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1 Algorithms (308)

1.1 Algorithm Design (7) top

1.1.1 Algorithm Design: GATE CSE 1992 | Question: 8 top

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

Answer key

1.1.2 Algorithm Design: GATE CSE 1994 | Question: 7 top

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 fill-in-the-blanks

Answer key

1.1.3 Algorithm Design: GATE CSE 2006 | Question: 17 top

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 $\Theta(n^2)$

gatecse-2006 algorithms normal algorithm-design

Answer key

1.1.4 Algorithm Design: GATE CSE 2006 | Question: 54 top

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

gatecse-2006 algorithms normal algorithm-design time-complexity

Answer key

1.1.5 Algorithm Design: GATE CSE 2014 Set 1 | Question: 37 top

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 ___.

gatecse-2014-set1 algorithms numerical-answers normal algorithm-design

Answer key

1.1.6 Algorithm Design: GATE CSE 2019 | Question: 25 top

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: _____

gatecse-2019 numerical-answers algorithms algorithm-design 1-mark

Answer key

1.1.7 Algorithm Design: GATE CSE 2021 Set 1 | Question: 40 top

Define R_n to be the maximum amount earned by cutting a rod of length n meters into one or more pieces of integer length and selling them. For $i > 0$, let $p[i]$ denote the selling price of a rod whose length is i meters. Consider the array of prices:

$$\mathrm{p}[1] = 1, \mathrm{p}[2] = 5, \mathrm{p}[3] = 8, \mathrm{p}[4] = 9, \mathrm{p}[5] = 10, \mathrm{p}[6] = 17, \mathrm{p}[7] = 18$$

Which of the following statements is/are correct about R_7?

A. $R_7 = 18$
B. $R_7 = 19$
C. R_7 is achieved by three different solutions
D. R_7 cannot be achieved by a solution consisting of three pieces

gatecse-2021-set1 multiple-selects algorithms algorithm-design 2-marks

Answer key

1.2 Algorithm Design Techniques (9) top

1.2.1 Algorithm Design Techniques: GATE CSE 1990 | Question: 12b top

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, $\left|\sum_{i \in A} a_i - \sum_{i \in B} a_i\right|$ 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

Answer key

1.2.2 Algorithm Design Techniques: GATE CSE 1990 | Question: 2-vii top

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

Answer key

1.2.3 Algorithm Design Techniques: GATE CSE 1994 | Question: 1.19, ISRO2016-31 top

Algorithm design technique used in quicksort algorithm is?

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

gate1994 algorithms algorithm-design-techniques quick-sort easy isro2016

Answer key

1.2.4 Algorithm Design Techniques: GATE CSE 1995 | Question: 1.5 top

Merge sort uses:

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

gate1995 algorithms sorting easy algorithm-design-techniques merge-sort

Answer key

1.2.5 Algorithm Design Techniques: GATE CSE 1997 | Question: 1.5 top

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

gate1997 algorithms normal algorithm-design-techniques

Answer key

1.2.6 Algorithm Design Techniques: GATE CSE 1998 | Question: 1.21, ISRO2008-16 top

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 algorithm-design-techniques easy isro2008

Answer key

1.2.7 Algorithm Design Techniques: GATE CSE 2015 Set 1 | Question: 6 top

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

gatecse-2015-set1 algorithms normal algorithm-design-techniques

Answer key

1.2.8 Algorithm Design Techniques: GATE CSE 2015 Set 2 | Question: 36 top

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

gatecse-2015-set2 algorithms easy algorithm-design-techniques

Answer key

1.2.9 Algorithm Design Techniques: GATE CSE 2017 Set 1 | Question: 05 top

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. $(P) \leftrightarrow (i), (Q) \leftrightarrow (ii), (R) \leftrightarrow (iii)$

gatecse-2017-set1 algorithms algorithm-design-techniques

Answer key

1.3 Asymptotic Notations (20) top

1.3.1 Asymptotic Notations: GATE CSE 1994 | Question: 1.23 top

Consider the following two functions:

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

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

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 multiple-selects

Answer key

1.3.2 Asymptotic Notations: GATE CSE 1996 | Question: 1.11 top

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

Answer key

1.3.3 Asymptotic Notations: GATE CSE 1999 | Question: 2.21 top

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-relation asymptotic-notations normal

Answer key

1.3.4 Asymptotic Notations: GATE CSE 2000 | Question: 2.17 top

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 $O(g(n))$

gatecse-2000 algorithms asymptotic-notations normal

Answer key

1.3.5 Asymptotic Notations: GATE CSE 2001 | Question: 1.16 top

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 $g(n) = O(f(n))$

gatecse-2001 algorithms asymptotic-notations time-complexity normal

Answer key

1.3.6 Asymptotic Notations: GATE CSE 2003 | Question: 20 top

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

gatecse-2003 algorithms asymptotic-notations normal

Answer key

1.3.7 Asymptotic Notations: GATE CSE 2004 | Question: 29 top

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. $n \log^2 n$

gatecse-2004 algorithms sorting asymptotic-notations easy

Answer key

1.3.8 Asymptotic Notations: GATE CSE 2005 | Question: 37 top

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. $T(n) = O(n \log n)$

gatecse-2005 algorithms asymptotic-notations recurrence-relation normal

Answer key

1.3.9 Asymptotic Notations: GATE CSE 2008 | Question: 39 top

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. $h(n) = O(f(n)); g(n) = \Omega(f(n))$

gatecse-2008 algorithms asymptotic-notations normal

Answer key

1.3.10 Asymptotic Notations: GATE CSE 2011 | Question: 37 top

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

gatecse-2011 algorithms asymptotic-notations normal

Answer key

1.3.11 Asymptotic Notations: GATE CSE 2012 | Question: 18 top

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. $A(n) = \mathrm{o}(W(n))$

gatecse-2012 algorithms easy asymptotic-notations

Answer key

1.3.12 Asymptotic Notations: GATE CSE 2015 Set 3 | Question: 4 top

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

gatecse-2015-set3 algorithms asymptotic-notations normal

Answer key

1.3.13 Asymptotic Notations: GATE CSE 2015 Set 3 | Question: 42 top

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

gatecse-2015-set3 algorithms asymptotic-notations normal

Answer key

1.3.14 Asymptotic Notations: GATE CSE 2017 Set 1 | Question: 04 top

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. $\frac{100}{n}, \log_2 n, 10, \sqrt{n}, n$

gatecse-2017-set1 algorithms asymptotic-notations normal

Answer key

1.3.15 Asymptotic Notations: GATE CSE 2021 Set 1 | Question: 3 top

Consider the following three functions.

$$f_1 = 10^n \quad f_2 = n^{\log n} \quad f_3 = n^{\sqrt{n}}$$

Which one of the following options arranges the functions in the increasing order of asymptotic growth rate?

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

gatecse-2021-set1 algorithms asymptotic-notations 1-mark

Answer key

1.3.16 Asymptotic Notations: GATE CSE 2022 | Question: 1 top

Which one of the following statements is TRUE for all positive functions $f(n)$?

A. $f(n^2) = \theta(f(n)^2)$, when $f(n)$ is a polynomial
B. $f(n^2) = o(f(n)^2)$
C. $f(n^2) = O(f(n)^2)$, when $f(n)$ is an exponential function
D. $f(n^2) = \Omega(f(n)^2)$

gatecse-2022 algorithms asymptotic-notations 1-mark

Answer key

1.3.17 Asymptotic Notations: GATE CSE 2023 | Question: 19 top

Let f and g be functions of natural numbers given by $f(n) = n$ and $g(n) = n^2$. Which of the following statements is/are TRUE?

A. $f \in O(g)$
B. $f \in \Omega(g)$
C. $f \in o(g)$
D. $f \in \Theta(g)$

gatecse-2023 algorithms asymptotic-notations multiple-selects 1-mark

Answer key

1.3.18 Asymptotic Notations: GATE CSE 2023 | Question: 44 top

Consider functions Function_1 and Function_2 expressed in pseudocode as follows:

```
Function_1                  | Function_2
  while n > 1 do            |   for i = 1 to 100 * n do
    for i = 1 to n do       |     x = x + 1;
      x = x + 1;            |   end for
    end for                 |
    n = ⌊n/2⌋;              |
end while                   |
```

Let $f_1(n)$ and $f_2(n)$ denote the number of times the statement "x = x + 1" is executed in Function_1 and Function_2, respectively.

Which of the following statements is/are TRUE?

A. $f_1(n) \in \Theta(f_2(n))$
B. $f_1(n) \in o(f_2(n))$
C. $f_1(n) \in \omega(f_2(n))$
D. $f_1(n) \in O(n)$

gatecse-2023 algorithms asymptotic-notations multiple-selects 2-marks

Answer key

1.3.19 Asymptotic Notations: GATE IT 2004 | Question: 55 top

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. $f(n)h(n) \neq O(g(n)h(n))$

gateit-2004 algorithms asymptotic-notations normal

Answer key

1.3.20 Asymptotic Notations: GATE IT 2008 | Question: 10 top

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

gateit-2008 algorithms asymptotic-notations normal

Answer key

1.4 Binary Search (1) top

1.4.1 Binary Search: GATE CSE 2021 Set 2 | Question: 8 top

What is the worst-case number of arithmetic operations performed by recursive binary search on a sorted array of size n?

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

gatecse-2021-set2 algorithms binary-search time-complexity 1-mark

Answer key

1.5 Breadth First Search (1) top

1.5.1 Breadth First Search: GATE CSE 2023 | Question: 46 top

Let $U = \{1, 2, 3\}$. Let 2^U denote the powerset of U. Consider an undirected graph G whose vertex set is 2^U. For any $A, B \in 2^U$, (A, B) is an edge in G if and only if (i) $A \neq B$, and (ii) either $A \subsetneq B$ or $B \subsetneq A$. For any vertex A in G, the set of all possible orderings in which the vertices of G can be visited in a Breadth First Search (BFS) starting from A is denoted by $\mathcal{B}(A)$.

If $\emptyset$ denotes the empty set, then the cardinality of $\mathcal{B}(\emptyset)$ is _____.

gatecse-2023 algorithms breadth-first-search numerical-answers 2-marks

Answer key

1.6 Directed Acyclic Graph (1) top

1.6.1 Directed Acyclic Graph: GATE CSE 2021 Set 2 | Question: 55 top

In a directed acyclic graph with a source vertex **s**, the $quality\text{-}score$ of a directed path is defined to be the product of the weights of the edges on the path. Further, for a vertex v other than **s**, the quality-score of v is defined to be the maximum among the quality-scores of all the paths from **s** to v. The quality-score of **s** is assumed to be 1.

The sum of the quality-scores of all vertices on the graph shown above is _____

gatecse-2021-set2 algorithms graph-algorithms directed-acyclic-graph numerical-answers 2-marks

Answer key

1.7 Dynamic Programming (12) top

1.7.1 Dynamic Programming: GATE CSE 2008 | Question: 80 top

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. $X[i,j], 1 \le i \le n, 0 \le j \le W$, 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 $2 \le i \le n$, and $a_i \le j \le W$?

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

gatecse-2008 algorithms normal dynamic-programming

Answer key

1.7.2 Dynamic Programming: GATE CSE 2008 | Question: 81 top

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. $X[i,j], 1 \le i \le n, 0 \le j \le W$, 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. $X[n-1,n]$

gatecse-2008 algorithms normal dynamic-programming

Answer key

1.7.3 Dynamic Programming: GATE CSE 2009 | Question: 53 top

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. $\text{expr2} = \max(l(i-1,j-1), l(i,j))$

gatecse-2009 algorithms normal dynamic-programming recursion

Answer key

1.7.4 Dynamic Programming: GATE CSE 2009 | Question: 54 top

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 $q < s$.

gatecse-2009 normal algorithms dynamic-programming recursion

Answer key

1.7.5 Dynamic Programming: GATE CSE 2010 | Question: 34 top

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. $a_0 + Y/2$

gatecse-2010 algorithms dynamic-programming normal

Answer key

1.7.6 Dynamic Programming: GATE CSE 2011 | Question: 25 top

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

gatecse-2011 algorithms easy dynamic-programming

Answer key

1.7.7 Dynamic Programming: GATE CSE 2011 | Question: 38 top

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

gatecse-2011 algorithms dynamic-programming normal

Answer key

1.7.8 Dynamic Programming: GATE CSE 2014 Set 2 | Question: 37 top

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 $x + 10y =$ ___.

gatecse-2014-set2 algorithms normal numerical-answers dynamic-programming

Answer key

1.7.9 Dynamic Programming: GATE CSE 2014 Set 3 | Question: 37 top

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 _____.

gatecse-2014-set3 algorithms normal numerical-answers dynamic-programming

Answer key

1.7.10 Dynamic Programming: GATE CSE 2016 Set 2 | Question: 14 top

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.

gatecse-2016-set2 algorithms dynamic-programming easy

Answer key

1.7.11 Dynamic Programming: GATE CSE 2016 Set 2 | Question: 38 top

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 $A_1 A_2 A_3 A_4$ using the basic matrix multiplication method is _____.

gatecse-2016-set2 dynamic-programming algorithms normal numerical-answers

Answer key

1.7.12 Dynamic Programming: GATE CSE 2018 | Question: 31 top

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 $G_1 G_2 G_3 \ldots G_n$ can be done by parenthesizing in different ways. Define $G_i G_{i+1}$ as an **explicitly computed pair** for a given paranthesization if they are directly multiplied. For example, in the matrix multiplication chain $G_1 G_2 G_3 G_4 G_5 G_6$ using parenthesization $(G_1(G_2 G_3))(G_4(G_5 G_6)), G_2 G_3$ and $G_5 G_6$ are only explicitly computed pairs.

Consider a matrix multiplication chain $F_1 F_2 F_3 F_4 F_5$, 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 $F_1 F_2 F_3 F_4 F_5$ that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

A. $F_1 F_2$ and $F_3 F_4$ only
B. $F_2 F_3$ only
C. $F_3 F_4$ only
D. $F_1 F_2$ and $F_4 F_5$ only

gatecse-2018 algorithms dynamic-programming 2-marks

Answer key

1.8 Graph Algorithms (35) top

1.8.1 Graph Algorithms: GATE CSE 1994 | Question: 1.22 top

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

Answer key

1.8.2 Graph Algorithms: GATE CSE 1994 | Question: 24 top

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}
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 descriptive

Answer key

1.8.3 Graph Algorithms: GATE CSE 1996 | Question: 17 top

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 descriptive

Answer key

1.8.4 Graph Algorithms: GATE CSE 2000 | Question: 2.19 top

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

gatecse-2000 algorithms graph-algorithms normal

Answer key

1.8.5 Graph Algorithms: GATE CSE 2002 | Question: 12 top

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(___).

gatecse-2002 algorithms graph-algorithms time-complexity normal descriptive

Answer key

1.8.6 Graph Algorithms: GATE CSE 2003 | Question: 67 top

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

gatecse-2003 algorithms graph-algorithms normal

Answer key

1.8.7 Graph Algorithms: GATE CSE 2003 | Question: 70 top

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

gatecse-2003 algorithms graph-algorithms normal

Answer key

1.8.8 Graph Algorithms: GATE CSE 2004 | Question: 44 top

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

gatecse-2004 algorithms graph-algorithms normal

Answer key

1.8.9 Graph Algorithms: GATE CSE 2004 | Question: 81 top

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

gatecse-2004 algorithms graph-algorithms normal

Answer key

1.8.10 Graph Algorithms: GATE CSE 2005 | Question: 38 top

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. $O\left(|E| + |V| \log |V|\right)$
C. $O\left(|V| \log |V|\right)$
D. $O\left((|E| + |V|) \log |V|\right)$

gatecse-2005 algorithms graph-algorithms normal

Answer key

1.8.11 Graph Algorithms: GATE CSE 2005 | Question: 82a top

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

gatecse-2005 algorithms graph-algorithms normal

Answer key

1.8.12 Graph Algorithms: GATE CSE 2005 | Question: 82b top

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

gatecse-2005 algorithms graph-algorithms normal

Answer key

1.8.13 Graph Algorithms: GATE CSE 2006 | Question: 12 top

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

gatecse-2006 algorithms graph-algorithms easy

Answer key

1.8.14 Graph Algorithms: GATE CSE 2006 | Question: 48 top

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

gatecse-2006 algorithms graph-algorithms normal

Answer key

1.8.15 Graph Algorithms: GATE CSE 2007 | Question: 41 top

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.

gatecse-2007 algorithms graph-algorithms easy

Answer key

1.8.16 Graph Algorithms: GATE CSE 2007 | Question: 5 top

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. $3\,2\,4\,1\,6\,5$

gatecse-2007 algorithms graph-algorithms

Answer key

1.8.17 Graph Algorithms: GATE CSE 2008 | Question: 45 top

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

gatecse-2008 algorithms graph-algorithms normal

Answer key

1.8.18 Graph Algorithms: GATE CSE 2008 | Question: 7 top

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. $\Theta(mn)$

gatecse-2008 algorithms graph-algorithms time-complexity normal

Answer key

1.8.19 Graph Algorithms: GATE CSE 2009 | Question: 13 top

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

gatecse-2009 algorithms graph-algorithms normal

Answer key

1.8.20 Graph Algorithms: GATE CSE 2012 | Question: 40 top

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

gatecse-2012 algorithms graph-algorithms normal

Answer key

1.8.21 Graph Algorithms: GATE CSE 2013 | Question: 19 top

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. $\theta(n^3 \log n)$

gatecse-2013 algorithms graph-algorithms normal

Answer key

1.8.22 Graph Algorithms: GATE CSE 2014 Set 1 | Question: 13 top

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.

gatecse-2014-set1 graph-algorithms easy

Answer key

1.8.23 Graph Algorithms: GATE CSE 2016 Set 1 | Question: 11 top

Consider the following directed graph:

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

gatecse-2016-set1 algorithms graph-algorithms normal numerical-answers

Answer key

1.8.24 Graph Algorithms: GATE CSE 2016 Set 2 | Question: 41 top

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. $\Theta(n^4)$

gatecse-2016-set2 algorithms graph-algorithms normal

Answer key

1.8.25 Graph Algorithms: GATE CSE 2017 Set 1 | Question: 26 top

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

gatecse-2017-set1 algorithms graph-algorithms normal

Answer key

1.8.26 Graph Algorithms: GATE CSE 2018 | Question: 43 top

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, $y + 10z =$ _____.

gatecse-2018 algorithms graph-algorithms numerical-answers 2-marks

Answer key

1.8.27 Graph Algorithms: GATE CSE 2020 | Question: 40 top

Let $G = (V, E)$ be a directed, weighted graph with weight function $w : E \to \mathbb{R}$. For some function $f : V \to \mathbb{R}$, for each edge $(u, v) \in E$, define $w'(u, v)$ as $w(u, v) + f(u) - f(v)$.

Which one of the options completes the following sentence so that it is TRUE?

"The shortest paths in G under w are shortest paths under w' too,_____".

A. for every $f : V \to \mathbb{R}$
B. if and only if $\forall u \in V,\ f(u)$ is positive
C. if and only if $\forall u \in V,\ f(u)$ is negative
D. if and only if $f(u)$ is the distance from s to u in the graph obtained by adding a new vertex s to G and edges of zero weight from s to every vertex of G

gatecse-2020 algorithms graph-algorithms 2-marks

Answer key

1.8.28 Graph Algorithms: GATE CSE 2020 | Question: 49 top

Consider a graph $G = (V, E)$, where $V = \{v_1, v_2, \ldots, v_{100}\}$, $E = \{(v_i, v_j) \mid 1 \leq i < j \leq 100\}$, and weight of the edge (v_i, v_j) is $|i - j|$. The weight of minimum spanning tree of G is _____

gatecse-2020 numerical-answers algorithms graph-algorithms 2-marks

Answer key

1.8.29 Graph Algorithms: GATE CSE 2021 Set 2 | Question: 46 top

Consider the following directed graph:

Which of the following is/are correct about the graph?

A. The graph does not have a topological order
B. A depth-first traversal starting at vertex S classifies three directed edges as back edges
C. The graph does not have a strongly connected component
D. For each pair of vertices u and v, there is a directed path from u to v

gatecse-2021-set2 multiple-selects algorithms graph-algorithms 2-marks

Answer key

1.8.30 Graph Algorithms: GATE IT 2004 | Question: 56 top

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

gateit-2004 algorithms graph-algorithms normal

Answer key

1.8.31 Graph Algorithms: GATE IT 2005 | Question: 15 top

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

gateit-2005 algorithms graph-algorithms normal

Answer key

1.8.32 Graph Algorithms: GATE IT 2005 | Question: 84a top

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 $E_2 : i = j + 1;$

gateit-2005 algorithms graph-algorithms normal

Answer key

1.8.33 Graph Algorithms: GATE IT 2005 | Question: 84b top

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. $(A[i][j]$ || $!A[j][i])$

gateit-2005 algorithms graph-algorithms normal

Answer key

1.8.34 Graph Algorithms: GATE IT 2006 | Question: 46 top

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. $\{P, Q, R, S, T, U, V\}$

gateit-2006 algorithms graph-algorithms normal

Answer key

1.8.35 Graph Algorithms: GATE IT 2007 | Question: 3, UGCNET-June2012-III: 34 top

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 $(u, v) > 12$

gateit-2007 algorithms graph-algorithms normal ugcnetcse-june2012-paper3

Answer key

1.9 Graph Search (15) top

1.9.1 Graph Search: GATE CSE 2000 | Question: 1.13 top

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. $\mathrm{X}-1,\ \mathrm{Y}-2,\ \mathrm{Z}-3$
B. $\mathrm{X}-3,\ \mathrm{Y}-1,\ \mathrm{Z}-2$
C. $\mathrm{X}-3,\ \mathrm{Y}-2,\ \mathrm{Z}-1$
D. $\mathrm{X}-2,\ \mathrm{Y}-3,\ \mathrm{Z}-1$

gatecse-2000 algorithms easy graph-algorithms graph-search

Answer key

1.9.2 Graph Search: GATE CSE 2001 | Question: 2.14 top

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

gatecse-2001 algorithms graph-algorithms normal graph-search

Answer key

1.9.3 Graph Search: GATE CSE 2003 | Question: 21 top

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

gatecse-2003 algorithms graph-algorithms normal graph-search

Answer key

1.9.4 Graph Search: GATE CSE 2008 | Question: 19 top

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

gatecse-2008 normal algorithms graph-algorithms graph-search

Answer key

1.9.5 Graph Search: GATE CSE 2014 Set 1 | Question: 11 top

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. $\Theta(m^2)$

gatecse-2014-set1 algorithms graph-algorithms normal graph-search

Answer key

1.9.6 Graph Search: GATE CSE 2014 Set 2 | Question: 14 top

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.

gatecse-2014-set2 algorithms graph-algorithms normal graph-search

Answer key

1.9.7 Graph Search: GATE CSE 2014 Set 3 | Question: 13 top

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 _____.

gatecse-2014-set3 algorithms graph-algorithms numerical-answers normal graph-search

Answer key

1.9.8 Graph Search: GATE CSE 2015 Set 1 | Question: 45 top

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

gatecse-2015-set1 algorithms graph-algorithms normal graph-search

Answer key

1.9.9 Graph Search: GATE CSE 2016 Set 2 | Question: 11 top

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 nth vertex in this BFS traversal, then the maximum possible value of n is _____

gatecse-2016-set2 algorithms graph-algorithms normal numerical-answers graph-search

Answer key

1.9.10 Graph Search: GATE CSE 2017 Set 2 | Question: 15 top

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

gatecse-2017-set2 algorithms graph-algorithms graph-search

Answer key

1.9.11 Graph Search: GATE CSE 2018 | Question: 30 top

Let G be a simple undirected graph. Let T_D be a depth first search tree of G. Let T_B be a breadth first search tree of G. Consider the following statements.

I. No edge of G is a cross edge with respect to T_D. (A cross edge in G is between two nodes neither of which is an ancestor of the other in T_D).
II. For every edge (u, v) of G, if u is at depth i and v is at depth j in T_B, then $|i - j| = 1$.

Which of the statements above must necessarily be true?

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

gatecse-2018 algorithms graph-algorithms graph-search normal 2-marks

Answer key

1.9.12 Graph Search: GATE IT 2005 | Question: 14 top

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. $n-k$

gateit-2005 algorithms graph-algorithms normal graph-search

Answer key

1.9.13 Graph Search: GATE IT 2006 | Question: 47 top

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

gateit-2006 algorithms graph-algorithms normal graph-search

Answer key

1.9.14 Graph Search: GATE IT 2007 | Question: 24 top

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. $f[u] > f[v]$

gateit-2007 algorithms graph-algorithms normal graph-search

Answer key

1.9.15 Graph Search: GATE IT 2008 | Question: 47 top

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

gateit-2008 algorithms graph-algorithms normal graph-search

Answer key

1.10 Greedy Algorithm (7) top

1.10.1 Greedy Algorithm: GATE CSE 1999 | Question: 2.20 top

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

Answer key

1.10.2 Greedy Algorithm: GATE CSE 2003 | Question: 69 top

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

gatecse-2003 algorithms normal greedy-algorithm

Answer key

1.10.3 Greedy Algorithm: GATE CSE 2005 | Question: 84a top

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

gatecse-2005 algorithms greedy-algorithm process-scheduling normal

Answer key

1.10.4 Greedy Algorithm: GATE CSE 2005 | Question: 84b top

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

gatecse-2005 algorithms greedy-algorithm process-scheduling normal

Answer key

1.10.5 Greedy Algorithm: GATE CSE 2007 | Question: 76 top

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. $110, 100, 010, 000, 001, 111$

gatecse-2007 algorithms greedy-algorithm normal

Answer key

1.10.6 Greedy Algorithm: GATE CSE 2018 | Question: 48 top

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 ____

gatecse-2018 algorithms greedy-algorithm numerical-answers 2-marks

Answer key

1.10.7 Greedy Algorithm: GATE IT 2006 | Question: 48 top

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. $fehdg$

gateit-2006 algorithms greedy-algorithm normal

Answer key

1.11 Hashing (6) top

1.11.1 Hashing: GATE CSE 1989 | Question: 1-vii, ISRO2015-14 top

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 algorithms normal

Answer key

1.11.2 Hashing: GATE CSE 1990 | Question: 13b top

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 descriptive

Answer key

1.11.3 Hashing: GATE CSE 2020 | Question: 23 top

Consider a double hashing scheme in which the primary hash function is $h_1(k) = k \bmod 23$, and the secondary hash function is $h_2(k) = 1 + (k \bmod 19)$. Assume that the table size is 23. Then the address returned by probe 1 in the probe sequence (assume that the probe sequence begins at probe 0) for key value $k = 90$ is_____.

gatecse-2020 numerical-answers algorithms hashing 1-mark

Answer key

1.11.4 Hashing: GATE CSE 2021 Set 1 | Question: 47 top

Consider a $dynamic$ hashing approach for 4-bit integer keys:

1. There is a main hash table of size 4.
2. The 2 least significant bits of a key is used to index into the main hash table.
3. Initially, the main hash table entries are empty.
4. Thereafter, when more keys are hashed into it, to resolve collisions, the set of all keys corresponding to a main hash table entry is organized as a binary tree that grows on demand.
5. First, the 3rd least significant bit is used to divide the keys into left and right subtrees.
6. To resolve more collisions, each node of the binary tree is further sub-divided into left and right subtrees based on the 4th least significant bit.
7. A split is done only if it is needed, i.e., only when there is a collision.

Consider the following state of the hash table.

Which of the following sequences of key insertions can cause the above state of the hash table (assume the keys are in decimal notation)?

A. $5, 9, 4, 13, 10, 7$
B. $9, 5, 10, 6, 7, 1$
C. $10, 9, 6, 7, 5, 13$
D. $9, 5, 13, 6, 10, 14$

gatecse-2021-set1 multiple-selects algorithms hashing 2-marks

Answer key

1.11.5 Hashing: GATE CSE 2023 | Question: 10 top

An algorithm has to store several keys generated by an adversary in a hash table. The adversary is malicious who tries to maximize the number of collisions. Let k be the number of keys, m be the number of slots in the hash table, and $k > m$.

Which one of the following is the best hashing strategy to counteract the adversary?

A. Division method, i.e., use the hash function $h(k) = k \bmod m$.
B. Multiplication method, i.e., use the hash function $h(k) = \lfloor m(kA - \lfloor kA \rfloor) \rfloor$, where A is a carefully chosen constant.
C. Universal hashing method.
D. If k is a prime number, use Division method. Otherwise, use Multiplication method.

gatecse-2023 algorithms hashing 1-mark

Answer key

1.11.6 Hashing: GATE IT 2005 | Question: 16 top

A hash table contains 10 buckets and uses linear probing to resolve collisions. The key values are integers and the hash function used is $\text{key}\%10$. 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

gateit-2005 algorithms hashing easy

Answer key

1.12 Heap Sort (1) top

1.12.1 Heap Sort: GATE CSE 2013 | Question: 30 top

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. $\Theta(\log n)$

gatecse-2013 algorithms sorting normal heap-sort

Answer key

1.13 Huffman Code (4) top

1.13.1 Huffman Code: GATE CSE 1989 | Question: 13a top

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

Answer key

1.13.2 Huffman Code: GATE CSE 2007 | Question: 77 top

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

gatecse-2007 algorithms greedy-algorithm normal huffman-code

Answer key

1.13.3 Huffman Code: GATE CSE 2017 Set 2 | Question: 50 top

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 _____.

gatecse-2017-set2 huffman-code numerical-answers algorithms

Answer key

1.13.4 Huffman Code: GATE CSE 2021 Set 2 | Question: 26 top

Consider the string $\mathrm{abbccddeee}$. Each letter in the string must be assigned a binary code satisfying the following properties:

1. For any two letters, the code assigned to one letter must not be a prefix of the code assigned to the other letter.
2. For any two letters of the same frequency, the letter which occurs earlier in the dictionary order is assigned a code whose length is at most the length of the code assigned to the other letter.

Among the set of all binary code assignments which satisfy the above two properties, what is the minimum length of the encoded string?

A. 21 B. 23 C. 25 D. 30

gatecse-2021-set2 algorithms huffman-code 2-marks

Answer key

1.14 Identify Function (40) top

1.14.1 Identify Function: GATE CSE 1989 | Question: 8a top

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 ith 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

Answer key

1.14.2 Identify Function: GATE CSE 1990 | Question: 11b top

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

Answer key

1.14.3 Identify Function: GATE CSE 1991 | Question: 03-viii top

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 multiple-selects

Answer key

1.14.4 Identify Function: GATE CSE 1993 | Question: 7.4 top

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

Answer key

1.14.5 Identify Function: GATE CSE 1994 | Question: 6 top

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 descriptive

Answer key

1.14.6 Identify Function: GATE CSE 1995 | Question: 1.4 top

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

Answer key

1.14.7 Identify Function: GATE CSE 1995 | Question: 2.3 top

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

Answer key

1.14.8 Identify Function: GATE CSE 1995 | Question: 4 top

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

```
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 descriptive

Answer key

1.14.9 Identify Function: GATE CSE 1998 | Question: 2.12 top

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

Answer key

1.14.10 Identify Function: GATE CSE 1999 | Question: 2.24 top

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

Answer key

1.14.11 Identify Function: GATE CSE 2000 | Question: 2.15 top

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

gatecse-2000 algorithms normal identify-function

Answer key

1.14.12 Identify Function: GATE CSE 2003 | Question: 1 top

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

gatecse-2003 algorithms identify-function normal

Answer key

1.14.13 Identify Function: GATE CSE 2003 | Question: 88 top

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 $\geqslant 3$, 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. $\{\}$

gatecse-2003 algorithms identify-function normal

Answer key

1.14.14 Identify Function: GATE CSE 2004 | Question: 41 top

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

gatecse-2004 algorithms normal identify-function

Answer key

1.14.15 Identify Function: GATE CSE 2004 | Question: 42 top

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. $m^{\frac{1}{3}}$

gatecse-2004 algorithms identify-function normal

Answer key

1.14.16 Identify Function: GATE CSE 2005 | Question: 31 top

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. $2, 0, 4, 8, 0$

gatecse-2005 algorithms identify-function recursion normal

Answer key

1.14.17 Identify Function: GATE CSE 2006 | Question: 50 top

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. $(X - Y) \cup (Y - X)$

gatecse-2006 algorithms identify-function normal

Answer key

1.14.18 Identify Function: GATE CSE 2006 | Question: 53 top

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)

gatecse-2006 algorithms identify-function normal

Answer key

1.14.19 Identify Function: GATE CSE 2009 | Question: 18 top

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

gatecse-2009 algorithms recursion identify-function normal

Answer key

1.14.20 Identify Function: GATE CSE 2010 | Question: 35 top

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

gatecse-2010 algorithms recursion identify-function normal

Answer key

1.14.21 Identify Function: GATE CSE 2011 | Question: 48 top

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

gatecse-2011 algorithms recursion identify-function normal

Answer key

1.14.22 Identify Function: GATE CSE 2011 | Question: 49 top

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

gatecse-2011 algorithms recursion identify-function normal

Answer key

1.14.23 Identify Function: GATE CSE 2013 | Question: 31 top

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. $\Theta(n^3 \log n)$

gatecse-2013 algorithms identify-function normal

Answer key

1.14.24 Identify Function: GATE CSE 2014 Set 1 | Question: 41 top

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.**

gatecse-2014-set1 algorithms identify-function normal

Answer key

1.14.25 Identify Function: GATE CSE 2014 Set 2 | Question: 10 top

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 _____

gatecse-2014-set2 algorithms identify-function numerical-answers easy

Answer key

1.14.26 Identify Function: GATE CSE 2014 Set 3 | Question: 10 top

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

gatecse-2014-set3 algorithms identify-function easy

Answer key

1.14.27 Identify Function: GATE CSE 2015 Set 1 | Question: 31 top

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. $n \log(\log n)$

gatecse-2015-set1 algorithms normal identify-function

Answer key

1.14.28 Identify Function: GATE CSE 2015 Set 2 | Question: 11 top

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 _____.

gatecse-2015-set2 algorithms identify-function recurrence-relation normal numerical-answers

Answer key

1.14.29 Identify Function: GATE CSE 2015 Set 3 | Question: 49 top

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 _____.

gatecse-2015-set3 algorithms identify-function normal numerical-answers

Answer key

1.14.30 Identify Function: GATE CSE 2017 Set 2 | Question: 14 top

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. $1,1$

gatecse-2017-set2 identify-function

Answer key

1.14.31 Identify Function: GATE CSE 2019 | Question: 18 top

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 _____.

gatecse-2019 numerical-answers identify-function 1-mark

Answer key

1.14.32 Identify Function: GATE CSE 2019 | Question: 26 top

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

gatecse-2019 algorithms identify-function 2-marks

Answer key

1.14.33 Identify Function: GATE CSE 2020 | Question: 48 top

Consider the following C functions.

