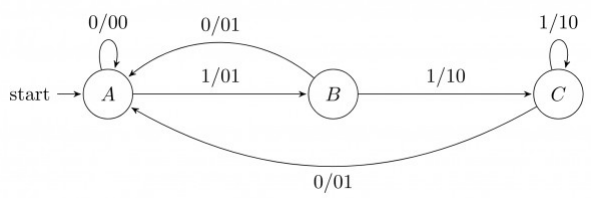
A. $L = \{w \mid w \in \{a,b\}^*, \text{ w has baab as a substring }\}$
B. $L = \{w \mid w \in \{a,b\}^*, \text{ w has an odd number of a's and an odd number of b's }\}$

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 $(a \mid b)^*abb$

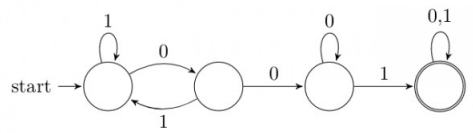
A. Give an NFA for this purpose
B. Give a DFA for this purpose

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

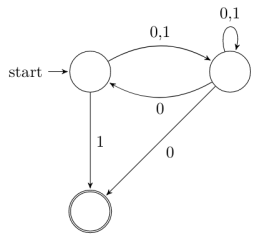
A. 1 B. 5 C. 7 D. 8

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?

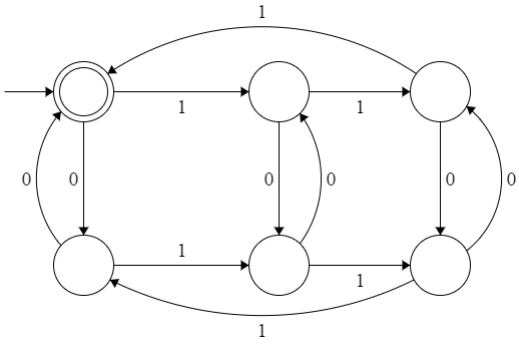
A. $L_1 = \{0,1\}^* - L$ B. $L_1 = \{0,1\}^*$ C. $L_1 \subseteq L$ D. $L_1 = L$

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 $L(G) = L(M)$?

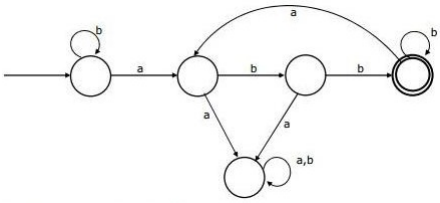
A. $\{A \rightarrow aB, A \rightarrow bA, B \rightarrow bA, B \rightarrow aA, B \rightarrow \epsilon)$
B. $\{A \rightarrow aA, A \rightarrow bB, B \rightarrow aB, B \rightarrow bA, B \rightarrow \epsilon)$
C. $\{A \rightarrow bB, A \rightarrow aB, B \rightarrow aA, B \rightarrow bA, B \rightarrow \epsilon)$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

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:

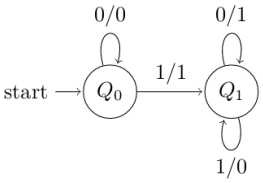
A. $\{w \in \{a,b\}^* \mid \text{every a in } w \text{ is followed by exactly two } b\text{'s}\}$
B. $\{w \in \{a,b\}^* \mid \text{every a in } w \text{ is followed by at least two } b\text{'s}\}$
C. $\{w \in \{a,b\}^* \mid w \text{ contains the substring '}abb\text{'}\}$
D. $\{w \in \{a,b\}^* \mid w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

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?

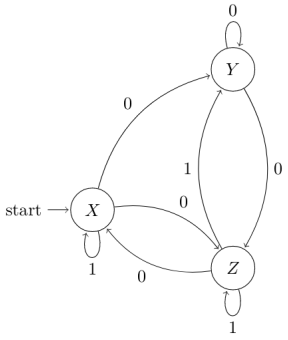
A. It computes 1's complement of the input number
B. It computes 2's complement of the input number
C. It increments the input number
D. it decrements the input number

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?