```
int tob (int b, int* arr) {
  int i;
  for (i = 0; b>0; i++)  {
     if (b%2)  arr [i] = 1;
     else      arr[i] = 0;
     b = b/2;
  }
  return (i);
}
```

```
int pp(int a, int b)  {
  int  arr[20];
  int i, tot = 1, ex, len;
  ex = a;
  len = tob(b, arr);
  for (i=0; i<len ; i++) {
     if (arr[i] ==1)
        tot = tot * ex;
     ex= ex*ex;
  }
return (tot) ;
}
```

The value returned by $pp(3, 4)$ is _____.

gatecse-2020 numerical-answers identify-function 2-marks

Answer key

1.14.34 Identify Function: GATE CSE 2021 Set 1 | Question: 48 top

Consider the following ANSI C function:

```
int SimpleFunction(int Y[], int n, int x)
{
  int total = Y[0], loopIndex;
  for (loopIndex=1; loopIndex<=n-1; loopIndex++)
     total=x*total +Y[loopIndex];
  return total;
}
```

Let Z be an array of 10 elements with $\mathsf{Z}[i] = 1$, for all i such that $0 \leq i \leq 9$. The value returned by $\mathsf{SimpleFunction}(\mathsf{Z}, 10, 2)$ is _____

gatecse-2021-set1 algorithms numerical-answers identify-function 2-marks

Answer key

1.14.35 Identify Function: GATE CSE 2021 Set 2 | Question: 23 top

Consider the following ANSI C function:

```
int SomeFunction (int x, int y)
{
   if ((x==1) || (y==1)) return 1;
   if (x==y) return x;
   if (x > y) return SomeFunction(x-y, y);
   if (y > x) return SomeFunction (x, y-x);

}
```

The value returned by $\text{SomeFunction}(15, 255)$ is _____

gatecse-2021-set2 numerical-answers algorithms identify-function output 1-mark

Answer key

1.14.36 Identify Function: GATE IT 2005 | Question: 53 top

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++]]--

gateit-2005 normal identify-function

Answer key

1.14.37 Identify Function: GATE IT 2005 | Question: 57 top

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

gateit-2005 algorithms identify-function normal

Answer key

1.14.38 Identify Function: GATE IT 2006 | Question: 52 top

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. $(n == 0)$ && $(m == n)$

gateit-2006 algorithms identify-function normal

Answer key

1.14.39 Identify Function: GATE IT 2008 | Question: 82 top

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

gateit-2008 algorithms recursion identify-function normal

Answer key

1.14.40 Identify Function: GATE IT 2008 | Question: 83 top

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 $P2$

gateit-2008 algorithms recursion identify-function normal

Answer key

1.15 Insertion Sort (1) top

1.15.1 Insertion Sort: GATE CSE 2003 | Question: 62 top

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. $\Theta(n)$

gatecse-2003 algorithms sorting normal insertion-sort

Answer key

1.16 Inversion (1) top

1.16.1 Inversion: GATE CSE 2003 | Question: 61 top

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. $2n[\log_2 n]$

gatecse-2003 algorithms sorting inversion normal

Answer key

1.17 Maximum Minimum (1) top

1.17.1 Maximum Minimum: GATE CSE 2014 Set 1 | Question: 39 top

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

gatecse-2014-set1 algorithms numerical-answers normal maximum-minimum

Answer key

1.18 Merge Sort (1) top

1.18.1 Merge Sort: GATE CSE 1999 | Question: 1.14, ISRO2015-42 top

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 merge-sort normal isro2015

Answer key

1.19 Minimum Spanning Tree (4) top

1.19.1 Minimum Spanning Tree: GATE CSE 2018 | Question: 47 top

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 ____.

gatecse-2018 algorithms graph-algorithms minimum-spanning-tree numerical-answers 2-marks

Answer key

1.19.2 Minimum Spanning Tree: GATE CSE 2020 | Question: 31 top

Let $G = (V, E)$ be a weighted undirected graph and let T be a Minimum Spanning Tree (MST) of G maintained using adjacency lists. Suppose a new weighed edge $(u, v) \in V \times V$ is added to G. The worst case time complexity of determining if T is still an MST of the resultant graph is

A. $\Theta(|E| + |V|)$
B. $\Theta(|E||V|)$
C. $\Theta(E|\log|V|)$
D. $\Theta(|V|)$

gatecse-2020 algorithms minimum-spanning-tree graph-algorithms 2-marks

Answer key

1.19.3 Minimum Spanning Tree: GATE CSE 2021 Set 1 | Question: 17 top

Consider the following undirected graph with edge weights as shown:

The number of minimum-weight spanning trees of the graph is _____.

gatecse-2021-set1 algorithms graph-algorithms minimum-spanning-tree numerical-answers 1-mark

Answer key

1.19.4 Minimum Spanning Tree: GATE CSE 2021 Set 2 | Question: 1 top

Let G be a connected undirected weighted graph. Consider the following two statements.

- S_1: There exists a minimum weight edge in G which is present in every minimum spanning tree of G.
- S_2: If every edge in G has distinct weight, then G has a unique minimum spanning tree.

Which one of the following options is correct?

A. Both S_1 and S_2 are true
B. S_1 is true and S_2 is false
C. S_1 is false and S_2 is true
D. Both S_1 and S_2 are false

gatecse-2021-set2 algorithms graph-algorithms minimum-spanning-tree 1-mark

Answer key

1.20 Quick Sort (4) top

1.20.1 Quick Sort: GATE CSE 1987 | Question: 1-xviii top

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 quick-sort

Answer key

1.20.2 Quick Sort: GATE CSE 1989 | Question: 9 top

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 quick-sort

Answer key

1.20.3 Quick Sort: GATE CSE 1992 | Question: 03,iv top

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 quick-sort descriptive

Answer key

1.20.4 Quick Sort: GATE CSE 2019 | Question: 20 top

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 _____

gatecse-2019 numerical-answers algorithms quick-sort probability 1-mark

Answer key

1.21 Recurrence Relation (33) top

1.21.1 Recurrence Relation: GATE CSE 1987 | Question: 10a top

Solve the recurrence equations:

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

gate1987 algorithms recurrence-relation descriptive

Answer key

1.21.2 Recurrence Relation: GATE CSE 1988 | Question: 13iv top

Solve the recurrence equations:

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

gate1988 descriptive algorithms recurrence-relation

Answer key

1.21.3 Recurrence Relation: GATE CSE 1989 | Question: 13b top

Find a solution to the following recurrence equation:

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

gate1989 descriptive algorithms recurrence-relation

Answer key

1.21.4 Recurrence Relation: GATE CSE 1990 | Question: 17a top

Express $T(n)$ in terms of the harmonic number $H_n = \sum_{i=1}^{n} \frac{1}{i}, \quad n \geq 1$, 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-relation

Answer key

1.21.5 Recurrence Relation: GATE CSE 1992 | Question: 07a top

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-relation descriptive

Answer key

1.21.6 Recurrence Relation: GATE CSE 1992 | Question: 07b top

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]

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

gate1992 algorithms recurrence-relation descriptive

Answer key

1.21.7 Recurrence Relation: GATE CSE 1993 | Question: 15 top

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-relation normal descriptive

Answer key

1.21.8 Recurrence Relation: GATE CSE 1994 | Question: 1.7, ISRO2017-14 top

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

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

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

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

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

gate1994 algorithms recurrence-relation easy isro2017

Answer key

1.21.9 Recurrence Relation: GATE CSE 1996 | Question: 2.12 top

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-relation normal

Answer key

1.21.10 Recurrence Relation: GATE CSE 1997 | Question: 15 top

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 $\binom{n}{k} = \binom{n-1}{k} + \binom{n}{k-1}$ 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-relation descriptive

Answer key

1.21.11 Recurrence Relation: GATE CSE 1997 | Question: 4.6 top

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-relation normal

Answer key

1.21.12 Recurrence Relation: GATE CSE 1998 | Question: 6a top

Solve the following recurrence relation

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

$$x_1 = 2$$

gate1998 algorithms recurrence-relation descriptive

Answer key

1.21.13 Recurrence Relation: GATE CSE 2002 | Question: 1.3 top

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. $2^{\log_3 k}$

gatecse-2002 algorithms recurrence-relation normal

Answer key

1.21.14 Recurrence Relation: GATE CSE 2002 | Question: 2.11 top

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. $O(1)$

gatecse-2002 algorithms recurrence-relation normal

Answer key

1.21.15 Recurrence Relation: GATE CSE 2003 | Question: 35 top

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. $\frac{m}{6}(5m^3 - 34m^2 + 137m - 104) + \frac{5}{6}$

gatecse-2003 algorithms time-complexity recurrence-relation difficult

Answer key

1.21.16 Recurrence Relation: GATE CSE 2004 | Question: 83, ISRO2015-40 top

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. $O(2^n)$

gatecse-2004 algorithms recurrence-relation time-complexity normal isro2015

Answer key

1.21.17 Recurrence Relation: GATE CSE 2004 | Question: 84 top

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. $2^n + n$

gatecse-2004 algorithms recurrence-relation normal

Answer key

1.21.18 Recurrence Relation: GATE CSE 2006 | Question: 51, ISRO2016-34 top

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-relation isro2016 gatecse-2006

Answer key

1.21.19 Recurrence Relation: GATE CSE 2008 | Question: 78 top

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. $x_n = x_{n-1} + x_{n-2}$

gatecse-2008 algorithms recurrence-relation normal

Answer key

1.21.20 Recurrence Relation: GATE CSE 2008 | Question: 79 top

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

gatecse-2008 algorithms recurrence-relation normal

Answer key

1.21.21 Recurrence Relation: GATE CSE 2009 | Question: 35 top

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. $\Theta(n^2 \log n)$

gatecse-2009 algorithms recurrence-relation time-complexity normal

Answer key

1.21.22 Recurrence Relation: GATE CSE 2012 | Question: 16 top

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. $T(n) = 2T(n-1) + 1$

gatecse-2012 algorithms easy recurrence-relation

Answer key

1.21.23 Recurrence Relation: GATE CSE 2014 Set 2 | Question: 13 top

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. $\Theta(\log n)$

gatecse-2014-set2 algorithms recurrence-relation normal

Answer key

1.21.24 Recurrence Relation: GATE CSE 2015 Set 1 | Question: 49 top

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

gatecse-2015-set1 algorithms recurrence-relation normal

Answer key

1.21.25 Recurrence Relation: GATE CSE 2015 Set 3 | Question: 39 top

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

gatecse-2015-set3 algorithms recurrence-relation normal

Answer key

1.21.26 Recurrence Relation: GATE CSE 2016 Set 2 | Question: 39 top

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 $A(n)$.

gatecse-2016-set2 algorithms time-complexity recurrence-relation normal numerical-answers

Answer key

1.21.27 Recurrence Relation: GATE CSE 2017 Set 2 | Question: 30 top

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. $\Theta(n)$

gatecse-2017-set2 algorithms recurrence-relation

Answer key

1.21.28 Recurrence Relation: GATE CSE 2020 | Question: 2 top

For parameters a and b, both of which are $\omega(1)$, $T(n) = T(n^{1/a}) + 1$, and $T(b) = 1$. Then $T(n)$ is

A. $\Theta(\log_a \log_b n)$
B. $\Theta(\log_{ab} n)$
C. $\Theta(\log_b \log_a n)$
D. $\Theta(\log_2 \log_2 n)$

gatecse-2020 algorithms recurrence-relation 1-mark

Answer key

1.21.29 Recurrence Relation: GATE CSE 2021 Set 1 | Question: 30 top

Consider the following recurrence relation.

$$T(n) = \begin{cases} T(n/2) + T(2n/5) + 7n & \text{if } n > 0 \\ 1 & \text{if } n = 0 \end{cases}$$

Which one of the following options is correct?

A. $T(n) = \Theta(n^{5/2})$
B. $T(n) = \Theta(n \log n)$
C. $T(n) = \Theta(n)$
D. $T(n) = \Theta((\log n)^{5/2})$

gatecse-2021-set1 algorithms recurrence-relation time-complexity 2-marks

Answer key

1.21.30 Recurrence Relation: GATE CSE 2021 Set 2 | Question: 39 top

For constants $a \geq 1$ and $b > 1$, consider the following recurrence defined on the non-negative integers:

$$T(n) = a \cdot T\left(\frac{n}{b}\right) + f(n)$$

Which one of the following options is correct about the recurrence $T(n)$?

A. If $f(n)$ is $n \log_2(n)$, then $T(n)$ is $\Theta(n \log_2(n))$
B. If $f(n)$ is $\dfrac{n}{\log_2(n)}$, then $T(n)$ is $\Theta(\log_2(n))$
C. If $f(n)$ is $O(n^{\log_b(a) - \epsilon})$ for some $\epsilon > 0$, then $T(n)$ is $\Theta(n^{\log_b(a)})$
D. If $f(n)$ is $\Theta(n^{\log_b(a)})$, then $T(n)$ is $\Theta(n^{\log_b(a)})$

gatecse-2021-set2 algorithms recurrence-relation 2-marks

Answer key

1.21.31 Recurrence Relation: GATE IT 2004 | Question: 57 top

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

gateit-2004 algorithms recurrence-relation normal

Answer key

1.21.32 Recurrence Relation: GATE IT 2005 | Question: 51 top

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. $T(n) = \Theta(n \log n)$

gateit-2005 algorithms recurrence-relation easy

Answer key

1.21.33 Recurrence Relation: GATE IT 2008 | Question: 44 top

When $n = 2^{2k}$ for some $k \geqslant 0$, the recurrence relation

$T(n) = \surd(2)T(n/2) + \sqrt{n}, T(1) = 1$

evaluates to :

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

gateit-2008 algorithms recurrence-relation normal

Answer key

1.22 Recursion (4) top

1.22.1 Recursion: GATE CSE 1995 | Question: 2.9 top

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

Answer key

1.22.2 Recursion: GATE CSE 2007 | Question: 44 top

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. $\Theta(\sqrt{n})$

gatecse-2007 algorithms recursion time-complexity normal

Answer key

1.22.3 Recursion: GATE CSE 2018 | Question: 45 top

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 _____

gatecse-2018 numerical-answers algorithms recursion 2-marks

Answer key

1.22.4 Recursion: GATE CSE 2021 Set 2 | Question: 49 top

Consider the following ANSI C program

```
#include <stdio.h>
int foo(int x, int y, int q)
   {
      if ((x<=0) && (y<=0))
      return q;
      if (x<=0)
      return foo(x, y-q, q);
      if (y<=0)
      return foo(x-q, y, q);
      return foo(x, y-q, q) + foo(x-q, y, q);
   }
int main( )
```

```
{
  int r = foo(15, 15, 10);
  printf("%d", r);
  return 0;
}
```

The output of the program upon execution is _____

gatecse-2021-set2 algorithms recursion output numerical-answers 2-marks

Answer key

1.23 Searching (6) top

1.23.1 Searching: GATE CSE 1996 | Question: 18 top

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 descriptive

Answer key

1.23.2 Searching: GATE CSE 1996 | Question: 2.13, ISRO2016-28 top

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

Answer key

1.23.3 Searching: GATE CSE 2002 | Question: 2.10 top

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. $\frac{n}{2}$

gatecse-2002 searching normal

Answer key

1.23.4 Searching: GATE CSE 2008 | Question: 84 top

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 i, 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

gatecse-2008 algorithms searching normal

Answer key

1.23.5 Searching: GATE CSE 2008 | Question: 85 top

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 i, 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 $((Y[k] == x) \&\& (i < j))$;

gatecse-2008 algorithms searching normal

Answer key

1.23.6 Searching: GATE CSE 2017 Set 1 | Question: 48 top

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 _____.

gatecse-2017-set1 algorithms normal numerical-answers searching

Answer key

1.24 Sorting (35) top

1.24.1 Sorting: GATE CSE 1988 | Question: 1iii top

Quicksort is _____ efficient than heapsort in the worst case.

gate1988 algorithms sorting fill-in-the-blanks

Answer key

1.24.2 Sorting: GATE CSE 1990 | Question: 3-v top

The complexity of comparison based sorting algorithms is:

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

gate1990 normal algorithms sorting time-complexity multiple-selects

Answer key

1.24.3 Sorting: GATE CSE 1991 | Question: 01,vii top

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

gate1991 normal algorithms sorting numerical-answers

Answer key

1.24.4 Sorting: GATE CSE 1991 | Question: 13 top

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 descriptive

Answer key

1.24.5 Sorting: GATE CSE 1992 | Question: 02,ix top

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 multiple-selects

Answer key

1.24.6 Sorting: GATE CSE 1995 | Question: 1.16 top

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

Answer key

1.24.7 Sorting: GATE CSE 1995 | Question: 12 top

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 descriptive

Answer key

1.24.8 Sorting: GATE CSE 1996 | Question: 14 top

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 $A[i][j] < A[i+1][j]$

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 descriptive

Answer key

1.24.9 Sorting: GATE CSE 1996 | Question: 2.15 top

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

Answer key

1.24.10 Sorting: GATE CSE 1998 | Question: 1.22 top

Give the correct matching for the following pairs:

(A)	$O(\log n)$	(P)	Selection
(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

Answer key

1.24.11 Sorting: GATE CSE 1999 | Question: 1.12 top

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

Answer key

1.24.12 Sorting: GATE CSE 1999 | Question: 8 top

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 1st, 2nd and 3rd smallest elements in minimum number of comparisons.

gate1999 algorithms sorting normal descriptive

Answer key

1.24.13 Sorting: GATE CSE 2000 | Question: 17 top

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.

gatecse-2000 algorithms sorting normal descriptive

Answer key

1.24.14 Sorting: GATE CSE 2001 | Question: 1.14 top

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. $O(n!)$

gatecse-2001 algorithms sorting time-complexity easy

Answer key

1.24.15 Sorting: GATE CSE 2003 | Question: 22 top

The usual $\Theta(n^2)$ 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 $\Theta(n)$

gatecse-2003 algorithms sorting time-complexity normal

Answer key

1.24.16 Sorting: GATE CSE 2005 | Question: 39 top

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. $\Omega\left(n^{3/2}\right)$

gatecse-2005 algorithms sorting normal

Answer key

1.24.17 Sorting: GATE CSE 2006 | Question: 14, ISRO2011-14 top

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

gatecse-2006 algorithms sorting easy isro2011

Answer key

1.24.18 Sorting: GATE CSE 2006 | Question: 52 top

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. $\Theta(n^3)$

gatecse-2006 algorithms sorting easy

Answer key

1.24.19 Sorting: GATE CSE 2007 | Question: 14 top

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

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

gatecse-2007 algorithms sorting time-complexity easy

Answer key

1.24.20 Sorting: GATE CSE 2008 | Question: 43 top

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. $T(n) \leq 2T(n/2) + n$

gatecse-2008 algorithms sorting easy

Answer key

1.24.21 Sorting: GATE CSE 2009 | Question: 11 top

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. $\Theta(n^2 \log n)$

gatecse-2009 algorithms sorting easy

Answer key

1.24.22 Sorting: GATE CSE 2009 | Question: 39 top

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. $\Theta(n^2 \log n)$

gatecse-2009 algorithms sorting normal

Answer key

1.24.23 Sorting: GATE CSE 2012 | Question: 39 top

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. $O(n^2)$

gatecse-2012 algorithms sorting normal

Answer key

1.24.24 Sorting: GATE CSE 2013 | Question: 6 top

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. $O(n^2)$

gatecse-2013 algorithms sorting easy

Answer key

1.24.25 Sorting: GATE CSE 2014 Set 1 | Question: 14 top

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. $t_1 = t_2$

gatecse-2014-set1 algorithms sorting easy

Answer key

1.24.26 Sorting: GATE CSE 2014 Set 2 | Question: 38 top

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 ____.

gatecse-2014-set2 algorithms sorting normal numerical-answers

Answer key

1.24.27 Sorting: GATE CSE 2014 Set 3 | Question: 14 top

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. $O(n^3)$

gatecse-2014-set3 algorithms sorting easy

Answer key

1.24.28 Sorting: GATE CSE 2015 Set 1 | Question: 2 top

Which one of the following is the recurrence equation for the worst case time complexity of the quick sort algorithm for sorting $n\ (\geq 2)$ 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. $T(n) = T(n/2) + cn$

gatecse-2015-set1 algorithms recurrence-relation sorting easy

Answer key

1.24.29 Sorting: GATE CSE 2015 Set 2 | Question: 45 top

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 kth 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$, k)$

gatecse-2015-set2 algorithms normal sorting

Answer key

1.24.30 Sorting: GATE CSE 2015 Set 3 | Question: 27 top

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

gatecse-2015-set3 algorithms sorting

Answer key

1.24.31 Sorting: GATE CSE 2016 Set 1 | Question: 13 top

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 $\Theta(n^2)$

gatecse-2016-set1 algorithms sorting easy

Answer key

1.24.32 Sorting: GATE CSE 2016 Set 2 | Question: 13 top

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

gatecse-2016-set2 algorithms sorting time-complexity normal ambiguous

Answer key

1.24.33 Sorting: GATE CSE 2021 Set 1 | Question: 9 top

Consider the following array.

23	32	45	69	72	73	89	97

Which algorithm out of the following options uses the least number of comparisons (among the array elements) to sort the above array in ascending order?

A. Selection sort
B. Mergesort
C. Insertion sort
D. Quicksort using the last element as pivot

gatecse-2021-set1 algorithms sorting 1-mark

Answer key

1.24.34 Sorting: GATE IT 2005 | Question: 59 top

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

gateit-2005 algorithms sorting normal

Answer key

1.24.35 Sorting: GATE IT 2008 | Question: 43 top

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. $\Theta(n^2)$

gateit-2008 algorithms sorting normal

Answer key

1.25 Space Complexity (1) top

1.25.1 Space Complexity: GATE CSE 2005 | Question: 81a top

```
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

gatecse-2005 algorithms recursion normal space-complexity

Answer key

1.26 Spanning Tree (29) top

1.26.1 Spanning Tree: GATE CSE 1989 | Question: 4-vii top

In the graph shown above, the depth-first spanning tree edges are marked with a $'T'$. Identify the forward, backward, and cross edges.

gate1989 descriptive algorithms graph-algorithms spanning-tree depth-first-search

Answer key

1.26.2 Spanning Tree: GATE CSE 1991 | Question: 03,vi top

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 graph-algorithms spanning-tree minimum-spanning-tree time-complexity multiple-selects

Answer key

1.26.3 Spanning Tree: GATE CSE 1992 | Question: 01,ix top

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 fill-in-the-blanks

Answer key

1.26.4 Spanning Tree: GATE CSE 1995 | Question: 22 top

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

gate1995 algorithms graph-algorithms spanning-tree easy descriptive

Answer key

1.26.5 Spanning Tree: GATE CSE 1996 | Question: 16 top

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 descriptive

Answer key

1.26.6 Spanning Tree: GATE CSE 1997 | Question: 9 top

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 $|x_1 - x_2| \leq 1 \text{ and } |y_1 - y_2| \leq 1$. 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 descriptive

Answer key

1.26.7 Spanning Tree: GATE CSE 2000 | Question: 2.18 top

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

gatecse-2000 algorithms spanning-tree normal

Answer key

1.26.8 Spanning Tree: GATE CSE 2001 | Question: 15 top

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?

gatecse-2001 algorithms spanning-tree normal descriptive

Answer key

1.26.9 Spanning Tree: GATE CSE 2003 | Question: 68 top

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

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

gatecse-2003 algorithms spanning-tree normal

Answer key

1.26.10 Spanning Tree: GATE CSE 2005 | Question: 6 top

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

gatecse-2005 algorithms spanning-tree normal

Answer key

1.26.11 Spanning Tree: GATE CSE 2006 | Question: 11 top

Consider a weighted complete graph G on the vertex set $\{v_1, v_2, \ldots\ldots v_n\}$ 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

gatecse-2006 algorithms spanning-tree normal

Answer key

1.26.12 Spanning Tree: GATE CSE 2006 | Question: 47 top

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. $(d-f),(a-b),(b-f),(d-e),(d-c)$

gatecse-2006 algorithms graph-algorithms spanning-tree normal

Answer key

1.26.13 Spanning Tree: GATE CSE 2007 | Question: 49 top

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

gatecse-2007 algorithms spanning-tree normal

Answer key

1.26.14 Spanning Tree: GATE CSE 2009 | Question: 38 top

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. $(b, e)\ (e, f)\ (b, c)\ (a, c)\ (f, g)\ (c, d)$

gatecse-2009 algorithms spanning-tree normal

Answer key

1.26.15 Spanning Tree: GATE CSE 2010 | Question: 50 top

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

gatecse-2010 algorithms spanning-tree normal

Answer key

1.26.16 Spanning Tree: GATE CSE 2010 | Question: 51 top

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

gatecse-2010 normal algorithms spanning-tree

Answer key

1.26.17 Spanning Tree: GATE CSE 2011 | Question: 54 top

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 $0 < \mid i - j \mid \leq 2$. 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. $2n + 1$

gatecse-2011 algorithms graph-algorithms spanning-tree normal

Answer key

1.26.18 Spanning Tree: GATE CSE 2011 | Question: 55 top

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 $0 < \mid i - j \mid \leq 2$. 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

gatecse-2011 algorithms graph-algorithms spanning-tree normal

Answer key

1.26.19 Spanning Tree: GATE CSE 2012 | Question: 29 top

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

gatecse-2012 algorithms spanning-tree normal marks-to-all

Answer key

1.26.20 Spanning Tree: GATE CSE 2014 Set 2 | Question: 52 top

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

gatecse-2014-set2 algorithms spanning-tree numerical-answers normal

Answer key

1.26.21 Spanning Tree: GATE CSE 2015 Set 1 | Question: 43 top

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_____.

gatecse-2015-set1 algorithms spanning-tree normal numerical-answers

Answer key

1.26.22 Spanning Tree: GATE CSE 2015 Set 3 | Question: 40 top

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 _____.

gatecse-2015-set3 algorithms spanning-tree easy numerical-answers

Answer key

1.26.23 Spanning Tree: GATE CSE 2016 Set 1 | Question: 14 top

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

gatecse-2016-set1 algorithms spanning-tree normal

Answer key

1.26.24 Spanning Tree: GATE CSE 2016 Set 1 | Question: 39 top

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 _____

gatecse-2016-set1 algorithms spanning-tree normal numerical-answers

Answer key

1.26.25 Spanning Tree: GATE CSE 2016 Set 1 | Question: 40 top

$G = (V, E)$ 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.

gatecse-2016-set1 algorithms spanning-tree normal

Answer key

1.26.26 Spanning Tree: GATE CSE 2022 | Question: 39 top

Consider a simple undirected weighted graph G, all of whose edge weights are distinct. Which of the following statements about the minimum spanning trees of G is/are TRUE?

A. The edge with the second smallest weight is always part of any minimum spanning tree of G.
B. One or both of the edges with the third smallest and the fourth smallest weights are part of any minimum spanning tree of G.
C. Suppose $S \subseteq V$ be such that $S \neq \phi$ and $S \neq V$. Consider the edge with the minimum weight such that one of its vertices is in S and the other in $V \setminus S$. Such an edge will always be part of any minimum spanning tree of G.
D. G can have multiple minimum spanning trees.

gatecse-2022 algorithms spanning-tree minimum-spanning-tree multiple-selects 2-marks

Answer key

1.26.27 Spanning Tree: GATE CSE 2022 | Question: 48 top

Let $G(V,E)$ be a directed graph, where $V = \{1, 2, 3, 4, 5\}$ is the set of vertices and E is the set of directed edges, as defined by the following adjacency matrix A.

$$A[i][j] = \begin{cases} 1, & 1 \leq j \leq i \leq 5 \\ 0, & \text{otherwise} \end{cases}$$

$A[i][j] = 1$ indicates a directed edge from node i to node j. A $directed\ spanning\ tree$ of G, rooted at $r \in V$, is defined as a subgraph T of G such that the undirected version of T is a tree, and T contains a directed path from r to every other vertex in V. The number of such directed spanning trees rooted at vertex 5 is _____.

gatecse-2022 numerical-answers algorithms spanning-tree 2-marks

Answer key

1.26.28 Spanning Tree: GATE IT 2005 | Question: 52 top

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.

gateit-2005 algorithms spanning-tree normal

Answer key

1.26.29 Spanning Tree: GATE IT 2008 | Question: 45 top

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

gateit-2008 algorithms graph-algorithms spanning-tree normal

Answer key

1.27 Time Complexity (28) top

1.27.1 Time Complexity: GATE CSE 1988 | Question: 6i top

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

Answer key

1.27.2 Time Complexity: GATE CSE 1989 | Question: 2-iii top

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 kth smallest element in a set of n elements

gate1989 match-the-following algorithms time-complexity

Answer key

1.27.3 Time Complexity: GATE CSE 1993 | Question: 8.7 top

$\sum_{1 \leq k \leq n} O(n)$, 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

Answer key

1.27.4 Time Complexity: GATE CSE 1999 | Question: 1.13 top

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

Answer key

1.27.5 Time Complexity: GATE CSE 1999 | Question: 1.16 top

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

Answer key

1.27.6 Time Complexity: GATE CSE 1999 | Question: 11a top

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 descriptive

Answer key

1.27.7 Time Complexity: GATE CSE 2000 | Question: 1.15 top

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

gatecse-2000 easy algorithms time-complexity

Answer key

1.27.8 Time Complexity: GATE CSE 2003 | Question: 66 top

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 $O((\log \log n)^{0.5})$

gatecse-2003 algorithms time-complexity normal

Answer key

1.27.9 Time Complexity: GATE CSE 2004 | Question: 39 top

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

gatecse-2004 algorithms time-complexity easy

Answer key

1.27.10 Time Complexity: GATE CSE 2004 | Question: 82 top

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. $o(n)$

gatecse-2004 algorithms time-complexity normal

Answer key

1.27.11 Time Complexity: GATE CSE 2006 | Question: 15 top

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. $val(j) = \Theta(n \log n)$

gatecse-2006 algorithms normal time-complexity

Answer key

1.27.12 Time Complexity: GATE CSE 2007 | Question: 15, ISRO2016-26 top

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. $\lfloor \log_2 n \rfloor + 1$

gatecse-2007 algorithms time-complexity normal isro2016

Answer key

1.27.13 Time Complexity: GATE CSE 2007 | Question: 45 top

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. $\Theta(\log_2 \log_2 n)$

gatecse-2007 algorithms time-complexity normal

Answer key

1.27.14 Time Complexity: GATE CSE 2007 | Question: 50 top

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

gatecse-2007 algorithms time-complexity easy

Answer key

1.27.15 Time Complexity: GATE CSE 2007 | Question: 51 top

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

gatecse-2007 algorithms time-complexity normal

Answer key

1.27.16 Time Complexity: GATE CSE 2008 | Question: 40 top

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. $\Theta(1)$

gatecse-2008 normal algorithms time-complexity

Answer key

1.27.17 Time Complexity: GATE CSE 2008 | Question: 47 top

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. $\Theta(n^2)$

gatecse-2008 algorithms time-complexity normal

Answer key

1.27.18 Time Complexity: GATE CSE 2008 | Question: 74 top

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 $\Theta(2^n)$

gatecse-2008 algorithms time-complexity normal

Answer key

1.27.19 Time Complexity: GATE CSE 2008 | Question: 75 top

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

gatecse-2008 normal algorithms time-complexity

Answer key

1.27.20 Time Complexity: GATE CSE 2010 | Question: 12 top

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

gatecse-2010 algorithms time-complexity easy

Answer key

1.27.21 Time Complexity: GATE CSE 2014 Set 1 | Question: 42 top

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.

gatecse-2014-set1 algorithms time-complexity normal

Answer key

1.27.22 Time Complexity: GATE CSE 2015 Set 1 | Question: 40 top

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

gatecse-2015-set1 algorithms data-structures normal time-complexity

Answer key

1.27.23 Time Complexity: GATE CSE 2015 Set 2 | Question: 22 top

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. $\Theta(1)$

gatecse-2015-set2 algorithms time-complexity easy

Answer key

1.27.24 Time Complexity: GATE CSE 2017 Set 2 | Question: 03 top

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. $P \rightarrow (iii) \quad Q \rightarrow (iv) \quad r \rightarrow (i) \quad S \rightarrow (ii)$
B. $P \rightarrow (iv) \quad Q \rightarrow (iii) \quad r \rightarrow (i) \quad S \rightarrow (ii)$
C. $P \rightarrow (iii) \quad Q \rightarrow (iv) \quad r \rightarrow (ii) \quad S \rightarrow (i)$
D. $P \rightarrow (iv) \quad Q \rightarrow (iii) \quad r \rightarrow (ii) \quad S \rightarrow (i)$

gatecse-2017-set2 algorithms time-complexity

Answer key

1.27.25 Time Complexity: GATE CSE 2017 Set 2 | Question: 38 top

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. $\Theta(n^2 \log n)$

gatecse-2017-set2 algorithms time-complexity

Answer key

1.27.26 Time Complexity: GATE CSE 2019 | Question: 37 top

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. $\Omega(n^2 \log n)$

gatecse-2019 algorithms time-complexity 2-marks

Answer key

1.27.27 Time Complexity: GATE IT 2007 | Question: 17 top

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. $O(n)$

gateit-2007 algorithms time-complexity normal

Answer key

1.27.28 Time Complexity: GATE IT 2007 | Question: 81 top

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. $\Theta(n^2)$

gateit-2007 algorithms time-complexity normal

Answer key

1.28 Uniform Hashing (1) top

1.28.1 Uniform Hashing: GATE CSE 2022 | Question: 6 top

Suppose we are given n keys, m hash table slots, and two simple uniform hash functions h_1 and h_2. Further suppose our hashing scheme uses h_1 for the odd keys and h_2 for the even keys. What is the expected number of keys in a slot?

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

gatecse-2022 algorithms hashing uniform-hashing 1-mark

Answer key

Answer Keys

1.1.1	N/A	1.1.2	N/A	1.1.3	B	1.1.4	C	1.1.5	12
1.1.6	29	1.1.7	A;C	1.2.1	N/A	1.2.2	N/A	1.2.3	C
1.2.4	A	1.2.5	B	1.2.6	A	1.2.7	C	1.2.8	C
1.2.9	C	1.3.1	A;B	1.3.2	B	1.3.3	X	1.3.4	D
1.3.6	A	1.3.7	C	1.3.8	C	1.3.9	D	1.3.10	A
1.3.11	C	1.3.12	C	1.3.13	D	1.3.15	D	1.3.16	A
1.3.17	A;C	1.3.18	A;D	1.3.19	D	1.3.20	A	1.4.1	B
1.5.1	5040	1.6.1	929 : 929	1.7.1	B	1.7.2	C	1.7.3	C
1.7.4	B	1.7.5	B	1.7.6	A	1.7.7	C	1.7.8	34
1.7.10	C	1.7.11	1500	1.7.12	C	1.8.1	B	1.8.2	N/A
1.8.3	N/A	1.8.4	C	1.8.5	N/A	1.8.6	B	1.8.7	D

1.8.8	B	1.8.9	B	1.8.10	D	1.8.11	A	1.8.12	A
1.8.13	A	1.8.15	D	1.8.16	D	1.8.17	D	1.8.18	C
1.8.19	B	1.8.20	D	1.8.21	C	1.8.22	C	1.8.24	B
1.8.25	A	1.8.26	109	1.8.27	A	1.8.28	99	1.8.29	A;B
1.8.30	D	1.8.31	A	1.8.32	C	1.8.33	D	1.8.34	B
1.8.35	C	1.9.1	C	1.9.2	C	1.9.3	D	1.9.4	C
1.9.5	C	1.9.6	B	1.9.7	19	1.9.8	D	1.9.9	31
1.9.10	D	1.9.11	A	1.9.12	D	1.9.13	D	1.9.14	D
1.9.15	B	1.10.1	A	1.10.2	B	1.10.3	D	1.10.4	A
1.10.5	A	1.10.6	16	1.10.7	A	1.11.1	B	1.11.2	N/A
1.11.3	13	1.11.4	C	1.11.5	C	1.11.6	D	1.12.1	C
1.13.1	2.33	1.13.2	D	1.13.3	225	1.13.4	B	1.14.1	N/A
1.14.2	N/A	1.14.3	C	1.14.4	A	1.14.5	N/A	1.14.6	C
1.14.7	C	1.14.8	N/A	1.14.9	C	1.14.10	D	1.14.11	A
1.14.12	B	1.14.13	D	1.14.14	C	1.14.15	C	1.14.16	D
1.14.17	D	1.14.18	D	1.14.19	B	1.14.21	B	1.14.22	D
1.14.23	B	1.14.24	A	1.14.25	9	1.14.26	A	1.14.27	D
1.14.28	51	1.14.29	0	1.14.30	C	1.14.31	26	1.14.32	D
1.14.33	81	1.14.34	1023 : 1023	1.14.35	15 : 15	1.14.36	D	1.14.37	C
1.14.38	C	1.14.39	D	1.15.1	D	1.16.1	B	1.17.1	147.1 : 148.1
1.18.1	B	1.19.1	4	1.19.2	D	1.19.3	3 : 3	1.19.4	C
1.20.1	C	1.20.2	N/A	1.20.3	N/A	1.20.4	0.08	1.21.1	N/A
1.21.2	N/A	1.21.3	N/A	1.21.4	N/A	1.21.5	N/A	1.21.6	N/A
1.21.7	N/A	1.21.8	B	1.21.9	A	1.21.10	N/A	1.21.11	B
1.21.12	N/A	1.21.13	B	1.21.14	C	1.21.15	B	1.21.16	D
1.21.18	B	1.21.19	D	1.21.20	X	1.21.21	A	1.21.22	D
1.21.23	A	1.21.24	A	1.21.25	B	1.21.27	B	1.21.28	A
1.21.30	C	1.21.31	B	1.21.32	C	1.21.33	A	1.22.1	C
1.22.2	A	1.22.3	10230	1.22.4	60 : 60	1.23.1	N/A	1.23.2	C
1.23.3	A	1.23.4	C	1.23.5	A	1.24.1	N/A	1.24.2	A
1.24.3	7	1.24.4	N/A	1.24.5	D	1.24.6	C	1.24.7	N/A
1.24.8	N/A	1.24.9	C	1.24.10	B	1.24.11	B	1.24.12	N/A
1.24.13	N/A	1.24.15	A	1.24.16	A	1.24.17	C	1.24.18	B
1.24.19	A	1.24.20	B	1.24.21	A	1.24.22	B	1.24.23	B

1.24.24	B	1.24.25	C	1.24.26	358	1.24.27	A	1.24.28	B
1.24.29	A	1.24.30	B	1.24.31	D	1.24.32	D	1.24.33	C
1.24.34	C	1.24.35	C	1.25.1	B	1.26.1	N/A	1.26.2	B;D;E
1.26.3	N/A	1.26.4	2	1.26.5	N/A	1.26.6	N/A	1.26.7	C
1.26.8	N/A	1.26.9	B	1.26.10	C	1.26.11	B	1.26.12	D
1.26.13	D	1.26.14	D	1.26.15	D	1.26.16	B	1.26.17	B
1.26.18	C	1.26.19	X	1.26.20	6	1.26.21	69	1.26.22	995
1.26.23	A	1.26.26	A;B;C	1.26.27	24	1.26.28	A	1.26.29	C
1.27.1	N/A	1.27.2	N/A	1.27.3	B;C;D;E	1.27.4	D	1.27.5	A
1.27.6	N/A	1.27.7	A	1.27.8	C	1.27.9	D	1.27.10	C
1.27.11	C	1.27.12	X	1.27.13	D	1.27.14	B	1.27.15	B
1.27.16	B	1.27.17	B	1.27.18	B	1.27.19	C	1.27.20	C
1.27.21	C	1.27.22	A	1.27.23	D	1.27.24	C	1.27.25	C
1.27.27	A	1.27.28	B	1.28.1	B				

2 Compiler Design (209)

2.1 Abstract Syntax Tree (1) top

2.1.1 Abstract Syntax Tree: GATE CSE 2015 Set 2 | Question: 14 top

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

gatecse-2015-set2 compiler-design easy abstract-syntax-tree

Answer key

2.2 Assembler (9) top

2.2.1 Assembler: GATE CSE 1992 | Question: 01,viii top

The purpose of instruction location counter in an assembler is _____

gate1992 compiler-design assembler normal fill-in-the-blanks

Answer key

2.2.2 Assembler: GATE CSE 1992 | Question: 03,ii top

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 match-the-following

Answer key

2.2.3 Assembler: GATE CSE 1992 | Question: 3,i top

Write short answers to the following:

i. Which of the following macros can put a macro assembler into an infinite loop?

.MACRO M1,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 descriptive

Answer key

2.2.4 Assembler: GATE CSE 1993 | Question: 7.6 top

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 multiple-selects

Answer key

2.2.5 Assembler: GATE CSE 1994 | Question: 17a top

State whether the following statements are True or False with reasons for your answer:

Coroutine is just another name for a subroutine.

gate1994 compiler-design normal assembler true-false descriptive

Answer key

2.2.6 Assembler: GATE CSE 1994 | Question: 17b top

State whether the following statements are True or False with reasons for your answer:

A two pass assembler uses its machine opcode table in the first pass of assembly.

gate1994 compiler-design normal assembler true-false descriptive

Answer key

2.2.7 Assembler: GATE CSE 1994 | Question: 18a top

State whether the following statements are True or False with reasons for your answer

A subroutine cannot always be used to replace a macro in an assembly language program.

gate1994 compiler-design normal assembler true-false descriptive

Answer key

2.2.8 Assembler: GATE CSE 1994 | Question: 18b top

State whether the following statements are True or False with reasons for your answer

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 descriptive

Answer key

2.2.9 Assembler: GATE CSE 1996 | Question: 1.17 top

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

Answer key

2.3 Code Optimization (7) top

2.3.1 Code Optimization: GATE CSE 2006 | Question: 60 top

Consider the following C code segment.

```
for (i = 0, i < n; i++)
{
   for (j = 0; j < n; j++)
   {
      if (i%2)
      {
         x += (4*j + 5*i);
         y += (7 + 4*j);
      }
   }
}
```

Which one of the following is false?

A. The code contains loop invariant computation
B. There is scope of common sub-expression elimination in this code
C. There is scope of strength reduction in this code
D. There is scope of dead code elimination in this code

gatecse-2006 compiler-design code-optimization

Answer key

2.3.2 Code Optimization: GATE CSE 2008 | Question: 12 top

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

gatecse-2008 normal code-optimization compiler-design

Answer key

2.3.3 Code Optimization: GATE CSE 2014 Set 1 | Question: 17 top

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.

gatecse-2014-set1 compiler-design code-optimization normal

Answer key

2.3.4 Code Optimization: GATE CSE 2014 Set 3 | Question: 11 top

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 _____.

gatecse-2014-set3 compiler-design numerical-answers normal code-optimization

Answer key

2.3.5 Code Optimization: GATE CSE 2014 Set 3 | Question: 34 top

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

gatecse-2014-set3 compiler-design code-optimization normal

Answer key

2.3.6 Code Optimization: GATE CSE 2021 Set 2 | Question: 30 top

Consider the following ANSI C code segment:

```
z=x + 3 + y->f1 + y->f2;
for (i = 0; i < 200; i = i + 2)
{
  if (z > i)
  {
    p = p + x + 3;
    q = q + y->f1;
  } else
  {
    p = p + y->f2;
    q = q + x + 3;
  }
}
```

Assume that the variable y points to a **struct** (allocated on the heap) containing two fields **f1** and **f2**, and the local variables **x, y, z, p, q,** and **i** are allotted registers. Common sub-expression elimination (CSE) optimization is applied on the code. The number of addition and the dereference operations (of the form **y ->f1** or **y ->f2**) in the optimized code, respectively, are:

A. 403 and 102 B. 203 and 2 C. 303 and 102 D. 303 and 2

gatecse-2021-set2 code-optimization compiler-design 2-marks

Answer key

2.3.7 Code Optimization: GATE CSE 2021 Set 2 | Question: 38 top

For a statement S in a program, in the context of liveness analysis, the following sets are defined:

$\mathrm{USE}(S)$: the set of variables used in S

$\mathrm{IN}(S)$: the set of variables that are live at the entry of S

$\mathrm{OUT}(S)$: the set of variables that are live at the exit of S

Consider a basic block that consists of two statements, S_1 followed by S_2. Which one of the following statements is correct?

A. $\mathrm{OUT}(S_1) = \mathrm{IN}(S_2)$
B. $\mathrm{OUT}(S_1) = \mathrm{IN}(S_1) \cup \mathrm{USE}(S_1)$
C. $\mathrm{OUT}(S_1) = \mathrm{IN}(S_2) \cup \mathrm{OUT}(S_2)$
D. $\mathrm{OUT}(S_1) = \mathrm{USE}(S_1) \cup \mathrm{IN}(S_2)$

gatecse-2021-set2 code-optimization compiler-design 2-marks

Answer key

2.4 Code Transformation (1) top

2.4.1 Code Transformation: GATE CSE 2006 | Question: 55 top

Consider these two functions and two statements S1 and S2 about them.

```
int work1(int *a, int i, int j)
{
    int x = a[i+2];
    a[j] = x+1;
    return a[i+2] - 3;
}
```

```
int work2(int *a, int i, int j)
{
    int t1 = i+2;
    int t2 = a[t1];
    a[j] = t2+1;
    return t2 - 3;
}
```

S1: The transformation form *work1* to *work2* is valid, i.e., for any program state and input arguments, *work2* will compute the same output and have the same effect on program state as *work1*

S2: All the transformations applied to *work1* to get *work2* will always improve the performance (i.e reduce CPU time) of *work2* compared to *work1*

A. S1 is false and S2 is false
B. S1 is false and S2 is true
C. S1 is true and S2 is false
D. S1 is true and S2 is true

gatecse-2006 compiler-design code-transformation normal code-optimization

Answer key

2.5 Compilation Phases (11) top

2.5.1 Compilation Phases: GATE CSE 1987 | Question: 1-xi top

In a compiler the module that 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

Answer key

2.5.2 Compilation Phases: GATE CSE 1990 | Question: 2-ix top

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

Answer key

2.5.3 Compilation Phases: GATE CSE 2005 | Question: 61 top

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

gatecse-2005 compiler-design compilation-phases normal

Answer key

2.5.4 Compilation Phases: GATE CSE 2009 | Question: 17 top

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

gatecse-2009 compiler-design easy compilation-phases

Answer key

2.5.5 Compilation Phases: GATE CSE 2015 Set 2 | Question: 19 top

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

gatecse-2015-set2 compiler-design normal compilation-phases

Answer key

2.5.6 Compilation Phases: GATE CSE 2016 Set 2 | Question: 19 top

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

gatecse-2016-set2 compiler-design easy compilation-phases

Answer key

2.5.7 Compilation Phases: GATE CSE 2017 Set 2 | Question: 05 top

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

gatecse-2017-set2 compiler-design compilation-phases easy

Answer key

2.5.8 Compilation Phases: GATE CSE 2018 | Question: 8 top

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

gatecse-2018 compiler-design easy compilation-phases 1-mark

Answer key

2.5.9 Compilation Phases: GATE CSE 2020 | Question: 9 top

Consider the following statements.

I. Symbol table is accessed only during lexical analysis and syntax analysis.
II. Compilers for programming languages that support recursion necessarily need heap storage for memory allocation in the run-time environment.

III. Errors violating the condition '*any variable must be declared before its use*' are detected during syntax analysis.

Which of the above statements is/are TRUE?

A. I only
B. I and III only
C. II only
D. None of I, II and III

gatecse-2020 compiler-design compilation-phases runtime-environment 1-mark

Answer key

2.5.10 Compilation Phases: GATE CSE 2021 Set 2 | Question: 3 top

Consider the following ANSI C program:

```
int main () {
  Integer x;
  return 0;
}
```

Which one of the following phases in a seven-phase C compiler will throw an error?

A. Lexical analyzer
B. Syntax analyzer
C. Semantic analyzer
D. Machine dependent optimizer

gatecse-2021-set2 compilation-phases compiler-design 1-mark

Answer key

2.5.11 Compilation Phases: GATE CSE 2023 | Question: 1 top

Consider the following statements regarding the front-end and back-end of a compiler.

S1: The front-end includes phases that are independent of the target hardware.
S2: The back-end includes phases that are specific to the target hardware.
S3: The back-end includes phases that are specific to the programming language used in the source code.

Identify the CORRECT option.

A. Only $\mathbf{S1}$ is TRUE.
B. Only $\mathbf{S1}$ and $\mathbf{S2}$ are TRUE.
C. $\mathbf{S1}, \mathbf{S2}$, and $\mathbf{S3}$ are all TRUE.
D. Only $\mathbf{S1}$ and $\mathbf{S3}$ are TRUE.

gatecse-2023 compiler-design compilation-phases 1-mark

Answer key

2.6 Compiler Tokenization (1) top

2.6.1 Compiler Tokenization: GATE CSE 2000 | Question: 1.18, ISRO2015-25 top

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

gatecse-2000 compiler-design compiler-tokenization easy isro2015

Answer key

2.7 Context Free Grammar (1) top

2.7.1 Context Free Grammar: GATE IT 2008 | Question: 79 top

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

gateit-2008 compiler-design context-free-grammar parsing normal

Answer key

2.8 Context Free Language (2) top

2.8.1 Context Free Language: GATE CSE 2006 | Question: 32, ISRO2016-35 top

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

gatecse-2006 compiler-design context-free-language normal isro2016

Answer key

2.8.2 Context Free Language: GATE IT 2008 | Question: 78 top

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. $abababb$ D. $aabbaab$

gateit-2008 parsing normal context-free-language

Answer key

2.9 Directed Acyclic Graph (1) top

2.9.1 Directed Acyclic Graph: GATE CSE 2021 Set 1 | Question: 50 top

Consider the following C code segment:

```
a = b + c;
e = a + 1;
d = b + c;
f = d + 1;
g = e + f;
```

In a compiler, this code segment is represented internally as a directed acyclic graph (DAG). The number of nodes in the DAG is _____

gatecse-2021-set1 compiler-design code-optimization directed-acyclic-graph numerical-answers 2-marks

Answer key

2.10 Expression Evaluation (2) top

2.10.1 Expression Evaluation: GATE CSE 2002 | Question: 2.19 top

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

gatecse-2002 compiler-design expression-evaluation easy

Answer key

2.10.2 Expression Evaluation: GATE CSE 2014 Set 2 | Question: 39 top

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 ___.

gatecse-2014-set2 compiler-design normal expression-evaluation numerical-answers

Answer key

2.11 Grammar (45) top

2.11.1 Grammar: GATE CSE 1988 | Question: 10ia top

Consider the following grammar:

- $S \rightarrow S$
- $S \rightarrow SS \mid a \mid \epsilon$

Construct the collection of sets of $\mathrm{LR}\ (0)$ items for this grammar and draw its goto graph.

gate1988 compiler-design descriptive grammar parsing

Answer key

2.11.2 Grammar: GATE CSE 1988 | Question: 10ib top

Consider the following grammar:

- $S \rightarrow S$
- $S \rightarrow SS \mid a \mid \epsilon$

Indicate the shift-reduce and reduce-reduce conflict (if any) in the various states of the $\mathrm{LR}(0)$ parser.

gate1988 compiler-design descriptive grammar parsing

Answer key

2.11.3 Grammar: GATE CSE 1990 | Question: 16a top

Show that grammar G_1 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

Answer key

2.11.4 Grammar: GATE CSE 1991 | Question: 10a top

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

Answer key

2.11.5 Grammar: GATE CSE 1991 | Question: 10b top

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

Answer key

2.11.6 Grammar: GATE CSE 1991 | Question: 10c top

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

Answer key

2.11.7 Grammar: GATE CSE 1994 | Question: 1.18 top

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

Answer key

2.11.8 Grammar: GATE CSE 1994 | Question: 20 top

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 descriptive

Answer key

2.11.9 Grammar: GATE CSE 1994 | Question: 3.5 top

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 match-the-following

Answer key

2.11.10 Grammar: GATE CSE 1995 | Question: 1.10 top

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

Answer key

2.11.11 Grammar: GATE CSE 1995 | Question: 9 top

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 $A \overset{+}{\Rightarrow} A$

Show that no grammar that has cycles can be $\mathrm{LL}(1)$.

gate1995 compiler-design grammar normal descriptive

Answer key

2.11.12 Grammar: GATE CSE 1996 | Question: 11 top

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 descriptive

Answer key

2.11.13 Grammar: GATE CSE 1996 | Question: 2.10 top

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

Answer key

2.11.14 Grammar: GATE CSE 1997 | Question: 1.6 top

In the following grammar

- $X ::= X \oplus Y \mid Y$
- $Y ::= Z * Y \mid Z$
- $Z ::= id$

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

Answer key

2.11.15 Grammar: GATE CSE 1997 | Question: 11 top

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 descriptive

Answer key

2.11.16 Grammar: GATE CSE 1998 | Question: 14 top

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

Answer key

2.11.17 Grammar: GATE CSE 1998 | Question: 6b top

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

Answer key

2.11.18 Grammar: GATE CSE 1999 | Question: 2.15 top

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

Answer key

2.11.19 Grammar: GATE CSE 2001 | Question: 1.18 top

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

gatecse-2001 compiler-design grammar normal

Answer key

2.11.20 Grammar: GATE CSE 2001 | Question: 18 top

A. Remove left-recursion from the following grammar: $S \rightarrow Sa \mid Sb \mid a \mid b$
B. Consider the following grammar:

$$S \rightarrow aSbS \mid bSaS \mid \in$$

Construct all possible parse trees for the string abab. Is the grammar ambiguous?

gatecse-2001 compiler-design grammar descriptive

Answer key

2.11.21 Grammar: GATE CSE 2003 | Question: 56 top

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 $\{S' \rightarrow \epsilon\}$

gatecse-2003 compiler-design grammar normal parsing

Answer key

2.11.22 Grammar: GATE CSE 2003 | Question: 57 top

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)

gatecse-2003 compiler-design grammar parsing normal

Answer key

2.11.23 Grammar: GATE CSE 2003 | Question: 58 top

Consider the translation scheme shown below.

- $S \rightarrow T\ R$
- $R \rightarrow +T\{\text{print}(`+');\}R \mid \varepsilon$
- $T \rightarrow$ **num** $\{\text{print}($**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. $++9\ 5\ 2$

gatecse-2003 compiler-design grammar normal

Answer key

2.11.24 Grammar: GATE CSE 2004 | Question: 45 top

Consider the grammar with the following translation rules and E as the start symbol

$$\begin{array}{ll} E \rightarrow E_1 \# T & \{E.value = E_1.value * T.value\} \\ \quad\quad \mid T & \{E.value = T.value\} \\ T \rightarrow T_1 \& F & \{T.value = T_1.value + F.value\} \\ \quad\quad \mid F & \{T.value = F.value\} \\ F \rightarrow \text{num} & \{F.value = num.value\} \end{array}$$

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

gatecse-2004 compiler-design grammar normal

Answer key

2.11.25 Grammar: GATE CSE 2004 | Question: 8 top

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. $P \rightarrow QR$
II. $P \rightarrow QsR$
III. $P \rightarrow \varepsilon$
IV. $P \rightarrow QtRr$

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

gatecse-2004 compiler-design grammar normal

Answer key

2.11.26 Grammar: GATE CSE 2004 | Question: 88 top

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. $\{w \mid N_b(w) = 3k, k \in \{0,1,2,\ldots\}\}$

gatecse-2004 compiler-design grammar normal

Answer key

2.11.27 Grammar: GATE CSE 2005 | Question: 14 top

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

gatecse-2005 compiler-design parsing grammar easy

Answer key

2.11.28 Grammar: GATE CSE 2005 | Question: 59 top

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 $E \times n$

gatecse-2005 compiler-design grammar normal

Answer key

2.11.29 Grammar: GATE CSE 2006 | Question: 59 top

Consider the following translation scheme.

- $S \rightarrow ER$
- $R \rightarrow *E\,\{\text{print}(`*`);\}\,R \mid \varepsilon$
- $E \rightarrow F + E\,\{\text{print}(`+`);\} \mid F$
- $F \rightarrow (S) \mid id\,\{\text{print}(id.value);\}$

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. $2\ 3\ 4 + *$

gatecse-2006 compiler-design grammar normal

Answer key

2.11.30 Grammar: GATE CSE 2006 | Question: 84 top

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

A. $S \to AC \mid CB$
$C \to aCb \mid a \mid b$
$A \to aA \mid \varepsilon$
$B \to Bb \mid \varepsilon$

B. $S \to aS \mid Sb \mid aCb$
$C \to aCb \mid \varepsilon$
$A \to aA \mid \varepsilon$
$B \to Bb \mid \varepsilon$

C. $S \to AC \mid CB$
$C \to aCb \mid \varepsilon$
$A \to aA \mid a$
$B \to Bb \mid b$

D. $S \to AC \mid CB$
$C \to aCb \mid \varepsilon$
$A \to aA \mid a$
$B \to Bb \mid b$

gatecse-2006 compiler-design grammar normal theory-of-computation

Answer key

2.11.31 Grammar: GATE CSE 2006 | Question: 85 top

The grammar

- $S \to AC \mid CB$
- $C \to aCb \mid \epsilon$
- $A \to aA \mid a$
- $B \to Bb \mid b$

generates the language $L = \{a^i b^j \mid i \neq j\}$. In this 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. $\max(l,m) + 3$

gatecse-2006 compiler-design grammar normal

Answer key

2.11.32 Grammar: GATE CSE 2007 | Question: 52 top

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:

$S \to iCtSS_1 \mid a$

$S_1 \to eS \mid \epsilon$

$C \to b$

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

gatecse-2007 compiler-design grammar normal

Answer key

2.11.33 Grammar: GATE CSE 2007 | Question: 53 top

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

gatecse-2007 compiler-design grammar normal

Answer key

2.11.34 Grammar: GATE CSE 2007 | Question: 78 top

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. $abbbba$

gatecse-2007 compiler-design grammar normal

Answer key

2.11.35 Grammar: GATE CSE 2007 | Question: 79 top

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

gatecse-2007 compiler-design grammar normal

Answer key

2.11.36 Grammar: GATE CSE 2008 | Question: 50 top

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

gatecse-2008 normal compiler-design grammar

Answer key

2.11.37 Grammar: GATE CSE 2010 | Question: 38 top

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)

gatecse-2010 compiler-design grammar normal

Answer key

2.11.38 Grammar: GATE CSE 2014 Set 2 | Question: 17 top

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

gatecse-2014-set2 compiler-design grammar normal

Answer key

2.11.39 Grammar: GATE CSE 2016 Set 2 | Question: 45 top

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. $S \rightarrow Aa \mid Bb \mid c$, $A \rightarrow Bd \mid \epsilon$, $B \rightarrow Ae \mid \epsilon$

gatecse-2016-set2 compiler-design grammar easy

Answer key

2.11.40 Grammar: GATE CSE 2016 Set 2 | Question: 46 top

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**

gatecse-2016-set2 compiler-design grammar normal

Answer key

2.11.41 Grammar: GATE CSE 2017 Set 2 | Question: 32 top

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. $E \rightarrow E - T \mid T$
$T \rightarrow T + F \mid F$
$F \rightarrow (E) \mid id$

B. $E \rightarrow TE'$
$E' \rightarrow -TE' \mid \epsilon$
$T \rightarrow T + F \mid F$
$F \rightarrow (E) \mid id$

C. $E \rightarrow TX$
$X \rightarrow -TX \mid \epsilon$
$T \rightarrow FY$
$Y \rightarrow +FY \mid \epsilon$
$F \rightarrow (E) \mid id$

D. $E \rightarrow TX \mid (TX)$
$X \rightarrow -TX \mid +TX \mid \epsilon$
$T \rightarrow id$

gatecse-2017-set2 grammar

Answer key

2.11.42 Grammar: GATE CSE 2019 | Question: 43 top

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_____

gatecse-2019 numerical-answers compiler-design grammar 2-marks

Answer key

2.11.43 Grammar: GATE CSE 2021 Set 1 | Question: 31 top

Consider the following context-free grammar where the set of terminals is $\{a, b, c, d, f\}$.

$$\begin{aligned} \text{S} &\rightarrow d\,a\,\text{T} \mid \text{R}\,f \\ \text{T} &\rightarrow a\,\text{S} \mid b\,a\,\text{T} \mid \epsilon \\ \text{R} &\rightarrow c\,a\,\text{T}\,\text{R} \mid \epsilon \end{aligned}$$

The following is a partially-filled $\text{LL}(1)$ parsing table.

	a	b	c	d	f	\$
S			$\boxed{1}$	$S \to daT$	$\boxed{2}$	
T	$T \to aS$	$T \to baT$	$\boxed{3}$		$T \to \varepsilon$	$\boxed{4}$
R			$R \to caTR$		$R \to \varepsilon$	

Which one of the following choices represents the correct combination for the numbered cells in the parsing table ("blank" denotes that the corresponding cell is empty)?

A. $\boxed{1}$ $S \to Rf$ $\boxed{2}$ $S \to Rf$ $\boxed{3}$ $T \to \varepsilon$ $\boxed{4}$ $T \to \varepsilon$
B. $\boxed{1}$ blank $\boxed{2}$ $S \to Rf$ $\boxed{3}$ $T \to \varepsilon$ $\boxed{4}$ $T \to \varepsilon$
C. $\boxed{1}$ $S \to Rf$ $\boxed{2}$ blank $\boxed{3}$ blank $\boxed{4}$ $T \to \varepsilon$
D. $\boxed{1}$ blank $\boxed{2}$ $S \to Rf$ $\boxed{3}$ blank $\boxed{4}$ blank

gatecse-2021-set1 compiler-design grammar 2-marks

Answer key

2.11.44 Grammar: GATE IT 2005 | Question: 83a top

Consider the context-free grammar

$E \to E + E$
$E \to (E * E)$
$E \to id$

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. $((id * id + id) * id)$

gateit-2005 compiler-design grammar parsing easy

Answer key

2.11.45 Grammar: GATE IT 2007 | Question: 9 top

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

gateit-2007 compiler-design grammar normal

Answer key

2.12 Intermediate Code (9) top

2.12.1 Intermediate Code: GATE CSE 1988 | Question: 2xvii top

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

Answer key

2.12.2 Intermediate Code: GATE CSE 1989 | Question: 4-v top

Is the following code template for the if-then-else statement correct? if not, correct it.

- $\text{if expression then statement } 1$
  $\text{else statement } 2$

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

Answer key

2.12.3 Intermediate Code: GATE CSE 1992 | Question: 11b top

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

Answer key

2.12.4 Intermediate Code: GATE CSE 1994 | Question: 1.12 top

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

Answer key

2.12.5 Intermediate Code: GATE CSE 2014 Set 2 | Question: 34 top

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** $\mathbf{X[32][16][2]}$**"**.

gatecse-2014-set2 compiler-design intermediate-code programming-in-c normal

Answer key

2.12.6 Intermediate Code: GATE CSE 2014 Set 3 | Question: 17 top

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.

gatecse-2014-set3 compiler-design intermediate-code easy

Answer key

2.12.7 Intermediate Code: GATE CSE 2015 Set 1 | Question: 8 top

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 $S3$

gatecse-2015-set1 compiler-design intermediate-code normal

Answer key

2.12.8 Intermediate Code: GATE CSE 2015 Set 2 | Question: 29 top

Consider the intermediate code given below.

```
(1) i=1
(2) j=1
(3) t1 = 5 * i
(4) t2 = t1 + j
(5) t3 = 4 * t2
(6) t4 = t3
(7) a[t4] = -1
```

```
(8) j = j + 1
(9) if j <= 5 goto (3)
(10) i = i +1
(11) if i < 5 goto (2)
```

The number of nodes and edges in control-flow-graph constructed for the above code, respectively, are

A. 5 and 7 B. 6 and 7 C. 5 and 5 D. 7 and 8

gatecse-2015-set2 compiler-design intermediate-code normal

Answer key

2.12.9 Intermediate Code: GATE CSE 2021 Set 2 | Question: 13 top

In the context of compilers, which of the following is/are NOT an intermediate representation of the source program?

A. Three address code
B. Abstract Syntax Tree (AST)
C. Control Flow Graph (CFG)
D. Symbol table

gatecse-2021-set2 multiple-selects compiler-design intermediate-code 1-mark

Answer key

2.13 Lexical Analysis (5) top

2.13.1 Lexical Analysis: GATE CSE 1987 | Question: 1-xvii top

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

Answer key

2.13.2 Lexical Analysis: GATE CSE 2010 | Question: 13 top

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

gatecse-2010 compiler-design lexical-analysis easy

Answer key

2.13.3 Lexical Analysis: GATE CSE 2011 | Question: 1 top

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

gatecse-2011 compiler-design lexical-analysis easy

Answer key

2.13.4 Lexical Analysis: GATE CSE 2011 | Question: 19 top

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

gatecse-2011 compiler-design lexical-analysis easy

Answer key

2.13.5 Lexical Analysis: GATE CSE 2018 | Question: 37 top

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 processed 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

gatecse-2018 compiler-design lexical-analysis normal 2-marks

Answer key

2.14 Linker (3) top

2.14.1 Linker: GATE CSE 1991 | Question: 03,ix top

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 linker multiple-selects

Answer key

2.14.2 Linker: GATE CSE 2003 | Question: 76 top

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

gatecse-2003 compiler-design runtime-environment linker easy

Answer key

2.14.3 Linker: GATE CSE 2004 | Question: 9 top

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

gatecse-2004 compiler-design easy linker

Answer key

2.15 Live Variable (1) top

2.15.1 Live Variable: GATE CSE 2023 | Question: 27 top

Consider the control flow graph shown.

Which one of the following choices correctly lists the set of *live* variables at the exit point of each basic block?

A. B1: { }, B2: {a}, B3: {a}, B4: {a}
B. B1: {i, j}, B2: {a}, B3: {a}, B4: {i}
C. B1: {a, i, j}, B2: {a, i, j}, B3: {a, i}, B4: {a}
D. B1: {a, i, j}, B2: {a, j}, B3: {a, j}, B4: {a, i, j}

gatecse-2023 compiler-design live-variable 2-marks

Answer key

2.16 Live Variable Analysis (1) top

2.16.1 Live Variable Analysis: GATE CSE 2015 Set 1 | Question: 50 top

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. $\mathrm{p, s, u}$ B. $\mathrm{r, s, u}$ C. $\mathrm{r, u}$ D. $\mathrm{q, v}$

gatecse-2015-set1 compiler-design live-variable-analysis normal

Answer key

2.17 Lr Parser (4) top

2.17.1 Lr Parser: GATE CSE 2020 | Question: 24 top

Consider the following grammar.

- $S \rightarrow aSB \mid d$
- $B \rightarrow b$

The number of reduction steps taken by a bottom-up parser while accepting the string $aaadbbb$ is _____.

gatecse-2020 numerical-answers compiler-design lr-parser 1-mark

Answer key

2.17.2 Lr Parser: GATE CSE 2021 Set 1 | Question: 5 top

Consider the following statements.

- S_1 : Every $\mathrm{SLR}(1)$ grammar is unambiguous but there are certain unambiguous grammars that are not $\mathrm{SLR}(1)$.
- S_2 : For any context-free grammar, there is a parser that takes at most $O(n^3)$ time to parse a string of length n.

Which one of the following options is correct?

A. S_1 is true and S_2 is false
B. S_1 is false and S_2 is true
C. S_1 is true and S_2 is true
D. S_1 is false and S_2 is false

gatecse-2021-set1 compiler-design lr-parser 1-mark

Answer key

2.17.3 Lr Parser: GATE CSE 2021 Set 2 | Question: 51 top

Consider the following augmented grammar with $\{\#, @, <, >, a, b, c\}$ as the set of terminals.

$$
\begin{aligned}
&S' \rightarrow S \\
&S \rightarrow S\#cS \\
&S \rightarrow SS \\
&S \rightarrow S@ \\
&S \rightarrow < S > \\
&S \rightarrow a \\
&S \rightarrow b \\
&S \rightarrow c
\end{aligned}
$$

Let $I_0 = \mathrm{CLOSURE}(\{S' \rightarrow \bullet S\})$. The number of items in the set $\mathrm{GOTO}(\mathrm{GOTO}(I_0 <), <)$ is _____

gatecse-2021-set2 compiler-design lr-parser numerical-answers 2-marks

Answer key

2.17.4 Lr Parser: GATE CSE 2022 | Question: 19 top

Consider the augmented grammar with $\{+, *, (,), \text{id}\}$ as the set of terminals.

- $S' \rightarrow S$
- $S \rightarrow S + R \mid R$
- $R \rightarrow R{*}P \mid P$
- $P \rightarrow (S) \mid \text{id}$

If I_0 is the set of two $LR(0)$ items $\{[S' \rightarrow S.], [S \rightarrow S. + R]\}$, then $goto(closure(I_0), +)$ contains exactly _____ items.

gatecse-2022 numerical-answers compiler-design parsing lr-parser 1-mark

Answer key

2.18 Macros (4) top

2.18.1 Macros: GATE CSE 1992 | Question: 01,vii top

Macro expansion is done in pass one instead of pass two in a two pass macro assembler because _____

gate1992 compiler-design macros easy fill-in-the-blanks

Answer key

2.18.2 Macros: GATE CSE 1995 | Question: 1.11 top

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

Answer key

2.18.3 Macros: GATE CSE 1996 | Question: 2.16 top

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 ≠ O 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

Answer key

2.18.4 Macros: GATE CSE 1997 | Question: 1.9 top

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

Answer key

2.19 Operator Precedence (1) top

2.19.1 Operator Precedence: GATE CSE 2000 | Question: 2.21, ISRO2015-24 top

Given the following expression grammar:

$$E \rightarrow E * F \mid F + E \mid F$$

$$F \rightarrow F - F \mid id$$

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 $*$

gatecse-2000 operator-precedence normal compiler-design isro2015

Answer key

2.20 Parameter Passing (14) top

2.20.1 Parameter Passing: GATE CSE 1988 | Question: 2xv top

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-environment parameter-passing numerical-answers

Answer key

2.20.2 Parameter Passing: GATE CSE 1988 | Question: 8i top

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-environment parameter-passing

Answer key

2.20.3 Parameter Passing: GATE CSE 1989 | Question: 3-viii top

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-environment compiler-design multiple-selects

Answer key

2.20.4 Parameter Passing: GATE CSE 1990 | Question: 11a top

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-environment parameter-passing

Answer key

2.20.5 Parameter Passing: GATE CSE 1991 | Question: 03,x top

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 difficult multiple-selects

Answer key

2.20.6 Parameter Passing: GATE CSE 1991 | Question: 09a top

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-environment descriptive

Answer key

2.20.7 Parameter Passing: GATE CSE 1991 | Question: 09b top

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-environment normal compiler-design parameter-passing descriptive

Answer key

2.20.8 Parameter Passing: GATE CSE 1993 | Question: 26 top

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-environment normal descriptive

Answer key

2.20.9 Parameter Passing: GATE CSE 1995 | Question: 2.4 top

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 compiler-design parameter-passing runtime-environment easy

Answer key

2.20.10 Parameter Passing: GATE CSE 1999 | Question: 15 top

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 parameter-passing normal runtime-environment descriptive

Answer key

2.20.11 Parameter Passing: GATE CSE 2003 | Question: 74 top

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. $115, 105$

gatecse-2003 programming compiler-design parameter-passing runtime-environment normal

Answer key

2.20.12 Parameter Passing: GATE CSE 2004 | Question: 2,ISRO2017-54 top

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

gatecse-2004 compiler-design programming-in-c parameter-passing easy isro2017 runtime-environment

Answer key

2.20.13 Parameter Passing: GATE CSE 2016 Set 1 | Question: 36 top

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. $4, 4$

gatecse-2016-set1 parameter-passing normal

Answer key

2.20.14 Parameter Passing: GATE IT 2007 | Question: 33 top

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 $:i = 10, j = 70$

gateit-2007 programming parameter-passing normal compiler-design runtime-environment

Answer key

2.21 Parsing (41) top

2.21.1 Parsing: GATE CSE 1987 | Question: 1-xiv top

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

Answer key

2.21.2 Parsing: GATE CSE 1989 | Question: 1-iii top

Merging states with a common core may produce _____ conflicts and does not produce _____ conflicts in an LALR parser.

gate1989 descriptive compiler-design parsing

Answer key

2.21.3 Parsing: GATE CSE 1992 | Question: 02,xiii top

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 multiple-selects

Answer key

2.21.4 Parsing: GATE CSE 1992 | Question: 02,xiv top

Consider the $\mathrm{SLR}(1)$ and $\mathrm{LALR}\ (1)$ 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 multiple-selects

Answer key

2.21.5 Parsing: GATE CSE 1993 | Question: 25 top

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 descriptive

Answer key

2.21.6 Parsing: GATE CSE 1995 | Question: 8 top

Construct the $\mathrm{LL}(1)$ 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 descriptive

Answer key

2.21.7 Parsing: GATE CSE 1998 | Question: 1.26 top

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

Answer key

2.21.8 Parsing: GATE CSE 1998 | Question: 1.27 top

Type checking is normally done during

A. lexical analysis
B. syntax analysis
C. syntax directed translation
D. code optimization

gate1998 compiler-design parsing easy

Answer key

2.21.9 Parsing: GATE CSE 1998 | Question: 22 top

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

Answer key

2.21.10 Parsing: GATE CSE 1999 | Question: 1.17 top

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

Answer key

2.21.11 Parsing: GATE CSE 2000 | Question: 1.19, UGCNET-Dec2013-II: 30 top

Which of the following derivations does a top-down parser use while parsing an input string? The input is scanned from left to right.