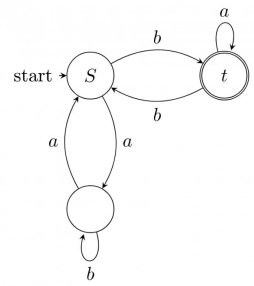
A. 2 B. 3 C. 4 D. 5

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?

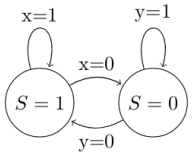
A. The automaton accepts u and v but not w
B. The automaton accepts each of u, v, and w
C. The automaton rejects each of u, v, and w
D. The automaton accepts u but rejects v and w

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



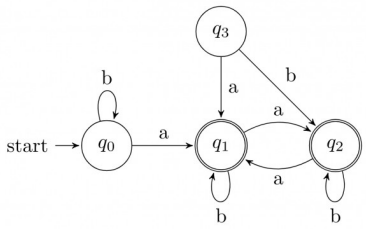
A. $S^+ = S'.y' + S.x$
B. $S^+ = S.x.y' + S'.y.x'$
C. $S^+ = x.y'$
D. $S^+ = S'.y + S.x'$

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

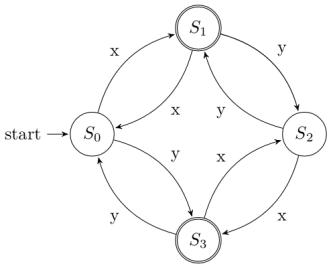
A. $b^*ab^*ab^*ab^*$ B. $(a+b)^*$ C. $b^*a(a+b)^*$ D. $b^*ab^*ab^*$

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?

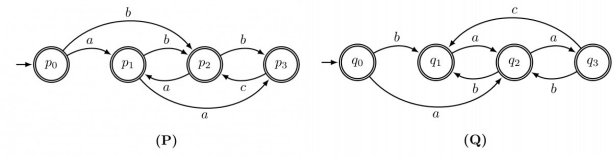
A. All strings of x and y
B. All strings of x and y which have either even number of x and even number of y or odd number of x and odd number of y
C. All strings of x and y which have equal number of x and y
D. All strings of x and y with either even number of x and odd number of y or odd number of x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

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

5.5.23 Finite Automata: GATE2007-IT-50

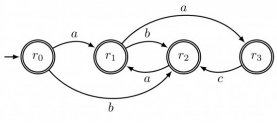
https://gateoverflow.in/3492

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.

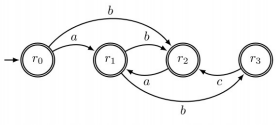


The automation which recognizes the language $L(P) \cap L(Q)$ is :

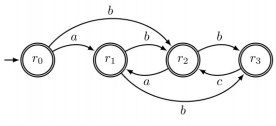
A.



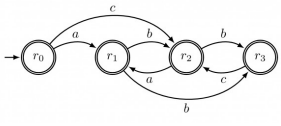
B.



C.



D.



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

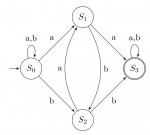
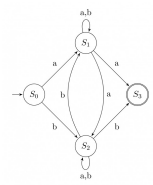
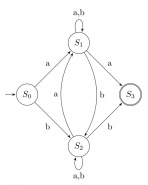
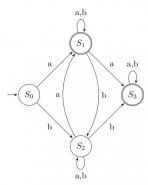
5.5.24 Finite Automata: GATE2007-IT-71

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.

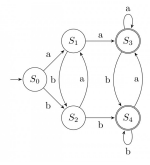
gate2007-it theory-of-computation finite-automata normal

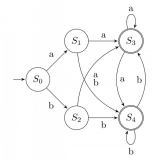
5.5.25 Finite Automata: GATE2007-IT-72

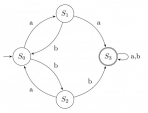
https://gateoverflow.in/3524

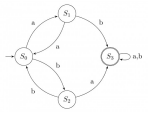
Consider the regular expression $R = (a+b)^*(aa+bb)(a+b)^*$

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.