A. Leftmost derivation
B. Leftmost derivation traced out in reverse
C. Rightmost derivation
D. Rightmost derivation traced out in reverse

gatecse-2000 compiler-design parsing normal ugcnetcse-dec2013-paper2

Answer key

2.21.12 Parsing: GATE CSE 2001 | Question: 16 top

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.

gatecse-2001 compiler-design parsing normal descriptive

Answer key

2.21.13 Parsing: GATE CSE 2002 | Question: 22 top

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?

gatecse-2002 compiler-design parsing normal descriptive

Answer key

2.21.14 Parsing: GATE CSE 2003 | Question: 16 top

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

gatecse-2003 compiler-design parsing easy

Answer key

2.21.15 Parsing: GATE CSE 2003 | Question: 17 top

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

gatecse-2003 compiler-design parsing easy

Answer key

2.21.16 Parsing: GATE CSE 2005 | Question: 60 top

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. $n_1 \geq n_3 \geq n_2$

gatecse-2005 compiler-design parsing normal

Answer key

2.21.17 Parsing: GATE CSE 2005 | Question: 83a top

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.

$$\begin{array}{r|l} E \rightarrow number & E.val = number.val \\ \mid E \text{ `+' } E & E^{(1)}.val = E^{(2)}.val + E^{(3)}.val \\ \mid E \text{ `}\times\text{' } E & E^{(1)}.val = E^{(2)}.val \times E^{(3)}.val \end{array}$$

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

gatecse-2005 compiler-design parsing difficult

Answer key

2.21.18 Parsing: GATE CSE 2005 | Question: 83b top

Consider the following expression grammar. The semantic rules for expression evaluation are stated next to each grammar production.

$$\begin{array}{r|l} E \rightarrow number & E.val = number.val \\ \mid E \text{ `+' } E & E^{(1)}.val = E^{(2)}.val + E^{(3)}.val \\ \mid E \text{ `}\times\text{' } E & E^{(1)}.val = E^{(2)}.val \times E^{(3)}.val \end{array}$$

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

gatecse-2005 compiler-design parsing normal

Answer key

2.21.19 Parsing: GATE CSE 2006 | Question: 58 top

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 $\{R \rightarrow \varepsilon\}$

gatecse-2006 compiler-design parsing normal

Answer key

2.21.20 Parsing: GATE CSE 2006 | Question: 7 top

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

gatecse-2006 compiler-design parsing normal

Answer key

2.21.21 Parsing: GATE CSE 2007 | Question: 18 top

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.

gatecse-2007 compiler-design parsing normal

Answer key

2.21.22 Parsing: GATE CSE 2008 | Question: 11 top

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

gatecse-2008 compiler-design parsing normal

Answer key

2.21.23 Parsing: GATE CSE 2008 | Question: 55 top

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

gatecse-2008 compiler-design parsing normal

Answer key

2.21.24 Parsing: GATE CSE 2009 | Question: 42 top

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

gatecse-2009 compiler-design parsing normal

Answer key

2.21.25 Parsing: GATE CSE 2011 | Question: 27 top

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.

gatecse-2011 compiler-design parsing normal

Answer key

2.21.26 Parsing: GATE CSE 2012 | Question: 52 top

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, | 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	$S \to \varepsilon$
A	$A \to S$	$A \to S$	error
B	$B \to S$	$B \to S$	$E3$

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. $\text{FIRST}(A) = \{a, b\} = \text{FIRST}(B)$
$\text{FOLLOW}(A) = \{a, b\}$
$\text{FOLLOW}(B) = \{a, b\}$

gatecse-2012 compiler-design parsing normal

Answer key

2.21.27 Parsing: GATE CSE 2012 | Question: 53 top

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, | separates alternate right hand sides of productions.

- $S \to aAbB \mid bAaB \mid \varepsilon$
- $A \to S$
- $B \to S$

	a	**b**	**$**
S	E1	E2	$S \to \varepsilon$
A	$A \to S$	$A \to S$	error
B	$B \to S$	$B \to S$	$E3$

The appropriate entries for $E1, E2,$ and $E3$ are

A. $E1 : S \to aAbB, A \to S$
$E2 : S \to bAaB, B \to S$
$E3 : B \to S$

B. $E1 : S \to aAbB, S \to \varepsilon$
$E2 : S \to bAaB, S \to \varepsilon$
$E3 : S \to \varepsilon$

C. $E1 : S \to aAbB, S \to \varepsilon$
$E2 : S \to bAaB, S \to \varepsilon$
$E3 : B \to S$

D. $E1 : A \to S, S \to \varepsilon$
$E2 : B \to S, S \to \varepsilon$
$E3 : B \to S$

normal gatecse-2012 compiler-design parsing

Answer key

2.21.28 Parsing: GATE CSE 2013 | Question: 40 top

Consider the following two sets of LR(1) items of an LR(1) grammar.

$X \rightarrow c.X, c/d$	$X \rightarrow c.X, \$$
$X \rightarrow .cX, c/d$	$X \rightarrow .cX, \$$
$X \rightarrow .d, c/d$	$X \rightarrow .d, \$$

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

gatecse-2013 compiler-design parsing normal

Answer key

2.21.29 Parsing: GATE CSE 2013 | Question: 9 top

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

gatecse-2013 compiler-design parsing normal

Answer key

2.21.30 Parsing: GATE CSE 2014 Set 1 | Question: 34 top

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.

gatecse-2014-set1 compiler-design parsing normal

Answer key

2.21.31 Parsing: GATE CSE 2015 Set 3 | Question: 16 top

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

gatecse-2015-set3 compiler-design parsing normal

Answer key

2.21.32 Parsing: GATE CSE 2015 Set 3 | Question: 31 top

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

gatecse-2015-set3 compiler-design parsing normal

Answer key

2.21.33 Parsing: GATE CSE 2016 Set 1 | Question: 45 top

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 _____.

gatecse-2016-set1 compiler-design parsing normal numerical-answers

Answer key

2.21.34 Parsing: GATE CSE 2017 Set 1 | Question: 17 top

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. $\{w,\$\}$

gatecse-2017-set1 compiler-design parsing

Answer key

2.21.35 Parsing: GATE CSE 2017 Set 1 | Question: 43 top

Consider the following grammar:

- stmt $\rightarrow$ **if** expr **then** expr **else** expr; stmt | Ò
- 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 $(\text{e.g., } <, >, \ldots)$, Ò 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 $e_1 \rightarrow e_3$.

gatecse-2017-set1 compiler-design parsing normal numerical-answers

Answer key

2.21.36 Parsing: GATE CSE 2017 Set 2 | Question: 6 top

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

gatecse-2017-set2 compiler-design parsing

Answer key

2.21.37 Parsing: GATE CSE 2018 | Question: 38 top

Consider the following parse tree for the expression a#bcd#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

gatecse-2018 compiler-design parsing normal 2-marks

Answer key

2.21.38 Parsing: GATE CSE 2019 | Question: 19 top

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)

gatecse-2019 numerical-answers compiler-design parsing 1-mark

Answer key

2.21.39 Parsing: GATE CSE 2019 | Question: 3 top

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

gatecse-2019 compiler-design parsing 1-mark

Answer key

2.21.40 Parsing: GATE CSE 2022 | Question: 3 top

Which one of the following statements is TRUE?

A. The $LALR(1)$ parser for a grammar G cannot have reduce-reduce conflict if the $LR(1)$ parser for G does not have reduce-reduce conflict.
B. Symbol table is accessed only during the lexical analysis phase.
C. Data flow analysis is necessary for run-time memory management.
D. $LR(1)$ parsing is sufficient for deterministic context-free languages.

gatecse-2022 compiler-design parsing 1-mark

Answer key

2.21.41 Parsing: GATE IT 2005 | Question: 83b top

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

gateit-2005 compiler-design parsing normal

Answer key

2.22 Register Allocation (2) top

2.22.1 Register Allocation: GATE CSE 2011 | Question: 36 top

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

gatecse-2011 compiler-design register-allocation normal

Answer key

2.22.2 Register Allocation: GATE CSE 2017 Set 1 | Question: 52 top

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 _____ .

gatecse-2017-set1 compiler-design register-allocation normal numerical-answers

Answer key

2.23 Runtime Environment (19) top

2.23.1 Runtime Environment: GATE CSE 1988 | Question: 2xii top

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-environment compiler-design

Answer key

2.23.2 Runtime Environment: GATE CSE 1989 | Question: 10a top

Will recursion work correctly in a language with static allocation of all variables? Explain.

gate1989 descriptive compiler-design runtime-environment

Answer key

2.23.3 Runtime Environment: GATE CSE 1989 | Question: 8b top

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-environment

Answer key

2.23.4 Runtime Environment: GATE CSE 1990 | Question: 2-v top

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-environment recursion

Answer key

2.23.5 Runtime Environment: GATE CSE 1990 | Question: 4-v top

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-environment

Answer key

2.23.6 Runtime Environment: GATE CSE 1993 | Question: 7.7 top

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-environment easy

Answer key

2.23.7 Runtime Environment: GATE CSE 1995 | Question: 1.14 top

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-environment normal

Answer key

2.23.8 Runtime Environment: GATE CSE 1997 | Question: 1.10 top

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-environment

Answer key

2.23.9 Runtime Environment: GATE CSE 1997 | Question: 1.8 top

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-environment

Answer key

2.23.10 Runtime Environment: GATE CSE 1998 | Question: 1.25, ISRO2008-41 top

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-environment normal isro2008

Answer key

2.23.11 Runtime Environment: GATE CSE 1998 | Question: 1.28 top

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-environment normal

Answer key

2.23.12 Runtime Environment: GATE CSE 1998 | Question: 2.15 top

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-environment

Answer key

2.23.13 Runtime Environment: GATE CSE 2001 | Question: 1.17 top

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

gatecse-2001 compiler-design runtime-environment easy

Answer key

2.23.14 Runtime Environment: GATE CSE 2008 | Question: 54 top

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

gatecse-2008 compiler-design difficult runtime-environment

Answer key

2.23.15 Runtime Environment: GATE CSE 2010 | Question: 14 top

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.

gatecse-2010 compiler-design easy runtime-environment

Answer key

2.23.16 Runtime Environment: GATE CSE 2012 | Question: 36 top

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: $\text{Main} \rightarrow \text{A1} \rightarrow \text{A2} \rightarrow \text{A21} \rightarrow \text{A1}$

The correct set of activation records along with their access links is given by:

gatecse-2012 compiler-design runtime-environment normal

Answer key

2.23.17 Runtime Environment: GATE CSE 2014 Set 2 | Question: 18 top

Which one of the following is **NOT** performed during compilation?

A. Dynamic memory allocation
B. Type checking
C. Symbol table management
D. Inline expansion

gatecse-2014-set2 compiler-design easy runtime-environment

Answer key

2.23.18 Runtime Environment: GATE CSE 2014 Set 3 | Question: 18 top

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

gatecse-2014-set3 compiler-design runtime-environment normal

Answer key

2.23.19 Runtime Environment: GATE CSE 2021 Set 1 | Question: 4 top

Consider the following statements.

- S_1 **:** The sequence of procedure calls corresponds to a preorder traversal of the activation tree.
- S_2 **:** The sequence of procedure returns corresponds to a postorder traversal of the activation tree.

Which one of the following options is correct?

A. S_1 is true and S_2 is false
B. S_1 is false and S_2 is true
C. S_1 is true and S_2 is true
D. S_1 is false and S_2 is false

gatecse-2021-set1 runtime-environment normal 1-mark

Answer key

2.24 Static Single Assignment (3) top

2.24.1 Static Single Assignment: GATE CSE 2015 Set 1 | Question: 55 top

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_____.

gatecse-2015-set1 compiler-design intermediate-code normal numerical-answers static-single-assignment

Answer key

2.24.2 Static Single Assignment: GATE CSE 2016 Set 1 | Question: 19 top

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 _____.

gatecse-2016-set1 compiler-design static-single-assignment normal numerical-answers

Answer key

2.24.3 Static Single Assignment: GATE CSE 2017 Set 1 | Question: 12 top

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

gatecse-2017-set1 compiler-design intermediate-code normal static-single-assignment

Answer key

2.25 Syntax Directed Translation (13) top

2.25.1 Syntax Directed Translation: GATE CSE 1992 | Question: 11a top

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 descriptive

Answer key

2.25.2 Syntax Directed Translation: GATE CSE 1995 | Question: 2.10 top

A shift reduce parser carries out the actions specified within braces immediately after reducing with the corresponding rule of grammar

- $S \rightarrow xxW$ $\{\text{print}“1”\}$
- $S \rightarrow y$ $\{\text{print}“2”\}$
- $W \rightarrow Sz$ $\{\text{print}“3”\}$

What is the translation of $xxxxyzz$ 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

Answer key

2.25.3 Syntax Directed Translation: GATE CSE 1996 | Question: 20 top

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 descriptive

Answer key

2.25.4 Syntax Directed Translation: GATE CSE 1998 | Question: 23 top

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

Answer key

2.25.5 Syntax Directed Translation: GATE CSE 2000 | Question: 19 top

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.

- $E \rightarrow E_1 * T \qquad \{E.val = E_1.val * T.val\}$
- $E \rightarrow T \qquad \{E.val = T.val\}$
- $T \rightarrow F - T_1 \qquad \{T.val = F.val - T_1.val\}$
- $T \rightarrow F \qquad \{T.val = F.val\}$
- $F \rightarrow 2 \qquad \{F.val = 2\}$
- $F \rightarrow 4 \qquad \{F.val = 4\}$

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.

gatecse-2000 compiler-design syntax-directed-translation normal descriptive

Answer key

2.25.6 Syntax Directed Translation: GATE CSE 2001 | Question: 17 top

The syntax of the repeat-until statement is given by the following grammar

$$S \rightarrow \text{ repeat } S_1 \text{ until } E$$

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.

gatecse-2001 compiler-design syntax-directed-translation normal descriptive

Answer key

2.25.7 Syntax Directed Translation: GATE CSE 2003 | Question: 18 top

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

gatecse-2003 compiler-design syntax-directed-translation normal

Answer key

2.25.8 Syntax Directed Translation: GATE CSE 2016 Set 1 | Question: 46 top

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

gatecse-2016-set1 compiler-design syntax-directed-translation normal

Answer key

2.25.9 Syntax Directed Translation: GATE CSE 2019 | Question: 36 top

Consider the following grammar and the semantic actions to support the 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. $X_1 = T,\ X_2 = L,\ X_3 = T,\ X_4 = L_1$

gatecse-2019 compiler-design syntax-directed-translation 2-marks

Answer key

2.25.10 Syntax Directed Translation: GATE CSE 2020 | Question: 33 top

Consider the productions $A \rightarrow PQ$ and $A \rightarrow XY$. Each of the five non-terminals $A, P, Q, X,$ and Y has two attributes: s is a synthesized attribute, and i is an inherited attribute. Consider the following rules.

- Rule 1 : $P.i = A.i + 2,\ Q.i = P.i + A.i,$ and $A.s = P.s + Q.s$
- Rule 2 : $X.i = A.i + Y.s$ and $Y.i = X.s + A.i$

Which one of the following is TRUE?

A. Both Rule 1 and Rule 2 are L-attributed.
B. Only Rule 1 is L-attributed.

C. Only Rule 2 is L-attributed.

D. Neither Rule 1 nor Rule 2 is L-attributed.

gatecse-2020 compiler-design syntax-directed-translation 2-marks

Answer key

2.25.11 Syntax Directed Translation: GATE CSE 2021 Set 1 | Question: 26 top

Consider the following grammar (that admits a series of declarations, followed by expressions) and the associated syntax directed translation (SDT) actions, given as pseudo-code

$$
\begin{aligned}
P &\rightarrow D^* E^* \\
D &\rightarrow \text{int ID}\{\text{record that ID.lexeme is of type int}\} \\
D &\rightarrow \text{bool ID}\{\text{record that ID.lexeme is of type bool}\} \\
E &\rightarrow E_1 + E_2\{\text{check that } E_1.\text{type} = E_2.\text{type} = \text{int; set } E.\text{type} := \text{int}\} \\
E &\rightarrow !E_1\{\text{check that } E_1.\text{type} = \text{bool; set } E.\text{type} := \text{bool}\} \\
E &\rightarrow \text{ID}\{\text{set } E.\text{type} := \text{int}\}
\end{aligned}
$$

With respect to the above grammar, which one of the following choices is correct?

A. The actions can be used to correctly type-check any syntactically correct program
B. The actions can be used to type-check syntactically correct integer variable declarations and integer expressions
C. The actions can be used to type-check syntactically correct boolean variable declarations and boolean expressions.
D. The actions will lead to an infinite loop

gatecse-2021-set1 compiler-design syntax-directed-translation 2-marks

Answer key

2.25.12 Syntax Directed Translation: GATE CSE 2022 | Question: 55 top

Consider the following grammar along with translation rules.

$$
\begin{aligned}
S &\rightarrow S_1 \# T && \{S.\text{val} = S_1.\text{val} * T.\text{val}\} \\
S &\rightarrow T && \{S.\text{val} = T.\text{val}\} \\
T &\rightarrow T_1 \% R && \{T.\text{val} = T_1.\text{val} \div R.\text{val}\} \\
T &\rightarrow R && \{T.\text{val} = R.\text{val}\} \\
R &\rightarrow \text{id} && \{R.\text{val} = \text{id}.\text{val}\}
\end{aligned}
$$

Here $\#$ and $\%$ are operators and id is a token that represents an integer and $\mathrm{id}.\text{val}$ represents the corresponding integer value. The set of non-terminals is $\{\mathrm{S}, \mathrm{T}, \mathrm{R}, \mathrm{P}\}$ and a subscripted non-terminal indicates an instance of the non-terminal.

Using this translation scheme, the computed value of $S.\text{val}$ for root of the parse tree for the expression $20\#10\%5\#8\%2\%2$ is _____.

gatecse-2022 numerical-answers compiler-design syntax-directed-translation 2-marks

Answer key

2.25.13 Syntax Directed Translation: GATE CSE 2023 | Question: 50 top

Consider the syntax directed translation given by the following grammar and semantic rules. Here N, I, F and B are non-terminals. N is the starting non-terminal, and $\#, \mathbf{0}$ and $\mathbf{1}$ are

lexical tokens corresponding to input letters "#", "0" and "1", respectively. $X.val$ denotes the synthesized attribute (a numeric value) associated with a non-terminal X. I_1 and F_1 denote occurrences of I and F on the right hand side of a production, respectively. For the tokens $\mathbf{0}$ and $\mathbf{1}, \mathbf{0}.val = 0$ and $\mathbf{1}.val = 1$.

$$\begin{array}{ll}
N \to I\#F & N.val = I.val + F.val \\
I \to I_1 B & I.val = (2I_1.val) + B.val \\
I \to B & I.val = \text{B.val} \\
F \to BF_1 & F.val = \frac{1}{2}(B.val + F_1.val) \\
F \to B & \text{F.val} = \frac{1}{2}B.val \\
B \to \mathbf{0} & B.val = \mathbf{0}.val \\
B \to \mathbf{1} & B.val = \mathbf{1}.val
\end{array}$$

The value computed by the translation scheme for the input string

$$10\#011$$

is _____. (Rounded off to three decimal places)

gatecse-2023 compiler-design syntax-directed-translation numerical-answers 2-marks

Answer key

2.26 Target Code Generation (5) top

2.26.1 Target Code Generation: GATE CSE 1997 | Question: 4.9 top

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

Answer key

2.26.2 Target Code Generation: GATE CSE 2003 | Question: 59 top

Consider the syntax directed definition shown below.

$$\begin{array}{ll}
S \to \mathbf{id} := E & \{gen(\mathbf{id}.place = E.place;);\} \\
E \to E_1 + E_2 & \{t = newtemp(); \\
 & gen(t = E_1.place + E_2.place;); \\
 & E.place = t;\} \\
E \to id & \{E.place = \mathbf{id}.place;\}
\end{array}$$

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 t_i'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. $t_1 = Y; t_2 = Z; t_3 = t_1 + t_2; X = t_3$

gatecse-2003 compiler-design target-code-generation normal

Answer key

2.26.3 Target Code Generation: GATE CSE 2004 | Question: 10 top

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

gatecse-2004 compiler-design target-code-generation normal

Answer key

2.26.4 Target Code Generation: GATE CSE 2010 | Question: 37 top

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

gatecse-2010 compiler-design target-code-generation register-allocation normal

Answer key

2.26.5 Target Code Generation: GATE CSE 2013 | Question: 48 top

The following code segment is executed on a processor which allows only register operands in its instructions. Each instruction can have atmost two source operands and one destination operand. Assume that all variables are dead after this code segment.

```
c = a + b;
d = c * a;
e = c + a;
x = c * c;
if (x > a) {
 y = a * a;
}
else {
 d = d * d;
 e = e * e;
}
```

Q.48 Suppose the instruction set architecture of the processor has only two registers. The only allowed compiler optimization is code motion, which moves statements from one place to another while preserving correctness. What is the minimum number of spills to memory in the compiled code?

A. 0 B. 1 C. 2 D. 3

gatecse-2013 normal compiler-design target-code-generation code-optimization

Answer key

2.27 Variable Scope (2) top

2.27.1 Variable Scope: GATE CSE 1987 | Question: 1-xix top

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 runtime-environment

Answer key

2.27.2 Variable Scope: GATE CSE 1987 | Question: 1-xx top

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 runtime-environment

Answer key

2.28 Viable Prefix (1) top

2.28.1 Viable Prefix: GATE CSE 2015 Set 1 | Question: 13 top

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

gatecse-2015-set1 compiler-design parsing normal viable-prefix

Answer key

Answer Keys

2.1.1	C	2.2.1	N/A	2.2.2	N/A	2.2.3	N/A	2.2.4	A;B;C
2.2.5	True	2.2.6	N/A	2.2.7	True	2.2.8	False	2.2.9	B
2.3.1	D	2.3.2	A	2.3.3	D	2.3.4	7	2.3.5	A
2.3.7	A	2.4.1	A	2.5.1	C	2.5.2	N/A	2.5.3	A
2.5.4	B	2.5.5	C	2.5.6	B	2.5.7	C	2.5.8	B
2.5.9	D	2.5.10	C	2.5.11	B	2.6.1	C	2.7.1	A
2.8.1	B	2.8.2	D	2.10.1	A	2.10.2	6	2.11.1	N/A
2.11.2	N/A	2.11.3	N/A	2.11.4	N/A	2.11.5	N/A	2.11.6	N/A
2.11.7	C	2.11.8	N/A	2.11.9	N/A	2.11.10	X	2.11.11	N/A
2.11.12	N/A	2.11.13	D	2.11.14	A	2.11.15	N/A	2.11.16	N/A
2.11.17	N/A	2.11.18	C	2.11.19	A	2.11.20	N/A	2.11.21	D
2.11.22	A	2.11.23	B	2.11.24	C	2.11.25	B	2.11.26	C
2.11.27	A	2.11.28	D	2.11.29	D	2.11.30	D	2.11.32	C
2.11.33	C	2.11.34	C	2.11.35	B	2.11.36	C	2.11.37	C
2.11.38	B	2.11.39	B	2.11.40	A	2.11.41	C	2.11.42	5
2.11.43	A	2.11.44	A	2.11.45	C	2.12.1	N/A	2.12.2	N/A
2.12.3	N/A	2.12.4	C	2.12.5	A	2.12.6	C	2.12.7	A
2.12.8	B	2.12.9	D	2.13.1	A	2.13.2	B	2.13.3	C

2.13.4	A	2.13.5	D	2.14.1	B	2.14.2	C	2.14.3	C
2.15.1	D	2.16.1	C	2.17.1	7	2.17.2	C	2.17.3	8 : 8
2.17.4	5	2.18.1	N/A	2.18.2	D	2.18.3	A	2.18.4	D
2.19.1	B	2.20.1	10	2.20.2	N/A	2.20.3	A;D	2.20.4	N/A
2.20.5	A;D	2.20.6	N/A	2.20.7	N/A	2.20.8	N/A	2.20.9	A
2.20.10	N/A	2.20.11	X	2.20.12	D	2.20.13	D	2.20.14	D
2.21.1	A	2.21.2	N/A	2.21.3	A;B	2.21.4	B;C;D	2.21.5	N/A
2.21.6	N/A	2.21.7	C	2.21.8	C	2.21.9	N/A	2.21.10	B
2.21.11	A	2.21.12	N/A	2.21.13	N/A	2.21.14	D	2.21.15	B
2.21.16	B	2.21.17	C	2.21.18	B	2.21.19	A	2.21.20	D
2.21.21	A	2.21.22	D	2.21.23	B	2.21.24	B	2.21.25	B
2.21.26	A	2.21.27	C	2.21.28	D	2.21.29	B	2.21.30	D
2.21.31	C	2.21.32	D	2.21.33	9	2.21.34	C	2.21.35	1024
2.21.36	A	2.21.37	A	2.21.38	31	2.21.39	D	2.21.40	D
2.21.41	A	2.22.1	D	2.22.2	2	2.23.1	N/A	2.23.2	N/A
2.23.3	N/A	2.23.4	N/A	2.23.5	True	2.23.6	D	2.23.7	C
2.23.8	B	2.23.9	C	2.23.10	C	2.23.11	B	2.23.12	C
2.23.13	C	2.23.14	A	2.23.15	C	2.23.16	D	2.23.17	A
2.23.18	D	2.24.1	8	2.24.2	10	2.24.3	B	2.25.1	N/A
2.25.2	A	2.25.3	N/A	2.25.4	N/A	2.25.5	N/A	2.25.6	N/A
2.25.7	B	2.25.8	C	2.25.9	A	2.25.10	B	2.25.11	B
2.25.12	80	2.25.13	2.375	2.26.1	A	2.26.2	B	2.26.3	B
2.26.4	B	2.26.5	B	2.27.1	A	2.27.2	B	2.28.1	C

3 Programming and DS: DS (218)

3.1 Abstract Data Type (1) top

3.1.1 Abstract Data Type: GATE CSE 2005 | Question: 2 top

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

gatecse-2005 data-structures normal abstract-data-type

Answer key

3.2 Array (13) top

3.2.1 Array: GATE CSE 1993 | Question: 12 top

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 $\boxed{\text{A}}$, $\boxed{\text{B}}$, $\boxed{\text{C}}$ and $\boxed{\text{D}}$ 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-structures array normal descriptive

Answer key

3.2.2 Array: GATE CSE 1994 | Question: 1.11 top

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-structures array normal

Answer key

3.2.3 Array: GATE CSE 1994 | Question: 25 top

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-structures array normal descriptive

Answer key

3.2.4 Array: GATE CSE 1997 | Question: 17 top

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-structures array normal descriptive

Answer key

3.2.5 Array: GATE CSE 1998 | Question: 2.14 top

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-structures array easy

Answer key

3.2.6 Array: GATE CSE 2000 | Question: 1.2 top

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. $n^2 \frac{(n+1)}{2}$

gatecse-2000 data-structures array easy

Answer key

3.2.7 Array: GATE CSE 2000 | Question: 15 top

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.

gatecse-2000 data-structures array easy descriptive

Answer key

3.2.8 Array: GATE CSE 2005 | Question: 5 top

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

gatecse-2005 data-structures array easy

Answer key

3.2.9 Array: GATE CSE 2013 | Question: 50 top

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. $oldc = \text{“}abc\text{”}, newc = \text{“}dab\text{”}$
2. $oldc = \text{“}cde\text{”}, newc = \text{“}bcd\text{”}$
3. $oldc = \text{“}bca\text{”}, newc = \text{“}cda\text{”}$
4. $oldc = \text{“}abc\text{”}, newc = \text{“}bac\text{”}$

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

gatecse-2013 data-structures array normal

Answer key

3.2.10 Array: GATE CSE 2013 | Question: 51 top

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. $oldc = \text{“}abc\text{”}, newc = \text{“}dab\text{”}$
2. $oldc = \text{“}cde\text{”}, newc = \text{“}bcd\text{”}$
3. $oldc = \text{“}bca\text{”}, newc = \text{“}cda\text{”}$
4. $oldc = \text{“}abc\text{”}, newc = \text{“}bac\text{”}$

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

gatecse-2013 data-structures array normal

Answer key

3.2.11 Array: GATE CSE 2014 Set 3 | Question: 42 top

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 $listA$.

gatecse-2014-set3 data-structures array easy

Answer key

3.2.12 Array: GATE CSE 2015 Set 2 | Question: 31 top

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 _____.

gatecse-2015-set2 databases array normal numerical-answers

Answer key

3.2.13 Array: GATE CSE 2021 Set 1 | Question: 2 top

Let P be an array containing n integers. Let t be the lowest upper bound on the number of comparisons of the array elements, required to find the minimum and maximum values in an arbitrary array of n elements. Which one of the following choices is correct?

A. $t > 2n - 2$
B. $t > 3\lceil \frac{n}{2} \rceil$ and $t \leq 2n - 2$
C. $t > n$ and $t \leq 3\lceil \frac{n}{2} \rceil$
D. $t > \lceil \log_2(n) \rceil$ and $t \leq n$

gatecse-2021-set1 data-structures array 1-mark

Answer key

3.3 Avl Tree (3) top

3.3.1 Avl Tree: GATE CSE 2009 | Question: 37,ISRO-DEC2017-55 top

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

gatecse-2009 data-structures binary-search-tree normal isrodec2017 avl-tree

Answer key

3.3.2 Avl Tree: GATE CSE 2020 | Question: 6 top

What is the worst case time complexity of inserting n^2 elements into an AVL-tree with n elements initially?

A. $\Theta(n^4)$
B. $\Theta(n^2)$
C. $\Theta(n^2 \log n)$
D. $\Theta(n^3)$

gatecse-2020 binary-tree avl-tree 1-mark

Answer key

3.3.3 Avl Tree: GATE IT 2008 | Question: 12 top

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 $O(n)$

gateit-2008 data-structures binary-search-tree easy avl-tree

Answer key

3.4 Binary Heap (4) top

3.4.1 Binary Heap: GATE CSE 2018 | Question: 46 top

The number of possible min-heaps containing each value from $\{1, 2, 3, 4, 5, 6, 7\}$ exactly once is _____

gatecse-2018 binary-heap numerical-answers combinatory 2-marks

Answer key

3.4.2 Binary Heap: GATE CSE 2020 | Question: 47 top

Consider the array representation of a binary min-heap containing 1023 elements. The minimum number of comparisons required to find the maximum in the heap is _____.

gatecse-2020 numerical-answers binary-heap 2-marks

Answer key

3.4.3 Binary Heap: GATE CSE 2021 Set 2 | Question: 2 top

Let H be a binary min-heap consisting of n elements implemented as an array. What is the worst case time complexity of an optimal algorithm to find the maximum element in H?

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

gatecse-2021-set2 data-structures heap binary-heap time-complexity 1-mark

Answer key

3.4.4 Binary Heap: GATE CSE 2023 | Question: 2 top

Which one of the following sequences when stored in an array at locations $A[1], \ldots, A[10]$ forms a max-heap?

A. $23, 17, 10, 6, 13, 14, 1, 5, 7, 12$
B. $23, 17, 14, 7, 13, 10, 1, 5, 6, 12$
C. $23, 17, 14, 6, 13, 10, 1, 5, 7, 15$
D. $23, 14, 17, 1, 10, 13, 16, 12, 7, 5$

gatecse-2023 data-structures binary-heap 1-mark

Answer key

3.5 Binary Search Tree (32) top

3.5.1 Binary Search Tree: GATE CSE 1996 | Question: 2.14 top

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-structures binary-search-tree normal

Answer key

3.5.2 Binary Search Tree: GATE CSE 1996 | Question: 4 top

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-structures binary-search-tree normal descriptive

Answer key

3.5.3 Binary Search Tree: GATE CSE 1997 | Question: 4.5 top

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-structures binary-search-tree normal

Answer key

3.5.4 Binary Search Tree: GATE CSE 2001 | Question: 14 top

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 ________;

}
```

gatecse-2001 data-structures binary-search-tree normal descriptive

Answer key

3.5.5 Binary Search Tree: GATE CSE 2003 | Question: 19, ISRO2009-24 top

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. $9\ 8\ 6\ 4\ 2\ 3\ 0\ 1\ 5\ 7$

gatecse-2003 binary-search-tree easy isro2009

Answer key

3.5.6 Binary Search Tree: GATE CSE 2003 | Question: 6 top

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. $n-k-2$

gatecse-2003 normal binary-search-tree

Answer key

3.5.7 Binary Search Tree: GATE CSE 2003 | Question: 63, ISRO2009-25 top

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

gatecse-2003 data-structures easy isro2009 binary-search-tree

Answer key

3.5.8 Binary Search Tree: GATE CSE 2004 | Question: 4, ISRO2009-26 top

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

gatecse-2004 data-structures binary-search-tree easy isro2009

Answer key

3.5.9 Binary Search Tree: GATE CSE 2004 | Question: 85 top

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. $\Theta(n^2 \log n)$

gatecse-2004 binary-search-tree normal data-structures

Answer key

3.5.10 Binary Search Tree: GATE CSE 2005 | Question: 33 top

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. $95, 50, 60, 40, 27, 23, 22, 25, 10, 9, 15, 29$

gatecse-2005 data-structures binary-search-tree easy

Answer key

3.5.11 Binary Search Tree: GATE CSE 2008 | Question: 46 top

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

gatecse-2008 data-structures binary-search-tree normal

Answer key

3.5.12 Binary Search Tree: GATE CSE 2012 | Question: 5 top

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. $\Theta(\log n)$

gatecse-2012 data-structures normal binary-search-tree

Answer key

3.5.13 Binary Search Tree: GATE CSE 2013 | Question: 43 top

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. $15, 10, 23, 25, 20, 35, 42, 39, 30$

gatecse-2013 data-structures binary-search-tree normal

Answer key

3.5.14 Binary Search Tree: GATE CSE 2013 | Question: 7 top

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. $O(n \log n)$

gatecse-2013 data-structures easy binary-search-tree

Answer key

3.5.15 Binary Search Tree: GATE CSE 2014 Set 3 | Question: 39 top

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 _____.

gatecse-2014-set3 data-structures binary-search-tree numerical-answers normal

Answer key

3.5.16 Binary Search Tree: GATE CSE 2015 Set 1 | Question: 10 top

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

gatecse-2015-set1 data-structures binary-search-tree easy

Answer key

3.5.17 Binary Search Tree: GATE CSE 2015 Set 1 | Question: 23 top

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

gatecse-2015-set1 data-structures binary-search-tree easy

Answer key

3.5.18 Binary Search Tree: GATE CSE 2015 Set 3 | Question: 13 top

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

gatecse-2015-set3 data-structures binary-search-tree easy

Answer key

3.5.19 Binary Search Tree: GATE CSE 2016 Set 2 | Question: 40 top

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.

gatecse-2016-set2 data-structures binary-search-tree normal numerical-answers

Answer key

3.5.20 Binary Search Tree: GATE CSE 2017 Set 1 | Question: 6 top

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.

gatecse-2017-set1 data-structures binary-search-tree easy

Answer key

3.5.21 Binary Search Tree: GATE CSE 2017 Set 2 | Question: 36 top

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. $7, 6, 2, 10, 9, 8, 15, 16, 17, 20, 19, 12$

gatecse-2017-set2 data-structures binary-search-tree

Answer key

3.5.22 Binary Search Tree: GATE CSE 2020 | Question: 41 top

In a balanced binary search tree with n elements, what is the worst case time complexity of reporting all elements in range $[a, b]$? Assume that the number of reported elements is k.

A. $\Theta(\log n)$
B. $\Theta(\log n + k)$
C. $\Theta(k \log n)$
D. $\Theta(n \log k)$

gatecse-2020 data-structures binary-search-tree 2-marks

Answer key

3.5.23 Binary Search Tree: GATE CSE 2020 | Question: 5 top

The preorder traversal of a binary search tree is $15, 10, 12, 11, 20, 18, 16, 19$. Which one of the following is the postorder traversal of the tree?

A. $10, 11, 12, 15, 16, 18, 19, 20$
B. $11, 12, 10, 16, 19, 18, 20, 15$
C. $20, 19, 18, 16, 15, 12, 11, 10$
D. $19, 16, 18, 20, 11, 12, 10, 15$

gatecse-2020 binary-search-tree 1-mark

Answer key

3.5.24 Binary Search Tree: GATE CSE 2021 Set 1 | Question: 10 top

A binary search tree T contains n distinct elements. What is the time complexity of picking an element in T that is smaller than the maximum element in T?

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

gatecse-2021-set1 data-structures binary-search-tree time-complexity 1-mark

Answer key

3.5.25 Binary Search Tree: GATE CSE 2022 | Question: 18 top

Suppose a binary search tree with 1000 distinct elements is also a complete binary tree. The tree is stored using the array representation of binary heap trees. Assuming that the array indices start with 0, the 3rd largest element of the tree is stored at index _____ .

gatecse-2022 numerical-answers data-structures binary-search-tree 1-mark

Answer key

3.5.26 Binary Search Tree: GATE IT 2005 | Question: 12 top

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. $n-p+1$

gateit-2005 data-structures normal binary-search-tree

Answer key

3.5.27 Binary Search Tree: GATE IT 2005 | Question: 55 top

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. $2, 1, 4, 3, 7, 8, 6, 5$

gateit-2005 data-structures binary-search-tree normal

Answer key

3.5.28 Binary Search Tree: GATE IT 2006 | Question: 45 top

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. $\{79, 14, 72, 56, 16, 53, 55\}$

gateit-2006 data-structures binary-search-tree normal

Answer key

3.5.29 Binary Search Tree: GATE IT 2007 | Question: 29 top

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

gateit-2007 data-structures binary-search-tree normal

Answer key

3.5.30 Binary Search Tree: GATE IT 2008 | Question: 71 top

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

gateit-2008 data-structures binary-search-tree normal

Answer key

3.5.31 Binary Search Tree: GATE IT 2008 | Question: 72 top

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

gateit-2008 data-structures binary-search-tree easy

Answer key

3.5.32 Binary Search Tree: GATE IT 2008 | Question: 73 top

How many distinct BSTs can be constructed with 3 distinct keys?

A. 4 B. 5 C. 6 D. 9

gateit-2008 data-structures binary-search-tree normal

Answer key

3.6 Binary Tree (51) top

3.6.1 Binary Tree: GATE CSE 1987 | Question: 2c top

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-structures normal true-false

Answer key

3.6.2 Binary Tree: GATE CSE 1987 | Question: 2g top

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-structures binary-tree true-false

Answer key

3.6.3 Binary Tree: GATE CSE 1987 | Question: 7b top

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-structures binary-tree descriptive

Answer key

3.6.4 Binary Tree: GATE CSE 1988 | Question: 7i top

Define the height of a binary tree or subtree and also define a height-balanced (AVL) tree.

gate1988 normal descriptive data-structures binary-tree

Answer key

3.6.5 Binary Tree: GATE CSE 1988 | Question: 7ii top

Mark the balance factor of each on the tree given on the below figure and state whether it is height-balanced.

gate1988 data-structures normal descriptive binary-tree

Answer key

3.6.6 Binary Tree: GATE CSE 1988 | Question: 7iii top

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-structures binary-tree

Answer key

3.6.7 Binary Tree: GATE CSE 1990 | Question: 3-iv top

The total external path length, EPL, of a binary tree with n external nodes is, $\text{EPL} = \sum_{w} I_w$, 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-structures binary-tree multiple-selects

Answer key

3.6.8 Binary Tree: GATE CSE 1991 | Question: 01,viii top

The weighted external path length of the binary tree in figure is _____

gate1991 binary-tree data-structures normal numerical-answers

Answer key

3.6.9 Binary Tree: GATE CSE 1991 | Question: 1,ix top

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-structures descriptive

Answer key

3.6.10 Binary Tree: GATE CSE 1991 | Question: 14,a top

Consider the binary tree in the figure below:

What structure is represented by the binary tree?

gate1991 data-structures binary-tree time-complexity normal descriptive

Answer key

3.6.11 Binary Tree: GATE CSE 1991 | Question: 14,b top

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-structures binary-tree normal descriptive

Answer key

3.6.12 Binary Tree: GATE CSE 1991 | Question: 14,c top

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-structures binary-tree time-complexity descriptive

Answer key

3.6.13 Binary Tree: GATE CSE 1993 | Question: 16 top

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-structures binary-tree normal descriptive

Answer key

3.6.14 Binary Tree: GATE CSE 1994 | Question: 8 top

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-structures binary-tree normal descriptive

Answer key

3.6.15 Binary Tree: GATE CSE 1995 | Question: 1.17 top

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-structures binary-tree normal

Answer key

3.6.16 Binary Tree: GATE CSE 1995 | Question: 6 top

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-structures binary-tree normal descriptive

Answer key

3.6.17 Binary Tree: GATE CSE 1996 | Question: 1.14 top

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-structures binary-tree normal

Answer key

3.6.18 Binary Tree: GATE CSE 1996 | Question: 1.15 top

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-structures binary-tree easy

Answer key

3.6.19 Binary Tree: GATE CSE 1997 | Question: 16 top

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-structures binary-tree normal descriptive proof

Answer key

3.6.20 Binary Tree: GATE CSE 1998 | Question: 20 top

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-structures binary-tree descriptive

Answer key

3.6.21 Binary Tree: GATE CSE 2000 | Question: 1.14 top

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. $(1\,(2\,3\,NULL)\,(4\,5))$

gatecse-2000 data-structures binary-tree easy

Answer key

3.6.22 Binary Tree: GATE CSE 2000 | Question: 2.16 top

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

gatecse-2000 data-structures binary-tree normal

Answer key

3.6.23 Binary Tree: GATE CSE 2002 | Question: 2.12 top

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. $\log_{\frac{3}{2}} n$

gatecse-2002 data-structures binary-tree normal

Answer key

3.6.24 Binary Tree: GATE CSE 2002 | Question: 6 top

Draw all binary trees having exactly three nodes labeled A, B and C on which preorder traversal gives the sequence C, B, A.

gatecse-2002 data-structures binary-tree easy descriptive

Answer key

3.6.25 Binary Tree: GATE CSE 2004 | Question: 35 top

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

gatecse-2004 data-structures binary-tree normal

Answer key

3.6.26 Binary Tree: GATE CSE 2004 | Question: 43 top

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

gatecse-2004 data-structures binary-tree normal

Answer key

3.6.27 Binary Tree: GATE CSE 2006 | Question: 13 top

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. $2^n - 1$

gatecse-2006 data-structures binary-tree normal

Answer key

3.6.28 Binary Tree: GATE CSE 2007 | Question: 12 top

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}

gatecse-2007 data-structures binary-tree easy

Answer key

3.6.29 Binary Tree: GATE CSE 2007 | Question: 13 top

The maximum number of binary trees that can be formed with three unlabeled nodes is:

A. 1 B. 5 C. 4 D. 3

gatecse-2007 data-structures binary-tree normal

Answer key

3.6.30 Binary Tree: GATE CSE 2007 | Question: 39, UGCNET-June2015-II: 22 top

The inorder and preorder traversal of a binary tree are

$\mathrm{d\ b\ e\ a\ f\ c\ g}$ and $\mathrm{a\ b\ d\ e\ c\ f\ g}$, respectively

The postorder traversal of the binary tree is:

A. $\mathrm{d\ e\ b\ f\ g\ c\ a}$ B. $\mathrm{e\ d\ b\ g\ f\ c\ a}$

C. $\mathrm{e\ d\ b\ f\ g\ c\ a}$ D. $\mathrm{d\ e\ f\ g\ b\ c\ a}$

gatecse-2007 data-structures binary-tree normal ugcnetcse-june2015-paper2

Answer key

3.6.31 Binary Tree: GATE CSE 2007 | Question: 46 top

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

gatecse-2007 data-structures binary-tree normal

Answer key

3.6.32 Binary Tree: GATE CSE 2010 | Question: 10 top

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. $n-1$

gatecse-2010 data-structures binary-tree normal

Answer key

3.6.33 Binary Tree: GATE CSE 2011 | Question: 29 top

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. $\frac{1}{n+1}.^{2n}C_n$

gatecse-2011 binary-tree normal

Answer key

3.6.34 Binary Tree: GATE CSE 2012 | Question: 47 top

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**: $\max(h1,h2)$

gatecse-2012 data-structures binary-tree normal

Answer key

3.6.35 Binary Tree: GATE CSE 2014 Set 1 | Question: 12 top

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 _____.

gatecse-2014-set1 data-structures binary-tree numerical-answers normal

Answer key

3.6.36 Binary Tree: GATE CSE 2015 Set 1 | Question: 25 top

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

gatecse-2015-set1 data-structures binary-tree easy

Answer key

3.6.37 Binary Tree: GATE CSE 2015 Set 2 | Question: 10 top

A binary tree T has 20 leaves. The number of nodes in T having two children is _____.

gatecse-2015-set2 data-structures binary-tree normal numerical-answers

Answer key

3.6.38 Binary Tree: GATE CSE 2015 Set 3 | Question: 25 top

Consider a binary tree T that has 200 leaf nodes. Then the number of nodes in T that have exactly two children are _____.

gatecse-2015-set3 data-structures binary-tree normal numerical-answers

Answer key

3.6.39 Binary Tree: GATE CSE 2016 Set 2 | Question: 36 top

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. $1\ 7\ 6 * + 2\ 5\ 4\ 3\ *\ - \wedge -$

gatecse-2016-set2 data-structures binary-tree normal

Answer key

3.6.40 Binary Tree: GATE CSE 2018 | Question: 20 top

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 _____

gatecse-2018 data-structures binary-tree numerical-answers 1-mark

Answer key

3.6.41 Binary Tree: GATE CSE 2019 | Question: 46 top

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) _____.

gatecse-2019 numerical-answers data-structures binary-tree 2-marks

Answer key

3.6.42 Binary Tree: GATE CSE 2021 Set 2 | Question: 16 top

Consider a complete binary tree with 7 nodes. Let A denote the set of first 3 elements obtained by performing Breadth-First Search (BFS) starting from the root. Let B denote the set of first 3 elements obtained by performing Depth-First Search (DFS) starting from the root.

The value of $|A - B|$ is _____

gatecse-2021-set2 numerical-answers data-structures binary-tree 1-mark

Answer key

3.6.43 Binary Tree: GATE CSE 2023 | Question: 37 top

Consider the C function foo and the binary tree shown.

```
typedef struct node {
   int val;
   struct node *left, *right;
} node;

int foo(node *p) {
   int retval;
   if (p == NULL)
      return 0;
   else {
      retval = p->val + foo(p->left) + foo(p->right);
      printf("%d ", retval);
      return retval;
   }
}
```

When foo is called with a pointer to the root node of the given binary tree, what will it print?

A. $3\ 8\ 5\ 13\ 11\ 10$
B. $3\ 5\ 8\ 10\ 11\ 13$
C. $3\ 8\ 16\ 13\ 24\ 50$
D. $3\ 16\ 8\ 50\ 24\ 13$

gatecse-2023 data-structures binary-tree 2-marks

Answer key

3.6.44 Binary Tree: GATE IT 2004 | Question: 54 top

Which one of the following binary trees has its inorder and preorder traversals as $BCAD$ and $ABCD$, respectively?

A.

B.

C.

D.

gateit-2004 binary-tree easy data-structures

Answer key

3.6.45 Binary Tree: GATE IT 2005 | Question: 50 top

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

gateit-2005 data-structures binary-tree normal

Answer key

3.6.46 Binary Tree: GATE IT 2006 | Question: 71 top

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. $\left\lceil \frac{i}{2} \right\rceil - 1$

gateit-2006 data-structures binary-tree normal

Answer key

3.6.47 Binary Tree: GATE IT 2006 | Question: 73 top

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. $\lceil \log_2 i \rceil$

gateit-2006 data-structures binary-tree normal

Answer key

3.6.48 Binary Tree: GATE IT 2006 | Question: 9 top

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

gateit-2006 data-structures binary-tree normal

Answer key

3.6.49 Binary Tree: GATE IT 2008 | Question: 46 top

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

gateit-2008 data-structures normal binary-tree

Answer key

3.6.50 Binary Tree: GATE IT 2008 | Question: 76 top

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. $n_2 - 1$

gateit-2008 data-structures binary-tree normal

Answer key

3.6.51 Binary Tree: GATE IT 2008 | Question: 77 top

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. $n_2 + n_1 - 2$

gateit-2008 data-structures binary-tree normal

Answer key

3.7 Data Structures (3) top

3.7.1 Data Structures: GATE CSE 1997 | Question: 6.2 top

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-structures normal graph-theory

Answer key

3.7.2 Data Structures: GATE CSE 2014 Set 1 | Question: 3 top

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 $E_3 = \{(u, v) |$ 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

gatecse-2014-set1 data-structures graph-theory ambiguous

Answer key

3.7.3 Data Structures: GATE CSE 2016 Set 1 | Question: 38 top

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 _____.

gatecse-2016-set1 data-structures graph-theory normal numerical-answers

Answer key

3.8 Graph Search (1) top

3.8.1 Graph Search: GATE CSE 1989 | Question: 3-ixa top

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 multiple-selects

Answer key

3.9 Hashing (15) top

3.9.1 Hashing: GATE CSE 1996 | Question: 1.13 top

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-structures hashing normal

Answer key

3.9.2 Hashing: GATE CSE 1996 | Question: 15 top

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

$$h(x) = (ord(x) - ord(\text{“}a\text{”}) + 1) \mod 10$$

and linear probing to resolve collisions.

A. Which insertions cause collisions?
B. Display the final hash table.

gate1996 data-structures hashing normal descriptive

Answer key

3.9.3 Hashing: GATE CSE 1997 | Question: 12 top

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 Kth 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 Kth insertion?

gate1997 data-structures hashing probability normal descriptive

Answer key

3.9.4 Hashing: GATE CSE 2004 | Question: 7 top

Given the following input $(4322, 1334, 1471, 9679, 1989, 6171, 6173, 4199)$ and the hash function x mod 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

gatecse-2004 data-structures hashing easy

Answer key

3.9.5 Hashing: GATE CSE 2007 | Question: 40 top

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

gatecse-2007 data-structures hashing easy

Answer key

3.9.6 Hashing: GATE CSE 2009 | Question: 36 top

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	

gatecse-2009 data-structures hashing normal

Answer key

3.9.7 Hashing: GATE CSE 2010 | Question: 52 top

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. $42, 46, 33, 23, 34, 52$

gatecse-2010 data-structures hashing normal

Answer key

3.9.8 Hashing: GATE CSE 2010 | Question: 53 top

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-structures hashing normal gatecse-2010

Answer key

3.9.9 Hashing: GATE CSE 2014 Set 1 | Question: 40 top

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

gatecse-2014-set1 data-structures hashing normal

Answer key

3.9.10 Hashing: GATE CSE 2014 Set 3 | Question: 40 top

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. $(97 \times 96 \times 95/(3! \times 100^3)$

gatecse-2014-set3 data-structures hashing probability normal

Answer key

3.9.11 Hashing: GATE CSE 2015 Set 2 | Question: 33 top

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. $h(i) = i^2 \bmod 10$
B. $h(i) = i^3 \bmod 10$

C. $h(i) = (11 * i^2) \bmod 10$

D. $h(i) = (12 * i^2) \bmod 10$

gatecse-2015-set2 data-structures hashing normal

Answer key

3.9.12 Hashing: GATE CSE 2015 Set 3 | Question: 17 top

Given that hash table T with 25 slots that stores 2000 elements, the load factor a for T is _____.

gatecse-2015-set3 data-structures hashing normal numerical-answers

Answer key

3.9.13 Hashing: GATE IT 2006 | Question: 20 top

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

gateit-2006 data-structures hashing normal

Answer key

3.9.14 Hashing: GATE IT 2007 | Question: 28 top

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

gateit-2007 data-structures hashing probability normal

Answer key

3.9.15 Hashing: GATE IT 2008 | Question: 48 top

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

gateit-2008 data-structures hashing normal

Answer key

3.10 Heap (24) top

3.10.1 Heap: GATE CSE 1990 | Question: 2-viii top

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)	$O(n \log_2 n)$

gate1990 match-the-following data-structures heap

Answer key

3.10.2 Heap: GATE CSE 1996 | Question: 2.11 top

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-structures heap easy

Answer key

3.10.3 Heap: GATE CSE 1999 | Question: 12 top

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-structures heap normal descriptive

Answer key

3.10.4 Heap: GATE CSE 2001 | Question: 1.15 top

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. $\frac{(i+1)}{2}$

gatecse-2001 data-structures heap easy

Answer key

3.10.5 Heap: GATE CSE 2003 | Question: 23 top

In a min-heap with n elements with the smallest element at the root, the 7th smallest element can be found in time

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

gatecse-2003 data-structures heap

Answer key

3.10.6 Heap: GATE CSE 2004 | Question: 37 top

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.

gatecse-2004 data-structures heap normal

Answer key

3.10.7 Heap: GATE CSE 2005 | Question: 34 top

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. $10,8,7,3,2,1,5$

gatecse-2005 data-structures heap normal

Answer key

3.10.8 Heap: GATE CSE 2006 | Question: 10 top

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. $O(1)$

gatecse-2006 data-structures heap easy

Answer key

3.10.9 Heap: GATE CSE 2006 | Question: 76 top

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. $9,5,6,8,3,1$

gatecse-2006 data-structures heap normal

Answer key

3.10.10 Heap: GATE CSE 2006 | Question: 77 top

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. $9,5,6,8,3,1$

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. $10,8,6,9,7,2,3,4,1,5$

gatecse-2006 data-structures heap normal

Answer key

3.10.11 Heap: GATE CSE 2007 | Question: 47 top

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. $\Theta(n \log_2 n)$

gatecse-2007 data-structures heap normal

Answer key

3.10.12 Heap: GATE CSE 2009 | Question: 59 top

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. $\{25,14,12,13,10,8,16\}$

gatecse-2009 data-structures heap normal

Answer key

3.10.13 Heap: GATE CSE 2009 | Question: 60 top

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. $\{14,13,12,8,10\}$

gatecse-2009 data-structures heap normal

Answer key

3.10.14 Heap: GATE CSE 2011 | Question: 23 top

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.

gatecse-2011 data-structures heap easy

Answer key

3.10.15 Heap: GATE CSE 2014 Set 2 | Question: 12 top

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. $10,8,7,5,3,2,1$

gatecse-2014-set2 data-structures heap normal

Answer key

3.10.16 Heap: GATE CSE 2015 Set 1 | Question: 32 top

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. $40,35,20,10,15,16,17,8,4,30$

gatecse-2015-set1 data-structures heap easy

Answer key

3.10.17 Heap: GATE CSE 2015 Set 2 | Question: 17 top

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. $\Omega(n^2)$

gatecse-2015-set2 data-structures heap normal

Answer key

3.10.18 Heap: GATE CSE 2015 Set 3 | Question: 19 top

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

gatecse-2015-set3 data-structures heap normal

Answer key

3.10.19 Heap: GATE CSE 2016 Set 1 | Question: 37 top

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 $O(2^d)$

gatecse-2016-set1 data-structures heap normal

Answer key

3.10.20 Heap: GATE CSE 2016 Set 2 | Question: 34 top

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 _____.

gatecse-2016-set2 data-structures heap normal numerical-answers

Answer key

3.10.21 Heap: GATE CSE 2019 | Question: 40 top

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 the above statements are TRUE?

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

gatecse-2019 data-structures heap 2-marks

Answer key

3.10.22 Heap: GATE IT 2004 | Question: 53 top

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. $O(n \log n)$

gateit-2004 data-structures heap normal

Answer key

3.10.23 Heap: GATE IT 2006 | Question: 44 top

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. $\{23, 17, 14, 7, 13, 10, 1, 12, 5, 7\}$

gateit-2006 data-structures heap easy

Answer key

3.10.24 Heap: GATE IT 2006 | Question: 72 top

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. $O(n \log \log n)$

gateit-2006 data-structures heap easy

Answer key

3.11 Infix Prefix (5) top

3.11.1 Infix Prefix: GATE CSE 1989 | Question: 4-ii top

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 data-structures stack infix-prefix

Answer key

3.11.2 Infix Prefix: GATE CSE 1997 | Question: 1.7 top

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-prefix stack data-structures

Answer key

3.11.3 Infix Prefix: GATE CSE 1998 | Question: 19b top

Compute the post fix equivalent of the following expression $3^* \log(x+1) - \frac{a}{2}$

gate1998 stack infix-prefix descriptive

Answer key

3.11.4 Infix Prefix: GATE CSE 2004 | Question: 38, ISRO2009-27 top

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. $- + a \times bc \hat{} \hat{} def$

gatecse-2004 stack isro2009 infix-prefix

Answer key

3.11.5 Infix Prefix: GATE CSE 2007 | Question: 38, ISRO2016-27 top

The following postfix expression with single digit operands is evaluated using a stack:

$$8\,2\,3\,\hat{}\,/\,2\,3\,*\,+\,5\,1\,*\,-$$

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. $1, 5$

gatecse-2007 data-structures stack normal infix-prefix isro2016

Answer key

3.12 Linked List (22) top

3.12.1 Linked List: GATE CSE 1987 | Question: 1-xv top

In a circular linked list organization, insertion of a record involves modification of

A. One pointer.
B. Two pointers.
C. Multiple pointers.
D. No pointer.

gate1987 data-structures linked-list

Answer key

3.12.2 Linked List: GATE CSE 1987 | Question: 6a top

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-structures linked-list descriptive

Answer key

3.12.3 Linked List: GATE CSE 1993 | Question: 13 top

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 jth 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-structures linked-list normal descriptive

Answer key

3.12.4 Linked List: GATE CSE 1994 | Question: 1.17, UGCNET-Sep2013-II: 32 top

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-structures linked-list normal ugcnetsep2013ii

Answer key

3.12.5 Linked List: GATE CSE 1995 | Question: 2.22 top

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-structures linked-list hashing

Answer key

3.12.6 Linked List: GATE CSE 1997 | Question: 1.4 top

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-structures linked-list easy

Answer key

3.12.7 Linked List: GATE CSE 1997 | Question: 18 top

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-structures linked-list normal descriptive

Answer key

3.12.8 Linked List: GATE CSE 1998 | Question: 19a top

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-structures linked-list normal descriptive

Answer key

3.12.9 Linked List: GATE CSE 1999 | Question: 11b top

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-structures linked-list descriptive

Answer key

3.12.10 Linked List: GATE CSE 2002 | Question: 1.5 top

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

gatecse-2002 easy data-structures linked-list

Answer key

3.12.11 Linked List: GATE CSE 2003 | Question: 90 top

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

gatecse-2003 data-structures linked-list normal

Answer key

3.12.12 Linked List: GATE CSE 2004 | Question: 36 top

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

gatecse-2004 data-structures linked-list normal

Answer key

3.12.13 Linked List: GATE CSE 2004 | Question: 40 top

Suppose each set is represented as a linked list with elements in arbitrary order. Which of the operations among $\text{union}, \text{intersection}, \text{membership}, \text{cardinality}$ will be the slowest?

A. union only
B. $\text{intersection}, \text{membership}$

C. membership, cardinality

D. union, intersection

gatecse-2004 data-structures linked-list normal

Answer key

3.12.14 Linked List: GATE CSE 2008 | Question: 62 top

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. $2, 3, 4, 5, 6, 7, 1$

gatecse-2008 data-structures linked-list normal

Answer key

3.12.15 Linked List: GATE CSE 2010 | Question: 36 top

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. $q \rightarrow next = NULL; p \rightarrow next = head; head = p;$

gatecse-2010 data-structures linked-list normal

Answer key

3.12.16 Linked List: GATE CSE 2016 Set 2 | Question: 15 top

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. $\Theta(N^2 \log N)$

gatecse-2016-set2 data-structures linked-list time-complexity normal algorithms

Answer key

3.12.17 Linked List: GATE CSE 2017 Set 1 | Question: 08 top

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.

gatecse-2017-set1 data-structures linked-list normal

Answer key

3.12.18 Linked List: GATE CSE 2020 | Question: 16 top

What is the worst case time complexity of inserting n elements into an empty linked list, if the linked list needs to be maintained in sorted order?

A. $\Theta(n)$ B. $\Theta(n \log n)$ C. $\Theta(n)^2$ D. $\Theta(1)$

gatecse-2020 linked-list 1-mark

Answer key

3.12.19 Linked List: GATE CSE 2022 | Question: 5 top

Consider the problem of reversing a singly linked list. To take an example, given the linked list below,

the reversed linked list should look like

Which one of the following statements is TRUE about the time complexity of algorithms that solve the above problem in $O(1)$ space?

A. The best algorithm for the problem takes $\theta(n)$ time in the worst case.
B. The best algorithm for the problem takes $\theta(n \log n)$ time in the worst case.
C. The best algorithm for the problem takes $\theta(n^2)$ time in the worst case.
D. It is not possible to reverse a singly linked list in $O(1)$ space.

gatecse-2022 data-structures linked-list 1-mark

Answer key

3.12.20 Linked List: GATE CSE 2023 | Question: 3 top

Let **SLLdel** be a function that deletes a node in a singly-linked list given a pointer to the node and a pointer to the head of the list. Similarly, let **DLLdel** be another function that deletes a node in a doubly-linked list given a pointer to the node and a pointer to the head of the list.
Let n denote the number of nodes in each of the linked lists. Which one of the following choices is TRUE about the worst-case time complexity of **SLLdel** and **DLLdel**?

A. **SLLdel** is $O(1)$ and **DLLdel** is $O(n)$
B. Both **SLLdel** and **DLLdel** are $O(\log(n))$
C. Both **SLLdel** and **DLLdel** are $O(1)$
D. **SLLdel** is $O(n)$ and **DLLdel** is $O(1)$

gatecse-2023 data-structures linked-list 1-mark

Answer key

3.12.21 Linked List: GATE IT 2004 | Question: 13 top

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. $O(1)$

gateit-2004 data-structures linked-list normal ambiguous

Answer key

3.12.22 Linked List: GATE IT 2005 | Question: 54 top

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. $2,3,4,5,6,7,1$

gateit-2005 data-structures linked-list normal

Answer key

3.13 Priority Queue (2) top

3.13.1 Priority Queue: GATE CSE 1997 | Question: 4.7 top

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-structures stack normal priority-queue

Answer key

3.13.2 Priority Queue: GATE CSE 2023 | Question: 36 top

Let A be a priority queue for maintaining a set of elements. Suppose A is implemented using a max-heap data structure. The operation $\text{EXTRACT-MAX}(A)$ extracts and deletes the maximum element from A. The operation $\text{INSERT}(A, key)$ inserts a new element key in A. The properties of a max-heap are preserved at the end of each of these operations.

When A contains n elements, which one of the following statements about the worst case running time of these two operations is TRUE?

A. Both $\text{EXTRACT-MAX}(A)$ and $\text{INSERT}(A, key)$ run in $O(1)$.
B. Both $\text{EXTRACT-MAX}(A)$ and $\text{INSERT}(A, key)$ run in $O(\log(n))$.
C. $\text{EXTRACT-MAX}(A)$ runs in $O(1)$ whereas $\text{INSERT}(A, key)$ runs in $O(n)$.
D. $\text{EXTRACT-MAX}(A)$ runs in $O(1)$ whereas $\text{INSERT}(A, key)$ runs in $O(\log(n))$.

gatecse-2023 data-structures priority-queue time-complexity 2-marks

Answer key

3.14 Queue (13) top

3.14.1 Queue: GATE CSE 1992 | Question: 09 top

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-structures normal descriptive queue

Answer key

3.14.2 Queue: GATE CSE 1994 | Question: 26 top

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-structures queue stack normal descriptive

Answer key

3.14.3 Queue: GATE CSE 1996 | Question: 1.12 top

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-structures easy queue stack linked-list

Answer key

3.14.4 Queue: GATE CSE 2001 | Question: 2.16 top

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

gatecse-2001 data-structures easy stack queue

Answer key

3.14.5 Queue: GATE CSE 2006 | Question: 49 top

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 $2m \leq y \leq 2n$

gatecse-2006 data-structures queue stack normal

Answer key

3.14.6 Queue: GATE CSE 2012 | Question: 35 top

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: $REAR == FRONT$

gatecse-2012 data-structures queue normal

Answer key

3.14.7 Queue: GATE CSE 2013 | Question: 44 top

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. $\Theta(n^2)$

gatecse-2013 data-structures algorithms normal queue

Answer key

3.14.8 Queue: GATE CSE 2016 Set 1 | Question: 10 top

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 $\Omega(\log n)$

gatecse-2016-set1 data-structures queue normal

Answer key

3.14.9 Queue: GATE CSE 2016 Set 1 | Question: 41 top

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 _____.

gatecse-2016-set1 data-structures queue difficult numerical-answers

Answer key

3.14.10 Queue: GATE CSE 2017 Set 2 | Question: 13 top

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).

gatecse-2017-set2 data-structures queue

Answer key

3.14.11 Queue: GATE CSE 2018 | Question: 3 top

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. $\Theta(n), \Theta(n)$

gatecse-2018 algorithms data-structures queue normal linked-list 1-mark

Answer key

3.14.12 Queue: GATE CSE 2022 | Question: 52 top

Consider the queues Q_1 containing four elements and Q_2 containing none (shown as the **Initial State** in the figure). The only operations allowed on these two queues are **Enqueue (Q, element)** and **Dequeue (Q).** The minimum number of **Enqueue** operations on Q_1 required to place the elements of Q_1 in Q_2 in reverse order (shown as the **Final State** in the figure) without using any additional storage is_____.

gatecse-2022 numerical-answers data-structures queue 2-marks

Answer key

3.14.13 Queue: GATE IT 2007 | Question: 30 top

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

gateit-2007 data-structures queue normal

Answer key

3.15 Stack (15) top

3.15.1 Stack: GATE CSE 1991 | Question: 03,vii top

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-structures stack easy multiple-selects

Answer key

3.15.2 Stack: GATE CSE 1994 | Question: 1.14 top

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-structures stack normal

Answer key

3.15.3 Stack: GATE CSE 1995 | Question: 2.21 top

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-structures stack easy

Answer key

3.15.4 Stack: GATE CSE 2000 | Question: 13 top

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

gatecse-2000 data-structures stack normal descriptive

Answer key

3.15.5 Stack: GATE CSE 2003 | Question: 64 top

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. $Y+2X$

gatecse-2003 data-structures stack normal

Answer key

3.15.6 Stack: GATE CSE 2004 | Question: 3 top

A single array $A[1 \ldots \text{MAXSIZE}]$ is used to implement two stacks. The two stacks grow from opposite ends of the array. Variables $top1$ and $top2$ $(top1 < top2)$ 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. $(top1 = \text{MAXSIZE}/2)$ $(top2 = \text{MAXSIZE}/2+1)$
B. $top1 + top2 = \text{MAXSIZE}$
C. $(top1 = \text{MAXSIZE}/2)$ or $(top2 = \text{MAXSIZE})$
D. $top1 = top2 - 1$

gatecse-2004 data-structures stack easy

Answer key

3.15.7 Stack: GATE CSE 2004 | Question: 5 top

The best data structure to check whether an arithmetic expression has balanced parentheses is a

A. queue B. stack C. tree D. list

gatecse-2004 data-structures easy stack

Answer key

3.15.8 Stack: GATE CSE 2014 Set 2 | Question: 41 top

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.

gatecse-2014-set2 data-structures stack easy

Answer key

3.15.9 Stack: GATE CSE 2015 Set 2 | Question: 38 top

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 _____.

gatecse-2015-set2 data-structures stack easy numerical-answers

Answer key

3.15.10 Stack: GATE CSE 2015 Set 3 | Question: 12 top

The result evaluating the postfix expression $10\ 5 + 60\ 6 / * 8 -$ is

A. 284 B. 213 C. 142 D. 71

gatecse-2015-set3 data-structures stack normal

Answer key

3.15.11 Stack: GATE CSE 2021 Set 1 | Question: 21 top

Consider the following sequence of operations on an empty stack.

$$\text{push}(54); \text{push}(52); \text{pop}(); \text{push}(55); \text{push}(62); s = \text{pop}();$$

Consider the following sequence of operations on an empty queue.

$$\text{enqueue}(21); \text{enqueue}(24); \text{dequeue}(); \text{enqueue}(28); \text{enqueue}(32); q = \text{dequeue}();$$

The value of $s+q$ is _____.

gatecse-2021-set1 data-structures stack numerical-answers 1-mark

Answer key

3.15.12 Stack: GATE CSE 2023 | Question: 49 top

Consider a sequence a of elements $a_0 = 1, a_1 = 5, a_2 = 7, a_3 = 8, a_4 = 9,$ and $a_5 = 2$. The following operations are performed on a stack S and a queue Q, both of which are initially empty.

I. **push** the elements of a from a_0 to a_5 in that order into S.
II. **enqueue** the elements of a from a_0 to a_5 in that order into Q.
III. **pop** an element from S.
IV. **dequeue** an element from Q.
V. **pop** an element from S.
VI. **dequeue** an element from Q.
VII. **dequeue** an element from Q and push the same element into S.
VIII. Repeat operation VII three times.
IX. **pop** an element from S.
X. **pop** an element from S.

The top element of S after executing the above operations is _____.

gatecse-2023 data-structures stack numerical-answers 2-marks

Answer key

3.15.13 Stack: GATE IT 2004 | Question: 52 top

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. $cabd$

gateit-2004 data-structures normal stack

Answer key

3.15.14 Stack: GATE IT 2005 | Question: 13 top

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

gateit-2005 data-structures stack normal

Answer key

3.15.15 Stack: GATE IT 2007 | Question: 32 top

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?
$5\,2\,*\,3\,3\,2\,+*+$

A. 15 B. 25 C. 30 D. 150

gateit-2007 stack normal

Answer key

3.16 Tree (14) top

3.16.1 Tree: GATE CSE 1990 | Question: 13a top

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 data-structures tree descriptive

Answer key

3.16.2 Tree: GATE CSE 1992 | Question: 02,vii top

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 tree data-structures normal multiple-selects

Answer key

3.16.3 Tree: GATE CSE 1994 | Question: 5 top

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-structures tree proof descriptive

Answer key

3.16.4 Tree: GATE CSE 1998 | Question: 1.24 top

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-structures tree multiple-selects normal

Answer key

3.16.5 Tree: GATE CSE 1998 | Question: 2.11 top

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-structures tree normal

Answer key

3.16.6 Tree: GATE CSE 1998 | Question: 21 top

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-structures tree descriptive numerical-answers

Answer key

3.16.7 Tree: GATE CSE 2002 | Question: 2.9 top

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. $\frac{(2n+1)}{3}$

gatecse-2002 data-structures tree normal

Answer key

3.16.8 Tree: GATE CSE 2004 | Question: 6 top

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

gatecse-2004 data-structures tree easy

Answer key

3.16.9 Tree: GATE CSE 2005 | Question: 36 top

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. $n(k-1)$

gatecse-2005 data-structures tree normal

Answer key

3.16.10 Tree: GATE CSE 2007 | Question: 43 top

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

gatecse-2007 data-structures tree normal

Answer key

3.16.11 Tree: GATE CSE 2014 Set 3 | Question: 12 top

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. $SQPTRUWV$

gatecse-2014-set3 data-structures tree easy

Answer key

3.16.12 Tree: GATE CSE 2014 Set 3 | Question: 41 top

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

gatecse-2014-set3 data-structures tree normal

Answer key

3.16.13 Tree: GATE CSE 2017 Set 1 | Question: 20 top

Let T be a tree with 10 vertices. The sum of the degrees of all the vertices in T is _____

gatecse-2017-set1 data-structures tree numerical-answers

Answer key

3.16.14 Tree: GATE CSE 2021 Set 1 | Question: 41 top

An $articulation\ point$ in a connected graph is a vertex such that removing the vertex and its incident edges disconnects the graph into two or more connected components.

Let T be a DFS tree obtained by doing DFS in a connected undirected graph G.

Which of the following options is/are correct?

A. Root of T can never be an articulation point in G.
B. Root of T is an articulation point in G if and only if it has 2 or more children.
C. A leaf of T can be an articulation point in G.
D. If u is an articulation point in G such that x is an ancestor of u in T and y is a descendent of u in T, then all paths from x to y in G must pass through u.

gatecse-2021-set1 multiple-selects data-structures tree 2-marks

Answer key

Answer Keys

3.1.1	C	3.2.1	N/A	3.2.2	C	3.2.3	N/A	3.2.4	N/A
3.2.5	A	3.2.6	A	3.2.7	N/A	3.2.8	A	3.2.11	B
3.2.12	5	3.3.1	B	3.3.2	C	3.3.3	A	3.4.2	511
3.4.3	C	3.4.4	B	3.5.1	B	3.5.2	N/A	3.5.3	D
3.5.4	N/A	3.5.5	C	3.5.6	B	3.5.7	B	3.5.8	B
3.5.9	B	3.5.10	A	3.5.11	B	3.5.12	C	3.5.13	D
3.5.14	C	3.5.16	A	3.5.17	B	3.5.18	B	3.5.19	64
3.5.20	B	3.5.21	B	3.5.22	B	3.5.23	B	3.5.24	D
3.5.25	509	3.5.26	C	3.5.27	D	3.5.28	C	3.5.31	C
3.5.32	B	3.6.1	False	3.6.2	False	3.6.3	N/A	3.6.4	N/A
3.6.6	N/A	3.6.7	B	3.6.8	144	3.6.9	N/A	3.6.10	N/A
3.6.11	N/A	3.6.12	N/A	3.6.13	N/A	3.6.14	N/A	3.6.15	B
3.6.16	N/A	3.6.17	B	3.6.18	C	3.6.19	N/A	3.6.20	N/A
3.6.21	C	3.6.22	D	3.6.24	N/A	3.6.25	B	3.6.26	D
3.6.28	C	3.6.29	B	3.6.30	A	3.6.31	C	3.6.32	A
3.6.34	A	3.6.36	A	3.6.37	19	3.6.38	199	3.6.40	4
3.6.42	1 : 1	3.6.43	C	3.6.44	D	3.6.45	B	3.6.46	D
3.6.47	C	3.6.48	B	3.6.49	D	3.6.50	B	3.7.1	B
3.7.2	B	3.7.3	12	3.8.1	A;C;D	3.9.1	C	3.9.2	N/A
3.9.3	N/A	3.9.4	C	3.9.5	B	3.9.6	C	3.9.7	C
3.9.9	A	3.9.10	A	3.9.11	B	3.9.12	80	3.9.13	C
3.9.14	B	3.9.15	D	3.10.1	N/A	3.10.2	C	3.10.3	N/A
3.10.4	B	3.10.5	D	3.10.6	A	3.10.7	D	3.10.8	A
3.10.9	D	3.10.10	A	3.10.11	B	3.10.13	D	3.10.14	B
3.10.15	A	3.10.16	B	3.10.17	A	3.10.18	D	3.10.19	B
3.10.20	8	3.10.21	A	3.10.22	B	3.10.23	C	3.10.24	B
3.11.1	N/A	3.11.3	N/A	3.11.4	A	3.11.5	A	3.12.1	B
3.12.2	N/A	3.12.3	N/A	3.12.4	B	3.12.5	D	3.12.6	C
3.12.7	N/A	3.12.8	N/A	3.12.9	N/A	3.12.10	D	3.12.11	B
3.12.12	A	3.12.13	D	3.12.14	B	3.12.15	D	3.12.16	C
3.12.17	B	3.12.18	C	3.12.19	A	3.12.20	D	3.12.21	A
3.12.22	B	3.13.1	D	3.13.2	B	3.14.1	N/A	3.14.2	N/A
3.14.3	A	3.14.4	B	3.14.5	A	3.14.6	A	3.14.7	A
3.14.8	A	3.14.9	256	3.14.10	B	3.14.11	B	3.14.12	0

3.14.13	B
3.15.5	C
3.15.11	86 : 86
3.16.1	N/A
3.16.6	N/A
3.16.12	D

3.15.1	B
3.15.6	D
3.15.12	8
3.16.2	A;D
3.16.7	D
3.16.13	18

3.15.2	B
3.15.7	B
3.15.13	D
3.16.3	N/A
3.16.8	D
3.16.14	B

3.15.3	B
3.15.8	C
3.15.14	C
3.16.4	B;C
3.16.9	C

3.15.4	N/A
3.15.10	C
3.15.15	B
3.16.5	A
3.16.11	A

4 Programming and DS: Programming (114)

4.1 Aliasing (1) top

4.1.1 Aliasing: GATE CSE 2000 | Question: 1.16 top

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

gatecse-2000 programming easy aliasing

Answer key

4.2 Array (12) top

4.2.1 Array: GATE CSE 2011 | Question: 22 top

What does the following fragment of C program print?