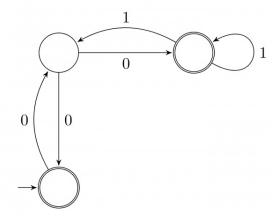
	a	b
$\rightarrow P$	S	Q
Q	S	R
R(F)	Q	P
S	Q	P

gate2008 normal theory-of-computation finite-automata

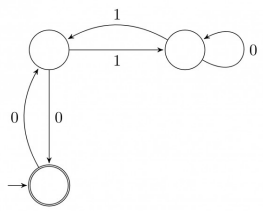
5.5.27 Finite Automata: GATE2008-52

https://gateoverflow.in/464

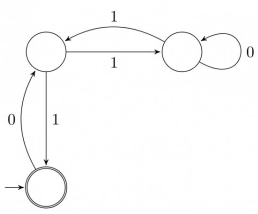
Match the following NFAs with the regular expressions they correspond to:



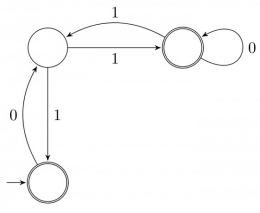
P



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

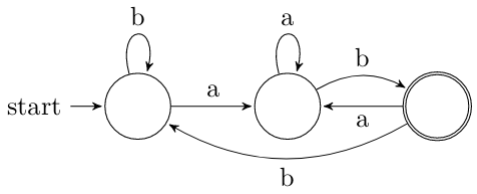
A. $P-2, Q-1, R-3, S-4$
B. $P-1, Q-3, R-2, S-4$
C. $P-1, Q-2, R-3, S-4$
D. $P-3, Q-2, R-1, S-4$

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?



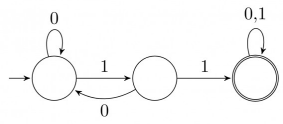
A. Set of all strings that do not end with ab
B. Set of all strings that begin with either an a or a b
C. Set of all strings that do not contain the substring ab,
D. The set described by the regular expression $b^*aa^*(ba)^*b^*$

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

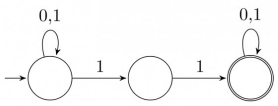
5.5.29 Finite Automata: GATE2008-IT-36

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

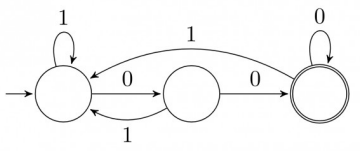
If the initial state is $A=0, B=0$ what is the minimum length of an input string which will take the machine to the state $A=0, B=1$ with $output=1$.

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

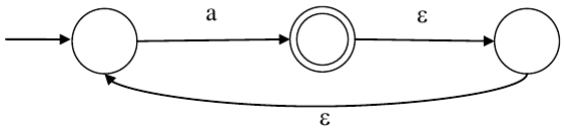
A. begin either with 0 or 1.
B. end with 0.
C. end with 00.
D. contain the substring 00.

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.



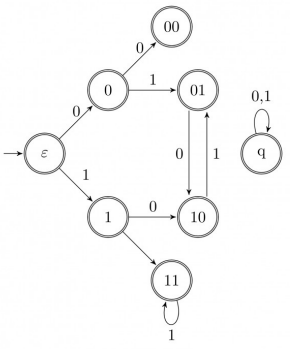
A. ϕ B. $\{\epsilon\}$ C. a^* D. $\{a, \epsilon\}$

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.

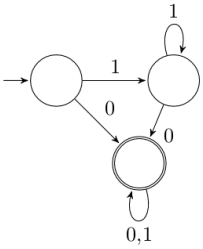
	00	01	10	11	q
00		1			0
01				1	
10	0				
11			0		

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.

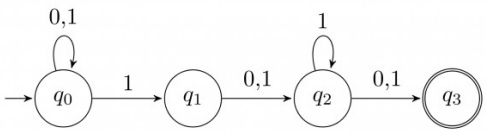
A. 1 and 3 only B. 2 and 4 only C. 2 and 3 only D. 3 and 4 only

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 $\sum^*$.
II. There exists a regular language A such that for all languages B, $A \cap B$ 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 $L = \{0^i 21^i \mid i \geq 0\}$ 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:

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

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

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.