```
char c[] = "GATE2011";
char *p = c;
printf("%s", p + p[3] - p[1]);
```

A. GATE2011 B. E2011 C. 2011 D. 011

gatecse-2011 programming programming-in-c normal array

Answer key

4.2.2 Array: GATE CSE 2015 Set 3 | Question: 30 top

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

gatecse-2015-set3 programming-in-c normal array

Answer key

4.2.3 Array: GATE CSE 2015 Set 3 | Question: 7 top

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

gatecse-2015-set3 programming programming-in-c normal array

Answer key

4.2.4 Array: GATE CSE 2017 Set 2 | Question: 55 top

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 _____

gatecse-2017-set2 programming-in-c numerical-answers array pointers

Answer key

4.2.5 Array: GATE CSE 2019 | Question: 24 top

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 _____

gatecse-2019 numerical-answers programming-in-c programming array 1-mark

Answer key

4.2.6 Array: GATE CSE 2020 | Question: 22 top

Consider the following C program.

```c
#include <stdio.h>
int main () {
   int  a[4] [5] = {{1, 2, 3, 4, 5},
                    {6, 7,8, 9, 10},
                    {11, 12, 13, 14, 15},
                    {16, 17,18, 19, 20}};
   printf("%d\n", *(*(a+**a+2)+3));
   return(0);
}
```

The output of the program is _____.

gatecse-2020 numerical-answers programming-in-c array 1-mark

Answer key

4.2.7 Array: GATE CSE 2021 Set 2 | Question: 10 top

Consider the following ANSI C program.

```c
#include <stdio.h>
int main()
{
   int arr[4][5];
   int  i, j;
   for (i=0; i<4; i++)
   {
      for (j=0; j<5; j++)
      {
         arr[i][j] = 10 * i + j;
      }
   }
   printf("%d", *(arr[1]+9));
   return 0;
}
```

What is the output of the above program?

A. 14 B. 20 C. 24 D. 30

gatecse-2021-set2 programming-in-c array output 1-mark

Answer key

4.2.8 Array: GATE CSE 2022 | Question: 33 top

What is printed by the following ANSI C program?

```c
#include<stdio.h>

int main (int argc, char *argv[])

{

      int a[3][3][3] =

      {{1, 2, 3, 4, 5, 6, 7, 8, 9},
       {10, 11, 12, 13, 14, 15, 16, 17, 18},
       {19, 20, 21, 22, 23, 24, 25, 26, 27}};

   int i = 0, j = 0, k = 0;

   for ( i = 0; i < 3; i ++) {

      for ( k = 0; k < 3; k++)

         printf("%d", a[i][j][k]);

      printf ("\n");
```

```
    }

    return 0;

}
```

A. $\begin{matrix} 1 & 2 & 3 \\ 10 & 11 & 12 \\ 19 & 20 & 21 \end{matrix}$

B. $\begin{matrix} 1 & 4 & 7 \\ 10 & 13 & 16 \\ 19 & 22 & 25 \end{matrix}$

C. $\begin{matrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{matrix}$

D. $\begin{matrix} 1 & 2 & 3 \\ 13 & 14 & 15 \\ 25 & 26 & 27 \end{matrix}$

gatecse-2022 programming programming-in-c array output 2-marks

Answer key

4.2.9 Array: GATE IT 2004 | Question: 58 top

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 (i = 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];
}
```

gateit-2004 programming easy programming-in-c array

Answer key

4.2.10 Array: GATE IT 2008 | Question: 49 top

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

gateit-2008 programming programming-in-c normal array

Answer key

4.2.11 Array: GATE IT 2008 | Question: 51 top

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. $3,3$

gateit-2008 programming programming-in-c normal array

Answer key

4.2.12 Array: GATE IT 2008 | Question: 52 top

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

gateit-2008 programming programming-in-c normal array

Answer key

4.3 Goto (2) top

4.3.1 Goto: GATE CSE 1989 | Question: 3-i top

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

Answer key

4.3.2 Goto: GATE CSE 1994 | Question: 1.5 top

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

Answer key

4.4 Identify Function (5) top

4.4.1 Identify Function: GATE CSE 1995 | Question: 3 top

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

Answer key

4.4.2 Identify Function: GATE CSE 1998 | Question: 2.13 top

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

Answer key

4.4.3 Identify Function: GATE CSE 2014 Set 2 | Question: 10 | Modified top

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:

a. 6
b. 9
c. Will loop forever
d. Depends on computer architecture

gatecse-2014-set2 algorithms identify-function numerical-answers easy

Answer key

4.4.4 Identify Function: GATE CSE 2017 Set 2 | Question: 43 top

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 _____

gatecse-2017-set2 programming algorithms numerical-answers identify-function

Answer key

4.4.5 Identify Function: GATE IT 2004 | Question: 15 top

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. $x = 1\%x;$

gateit-2004 programming easy identify-function

Answer key

4.5 Loop Invariants (8) top

4.5.1 Loop Invariants: GATE CSE 1987 | Question: 7a top

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 := 0;
   (*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 descriptive

Answer key

4.5.2 Loop Invariants: GATE CSE 1988 | Question: 6ii top

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

Answer key

4.5.3 Loop Invariants: GATE CSE 1988 | Question: 8ii top

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 statements and f as a function.

gate1988 programming descriptive loop-invariants

Answer key

4.5.4 Loop Invariants: GATE CSE 1991 | Question: 1,vi top

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 fill-in-the-blanks

Answer key

4.5.5 Loop Invariants: GATE CSE 2004 | Question: 32 top

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 ith 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** $\text{rev} = d_m\, \ldots\, d_2\, d_1$

gatecse-2004 programming loop-invariants normal

Answer key

4.5.6 Loop Invariants: GATE CSE 2015 Set 1 | Question: 33 top

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. $\{q + 1 < r - y \wedge y > 0\}$

gatecse-2015-set1 programming loop-invariants normal

Answer key

4.5.7 Loop Invariants: GATE CSE 2016 Set 2 | Question: 35 top

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. $X^Y = (res * a)^b$

gatecse-2016-set2 programming loop-invariants normal

Answer key

4.5.8 Loop Invariants: GATE CSE 2017 Set 2 | Question: 37 top

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. $(q == 0)\ \&\&\ (y > 0)$

gatecse-2017-set2 programming loop-invariants

Answer key

4.6 Output (2) top

4.6.1 Output: GATE CSE 2022 | Question: 34 top

What is printed by the following ANSI C program?

```
#include<stdio.h>

int main(int argc, char *argv[]) {

  char a = 'P';

  char b = 'x';

  char c = (a&b) + '*';

  char d = (a|b) – '-';

  char e = (a^b) + '+';

  printf("%c %c %c\n", c, d, e);

  return 0;

}
```

ASCII encoding for relevant characters is given below

A	B	C	...	Z
65	66	67	...	90

a	b	c	...	z
97	98	99	...	122

*	+	−
42	43	45

A. z K S B. 122 75 83 C. ∗ − + D. P x +

gatecse-2022 programming programming-in-c output 2-marks

Answer key

4.6.2 Output: GATE CSE 2023 | Question: 25 top

The integer value printed by the ANSI-C program given below is _____

```
#include<stdio.h>

int funcp(){
   static int x = 1;
   x++;
   return x;
}

int main(){
   int x,y;
   x = funcp();
   y = funcp()+x;
   printf("%d\n", (x+y));
   return 0;
}
```

gatecse-2023 programming programming-in-c output numerical-answers 1-mark

Answer key

4.7 Parameter Passing (12) top

4.7.1 Parameter Passing: GATE CSE 1992 | Question: 10b top

Show the activation records and the display structure just after the procedures called at lines marked x and y have started their execution. Be sure to indicate which of the two procedures named A you are referring to.

```
Program Test;
   Procedure A;
      Procedure B;
         Procedure A;
         begin
         ......
         end A;
      begin
         y: A;
      end B;
   begin
      B;
   end A;

begin
   x: A;
end Test
```

gate1992 parameter-passing programming runtime-environment normal descriptive

Answer key

4.7.2 Parameter Passing: GATE CSE 1994 | Question: 1.20 top

In which of the following cases is it possible to obtain different results for call-by-reference and call-by-name parameter passing methods?

A. Passing a constant value as a parameter
B. Passing the address of an array as a parameter
C. Passing an array element as a parameter
D. Passing an array

gate1994 programming parameter-passing easy

Answer key

4.7.3 Parameter Passing: GATE CSE 2001 | Question: 2.17 | UGCNET-AUG2016-III: 21 top

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

gatecse-2001 programming compiler-design parameter-passing normal runtime-environment ugcnetcse-aug2016-paper3

Answer key

4.7.4 Parameter Passing: GATE CSE 2003 | Question: 73 top

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. $115, 105$

gatecse-2003 compiler-design normal runtime-environment parameter-passing

Answer key

4.7.5 Parameter Passing: GATE CSE 2008 | Question: 60 top

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

gatecse-2008 programming programming-in-c normal parameter-passing

Answer key

4.7.6 Parameter Passing: GATE CSE 2010 | Question: 11 top

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. $0\ 2$

gatecse-2010 programming programming-in-c easy parameter-passing

Answer key

4.7.7 Parameter Passing: GATE CSE 2013 | Question: 42 top

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;
}
```

gatecse-2013 compiler-design normal marks-to-all numerical-answers parameter-passing runtime-environment

Answer key

4.7.8 Parameter Passing: GATE CSE 2016 Set 1 | Question: 15 top

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);
   printf("%d\n", a);
}
```

The output of the program is _____.

gatecse-2016-set1 programming-in-c easy numerical-answers parameter-passing

Answer key

4.7.9 Parameter Passing: GATE CSE 2016 Set 2 | Question: 12 top

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);
     printf ("%d", i+j);
    }
```

gatecse-2016-set2 programming-in-c normal numerical-answers parameter-passing

Answer key

4.7.10 Parameter Passing: GATE CSE 2018 | Question: 29 top

```
#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

gatecse-2018 programming-in-c pointers parameter-passing normal programming 2-marks

Answer key

4.7.11 Parameter Passing: GATE IT 2006 | Question: 50 top

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. $a = 6, b = 3$
$a = 15, b = 12$

gateit-2006 programming programming-in-c normal parameter-passing

Answer key

4.7.12 Parameter Passing: GATE IT 2008 | Question: 50 top

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. $4,4$

gateit-2008 programming programming-in-c normal parameter-passing

Answer key

4.8 Pointers (10) top

4.8.1 Pointers: GATE CSE 2000 | Question: 1.12 top

The most appropriate matching for the following pairs

$X:$	$\mathrm{m = malloc(5); m = NULL;}$	$1:$	using dangling pointers
$Y:$	$\mathrm{free(n); n\text{->}value = 5;}$	$2:$	using uninitialized pointers
$Z:$	$\mathrm{char\ *p\ ,\ *p = 'a'\ ;}$	$3:$	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. $X-3\ \ Y-1\ \ Z-2$

gatecse-2000 programming programming-in-c normal pointers

Answer key

4.8.2 Pointers: GATE CSE 2001 | Question: 2.18 top

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 $P3$

gatecse-2001 programming programming-in-c normal pointers

Answer key

4.8.3 Pointers: GATE CSE 2003 | Question: 2 top

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

gatecse-2003 programming programming-in-c easy pointers

Answer key

4.8.4 Pointers: GATE CSE 2003 | Question: 89 top

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. $7\ 6\ 6$

gatecse-2003 programming programming-in-c normal pointers

Answer key

4.8.5 Pointers: GATE CSE 2005 | Question: 1, ISRO2017-55 top

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

gatecse-2005 programming programming-in-c pointers easy isro2017

Answer key

4.8.6 Pointers: GATE CSE 2006 | Question: 57 top

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

gatecse-2006 programming programming-in-c normal pointers

Answer key

4.8.7 Pointers: GATE CSE 2014 Set 1 | Question: 10 top

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.

gatecse-2014-set1 programming programming-in-c easy pointers

Answer key

4.8.8 Pointers: GATE CSE 2015 Set 3 | Question: 26 top

Consider the following C program

```c
#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 _____.

gatecse-2015-set3 programming programming-in-c normal numerical-answers pointers

Answer key

4.8.9 Pointers: GATE CSE 2017 Set 1 | Question: 13 top

Consider the following C code:

```c
#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 $x == \text{NULL}$ and not as shown.
C. compiles successfully but execution may result in dangling pointer.
D. compiles successfully but execution may result in memory leak.

gatecse-2017-set1 programming-in-c programming pointers

Answer key

4.8.10 Pointers: GATE CSE 2022 | Question: 11 top

What is printed by the following ANSI C program?

```c
#include<stdio.h>

int main(int argc, char *argv[])

{

   int x = 1, z[2] = {10, 11};

   int *p = NULL;

   p = &x;

   *p = 10;
```

```
    p = &z[1];

    *(&z[0] + 1) += 3;

    printf("%d, %d, %d\n", x, z[0], z[1]);

    return 0;

}
```

A. $1, 10, 11$ B. $1, 10, 14$ C. $10, 14, 11$ D. $10, 10, 14$

gatecse-2022 programming programming-in-c pointers output 1-mark

Answer key

4.9 Programming Constructs (1) top

4.9.1 Programming Constructs: GATE CSE 1999 | Question: 2.5 top

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

Answer key

4.10 Programming In C (34) top

4.10.1 Programming In C: GATE CSE 2000 | Question: 2.20 top

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

gatecse-2000 programming programming-in-c easy

Answer key

4.10.2 Programming In C: GATE CSE 2002 | Question: 1.17 top

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.

gatecse-2002 programming programming-in-c easy descriptive

Answer key

4.10.3 Programming In C: GATE CSE 2002 | Question: 2.18 top

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

gatecse-2002 programming programming-in-c normal

Answer key

4.10.4 Programming In C: GATE CSE 2002 | Question: 2.8 top

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

gatecse-2002 programming-in-c programming easy

Answer key

4.10.5 Programming In C: GATE CSE 2004 | Question: 33 top

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

gatecse-2004 programming programming-in-c easy

Answer key

4.10.6 Programming In C: GATE CSE 2005 | Question: 32 top

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

gatecse-2005 programming programming-in-c compiler-design easy

Answer key

4.10.7 Programming In C: GATE CSE 2008 | Question: 18 top

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. $x = 5, y = 4, z = 5$

gatecse-2008 programming programming-in-c easy

Answer key

4.10.8 Programming In C: GATE CSE 2008 | Question: 61 top

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 $(getchar()! =' \backslash n')$

$?2$ is $getchar(c);$

B. $?1$ is $((c = getchar())! =' \backslash n')$

$?2$ is $getchar(c);$

C. $?1$ is $(c! =' \backslash n')$
$?2$ is $putchar(c);$

D. $?1$ is $((c = getchar())! =' \backslash n')$
$?2$ is $putchar(c);$

gatecse-2008 programming normal programming-in-c

Answer key

4.10.9 Programming In C: GATE CSE 2012 | Question: 3 top

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
B. Choice A
C. Choice A
Choice B No Choice
D. Program gives no output as it is erroneous

gatecse-2012 programming easy programming-in-c

Answer key

4.10.10 Programming In C: GATE CSE 2012 | Question: 48 top

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. $\begin{matrix} 3 & 1 \\ 4 & 1 \\ 4 & 2 \end{matrix}$ B. $\begin{matrix} 4 & 2 \\ 6 & 1 \\ 6 & 1 \end{matrix}$ C. $\begin{matrix} 4 & 2 \\ 6 & 2 \\ 2 & 0 \end{matrix}$ D. $\begin{matrix} 3 & 1 \\ 5 & 2 \\ 5 & 2 \end{matrix}$

gatecse-2012 programming programming-in-c normal

Answer key

4.10.11 Programming In C: GATE CSE 2012 | Question: 49 top

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. $\begin{matrix} 3 & 1 \\ 4 & 1 \\ 4 & 2 \end{matrix}$

B. $\begin{matrix} 4 & 2 \\ 6 & 1 \\ 6 & 1 \end{matrix}$

C. $\begin{matrix} 4 & 2 \\ 6 & 2 \\ 2 & 0 \end{matrix}$

D. $\begin{matrix} 4 & 2 \\ 4 & 2 \\ 2 & 0 \end{matrix}$

normal gatecse-2012 programming-in-c programming

Answer key

4.10.12 Programming In C: GATE CSE 2014 Set 2 | Question: 11 top

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. $p = n * (n-1) * (n-2)/6.0;$

gatecse-2014-set2 programming programming-in-c normal

Answer key

4.10.13 Programming In C: GATE CSE 2014 Set 2 | Question: 42 top

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 $j = 50$.

gatecse-2014-set2 programming programming-in-c

Answer key

4.10.14 Programming In C: GATE CSE 2015 Set 1 | Question: 11 top

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);
 }
```

gatecse-2015-set1 programming programming-in-c easy numerical-answers

Answer key

4.10.15 Programming In C: GATE CSE 2015 Set 1 | Question: 35 top

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. $2012, 4, 6$

gatecse-2015-set1 programming programming-in-c normal

Answer key

4.10.16 Programming In C: GATE CSE 2015 Set 2 | Question: 15 top

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. $DCBA$

gatecse-2015-set2 programming programming-in-c normal

Answer key

4.10.17 Programming In C: GATE CSE 2015 Set 3 | Question: 48 top

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 _____.

gatecse-2015-set3 programming programming-in-c normal numerical-answers

Answer key

4.10.18 Programming In C: GATE CSE 2015 Set 3 | Question: 54 top

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 _____.

gatecse-2015-set3 programming programming-in-c normal numerical-answers

Answer key

4.10.19 Programming In C: GATE CSE 2016 Set 1 | Question: 12 top

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. $f(i, *p)$

gatecse-2016-set1 programming-in-c easy

Answer key

4.10.20 Programming In C: GATE CSE 2016 Set 1 | Question: 34 top

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. $b\ !=a$

gatecse-2016-set1 programming-in-c normal

Answer key

4.10.21 Programming In C: GATE CSE 2017 Set 1 | Question: 53 top

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 _____ .

gatecse-2017-set1 programming programming-in-c normal numerical-answers

Answer key

4.10.22 Programming In C: GATE CSE 2017 Set 1 | Question: 55 top

The output of executing the following C program is _____ .

```
#include<stdio.h>
```

```c
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);
}
```

gatecse-2017-set1 programming programming-in-c normal numerical-answers

Answer key

4.10.23 Programming In C: GATE CSE 2017 Set 2 | Question: 2 top

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

gatecse-2017-set2 programming programming-in-c

Answer key

4.10.24 Programming In C: GATE CSE 2017 Set 2 | Question: 54 top

Consider the following C program.

```c
#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 _____

gatecse-2017-set2 programming-in-c numerical-answers

Answer key

4.10.25 Programming In C: GATE CSE 2018 | Question: 32 top

Consider the following C code. Assume that unsigned long int type length is 64 bits.

```c
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

gatecse-2018 programming-in-c normal programming 2-marks

Answer key

4.10.26 Programming In C: GATE CSE 2019 | Question: 27 top

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

gatecse-2019 programming-in-c programming 2-marks

Answer key

4.10.27 Programming In C: GATE CSE 2019 | Question: 52 top

Consider the following C program:

```
#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 _____

gatecse-2019 numerical-answers programming-in-c programming 2-marks

Answer key

4.10.28 Programming In C: GATE CSE 2019 | Question: 53 top

Consider the following C program:

```
#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 _____

gatecse-2019 numerical-answers programming-in-c programming 2-marks

Answer key

4.10.29 Programming In C: GATE CSE 2021 Set 1 | Question: 37 top

Consider the following ANSI C program.

```
#include <stdio.h>
int main()
{
    int i, j, count;
    count=0;
    i=0;
    for (j=-3; j<=3; j++)
    {
        if (( j >= 0) && (i++))
            count = count + j;
    }
    count = count +i;
    printf("%d", count);
    return 0;
}
```

Which one of the following options is correct?

A. The program will not compile successfully
B. The program will compile successfully and output 10 when executed
C. The program will compile successfully and output 8 when executed
D. The program will compile successfully and output 13 when executed

gatecse-2021-set1 programming-in-c 2-marks

Answer key

4.10.30 Programming In C: GATE IT 2004 | Question: 59 top

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. $32\ 32$

gateit-2004 programming programming-in-c normal

Answer key

4.10.31 Programming In C: GATE IT 2004 | Question: 60 top

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 $getchar()! =$ '\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 $putchar(c);$

gateit-2004 programming programming-in-c normal

Answer key

4.10.32 Programming In C: GATE IT 2005 | Question: 58 top

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. $a[i] - a[j] > S$

gateit-2005 programming normal programming-in-c

Answer key

4.10.33 Programming In C: GATE IT 2006 | Question: 51 top

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. $-12, -12, 27, -31, 56$

gateit-2006 programming programming-in-c normal

Answer key

4.10.34 Programming In C: GATE IT 2007 | Question: 31 top

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

gateit-2007 programming programming-in-c normal

Answer key

4.11 Programming Paradigms (2) top

4.11.1 Programming Paradigms: GATE CSE 2004 | Question: 1 top

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

gatecse-2004 programming easy programming-paradigms

Answer key

4.11.2 Programming Paradigms: GATE CSE 2004 | Question: 90 top

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. $P-3 \quad Q-4 \quad R-2 \quad S-1$

gatecse-2004 programming normal programming-paradigms

Answer key

4.12 Recursion (17) top

4.12.1 Recursion: GATE CSE 1991 | Question: 01,x top

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 numerical-answers

Answer key

4.12.2 Recursion: GATE CSE 1994 | Question: 21 top

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 descriptive

Answer key

4.12.3 Recursion: GATE CSE 2000 | Question: 16 top

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 $fib(n)$?

gatecse-2000 algorithms normal descriptive recursion

Answer key

4.12.4 Recursion: GATE CSE 2001 | Question: 13 top

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 $abc(s)$?

gatecse-2001 programming recursion normal descriptive

Answer key

4.12.5 Recursion: GATE CSE 2002 | Question: 11 top

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.

gatecse-2002 programming recursion descriptive

Answer key

4.12.6 Recursion: GATE CSE 2004 | Question: 31, ISRO2008-40 top

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

gatecse-2004 programming programming-in-c recursion easy isro2008

Answer key

4.12.7 Recursion: GATE CSE 2005 | Question: 81b top

```
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. $n!$

gatecse-2005 programming recursion normal

Answer key

4.12.8 Recursion: GATE CSE 2007 | Question: 42 top

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

gatecse-2007 programming recursion normal

Answer key

4.12.9 Recursion: GATE CSE 2014 Set 2 | Question: 40 top

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:_____.

gatecse-2014-set2 programming recursion numerical-answers normal

Answer key

4.12.10 Recursion: GATE CSE 2016 Set 1 | Question: 35 top

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. $3\,1\,2\,1\,1\,1\,2$

gatecse-2016-set1 programming-in-c recursion normal

Answer key

4.12.11 Recursion: GATE CSE 2016 Set 2 | Question: 37 top

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};
```

```
    printf(" %d", f(a, 5));
}
```

Note: $\max(x, y)$ returns the maximum of x and y.

The value printed by this program is _____.

gatecse-2016-set2 programming-in-c normal numerical-answers recursion

Answer key

4.12.12 Recursion: GATE CSE 2017 Set 1 | Question: 35 top

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 $\text{fun1}(5)$ is called is

A. 53423122233445
B. 53423120112233
C. 53423122132435
D. 53423120213243

gatecse-2017-set1 programming normal tricky recursion

Answer key

4.12.13 Recursion: GATE CSE 2017 Set 1 | Question: 36 top

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.

gatecse-2017-set1 programming-in-c programming normal recursion

Answer key

4.12.14 Recursion: GATE CSE 2018 | Question: 21 top

Consider the following C program:

```c
#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 _____.

gatecse-2018 programming-in-c numerical-answers recursion programming 1-mark

Answer key

4.12.15 Recursion: GATE CSE 2020 | Question: 46 top

Consider the following C functions.

```c
int fun1(int n) {
  static int i= 0;
  if (n > 0) {
    ++i;
    fun1(n-1);
  }
  return (i);
}
```

```c
int fun2(int n) {
  static int i= 0;
  if (n>0) {
    i = i+ fun1 (n) ;
    fun2(n-1) ;
  }
return (i);
}
```

The return value of $\mathrm{fun2}(5)$ is _____

gatecse-2020 numerical-answers programming-in-c recursion 2-marks

Answer key

4.12.16 Recursion: GATE CSE 2023 | Question: 26 top

Consider the following program:

```c
int main()      int f1()      int f2(int X)          int f3()
{               {             {                      {
  f1();           return(1);    f3();                  return(5);
  f2(2);        }             if(X==1)             }
  f3();                         return f1();
  return(0);                    else
}                               return (X*f2(X-1));
                              }
```

Which one of the following options represents the activation tree corresponding to the main function?

A.

B.

C.

D.

gatecse-2023 programming programming-in-c recursion 2-marks

Answer key

4.12.17 Recursion: GATE IT 2007 | Question: 27 top

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

gateit-2007 programming recursion normal

Answer key

4.13 Structure (5) top

4.13.1 Structure: GATE CSE 2000 | Question: 1.11 top

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

gatecse-2000 programming programming-in-c easy structure

Answer key

4.13.2 Structure: GATE CSE 2018 | Question: 2 top

Consider the following C program:

```c
#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'

gatecse-2018 programming-in-c programming structure pointers normal 1-mark

Answer key

4.13.3 Structure: GATE CSE 2021 Set 2 | Question: 35 top

Consider the following ANSI C program:

```c
#include <stdio.h>
#include <stdlib.h>
struct Node{
      int value;
      struct Node *next;};
int main( ) {
   struct Node *boxE, *head, *boxN; int index=0;
   boxE=head= (struct Node *) malloc(sizeof(struct Node));
   head → value = index;
   for (index =1; index<=3; index++){
      boxN = (struct Node *) malloc (sizeof(struct Node));
      boxE → next = boxN;
      boxN → value = index;
      boxE = boxN; }
for (index=0; index<=3; index++) {
   printf("Value at index %d is %d\n", index, head → value);
   head = head → next;
   printf("Value at index %d is %d\n", index+1, head → value); } }
```

Which one of the following statements below is correct about the program?

A. Upon execution, the program creates a linked-list of five nodes
B. Upon execution, the program goes into an infinite loop
C. It has a missing **return** which will be reported as an error by the compiler
D. It dereferences an uninitialized pointer that may result in a run-time error

gatecse-2021-set2 programming-in-c normal pointers structure 2-marks

Answer key

4.13.4 Structure: GATE IT 2004 | Question: 61 top

Consider the following C program:

```c
#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. $A\ B$
$U\ V$
$V\ W$
$U\ V$

gateit-2004 programming programming-in-c normal structure

Answer key

4.13.5 Structure: GATE IT 2006 | Question: 49 top

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

gateit-2006 programming programming-in-c normal structure

Answer key

4.14 Type Checking (1) top

4.14.1 Type Checking: GATE CSE 2003 | Question: 24 top

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

gatecse-2003 programming normal type-checking

Answer key

4.15 Union (1) top

4.15.1 Union: GATE CSE 2000 | Question: 1.17, ISRO2015-79 top

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

gatecse-2000 programming programming-in-c easy isro2015 union

Answer key

4.16 Variable Binding (1) top

4.16.1 Variable Binding: GATE IT 2007 | Question: 34, UGCNET-Dec2012-III: 52 top

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. $x = 20, y = 20$

gateit-2007 programming variable-binding normal ugcnetcse-dec2012-paper3

Answer key

Answer Keys

4.1.1	A	4.2.1	C	4.2.2	C	4.2.3	C	4.2.4	2
4.2.5	6	4.2.6	19	4.2.8	A	4.2.9	C	4.2.10	B
4.2.11	C	4.2.12	B	4.3.1	A	4.3.2	A	4.4.1	N/A
4.4.2	C	4.4.3	Q-Q	4.4.4	3	4.4.5	B	4.5.1	N/A
4.5.2	N/A	4.5.3	N/A	4.5.4	N/A	4.5.5	A	4.5.6	B
4.5.7	C	4.5.8	C	4.6.1	A	4.6.2	7	4.7.1	N/A
4.7.2	C	4.7.3	B	4.7.4	D	4.7.5	B	4.7.6	D
4.7.7	6561	4.7.8	2016	4.7.9	30	4.7.10	A	4.7.11	D
4.7.12	C	4.8.1	D	4.8.2	D	4.8.3	A	4.8.4	A
4.8.5	C	4.8.6	C	4.8.7	D	4.8.8	140	4.8.9	D
4.8.10	D	4.9.1	B	4.10.1	A	4.10.2	B	4.10.3	B
4.10.4	B	4.10.5	D	4.10.6	D	4.10.7	A	4.10.8	D
4.10.9	X	4.10.10	C	4.10.11	D	4.10.12	B	4.10.13	D
4.10.15	A	4.10.16	D	4.10.17	10	4.10.18	230	4.10.19	D
4.10.20	D	4.10.21	3	4.10.22	23	4.10.23	A	4.10.24	0
4.10.25	B	4.10.26	B	4.10.27	5	4.10.28	10	4.10.29	B
4.10.30	A	4.10.31	D	4.10.32	B	4.10.33	A	4.11.1	C
4.11.2	D	4.12.1	41	4.12.2	16	4.12.3	N/A	4.12.4	N/A
4.12.5	N/A	4.12.6	C	4.12.7	B	4.12.8	D	4.12.9	1.72 : 1.74
4.12.10	A	4.12.11	3	4.12.12	A	4.12.13	C	4.12.14	4
4.12.15	55	4.12.16	A	4.12.17	D	4.13.1	A	4.13.2	A
4.13.3	D	4.13.4	B	4.13.5	B	4.14.1	C	4.15.1	C
4.16.1	A								

5 Theory of Computation (279)

5.1 Ambiguous Grammar (1) top

5.1.1 Ambiguous Grammar: GATE CSE 1987 | Question: 1-xii top

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-grammar

Answer key

5.2 Closure Property (8) top

5.2.1 Closure Property: GATE CSE 1989 | Question: 3-ii top

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 multiple-selects

Answer key

5.2.2 Closure Property: GATE CSE 1992 | Question: 16 top

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 proof descriptive

Answer key

5.2.3 Closure Property: GATE CSE 2002 | Question: 2.14 top

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

gatecse-2002 theory-of-computation easy closure-property

Answer key

5.2.4 Closure Property: GATE CSE 2013 | Question: 17 top

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

gatecse-2013 theory-of-computation normal closure-property

Answer key

5.2.5 Closure Property: GATE CSE 2016 Set 2 | Question: 18 top

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

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

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

gatecse-2016-set2 theory-of-computation regular-language context-free-language closure-property normal

Answer key

5.2.6 Closure Property: GATE CSE 2017 Set 2 | Question: 04 top

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

gatecse-2017-set2 theory-of-computation closure-property

Answer key

5.2.7 Closure Property: GATE CSE 2018 | Question: 7 top

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

gatecse-2018 theory-of-computation closure-property easy 1-mark

Answer key

5.2.8 Closure Property: GATE IT 2006 | Question: 32 top

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

gateit-2006 theory-of-computation closure-property easy

Answer key

5.3 Context Free Grammar (1) top

5.3.1 Context Free Grammar: GATE CSE 2023 | Question: 29 top

Consider the context-free grammar G below

$$S \rightarrow aSb \mid X$$
$$X \rightarrow aX \mid Xb \mid a \mid b,$$

where S and X are non-terminals, and a and b are terminal symbols. The starting non-terminal is S. Which one of the following statements is CORRECT?

A. The language generated by G is $(a+b)^*$
B. The language generated by G is $a^*(a+b)b^*$
C. The language generated by G is $a^*b^*(a+b)$
D. The language generated by G is not a regular language

gatecse-2023 theory-of-computation context-free-grammar 2-marks

Answer key

5.4 Context Free Language (31) top

5.4.1 Context Free Language: GATE CSE 1987 | Question: 2k top

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 true-false

Answer key

5.4.2 Context Free Language: GATE CSE 1992 | Question: 02,xix top

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 multiple-selects

Answer key

5.4.3 Context Free Language: GATE CSE 1992 | Question: 02,xviii top

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 multiple-selects

Answer key

5.4.4 Context Free Language: GATE CSE 1995 | Question: 2.20 top

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

Answer key

5.4.5 Context Free Language: GATE CSE 1996 | Question: 2.8 top

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

Answer key

5.4.6 Context Free Language: GATE CSE 1996 | Question: 2.9 top

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

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

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

Answer key

5.4.7 Context Free Language: GATE CSE 1999 | Question: 1.5 top

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

Answer key

5.4.8 Context Free Language: GATE CSE 1999 | Question: 7 top

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 proof

Answer key

5.4.9 Context Free Language: GATE CSE 2000 | Question: 7 top

A. Construct as minimal finite state machine that accepts the language, over $\{0,1\}$, of all strings that contain neither the substring 00 nor the substring 11.
B. Consider the grammar
   - $S \rightarrow aSAb$
   - $S \rightarrow \epsilon$
   - $A \rightarrow bA$
   - $A \rightarrow \epsilon$

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

gatecse-2000 theory-of-computation descriptive regular-language context-free-language

Answer key

5.4.10 Context Free Language: GATE CSE 2001 | Question: 1.5 top

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

gatecse-2001 theory-of-computation context-free-language easy

Answer key

5.4.11 Context Free Language: GATE CSE 2003 | Question: 51 top

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 $L(G)$

gatecse-2003 theory-of-computation context-free-language normal

Answer key

5.4.12 Context Free Language: GATE CSE 2005 | Question: 57 top

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

gatecse-2005 theory-of-computation context-free-language easy

Answer key

5.4.13 Context Free Language: GATE CSE 2006 | Question: 19 top

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

gatecse-2006 theory-of-computation context-free-language normal

Answer key

5.4.14 Context Free Language: GATE CSE 2015 Set 3 | Question: 32 top

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

gatecse-2015-set3 theory-of-computation context-free-language normal

Answer key

5.4.15 Context Free Language: GATE CSE 2016 Set 1 | Question: 16 top

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. $\{a,b\}^*$

gatecse-2016-set1 theory-of-computation context-free-language normal

Answer key

5.4.16 Context Free Language: GATE CSE 2016 Set 1 | Question: 42 top

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 $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$

gatecse-2016-set1 theory-of-computation context-free-language normal

Answer key

5.4.17 Context Free Language: GATE CSE 2016 Set 2 | Question: 43 top

Consider the following languages:

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

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

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.

gatecse-2016-set2 theory-of-computation context-free-language normal

Answer key

5.4.18 Context Free Language: GATE CSE 2017 Set 1 | Question: 10 top

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

$$S \rightarrow abScT \mid abcT$$

$$T \rightarrow bT \mid b$$

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

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

gatecse-2017-set1 theory-of-computation context-free-language normal

Answer key

5.4.19 Context Free Language: GATE CSE 2017 Set 1 | Question: 34 top

If G is a grammar with productions

$S \rightarrow SaS \mid aSb \mid bSa \mid SS \mid \epsilon$

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. $babba$

gatecse-2017-set1 theory-of-computation context-free-language normal

Answer key

5.4.20 Context Free Language: GATE CSE 2017 Set 1 | Question: 38 top

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

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

gatecse-2017-set1 theory-of-computation context-free-language normal

Answer key

5.4.21 Context Free Language: GATE CSE 2017 Set 2 | Question: 16 top

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. $\{a^m b^n \mid m > n, n > 0\}$

gatecse-2017-set2 theory-of-computation context-free-language

Answer key

5.4.22 Context Free Language: GATE CSE 2019 | Question: 31 top

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. $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$

gatecse-2019 theory-of-computation context-free-language 2-marks

Answer key

5.4.23 Context Free Language: GATE CSE 2021 Set 1 | Question: 1 top

Suppose that L_1 is a regular language and L_2 is a context-free language. Which one of the following languages is NOT necessarily context-free?

A. $L_1 \cap L_2$ B. $L_1 \cdot L_2$ C. $L_1 - L_2$ D. $L_1 \cup L_2$

gatecse-2021-set1 context-free-language theory-of-computation 1-mark

Answer key

5.4.24 Context Free Language: GATE CSE 2021 Set 2 | Question: 41 top

For a string w, we define w^R to be the reverse of w. For example, if $w = 01101$ then $w^R = 10110$.

Which of the following languages is/are context-free?

A. $\{wxw^Rx^R \mid w,x \in \{0,1\}^*\}$
B. $\{ww^Rxx^R \mid w,x \in \{0,1\}^*\}$
C. $\{wxw^R \mid w,x \in \{0,1\}^*\}$
D. $\{wxx^Rw^R \mid w,x \in \{0,1\}^*\}$

gatecse-2021-set2 multiple-selects theory-of-computation context-free-language 2-marks

Answer key

5.4.25 Context Free Language: GATE CSE 2022 | Question: 38 top

Consider the following languages:

$L_1 = \{ww | w \in \{a,b\}^*\}$

$L_2 = \{a^n b^n c^m | m,n \geq 0\}$

$L_3 = \{a^m b^n c^n | m,n \geq 0\}$

Which of the following statements is/are FALSE?

A. L_1 is not context-free but L_2 and L_3 are deterministic context-free.
B. Neither L_1 nor L_2 is context-free.
C. L_2, L_3 and $L_2 \cap L_3$ all are context-free.
D. Neither L_1 nor its complement is context-free.

gatecse-2022 theory-of-computation context-free-language multiple-selects 2-marks

Answer key

5.4.26 Context Free Language: GATE IT 2006 | Question: 34 top

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. $\{a^m b^n \mid m \leq n\}$
C. $\{a^m b^n \mid m = n)$
D. a^*b^*

gateit-2006 theory-of-computation context-free-language normal

Answer key

5.4.27 Context Free Language: GATE IT 2006 | Question: 4 top

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. $babaaabab$

gateit-2006 theory-of-computation context-free-language easy

Answer key

5.4.28 Context Free Language: GATE IT 2007 | Question: 46 top

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

gateit-2007 theory-of-computation normal context-free-language

Answer key

5.4.29 Context Free Language: GATE IT 2007 | Question: 48 top

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

gateit-2007 theory-of-computation context-free-language normal

Answer key

5.4.30 Context Free Language: GATE IT 2007 | Question: 49 top

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

gateit-2007 theory-of-computation context-free-language normal

Answer key

5.4.31 Context Free Language: GATE IT 2008 | Question: 34 top

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

gateit-2008 theory-of-computation context-free-language normal

Answer key

5.5 Countable Uncountable Set (3) top

5.5.1 Countable Uncountable Set: GATE CSE 1997 | Question: 3.4 top

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

Answer key

5.5.2 Countable Uncountable Set: GATE CSE 2014 Set 3 | Question: 16 top

Let Σ be a finite non-empty alphabet and let 2^{Σ^*} be the power set of Σ^*. Which one of the following is **TRUE**?

A. Both 2^{Σ^*} and Σ^* are countable
B. 2^{Σ^*} is countable and Σ^* is uncountable
C. 2^{Σ^*} is uncountable and Σ^* is countable
D. Both 2^{Σ^*} and Σ^* are uncountable

gatecse-2014-set3 theory-of-computation normal countable-uncountable-set

Answer key

5.5.3 Countable Uncountable Set: GATE CSE 2019 | Question: 34 top

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

gatecse-2019 theory-of-computation countable-uncountable-set 2-marks

Answer key

5.6 Decidability (28) top

5.6.1 Decidability: GATE CSE 1987 | Question: 2l top

State whether the following statement are TRUE or FALSE.

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

gate1987 theory-of-computation turing-machine decidability true-false

Answer key

5.6.2 Decidability: GATE CSE 1987 | Question: 2m top

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 true-false

Answer key

5.6.3 Decidability: GATE CSE 1988 | Question: 2viii top

State the halting problem of the Turing machine.

gate1988 theory-of-computation descriptive decidability turing-machine

Answer key

5.6.4 Decidability: GATE CSE 1989 | Question: 3-iii top

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 multiple-selects

Answer key

5.6.5 Decidability: GATE CSE 1990 | Question: 3-vii top

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 multiple-selects

Answer key

5.6.6 Decidability: GATE CSE 1995 | Question: 11 top

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 proof descriptive

Answer key

5.6.7 Decidability: GATE CSE 1996 | Question: 1.9 top

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

Answer key

5.6.8 Decidability: GATE CSE 1997 | Question: 6.5 top

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

Answer key

5.6.9 Decidability: GATE CSE 1999 | Question: 10 top

Suppose we have a function HALTS which when applied to any arbitrary function f and its arguments will say TRUE if function f terminates for those arguments and FALSE otherwise. Example: Given the following function definition.

FACTORIAL (N) = IF (N=0) THEN 1 ELSE N*FACTORIAL (N-1)

Then HALTS (FACTORIAL, 4) = TRUE and HALTS (FACTORIAL, -5) = FALSE

Let us define the function FUNNY (f) = IF HALTS (f) THEN not (f) ELSE TRUE

a. Show that FUNNY terminates for all functions f.
b. use (a) to prove (by contradiction) that it is not possible to have a function like HALTS which for arbitrary functions and inputs says whether it will terminate on that input or not.

gate1999 theory-of-computation descriptive decidability

Answer key

5.6.10 Decidability: GATE CSE 2000 | Question: 2.9 top

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

gatecse-2000 theory-of-computation decidability normal

Answer key

5.6.11 Decidability: GATE CSE 2001 | Question: 2.7 top

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

gatecse-2001 theory-of-computation decidability normal

Answer key

5.6.12 Decidability: GATE CSE 2001 | Question: 7 top

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

gatecse-2001 theory-of-computation decidability turing-machine easy descriptive

Answer key

5.6.13 Decidability: GATE CSE 2002 | Question: 14 top

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

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

gatecse-2002 theory-of-computation decidability normal turing-machine descriptive difficult

Answer key

5.6.14 Decidability: GATE CSE 2003 | Question: 52 top

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

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

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

gatecse-2003 theory-of-computation normal decidability

Answer key

5.6.15 Decidability: GATE CSE 2007 | Question: 6 top

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

gatecse-2007 theory-of-computation decidability normal

Answer key

5.6.16 Decidability: GATE CSE 2008 | Question: 10 top

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

gatecse-2008 theory-of-computation decidability easy

Answer key

5.6.17 Decidability: GATE CSE 2012 | Question: 24 top

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, is $\bar{L}$ 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. $3,4$

gatecse-2012 theory-of-computation decidability normal

Answer key

5.6.18 Decidability: GATE CSE 2013 | Question: 41 top

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

gatecse-2013 theory-of-computation decidability normal

Answer key

5.6.19 Decidability: GATE CSE 2014 Set 3 | Question: 35 top

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.

gatecse-2014-set3 theory-of-computation context-free-language decidability normal

Answer key

5.6.20 Decidability: GATE CSE 2015 Set 2 | Question: 21 top

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

gatecse-2015-set2 theory-of-computation decidability easy

Answer key

5.6.21 Decidability: GATE CSE 2015 Set 3 | Question: 53 top

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

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

gatecse-2015-set3 theory-of-computation decidability normal

Answer key

5.6.22 Decidability: GATE CSE 2016 Set 1 | Question: 17 top

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

gatecse-2016-set1 theory-of-computation decidability easy

Answer key

5.6.23 Decidability: GATE CSE 2017 Set 1 | Question: 39 top

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.

gatecse-2017-set1 theory-of-computation decidability difficult

Answer key

5.6.24 Decidability: GATE CSE 2017 Set 2 | Question: 41 top

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

gatecse-2017-set2 theory-of-computation decidability

Answer key

5.6.25 Decidability: GATE CSE 2018 | Question: 36 top

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 $w \in L(G)$
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

gatecse-2018 theory-of-computation decidability easy 2-marks

Answer key

5.6.26 Decidability: GATE CSE 2020 | Question: 26 top

Which of the following languages are undecidable? Note that $\langle M \rangle$ indicates encoding of the Turing machine M.

- $L_1 = \{\langle M \rangle \mid L(M) = \varnothing\}$
- $L_2 = \{\langle M, w, q \rangle \mid M \text{ on input } w \text{ reaches state } q \text{ in exactly } 100 \text{ steps}\}$
- $L_3 = \{\langle M \rangle \mid L(M) \text{ is not recursive}\}$
- $L_4 = \{\langle M \rangle \mid L(M) \text{contains at least } 21 \text{ members}\}$

A. L_1, L_3, and L_4 only
B. L_1 and L_3 only
C. L_2 and L_3 only
D. L_2, L_3, and L_4 only

gatecse-2020 theory-of-computation decidability 2-marks

Answer key

5.6.27 Decidability: GATE CSE 2021 Set 2 | Question: 36 top

Consider the following two statements about regular languages:

- S_1: Every infinite regular language contains an undecidable language as a subset.
- S_2: Every finite language is regular.

Which one of the following choices is correct?

A. Only S_1 is true
B. Only S_2 is true
C. Both S_1 and S_2 are true
D. Neither S_1 nor S_2 is true

gatecse-2021-set2 theory-of-computation regular-language decidability 2-marks

Answer key

5.6.28 Decidability: GATE CSE 2022 | Question: 36 top

Which of the following is/are undecidable?

A. Given two Turing machines M_1 and M_2, decide if $L(M_1) = L(M_2)$.
B. Given a Turing machine M, decide if $L(M)$ is regular.
C. Given a Turing machine M, decide if M accepts all strings.
D. Given a Turing machine M, decide if M takes more than 1073 steps on every string.

gatecse-2022 theory-of-computation turing-machine decidability multiple-selects 2-marks

Answer key

5.7 Finite Automata (41) top

5.7.1 Finite Automata: GATE CSE 1988 | Question: 15 top

Consider the DFA M and NFA M_2 as defined below. Let the language accepted by machine M be L. What language machine M_2 accepts, if

i. $F2 = A$?
ii. $F2 = B$?
iii. $F2 = C$?
iv. $F2 = D$?

- $M = (Q, \Sigma, \delta, q_0, F)$
- $M_2 = (Q2, \Sigma, \delta_2, q_{00}, F2)$

Where,

$Q2 = (Q \times Q \times Q) \cup \{q_{00}\}$

$\delta_2(q_{00}, \epsilon) = \{\langle q_0, q, q\rangle \mid q \in Q\}$

$\delta_2(\langle p, q, r\rangle, \sigma) = \langle \delta(p, \sigma), \delta(q, \sigma), r\rangle$

for all $p, q, r \in Q$ and $\sigma \in \Sigma$

$A = \{\langle p, q, r\rangle \mid p \in F; q, r \in Q\}$

$B = \{\langle p, q, r\rangle \mid q \in F; p, r \in Q\}$

$C = \{\langle p, q, r\rangle \mid p, q, r \in Q; \exists s \in \Sigma^*, \delta(p, s) \in F\}$

$D = \{\langle p, q, r\rangle \mid p, q \in Q; r \in F\}$

gate1988 descriptive theory-of-computation finite-automata difficult

Answer key

5.7.2 Finite Automata: GATE CSE 1991 | Question: 17,b top

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 descriptive

Answer key

5.7.3 Finite Automata: GATE CSE 1993 | Question: 27 top

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 descriptive

Answer key

5.7.4 Finite Automata: GATE CSE 1994 | Question: 3.3 top

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 true-false

Answer key

5.7.5 Finite Automata: GATE CSE 1995 | Question: 2.23 top

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

Answer key

5.7.6 Finite Automata: GATE CSE 1996 | Question: 12 top

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 descriptive

Answer key

5.7.7 Finite Automata: GATE CSE 1997 | Question: 21 top

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

Answer key

5.7.8 Finite Automata: GATE CSE 1998 | Question: 1.10 top

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

Answer key

5.7.9 Finite Automata: GATE CSE 2001 | Question: 5 top

Construct DFA's for the following languages:

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

gatecse-2001 theory-of-computation easy descriptive finite-automata normal

Answer key

5.7.10 Finite Automata: GATE CSE 2002 | Question: 2.5 top

The finite state machine described by the following state diagram with A as starting state, where an arc label is x/y, 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

gatecse-2002 theory-of-computation normal finite-automata

Answer key

5.7.11 Finite Automata: GATE CSE 2002 | Question: 21 top

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

gatecse-2002 theory-of-computation finite-automata normal descriptive

Answer key

5.7.12 Finite Automata: GATE CSE 2003 | Question: 50 top

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

gatecse-2003 theory-of-computation finite-automata normal

Answer key

5.7.13 Finite Automata: GATE CSE 2003 | Question: 55 top

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. $L_1 = L$

gatecse-2003 theory-of-computation finite-automata normal

Answer key

5.7.14 Finite Automata: GATE CSE 2004 | Question: 86 top

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

gatecse-2004 theory-of-computation finite-automata easy

Answer key

5.7.15 Finite Automata: GATE CSE 2005 | Question: 53 top

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. $\{w \in \{a,b\}^* \mid w \text{ does not contain '}aa\text{' as a substring}\}$

gatecse-2005 theory-of-computation finite-automata normal

Answer key

5.7.16 Finite Automata: GATE CSE 2005 | Question: 63 top

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

gatecse-2005 theory-of-computation finite-automata easy

Answer key

5.7.17 Finite Automata: GATE CSE 2007 | Question: 74 top

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. $b^*ab^*ab^*$

gatecse-2007 theory-of-computation finite-automata normal

Answer key

5.7.18 Finite Automata: GATE CSE 2008 | Question: 49 top

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

gatecse-2008 normal theory-of-computation finite-automata

Answer key

5.7.19 Finite Automata: GATE CSE 2008 | Question: 52 top

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

gatecse-2008 theory-of-computation finite-automata normal

Answer key

5.7.20 Finite Automata: GATE CSE 2009 | Question: 27 top

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

gatecse-2009 theory-of-computation finite-automata normal

Answer key

5.7.21 Finite Automata: GATE CSE 2009 | Question: 41 top

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.

gatecse-2009 theory-of-computation finite-automata easy

Answer key

5.7.22 Finite Automata: GATE CSE 2012 | Question: 12 top

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. $\{a, \epsilon\}$

gatecse-2012 finite-automata easy theory-of-computation

Answer key

5.7.23 Finite Automata: GATE CSE 2012 | Question: 46 top

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		

gatecse-2012 theory-of-computation finite-automata normal

Answer key

5.7.24 Finite Automata: GATE CSE 2013 | Question: 33 top

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

gatecse-2013 theory-of-computation finite-automata normal

Answer key

5.7.25 Finite Automata: GATE CSE 2014 Set 1 | Question: 16 top

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. $\{q_3\}$

gatecse-2014-set1 theory-of-computation finite-automata easy

Answer key

5.7.26 Finite Automata: GATE CSE 2016 Set 2 | Question: 42 top

Consider the following two statements:

I. If all states of an **NFA** are accepting states then the language accepted by the **NFA** is Σ^*.
II. There exists a regular language A such that for all languages B, $A \cap B$ 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

gatecse-2016-set2 theory-of-computation finite-automata normal

Answer key

5.7.27 Finite Automata: GATE CSE 2017 Set 2 | Question: 39 top

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. $\{q_0, q_2, q_3\}$

gatecse-2017-set2 theory-of-computation finite-automata

Answer key

5.7.28 Finite Automata: GATE CSE 2021 Set 1 | Question: 38 top

Consider the following language:

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

Which one of the following deterministic finite automata accepts L?

A.

B.

C.

D.

gatecse-2021-set1 theory-of-computation finite-automata 2-marks

Answer key

5.7.29 Finite Automata: GATE CSE 2021 Set 2 | Question: 17 top

Consider the following deterministic finite automaton (DFA)

The number of strings of length 8 accepted by the above automaton is _____

gatecse-2021-set2 numerical-answers theory-of-computation finite-automata 1-mark

Answer key

5.7.30 Finite Automata: GATE CSE 2021 Set 2 | Question: 28 top

Suppose we want to design a synchronous circuit that processes a string of 0's and 1's. Given a string, it produces another string by replacing the first 1 in any subsequence of consecutive 1's by a 0. Consider the following example.

$$\begin{array}{ll} \text{Input sequence:} & 00100011000011100 \\ \text{Output sequence:} & 00000001000001100 \end{array}$$

A *Mealy Machine* is a state machine where both the next state and the output are functions of the present state and the current input.

The above mentioned circuit can be designed as a two-state Mealy machine. The states in the Mealy machine can be represented using Boolean values 0 and 1. We denote the current state, the next state, the next incoming bit, and the output bit of the Mealy machine by the variables s, t, b and y respectively.

Assume the initial state of the Mealy machine is 0.

What are the Boolean expressions corresponding to t and y in terms of s and b?

A.
$t = s + b$
$y = sb$

B.
$t = b$
$y = sb$

C.
$t = b$
$y = s\bar{b}$

D.
$t = s + b$
$y = s\bar{b}$

gatecse-2021-set2 theory-of-computation finite-automata 2-marks

Answer key

5.7.31 Finite Automata: GATE IT 2004 | Question: 41 top

Let $M = (K, \Sigma, \sigma, s, F)$ be a finite state automaton, where
$K = \{A, B\}, \Sigma = \{a, b\}, s = A, F = \{B\},$
$\sigma(A, a) = A, \sigma(A, b) = B, \sigma(B, a) = B$ and $\sigma(B, b) = A$

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

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

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

gateit-2004 theory-of-computation finite-automata normal

Answer key

5.7.32 Finite Automata: GATE IT 2005 | Question: 37 top

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

gateit-2005 theory-of-computation finite-automata normal

Answer key

5.7.33 Finite Automata: GATE IT 2005 | Question: 39 top

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

gateit-2005 theory-of-computation finite-automata normal

Answer key

5.7.34 Finite Automata: GATE IT 2006 | Question: 3 top

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

gateit-2006 theory-of-computation finite-automata normal

Answer key

5.7.35 Finite Automata: GATE IT 2006 | Question: 37 top

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. $S^+ = S'.y + S.x'$

gateit-2006 theory-of-computation finite-automata normal

Answer key

5.7.36 Finite Automata: GATE IT 2007 | Question: 47 top

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

gateit-2007 theory-of-computation finite-automata normal

Answer key

5.7.37 Finite Automata: GATE IT 2007 | Question: 50 top

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.

gateit-2007 theory-of-computation finite-automata normal

Answer key

5.7.38 Finite Automata: GATE IT 2007 | Question: 71 top

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.

gateit-2007 theory-of-computation finite-automata normal

Answer key

5.7.39 Finite Automata: GATE IT 2007 | Question: 72 top

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.

gateit-2007 theory-of-computation finite-automata normal

Answer key

5.7.40 Finite Automata: GATE IT 2008 | Question: 32 top

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 $b^*aa^*(ba)^*b^*$

gateit-2008 theory-of-computation finite-automata normal

Answer key

5.7.41 Finite Automata: GATE IT 2008 | Question: 36 top

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. $L_1 \cup L_2 \neq L_1$

gateit-2008 theory-of-computation finite-automata normal

Answer key

5.8 Grammar (2) top

5.8.1 Grammar: GATE CSE 2008 | Question: 51 top

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

gatecse-2008 normal theory-of-computation grammar

Answer key

5.8.2 Grammar: GATE CSE 2009 | Question: 12, ISRO2016-37 top

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

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

gatecse-2009 theory-of-computation grammar easy isro2016

Answer key

5.9 Identify Class Language (30) top

5.9.1 Identify Class Language: GATE CSE 1987 | Question: 1-xiii top

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

Answer key

5.9.2 Identify Class Language: GATE CSE 1988 | Question: 2ix top

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 theory-of-computation identify-class-language

Answer key

5.9.3 Identify Class Language: GATE CSE 1991 | Question: 17,a top

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 proof

Answer key

5.9.4 Identify Class Language: GATE CSE 1994 | Question: 19 top

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 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 descriptive

Answer key

5.9.5 Identify Class Language: GATE CSE 1999 | Question: 2.4 top

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 multiple-selects

Answer key

5.9.6 Identify Class Language: GATE CSE 2000 | Question: 1.5 top

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

gatecse-2000 theory-of-computation easy identify-class-language

Answer key

5.9.7 Identify Class Language: GATE CSE 2002 | Question: 1.7 top

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

gatecse-2002 theory-of-computation easy identify-class-language

Answer key

5.9.8 Identify Class Language: GATE CSE 2004 | Question: 87 top

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

gatecse-2004 theory-of-computation normal identify-class-language

Answer key

5.9.9 Identify Class Language: GATE CSE 2005 | Question: 55 top

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

gatecse-2005 theory-of-computation identify-class-language normal

Answer key

5.9.10 Identify Class Language: GATE CSE 2006 | Question: 30 top

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

gatecse-2006 theory-of-computation normal identify-class-language

Answer key

5.9.11 Identify Class Language: GATE CSE 2006 | Question: 33 top

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

gatecse-2006 theory-of-computation normal identify-class-language

Answer key

5.9.12 Identify Class Language: GATE CSE 2007 | Question: 30 top

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

gatecse-2007 theory-of-computation normal identify-class-language

Answer key

5.9.13 Identify Class Language: GATE CSE 2008 | Question: 9 top

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

gatecse-2008 theory-of-computation easy identify-class-language

Answer key

5.9.14 Identify Class Language: GATE CSE 2009 | Question: 40 top

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

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

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

Then L is

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

gatecse-2009 theory-of-computation easy identify-class-language

Answer key

5.9.15 Identify Class Language: GATE CSE 2010 | Question: 40 top

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

gatecse-2010 theory-of-computation context-free-language identify-class-language normal

Answer key

5.9.16 Identify Class Language: GATE CSE 2011 | Question: 26 top

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

$L1 = \{0^p1^q \mid p, q \in N\},$

$L2 = \{0^p1^q \mid p, q \in N\ and\ p = q\}\ and$

$L3 = \{0^p1^q0^r \mid p, q, r \in N\ and\ p = q = r\}.$

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

gatecse-2011 theory-of-computation identify-class-language normal

Answer key

5.9.17 Identify Class Language: GATE CSE 2013 | Question: 32 top

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.

gatecse-2013 theory-of-computation identify-class-language normal

Answer key

5.9.18 Identify Class Language: GATE CSE 2014 Set 3 | Question: 36 top

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

gatecse-2014-set3 theory-of-computation identify-class-language context-free-language normal

Answer key

5.9.19 Identify Class Language: GATE CSE 2017 Set 1 | Question: 37 top

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

gatecse-2017-set1 theory-of-computation context-free-language identify-class-language normal

Answer key

5.9.20 Identify Class Language: GATE CSE 2017 Set 2 | Question: 40 top

Consider the following languages.

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

Which of the following are CORRECT?

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

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

gatecse-2017-set2 theory-of-computation identify-class-language

Answer key

5.9.21 Identify Class Language: GATE CSE 2018 | Question: 35 top

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

gatecse-2018 theory-of-computation identify-class-language context-free-language normal 2-marks

Answer key

5.9.22 Identify Class Language: GATE CSE 2020 | Question: 10 top

Consider the language $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and the following statements.

I. L is deterministic context-free.
II. L is context-free but not deterministic context-free.
III. L is not $LL(k)$ for any k.

Which of the above statements is/are TRUE?

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

gatecse-2020 theory-of-computation identify-class-language 1-mark

Answer key

5.9.23 Identify Class Language: GATE CSE 2020 | Question: 32 top

Consider the following languages.

$$L_1 = \{wxyx \mid w, x, y \in (0+1)^+\}$$
$$L_2 = \{xy \mid x, y \in (a+b)^*, \mid x \mid = \mid y \mid, x \neq y\}$$

Which one of the following is TRUE?

A. L_1 is regular and L_2 is context- free.
B. L_1 context- free but not regular and L_2 is context-free.
C. Neither L_1 nor L_2 is context- free.
D. L_1 context- free but L_2 is not context-free.

gatecse-2020 theory-of-computation identify-class-language 2-marks

Answer key

5.9.24 Identify Class Language: GATE CSE 2021 Set 2 | Question: 12 top

Let L_1 be a regular language and L_2 be a context-free language. Which of the following languages is/are context-free?

A. $L_1 \cap \overline{L_2}$

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

C. $L_1 \cup (L_2 \cup \overline{L_2})$

D. $(L_1 \cap L_2) \cup (\overline{L_1} \cap L_2)$

gatecse-2021-set2 multiple-selects theory-of-computation identify-class-language 1-mark

Answer key

5.9.25 Identify Class Language: GATE CSE 2022 | Question: 13 top

Which of the following statements is/are TRUE?

A. Every subset of a recursively enumerable language is recursive.
B. If a language L and its complement $\overline{L}$ are both recursively enumerable, then L must be recursive.
C. Complement of a context-free language must be recursive.
D. If L_1 and L_2 are regular, then $L_1 \cap L_2$ must be deterministic context-free.

gatecse-2022 theory-of-computation identify-class-language recursive-and-recursively-enumerable-languages multiple-selects 1-mark

Answer key

5.9.26 Identify Class Language: GATE CSE 2022 | Question: 37 top

Consider the following languages:

$L_1 = \{a^n w a^n | w \in \{a, b\}^*\}$

$L_2 = \{wxw^R | w, x \in \{a, b\}^*, |w|, |x| > 0\}$

Note that w^R is the reversal of the string w. Which of the following is/are TRUE?

A. L_1 and L_2 are regular.
B. L_1 and L_2 are context-free.
C. L_1 is regular and L_2 is context-free.
D. L_1 and L_2 are context-free but not regular.

gatecse-2022 theory-of-computation identify-class-language context-free-language multiple-selects 2-marks

Answer key

5.9.27 Identify Class Language: GATE CSE 2023 | Question: 14 top

Which of the following statements is/are CORRECT?