$L_1 = \{0^p1^q0^r \mid p,q,r \geq 0\}$

$L_2 = \{0^p1^q0^r \mid p,q,r \geq 0, p \neq r\}$

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 $\sum = \{0,1,c\}$

$L_1 = \{0^n1^n \mid n \geq 0\}$

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

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

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.

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

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

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.

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

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 $a.a...a$ with i letters and let $\aleph$ be the set of natural numbers $1,2,\ldots$. 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 $\{A,B,C\}$):

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

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 $(0+1)(0+1)\ldots N$ 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

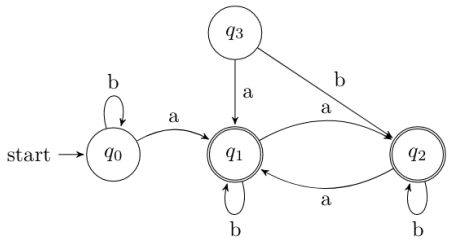
A. 15 states B. 11 states C. 10 states D. 9 states

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?

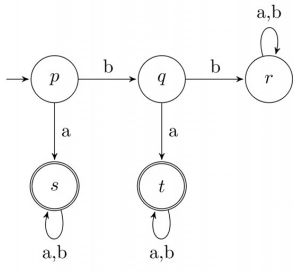
A. $k+1$ B. $n+1$ C. 2^{n+1} D. 2^{k+1}

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

5.8.17 Minimal State Automata: GATE2011-45

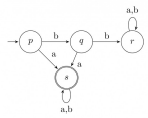
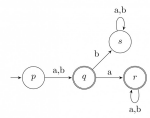
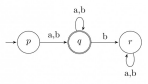
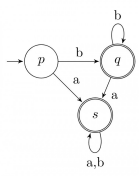
https://gateoverflow.in/2147

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 = { $w_1aw_2 \mid w_1, w_2 \in \{a,b\}^*$, $|w_1| = 2, |w_2| \geq 3$ } 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 $\{1,\ldots,5\}$ to $\{1,\ldots,5\}$, where id denotes the identity function, i.e. $id(j) = j, \forall j$. Let $\circ$ denote composition on functions. For a string $x = x_1x_2\ldots x_n \in \Sigma^n, n \geq 0$, let $\pi(x) = x_1 \circ x_2 \circ \cdots \circ x_n$. Consider the language $L = \{x \in \Sigma^* \mid \pi(x) = id\}$. The minimum number of states in any DFA accepting L is _____

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?

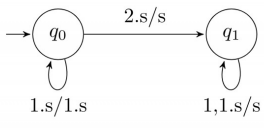
A. $L_1 = L_2$
B. $L_1 \supset L_2$
C. $L_1 \subset L_2$
D. None

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 $\{x2x^R \mid x \in \{0,1\}^*, x^R \text{ denotes reverse of x}\}$, by empty stack.
B. Describe a non-deterministic pda with three states in the above notation that accept the language $\{0^n1^m \mid n \leq m \leq 2n\}$ 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

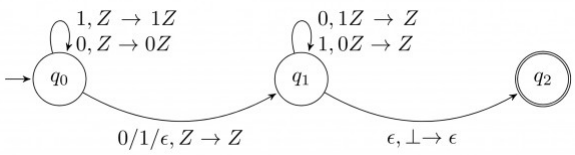
5.12.11 Pushdown Automata: GATE2015-1-51

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?

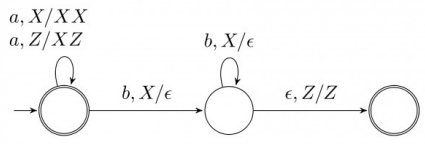
A. 10110 B. 10010 C. 01010 D. 01001

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?

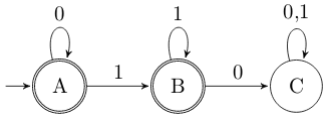
A. $r^{(*)} = r^*$
B. $(r^*s^*) = (r+s)^*$
C. $(r+s)^* = r^* + s^*$
D. $r^*s^* = r^* + s^*$

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

gate1998 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?

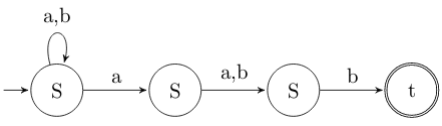
A. It represents a finite set of finite strings.
B. It represents an infinite set of finite strings.
C. It represents a finite set of infinite strings.
D. It represents an infinite set of infinite strings.

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?

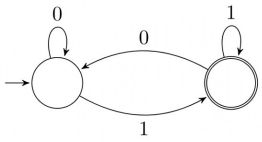
A. $(0^*10^*1)^*$
B. $0^*(10^*10^*)^*$
C. $0^*(10^*1)^*0^*$
D. $0^*1(10^*1)^*10^*$

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?

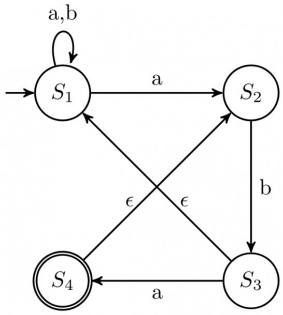
A. $(10^*10^*)^*$
B. $(0^*10^*1)^*$
C. $0^*1(10^*1)^*10^*$
D. $0^*1(0^*10^*10^*)^*10^*$
E. $(0^*10^*1)^*0^*$

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 ?

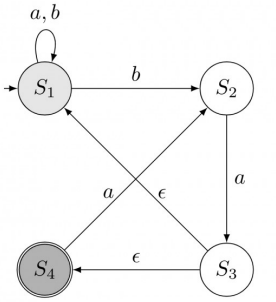
A. $(a+b)^*aba$ B. $aba(a+b)^*aba$ C. $(a+b)aba(b+a)^*$ D. $aba(a+b)^*$ E. $(ab)^*aba$

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:
  - $S \rightarrow aB$
  - $B \rightarrow bC$
  - $C \rightarrow xB$
  - $C \rightarrow c$

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

$S \rightarrow bS \mid aA \mid \epsilon$
$A \rightarrow aS \mid bA$

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:

$S_1 : \{0^{2n} \mid n \geq 1\}$ 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:

- $L1 = \{ww \mid w \in \{a,b\}^*\}$
- $L2 = \{ww^R \mid w \in \{a,b\}^*, w^R \text{ is the reverse of w}\}$
- $L3 = \{0^{2i} \mid \text{i is an integer}\}$
- $L4 = \{0^{i^2} \mid \text{i is an integer}\}$

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. $\{a^n b^n \mid n \geq 0\}$

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. $\{xww^R \mid x, w \in \{0,1\}^+\}$

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?

- $L_1 = \{0^m 1^n \mid 0 \leq m \leq n \leq 10000\}$
- $L_2 = \{w \mid w \text{ reads the same forward and backward}\}$
- $L_3 = \{w \in \{0,1\}^* \mid w \text{ contains an even number of 0's and an even number of 1's }\}$

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 $L = \{w \mid w \text{ has } 3k + 1 \text{ } b\text{'}s \text{ for some } k \in N \text{ with } \Sigma = \{a,b\}\}$ 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?

$L_1 : \{wxw^R \mid w,x \in \{a,b\}^* \text{ and } |w|, |x| > 0\}$, 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

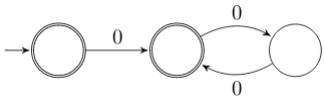
https://gateoverflow.in/204127

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

$$L/L' \overset{def}{=} \{w \in \Sigma^* : wx \in L \text{ for some } x \in L'\}$$

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. $\{0^m 1^n | 1 \leq m \leq n\}$

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 $\omega_1, \omega_2, \omega_3, \ldots$. 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

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