A. The intersection of two regular languages is regular.
B. The intersection of two context-free languages is context-free.
C. The intersection of two recursive languages is recursive.
D. The intersection of two recursively enumerable languages is recursively enumerable.

gatecse-2023 theory-of-computation identify-class-language multiple-selects 1-mark

Answer key

5.9.28 Identify Class Language: GATE IT 2005 | Question: 4 top

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

gateit-2005 theory-of-computation normal identify-class-language

Answer key

5.9.29 Identify Class Language: GATE IT 2005 | Question: 6 top

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

gateit-2005 theory-of-computation easy identify-class-language

Answer key

5.9.30 Identify Class Language: GATE IT 2008 | Question: 33 top

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.

gateit-2008 theory-of-computation normal identify-class-language

Answer key

5.10 Minimal State Automata (25) top

5.10.1 Minimal State Automata: GATE CSE 1987 | Question: 2j top

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

Answer key

5.10.2 Minimal State Automata: GATE CSE 1997 | Question: 20 top

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 descriptive

Answer key

5.10.3 Minimal State Automata: GATE CSE 1997 | Question: 70 top

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 descriptive

Answer key

5.10.4 Minimal State Automata: GATE CSE 1998 | Question: 2.5 top

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

Answer key

5.10.5 Minimal State Automata: GATE CSE 1998 | Question: 4 top

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 descriptive

Answer key

5.10.6 Minimal State Automata: GATE CSE 1999 | Question: 1.4 top

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

Answer key

5.10.7 Minimal State Automata: GATE CSE 2001 | Question: 1.6 top

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. $N!$

gatecse-2001 finite-automata theory-of-computation easy minimal-state-automata

Answer key

5.10.8 Minimal State Automata: GATE CSE 2001 | Question: 2.5 top

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

gatecse-2001 theory-of-computation finite-automata minimal-state-automata

Answer key

5.10.9 Minimal State Automata: GATE CSE 2002 | Question: 2.13 top

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

gatecse-2002 theory-of-computation normal finite-automata minimal-state-automata

Answer key

5.10.10 Minimal State Automata: GATE CSE 2006 | Question: 34 top

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

gatecse-2006 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.10.11 Minimal State Automata: GATE CSE 2007 | Question: 29 top

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

gatecse-2007 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.10.12 Minimal State Automata: GATE CSE 2007 | Question: 75 top

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 gatecse-2007 theory-of-computation finite-automata minimal-state-automata

Answer key

5.10.13 Minimal State Automata: GATE CSE 2010 | Question: 41 top

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}

gatecse-2010 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.10.14 Minimal State Automata: GATE CSE 2011 | Question: 42 top

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

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

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}

gatecse-2011 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.10.15 Minimal State Automata: GATE CSE 2011 | Question: 45 top

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.

gatecse-2011 theory-of-computation finite-automata easy minimal-state-automata

Answer key

5.10.16 Minimal State Automata: GATE CSE 2015 Set 1 | Question: 52 top

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_____.

gatecse-2015-set1 theory-of-computation finite-automata easy numerical-answers minimal-state-automata

Answer key

5.10.17 Minimal State Automata: GATE CSE 2015 Set 2 | Question: 53 top

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

gatecse-2015-set2 theory-of-computation finite-automata normal numerical-answers minimal-state-automata

Answer key

5.10.18 Minimal State Automata: GATE CSE 2015 Set 3 | Question: 18 top

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

gatecse-2015-set3 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.10.19 Minimal State Automata: GATE CSE 2016 Set 2 | Question: 16 top

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 _____.

gatecse-2016-set2 theory-of-computation finite-automata normal numerical-answers minimal-state-automata

Answer key

5.10.20 Minimal State Automata: GATE CSE 2017 Set 1 | Question: 22 top

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 _____ .

gatecse-2017-set1 theory-of-computation finite-automata numerical-answers minimal-state-automata

Answer key

5.10.21 Minimal State Automata: GATE CSE 2017 Set 2 | Question: 25 top

The minimum possible number of states of a deterministic finite automaton that accepts the regular language L = {w_1aw_2 | $w_1, w_2 \in \{a, b\}^*$, $|w_1| = 2, |w_2| \geq 3$} is _____ .

theory-of-computation gatecse-2017-set2 finite-automata numerical-answers minimal-state-automata

Answer key

5.10.22 Minimal State Automata: GATE CSE 2018 | Question: 6 top

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. $k \leq 2^n$

gatecse-2018 theory-of-computation minimal-state-automata normal 1-mark

Answer key

5.10.23 Minimal State Automata: GATE CSE 2019 | Question: 48 top

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 _____

gatecse-2019 numerical-answers theory-of-computation finite-automata minimal-state-automata difficult 2-marks

Answer key

5.10.24 Minimal State Automata: GATE CSE 2023 | Question: 53 top

Consider the language L over the alphabet $\{0,1\}$, given below:

$$L = \{w \in \{0,1\}^* \mid w \text{ does not contain three or more consecutive } 1\text{'s}\}.$$

The minimum number of states in a Deterministic Finite-State Automaton (DFA) for L is _____.

gatecse-2023 theory-of-computation minimal-state-automata numerical-answers 2-marks

Answer key

5.10.25 Minimal State Automata: GATE IT 2008 | Question: 6 top

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. $m = 2^n$

gateit-2008 theory-of-computation finite-automata normal minimal-state-automata

Answer key

5.11 Non Determinism (6) top

5.11.1 Non Determinism: GATE CSE 1992 | Question: 02,xx top

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-deterministic Turing machine.
D. For no machines M_1 and M_2, the above statement true.

gate1992 theory-of-computation easy non-determinism multiple-selects

Answer key

5.11.2 Non Determinism: GATE CSE 1994 | Question: 1.16 top

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

Answer key

5.11.3 Non Determinism: GATE CSE 1998 | Question: 1.11 top

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 Turing machines.
D. Multi-tape Turing machines are available are equivalent to Single-tape Turing machines.

gate1998 theory-of-computation easy non-determinism

Answer key

5.11.4 Non Determinism: GATE CSE 2005 | Question: 54 top

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 $D_p \subset N_p$

gatecse-2005 theory-of-computation easy non-determinism

Answer key

5.11.5 Non Determinism: GATE CSE 2011 | Question: 8 top

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

gatecse-2011 theory-of-computation easy non-determinism

Answer key

5.11.6 Non Determinism: GATE IT 2004 | Question: 9 top

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

gateit-2004 theory-of-computation easy non-determinism

Answer key

5.12 P Np Npc Nph (5) top

5.12.1 P Np Npc Nph: GATE CSE 2005 | Question: 58 top

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

gatecse-2005 theory-of-computation p-np-npc-nph normal

Answer key

5.12.2 P Np Npc Nph: GATE CSE 2006 | Question: 31 top

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

gatecse-2006 theory-of-computation p-np-npc-nph normal

Answer key

5.12.3 P Np Npc Nph: GATE CSE 2009 | Question: 14 top

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.

gatecse-2009 theory-of-computation p-np-npc-nph

Answer key

5.12.4 P Np Npc Nph: GATE CSE 2012 | Question: 4 top

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. $P = NP - complete$

gatecse-2012 theory-of-computation p-np-npc-nph

Answer key

5.12.5 P Np Npc Nph: GATE CSE 2013 | Question: 18 top

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

gatecse-2013 theory-of-computation p-np-npc-nph normal

Answer key

5.13 Pumping Lemma (2) top

5.13.1 Pumping Lemma: GATE CSE 2019 | Question: 15 top

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

gatecse-2019 theory-of-computation pumping-lemma 1-mark

Answer key

5.13.2 Pumping Lemma: GATE IT 2005 | Question: 40 top

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

gateit-2005 theory-of-computation pumping-lemma easy

Answer key

5.14 Pushdown Automata (15) top

5.14.1 Pushdown Automata: GATE CSE 1996 | Question: 13 top

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 descriptive

Answer key

5.14.2 Pushdown Automata: GATE CSE 1997 | Question: 6.6 top

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

Answer key

5.14.3 Pushdown Automata: GATE CSE 1998 | Question: 13 top

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

Answer key

5.14.4 Pushdown Automata: GATE CSE 1999 | Question: 1.6 top

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

Answer key

5.14.5 Pushdown Automata: GATE CSE 2000 | Question: 8 top

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

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

A. Introduce two edges with appropriate labels in the above diagram so that the resulting pda accepts the language $\left\{x2x^R \mid x \in \{0,1\}^*, x^R \text{ denotes reverse of x}\right\}$, by empty stack.
B. Describe a non-deterministic pda with three states in the above notation that accept the language $\{0^n1^m \mid n \leq m \leq 2n\}$ by empty stack

gatecse-2000 theory-of-computation descriptive pushdown-automata

Answer key

5.14.6 Pushdown Automata: GATE CSE 2001 | Question: 6 top

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

gatecse-2001 theory-of-computation normal pushdown-automata descriptive

Answer key

5.14.7 Pushdown Automata: GATE CSE 2009 | Question: 16, ISRO2017-12 top

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.

gatecse-2009 theory-of-computation easy isro2017 pushdown-automata

Answer key

5.14.8 Pushdown Automata: GATE CSE 2015 Set 1 | Question: 51 top

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

gatecse-2015-set1 theory-of-computation pushdown-automata normal

Answer key

5.14.9 Pushdown Automata: GATE CSE 2016 Set 1 | Question: 43 top

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

gatecse-2016-set1 theory-of-computation pushdown-automata normal

Answer key

5.14.10 Pushdown Automata: GATE CSE 2021 Set 1 | Question: 51 top

In a pushdown automaton $P = (Q, \Sigma, \Gamma, \delta, q_0, F)$, a transition of the form,

where $p, q \in Q$, $a \in \Sigma \cup \{\epsilon\}$, and $X, Y \in \Gamma \cup \{\epsilon\}$, represents

$$(q, Y) \in \delta(p, a, X).$$

Consider the following pushdown automaton over the input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{\#, A\}$.

The number of strings of length 100 accepted by the above pushdown automaton is _____

gatecse-2021-set1 theory-of-computation pushdown-automata numerical-answers 2-marks

Answer key

5.14.11 Pushdown Automata: GATE CSE 2023 | Question: 30 top

Consider the pushdown automaton (PDA) P below, which runs on the input alphabet $\{a, b\}$, has stack alphabet $\{\perp, A\}$, and has three states $\{s, p, q\}$, with s being the start state. A transition from state u to state v, labelled $c/X/\gamma$, where c is an input symbol or ϵ, X is a stack symbol, and γ is a string of stack symbols, represents the fact that in state u, the (PDA) can read c from the input, with X on the top of its stack, pop X from the stack, push in the string γ on the stack, and go to state v. In the initial configuration, the stack has only the symbol $\perp$ in it. The (PDA) accepts by empty stack.

Which one of the following options correctly describes the language accepted by P?

A. $\{a^m b^n \mid 1 \leq m \text{ and } n < m\}$
B. $\{a^m b^n \mid 0 \leq n \leq m\}$
C. $\{a^m b^n \mid 0 \leq m \text{ and } 0 \leq n\}$
D. $\{a^m \mid 0 \leq m\} \cup \{b^n \mid 0 \leq n\}$

gatecse-2023 theory-of-computation pushdown-automata 2-marks

Answer key

5.14.12 Pushdown Automata: GATE IT 2004 | Question: 40 top

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

gateit-2004 theory-of-computation pushdown-automata normal

Answer key

5.14.13 Pushdown Automata: GATE IT 2005 | Question: 38 top

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^*

gateit-2005 theory-of-computation pushdown-automata normal

Answer key

5.14.14 Pushdown Automata: GATE IT 2006 | Question: 31 top

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. $\{a^m b^n \mid m, n \geq 0\}$

gateit-2006 theory-of-computation pushdown-automata normal

Answer key

5.14.15 Pushdown Automata: GATE IT 2006 | Question: 33 top

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. $\{a^l b^m c^n \mid m = n\}$

gateit-2006 theory-of-computation pushdown-automata normal

Answer key

5.15 Recursive And Recursively Enumerable Languages (13) top

5.15.1 Recursive And Recursively Enumerable Languages: GATE CSE 1990 | Question: 3-vi top

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 multiple-selects

Answer key

5.15.2 Recursive And Recursively Enumerable Languages: GATE CSE 2003 | Question: 13 top

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 $P = NP$

gatecse-2003 theory-of-computation normal recursive-and-recursively-enumerable-languages

Answer key

5.15.3 Recursive And Recursively Enumerable Languages: GATE CSE 2003 | Question: 15 top

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 gatecse-2003 normal recursive-and-recursively-enumerable-languages

Answer key

5.15.4 Recursive And Recursively Enumerable Languages: GATE CSE 2005 | Question: 56 top

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

gatecse-2005 theory-of-computation recursive-and-recursively-enumerable-languages easy

Answer key

5.15.5 Recursive And Recursively Enumerable Languages: GATE CSE 2008 | Question: 13,

ISRO2016-36 top

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

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

gatecse-2008 theory-of-computation easy isro2016 recursive-and-recursively-enumerable-languages

Answer key

5.15.6 Recursive And Recursively Enumerable Languages: GATE CSE 2008 | Question: 48 top

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

gatecse-2008 theory-of-computation easy recursive-and-recursively-enumerable-languages

Answer key

5.15.7 Recursive And Recursively Enumerable Languages: GATE CSE 2010 | Question: 17 top

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.

gatecse-2010 theory-of-computation recursive-and-recursively-enumerable-languages decidability normal

Answer key

5.15.8 Recursive And Recursively Enumerable Languages: GATE CSE 2014 Set 1 | Question: 35 top

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.

gatecse-2014-set1 theory-of-computation easy recursive-and-recursively-enumerable-languages

Answer key

5.15.9 Recursive And Recursively Enumerable Languages: GATE CSE 2014 Set 2 | Question: 16

top

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.

gatecse-2014-set2 theory-of-computation recursive-and-recursively-enumerable-languages normal

Answer key

5.15.10 Recursive And Recursively Enumerable Languages: GATE CSE 2015 Set 1 | Question: 3

top

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

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

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

gatecse-2015-set1 theory-of-computation recursive-and-recursively-enumerable-languages normal

Answer key

5.15.11 Recursive And Recursively Enumerable Languages: GATE CSE 2016 Set 2 | Question: 44

top

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

gatecse-2016-set2 theory-of-computation recursive-and-recursively-enumerable-languages

Answer key

5.15.12 Recursive And Recursively Enumerable Languages: GATE CSE 2021 Set 1 | Question: 12

top

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

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

gatecse-2021-set1 multiple-selects theory-of-computation recursive-and-recursively-enumerable-languages 1-mark

Answer key

5.15.13 Recursive And Recursively Enumerable Languages: GATE CSE 2021 Set 1 | Question: 39

top

For a Turing machine M, $\langle M \rangle$ denotes an encoding of M. Consider the following two languages.

$$L_1 = \{\langle M \rangle \mid M \text{ takes more than 2021 steps on all inputs}\}$$
$$L_2 = \{\langle M \rangle \mid M \text{ takes more than 2021 steps on some input}\}$$

Which one of the following options is correct?

A. Both L_1 and L_2 are decidable
B. L_1 is decidable and L_2 is undecidable
C. L_1 is undecidable and L_2 is decidable
D. Both L_1 and L_2 are undecidable

gatecse-2021-set1 theory-of-computation recursive-and-recursively-enumerable-languages decidability easy 2-marks

Answer key

5.16 Reduction (2)

top

5.16.1 Reduction: GATE CSE 2005 | Question: 45

top

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

gatecse-2005 theory-of-computation decidability normal reduction

Answer key

5.16.2 Reduction: GATE CSE 2016 Set 1 | Question: 44

top

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.

gatecse-2016-set1 theory-of-computation easy recursive-and-recursively-enumerable-languages reduction

Answer key

5.17 Regular Expression (27) top

5.17.1 Regular Expression: GATE CSE 1987 | Question: 10d top

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-expression descriptive

Answer key

5.17.2 Regular Expression: GATE CSE 1991 | Question: 03,xiii top

Let $r = 1(1+0)^*, s = 11^*0 \text{ and } t = 1^*0$ 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-expression normal multiple-selects

Answer key

5.17.3 Regular Expression: GATE CSE 1992 | Question: 02,xvii top

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-expression easy multiple-selects

Answer key

5.17.4 Regular Expression: GATE CSE 1994 | Question: 2.10 top

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

gate1994 theory-of-computation finite-automata regular-expression easy fill-in-the-blanks

Answer key

5.17.5 Regular Expression: GATE CSE 1995 | Question: 1.9 , ISRO2017-13 top

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-expression easy isro2017

Answer key

5.17.6 Regular Expression: GATE CSE 1996 | Question: 1.8 top

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-expression easy

Answer key

5.17.7 Regular Expression: GATE CSE 1997 | Question: 6.4 top

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-expression normal

Answer key

5.17.8 Regular Expression: GATE CSE 1998 | Question: 1.12 top

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-expression easy multiple-selects

Answer key

5.17.9 Regular Expression: GATE CSE 1998 | Question: 1.9 top

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-expression normal

Answer key

5.17.10 Regular Expression: GATE CSE 1998 | Question: 3b top

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-expression easy descriptive

Answer key

5.17.11 Regular Expression: GATE CSE 2000 | Question: 1.4 top

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. $S \cap T=\phi$

gatecse-2000 theory-of-computation regular-expression easy

Answer key

5.17.12 Regular Expression: GATE CSE 2003 | Question: 14 top

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

gatecse-2003 theory-of-computation regular-expression easy

Answer key

5.17.13 Regular Expression: GATE CSE 2009 | Question: 15 top

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

gatecse-2009 theory-of-computation regular-expression easy

Answer key

5.17.14 Regular Expression: GATE CSE 2010 | Question: 39 top

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. $0^*1(10^*1)^*10^*$

gatecse-2010 theory-of-computation regular-expression normal

Answer key

5.17.15 Regular Expression: GATE CSE 2014 Set 1 | Question: 36 top

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

gatecse-2014-set1 theory-of-computation regular-expression finite-automata easy

Answer key

5.17.16 Regular Expression: GATE CSE 2014 Set 3 | Question: 15 top

The length of the shortest string NOT in the language (over $\Sigma = \{a, b\}$) of the following regular expression is _____.

$$a^*b^*(ba)^*a^*$$

gatecse-2014-set3 theory-of-computation regular-expression numerical-answers easy

Answer key

5.17.17 Regular Expression: GATE CSE 2016 Set 1 | Question: 18 top

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. $00(0+1)^*11 + 11(0+1)^*00$

gatecse-2016-set1 theory-of-computation regular-expression normal

Answer key

5.17.18 Regular Expression: GATE CSE 2020 | Question: 7 top

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

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

gatecse-2020 regular-expression normal theory-of-computation 1-mark

Answer key

5.17.19 Regular Expression: GATE CSE 2021 Set 2 | Question: 47 top

Which of the following regular expressions represent(s) the set of all binary numbers that are divisible by three? Assume that the string ϵ is divisible by three.

A. $(0 + 1(01^*0)^*1)^*$
B. $(0 + 11 + 10(1 + 00)^*01)^*$
C. $(0^*(1(01^*0)^*1)^*)^*$
D. $(0 + 11 + 11(1 + 00)^*00)^*$

gatecse-2021-set2 multiple-selects theory-of-computation regular-expression 2-marks

Answer key

5.17.20 Regular Expression: GATE CSE 2022 | Question: 2 top

Which one of the following regular expressions correctly represents the language of the finite automaton given below?

A. $ab^*bab^* + ba^*aba^*$
B. $(ab^*b)^*ab^* + (ba^*a)^*ba^*$

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

gatecse-2022 theory-of-computation finite-automata regular-expression 1-mark

Answer key

5.17.21 Regular Expression: GATE CSE 2023 | Question: 4 top

Consider the Deterministic Finite-state Automaton (DFA) $\mathcal{A}$ shown below. The DFA runs on the alphabet $\{0, 1\}$, and has the set of states $\{s, p, q, r\}$, with s being the start state and p being the only final state.

Which one of the following regular expressions correctly describes the language accepted by $\mathcal{A}$?

A. $1(0^*11)^*$ B. $0(0+1)^*$ C. $1(0+11)^*$ D. $1(110^*)^*$

gatecse-2023 theory-of-computation regular-expression 1-mark

Answer key

5.17.22 Regular Expression: GATE CSE 2023 | Question: 9 top

Consider the following definition of a lexical token **id** for an identifier in a programming language, using extended regular expressions:

$$\begin{aligned} \textbf{letter} &\rightarrow [\mathrm{A} - \mathrm{Za} - \mathrm{z}] \\ \textbf{digit} &\rightarrow [0 - 9] \\ \textbf{id} &\rightarrow \textbf{letter}\,(\,\textbf{letter} \mid \textbf{digit}\,)^* \end{aligned}$$

Which one of the following Non-deterministic Finite-state Automata with ϵ-transitions accepts the set of valid identifiers? (A double-circle denotes a final state)

A.

B.

C.

D.

gatecse-2023 theory-of-computation regular-expression 1-mark

Answer key

5.17.23 Regular Expression: GATE IT 2004 | Question: 7 top

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. $(a^*b^* + c^*)^*$

gateit-2004 theory-of-computation regular-expression normal

Answer key

5.17.24 Regular Expression: GATE IT 2005 | Question: 5 top

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.

gateit-2005 theory-of-computation regular-expression easy

Answer key

5.17.25 Regular Expression: GATE IT 2006 | Question: 5 top

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. $(a+b)^*$

gateit-2006 theory-of-computation regular-expression normal

Answer key

5.17.26 Regular Expression: GATE IT 2007 | Question: 73 top

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. $(a(ba)^*(a+bb) + b(ab)^*(b+aa))(a+b)^+$

gateit-2007 theory-of-computation regular-expression normal

Answer key

5.17.27 Regular Expression: GATE IT 2008 | Question: 5 top

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

gateit-2008 theory-of-computation regular-expression easy

Answer key

5.18 Regular Grammar (3) top

5.18.1 Regular Grammar: GATE CSE 1990 | Question: 15a top

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-language regular-grammar

Answer key

5.18.2 Regular Grammar: GATE CSE 2015 Set 2 | Question: 35 top

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

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

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

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

gatecse-2015-set2 theory-of-computation regular-grammar normal

Answer key

5.18.3 Regular Grammar: GATE IT 2006 | Question: 29 top

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. $\{\epsilon\}, \{wa \mid w \in (a+b)^* \text{and} \{wb \mid w \in (a+b)^*\}$

gateit-2006 theory-of-computation normal regular-grammar

Answer key

5.19 Regular Language (32) top

5.19.1 Regular Language: GATE CSE 1987 | Question: 2h top

State whether the following statements are TRUE or FALSE:

Regularity is preserved under the operation of string reversal.

gate1987 theory-of-computation regular-language true-false

Answer key

5.19.2 Regular Language: GATE CSE 1987 | Question: 2i top

State whether the following statements are TRUE or FALSE:

All subsets of regular sets are regular.

gate1987 theory-of-computation regular-language true-false

Answer key

5.19.3 Regular Language: GATE CSE 1990 | Question: 3-viii top

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-language multiple-selects

Answer key

5.19.4 Regular Language: GATE CSE 1991 | Question: 03,xiv top

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-language multiple-selects

Answer key

5.19.5 Regular Language: GATE CSE 1995 | Question: 2.24 top

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-language

Answer key

5.19.6 Regular Language: GATE CSE 1996 | Question: 1.10 top

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-language

Answer key

5.19.7 Regular Language: GATE CSE 1998 | Question: 2.6 top

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-language

Answer key

5.19.8 Regular Language: GATE CSE 1999 | Question: 6 top

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-language descriptive

Answer key

5.19.9 Regular Language: GATE CSE 2000 | Question: 2.8 top

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 $\{a^n \mid n \text{ is even}\}$

gatecse-2000 theory-of-computation easy regular-language

Answer key

5.19.10 Regular Language: GATE CSE 2001 | Question: 1.4 top

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

gatecse-2001 theory-of-computation easy regular-language

Answer key

5.19.11 Regular Language: GATE CSE 2001 | Question: 2.6 top

Consider the following languages:

- $L1 = \{ww \mid w \in \{a,b\}^*\}$
- $L2 = \left\{ww^R \mid w \in \{a,b\}^*, w^R \text{ is the reverse of w}\right\}$
- $L3 = \left\{0^{2i} \mid \text{ i is an integer}\right\}$
- $L4 = \left\{0^{i^2} \mid \text{ i is an integer}\right\}$

Which of the languages are regular?

A. Only $L1$ and $L2$ B. Only $L2, L3$ and $L4$ C. Only $L3$ and $L4$ D. Only $L3$

gatecse-2001 theory-of-computation normal regular-language

Answer key

5.19.12 Regular Language: GATE CSE 2006 | Question: 29 top

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

gatecse-2006 theory-of-computation normal regular-language

Answer key

5.19.13 Regular Language: GATE CSE 2007 | Question: 31 top

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. $\{xww^R \mid x, w \in \{0,1\}^+\}$

gatecse-2007 theory-of-computation normal regular-language

Answer key

5.19.14 Regular Language: GATE CSE 2007 | Question: 7 top

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

gatecse-2007 theory-of-computation easy regular-language

Answer key

5.19.15 Regular Language: GATE CSE 2008 | Question: 53 top

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

gatecse-2008 theory-of-computation normal regular-language

Answer key

5.19.16 Regular Language: GATE CSE 2011 | Question: 24 top

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. $\Sigma^* - Q$

gatecse-2011 theory-of-computation easy regular-language

Answer key

5.19.17 Regular Language: GATE CSE 2012 | Question: 25 top

Given the language $L = \{ab, aa, baa\}$, which of the following strings are in L^*?

1. $abaabaaabaa$
2. $aaaabaaaa$
3. $baaaaabaaaab$
4. $baaaaabaa$

A. $1, 2 \text{ and } 3$ B. $2, 3 \text{ and } 4$ C. $1, 2 \text{ and } 4$ D. $1, 3 \text{ and } 4$

gatecse-2012 theory-of-computation easy regular-language

Answer key

5.19.18 Regular Language: GATE CSE 2013 | Question: 8 top

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. $\{\epsilon, a\}$

gatecse-2013 theory-of-computation normal regular-language

Answer key

5.19.19 Regular Language: GATE CSE 2014 Set 1 | Question: 15 top

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

A. The language $L = \{a^n b^n \mid n \geq 0\}$ is regular.
B. The language $L = \{a^n \mid n \text{ is prime }\}$ is regular.
C. The language L= $\{w \mid w \text{ has } 3k + 1\ b's \text{ for some } k \in N \text{ with } \Sigma = \{a, b\}\}$ is regular.
D. The language $L = \{ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0, 1\}\}$ is regular.

gatecse-2014-set1 theory-of-computation regular-language normal

Answer key

5.19.20 Regular Language: GATE CSE 2014 Set 2 | Question: 15 top

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

gatecse-2014-set2 theory-of-computation normal regular-language

Answer key

5.19.21 Regular Language: GATE CSE 2014 Set 2 | Question: 36 top

Let $L_1 = \{w \in \{0,1\}^* \mid w \text{ has at least as many occurrences of } (110)'\text{s as } (011)'\text{s}\}$. Let $L_2 = \{w \in \{0,1\}^* \mid w \text{ has at least as many occurrences of } (000)'\text{s as } (111)'\text{s}\}$. 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

gatecse-2014-set2 theory-of-computation normal regular-language

Answer key

5.19.22 Regular Language: GATE CSE 2015 Set 2 | Question: 51 top

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

gatecse-2015-set2 theory-of-computation normal regular-language

Answer key

5.19.23 Regular Language: GATE CSE 2016 Set 2 | Question: 17 top

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.

gatecse-2016-set2 theory-of-computation normal regular-language

Answer key

5.19.24 Regular Language: GATE CSE 2018 | Question: 52 top

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 0) accepted by the following automaton.

The order of L_1 is _____.

gatecse-2018 theory-of-computation numerical-answers regular-language 2-marks

Answer key

5.19.25 Regular Language: GATE CSE 2019 | Question: 7 top

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

gatecse-2019 theory-of-computation regular-language 1-mark

Answer key

5.19.26 Regular Language: GATE CSE 2020 | Question: 51 top

Consider the following language.

$L = \{x \in \{a, b\}^* |$number of a's in x divisible by 2 but not divisible by $3\}$

The minimum number of states in DFA that accepts L is _____

gatecse-2020 numerical-answers theory-of-computation regular-language 2-marks

Answer key

5.19.27 Regular Language: GATE CSE 2020 | Question: 8 top

Consider the following statements.

I. If $L_1 \cup L_2$ is regular, then both L_1 and L_2 must be regular.
II. The class of regular languages is closed under infinite union.

Which of the above statements is/are TRUE?

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

gatecse-2020 theory-of-computation regular-language 1-mark

Answer key

5.19.28 Regular Language: GATE CSE 2021 Set 2 | Question: 9 top

Let $L \subseteq \{0,1\}^*$ be an arbitrary regular language accepted by a minimal DFA with k states. Which one of the following languages must necessarily be accepted by a minimal DFA with k states?

A. $L - \{01\}$ B. $L \cup \{01\}$ C. $\{0,1\}^* - L$ D. $L \cdot L$

gatecse-2021-set2 theory-of-computation finite-automata regular-language 1-mark

Answer key

5.19.29 Regular Language: GATE IT 2006 | Question: 30 top

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

gateit-2006 theory-of-computation easy regular-language

Answer key

5.19.30 Regular Language: GATE IT 2006 | Question: 80 top

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

gateit-2006 theory-of-computation normal regular-language

Answer key

5.19.31 Regular Language: GATE IT 2006 | Question: 81 top

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 I
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. $\{a^n b^n \mid n \geq 0\}$

gateit-2006 theory-of-computation normal regular-language

Answer key

5.19.32 Regular Language: GATE IT 2008 | Question: 35 top

Which of the following languages is (are) non-regular?

- $L_1 = \{0^m 1^n \mid 0 \leq m \leq n \leq 10000\}$
- $L_2 = \{w \mid w$ reads the same forward and backward$\}$
- $L_3 = \{w \in \{0,1\}^* \mid w$ contains an even number of 0's and an even number of 1's$\}$

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

gateit-2008 theory-of-computation normal regular-language

Answer key

5.20 Turing Machine (4) top

5.20.1 Turing Machine: GATE CSE 2003 | Question: 53 top

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

gatecse-2003 theory-of-computation turing-machine normal

Answer key

5.20.2 Turing Machine: GATE CSE 2003 | Question: 54 top

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 gatecse-2003 difficult

Answer key

5.20.3 Turing Machine: GATE CSE 2004 | Question: 89 top

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

gatecse-2004 theory-of-computation turing-machine difficult

Answer key

5.20.4 Turing Machine: GATE CSE 2014 Set 2 | Question: 35 top

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

gatecse-2014-set2 theory-of-computation turing-machine normal

Answer key

Answer Keys

5.1.1	B	5.2.1	A;C	5.2.2	N/A	5.2.3	A	5.2.4	C
5.2.5	D	5.2.6	B	5.2.7	B	5.2.8	D	5.3.1	B
5.4.1	False	5.4.2	A;D	5.4.3	C	5.4.4	A	5.4.5	B
5.4.6	B	5.4.7	B	5.4.8	N/A	5.4.9	N/A	5.4.10	B
5.4.11	C	5.4.12	B	5.4.13	D	5.4.14	B	5.4.15	D
5.4.16	D	5.4.17	B	5.4.18	B	5.4.19	D	5.4.20	A
5.4.21	C	5.4.22	C	5.4.23	C	5.4.24	B;C;D	5.4.25	B;C;D

5.4.26	B	5.4.27	B	5.4.28	A	5.4.29	C	5.4.30	D
5.4.31	B	5.5.1	B	5.5.2	C	5.5.3	B	5.6.1	True
5.6.2	True	5.6.3	N/A	5.6.4	B;D	5.6.5	B;C	5.6.6	N/A
5.6.7	D	5.6.8	B	5.6.9	N/A	5.6.10	A	5.6.11	B
5.6.12	N/A	5.6.13	N/A	5.6.14	C	5.6.15	B	5.6.16	B
5.6.17	D	5.6.18	D	5.6.19	A	5.6.20	D	5.6.21	C
5.6.22	C	5.6.23	A	5.6.24	D	5.6.25	D	5.6.26	A
5.6.27	C	5.6.28	A;B;C	5.7.1	N/A	5.7.2	N/A	5.7.3	N/A
5.7.4	True	5.7.5	B	5.7.6	N/A	5.7.7	N/A	5.7.8	A
5.7.9	N/A	5.7.10	A	5.7.11	N/A	5.7.12	C	5.7.13	B
5.7.14	A	5.7.15	B	5.7.16	B	5.7.17	C	5.7.18	A
5.7.19	C	5.7.20	A	5.7.21	C	5.7.22	B	5.7.23	D
5.7.24	D	5.7.25	A	5.7.26	B	5.7.27	C	5.7.28	D
5.7.29	256 : 256	5.7.30	B	5.7.31	B	5.7.32	A	5.7.33	B
5.7.34	D	5.7.35	A	5.7.36	D	5.7.38	A	5.7.39	A
5.7.40	A	5.7.41	A	5.8.1	C	5.8.2	B	5.9.1	C
5.9.2	N/A	5.9.3	N/A	5.9.4	N/A	5.9.5	A;C	5.9.6	B
5.9.7	B	5.9.8	B	5.9.9	A	5.9.10	D	5.9.11	B
5.9.12	B	5.9.13	D	5.9.15	D	5.9.16	C	5.9.17	D
5.9.18	C	5.9.19	B	5.9.20	D	5.9.21	B	5.9.22	C
5.9.23	A	5.9.24	B;C;D	5.9.25	B;C;D	5.9.26	A;B;C	5.9.27	A;C;D
5.9.28	D	5.9.29	A	5.9.30	B	5.10.1	0	5.10.2	N/A
5.10.3	N/A	5.10.4	B	5.10.5	N/A	5.10.6	B	5.10.7	B
5.10.8	D	5.10.9	B	5.10.10	D	5.10.11	A	5.10.12	B
5.10.13	C	5.10.14	B	5.10.15	A	5.10.16	1	5.10.17	3
5.10.18	B	5.10.19	2	5.10.20	4	5.10.21	8	5.10.22	D
5.10.24	4	5.10.25	A	5.11.1	A;C	5.11.2	C	5.11.3	B
5.11.4	D	5.11.5	B	5.11.6	C	5.12.1	D	5.12.2	A
5.12.3	C	5.12.4	B	5.12.5	A	5.13.1	D	5.13.2	D
5.14.1	N/A	5.14.2	A	5.14.3	N/A	5.14.4	A	5.14.6	N/A
5.14.7	D	5.14.8	B	5.14.9	D	5.14.11	A	5.14.12	B
5.14.13	D	5.14.14	B	5.14.15	C	5.15.1	A;D	5.15.2	A
5.15.4	B	5.15.5	D	5.15.6	D	5.15.7	B	5.15.8	C
5.15.9	D	5.15.10	D	5.15.12	D	5.16.1	C	5.16.2	C
5.17.1	N/A	5.17.2	A;C	5.17.3	A	5.17.4	N/A	5.17.5	C
5.17.6	C	5.17.7	D	5.17.8	C;D	5.17.9	D	5.17.10	N/A

5.17.11	C
5.17.16	3
5.17.21	C
5.17.27	C
5.19.2	False
5.19.7	B
5.19.13	C
5.19.18	A
5.19.23	C
5.19.28	C
5.20.1	A

5.17.12	A
5.17.17	B
5.17.22	C
5.18.1	N/A
5.19.3	B;C
5.19.8	N/A
5.19.14	B
5.19.19	C
5.19.24	2
5.19.29	C
5.20.2	D

5.17.13	C
5.17.18	X
5.17.23	C
5.18.2	C
5.19.4	D
5.19.9	X
5.19.15	A
5.19.20	A
5.19.25	B
5.19.30	B
5.20.3	A

5.17.14	B
5.17.19	A;B;C
5.17.24	B
5.18.3	A
5.19.5	C
5.19.10	A
5.19.16	C
5.19.21	A
5.19.26	6
5.19.31	A
5.20.4	B

5.17.15	B
5.17.20	D
5.17.25	A
5.19.1	True
5.19.6	D
5.19.11	D
5.19.17	C
5.19.22	A
5.19.27	D
5.19.32	D